EDUCATIONAL NETWORK ON SOIL AND PLANT ECOLOGY AND MANAGEMENT

Summer School Soil & Water 2017

Daily reports

Content

Monday, June 26th, 2017

Daily report

Reporters: Violetta Volokitina, Claude-Eric Marquet, Kateřina Kabeláčová

Lecturers of the day: Marian Kazda, Alar Astover, Eda Tursk, Merrit Shanskiy

The international course Soil & Water is an Erasmus project where are joining 4 universities during two weeks in Tartu in Estonia:

- Aix-Marseilles University
- University of Ulm
- Eesti Maaülikool
- University of South Bohemia

All students arrived on 25 June, settled in their rooms and together with teachers they attended to welcome party.

The program on 26 June begun with an introduction by professors who presented universities and their specialty about ecology and biology.

Prof. Marian Kazda talked about the history of the summer school and about aims of the project. The main goal is sharing the expertise, knowledge between universities and to meet colleagues from different countries. He was asking us on our motivation to participate in the summer school and he presented the topics and aims of summer school in this year.

They are:

- Interaction between soil, plants, and soil organisms
- Interdisciplinary insight into soil processes
- Effects of drought and flooding on plants
- Ecology of wetland
- Soil organic matter and soil organisms
- Plant stress and ecosystem response

- Soil degradation and its migration
- Environmental soil related problems on European level
- Link between soil function, economy, and society

Experts from different countries are going to participate in the Soil and Water international course and they are going to discuss the topics during next two weeks.

Eda Tursk presented about Estonian universities. She focused mainly on the Estonian University of Life Sciences with their 5 Ph.D. programs, Erasmus exchanges, and organizations. The University of Tartu was established in 1632. The Estonian University of Life Sciences was formed from the Tartu Veterinary Institute which was founded in 1848. The Estonian Univesity of Life Sciences has its new structure since November 2005.

It was followed by the first course on ecology by Merrit Shanskiy, about Estonian nature. She presented to us general knowledge on Estonia and more precisely the different soils, fauna, and flora present in this country.

Estonia has a very humid temperate climate, there is a transition zone between maritime and continental zone. The average precipitation is around 700 mm per year. The average elevation reaches only 50 m, the highest point Suur Munamagi has 317 m. 47% of the land is covered by forests and there are a lot of lakes and bogs. There are oil shale and limestone deposits.

She mentioned soil types of Estonia as Leptosols, Renzinas, Cambisols, Luvisols, Stagnosol, Planosols, Podzolic soils, Gleysols, Eroded soil, and Fluvisols.

We discussed important properties for soil such as pH levels, physical properties, the climate and the altitude.

Estonia has fauna and flora typical of forests and wetlands. The main fauna species are European lynx, wild boar, brown bear, and moose. There is also a wide wolf population. Estonia has diversity in birds, there are a lot of species of seabirds, wetland birds, and eagles. Common fishes are trouts, carps, whitefishs and there are also salmons.

Estonian flora is rich in forests and bogs species. The most common trees are pines, spruces, birches, aspens, and alders. The typical mosses for bogs are sphagnums. There are also a lot of orchid species which are all under the protection. Estonia has five national parks.

Students formed groups for different projects in the afternoon. The group works were:

- Soil properties
- Soil compaction

- Fast plant test with various substrates and compost
- Soil zoology
- Plant stress
- Allelopathy

Students had a tour in the center of Tartu. We met our guide in front of the city hall. The guide told us more about the history of Tartu, universities, the cathedral, and the university hospital. At the end of the day, we visited a pub to get to know each other better.

The Daily report of Day II

Summer School 2017

Jan Šmejkal and Bernhard Glocker

27.07.2017

Contents

List of Figures

1 Introduction to soil-water relations - by Marian Kazda

1.1 Soil components

Three phases System:

1. solid phase
2. liquid phase
3. gaseous phase

1.1.1 Soil a mixture of three phases

Solid phase

1. Inorganic material skeleton(>2 mm), → fine soil: sand, silt, clay
2. organic material: humus (basic soil chemistry)(consider on that by beeing a soil scientist - the oters are to variable), plant roots, soil animals, soil microorganisms an fungi

Liquid phase Soil water/soil solution: H2O with ions and DOC (dissolved organic Carbon)

Gaseous phase

1.1.2 Soil water status

saturated point, field capacity, wilting point, hygroscopic coeficient,
Soil water status as a function of pressure (tension)

1.1.3 soil water and porosity

air or gravity water (Vg) capilarity water & adsorbed water (Vc)

$$(Vg + Vs = Vp)$$

solids: rock, sand, etc (Vs)

$$(Vp + Vs = V)$$

Soil sizes: gravel, >2 mm sand, 2-0.063 mm silt, 0.063-0.002 mm clay; <0.002 mm

1.1.4 Importance of clay

High impact on:

- soil structure
- water retention
- cation exchange

$\Longrightarrow$ **Soil texture and available water**

Water supply to plant roots

$$W = A\frac{\Psi_{\text{soil}} - \Psi_{\text{root}}}{\sum r} \tag{1.1}$$

W=wateruptake
A=root area
$\sum r$= sum of resistance - it is increasing while soil gets dry

Transpiration in water limited ecosystems

They do not always transpirate as much as they can, because of physiological closing the stomata, if it is dry

Bernhard Glocker

2 Bog restoration ecology - by Hermann Muhle

2.1 Types of peatlands

- Bog
  - Is a king of peatland which is typically rich in accumulated peat in the soil horizon. These peatlands are usually very old and their surface is so high that it is not connected to the surface water anymore and its source of water is mainly precipitation.
  - Typical pH of a bog is very low because of acidifying effect of sphagnum moss, potential carbonate influence that would cause the pH to be higher is eliminated by the height of accumulated peat.
  - Bog is usually very pure of nutrients.
- Mire
  - Is usually connected to a source of surface water which brings nutrients, so the mire is usually rather mesotrophic than oligotrophic. Its peat layer is quite shallow comparing to the bog.
  - The pH of a mire is usually lower the the pH of a bog. It can still be buffered by carbonates. The lower pH and nutrients brought by surface water cause higher richness in species.

2.2 Peat use

- Fuel
  - Main use of peat was as a form of organic fuel used for heating houses. Peat is rich in carbon which can by oxidized during burning to crate CO_2.
- Agriculture
  - Peat can also be used as an organic addition to the field. Its addition increases content of soil organic matter, which improves soil exchange capacity, water holding capacity, soil texture and brings come nutrients too.
  - Another important use of peat in agriculture was the form of a litter which was used in cattle breeding.

2.3 Restoration

Nowadays the mined peatland areas are endangered by more degradation. Before mining, peatlands were usually drained, so the peat could be easily mined. The drainage causes better aeration in the soil which turns anaerobic conditions to aerobic, peat accumulation stops and the accumulated peat are relatively quickly decomposed and transformed to CO2 which is released to the atmosphere. The mined or partly mined areas can be rewatered by destroying the drainage systems or sometimes are used to cultivate some fruits especially blueberries.

Jan Šmejkal

3 Wetland plants and their adaption

3.1 Outline

- Trees of swamps and mangroves
- fully submersed plants
- mergent macrophytes
- sphagnum bog
- terrestrial plants under flooding/compact soil

3.2 Trees of swamps and mangroves: Anoxia only under flooding?

Conditions:

- Oxygen difuse in water 10000 timesslower
- use alternative electron acceptors
- similar in soils of low porosity (e.g. clay)
- Anoxia fairly above the ground water level

3.2.1 Stress under low oxygen supply:

- O_2 shortage (hypoxia/anoxia)
- chemical changes of soil properties
  - reduction of previosly oxidised compounds as alternative electron acceptors
- postanoxic oxidative stress
  - burst of lipid peroxidation
  - damage of membranes
  - denaturation of proteins and nucleic acid

Adaption in mangroves

Adaptions to saltwater and tides (i.e. aerenchyma)

3.2.2 Adaption to substrate anoxia in trees

- Formation of adventive roots
- Formation of hypertrophied lenticels
- Oxygen production by stem photosynthesis
- Oxygen loss from the roots (ROL)
- *no aerenchyma (partly large intercellular spaces)*
- *only limites pressurization*

3.3 Wetland plants: Fully submersed plants

3.3.1 Physiological adaption to Energy shortage and anoxia

Energy is storaged in the rhizome

3.4 Emergent macrophytes: the best anoxia adaption plants

- Adaption to anoxia in the rooting zone
- low biodiversity, few highly adapted species
- growing so compact, there is no place for other livings

Adaption to substrate anoxia

- aeration system of submersed organs
  - Humidity-induced pressurisation
  - Thermo-osmotic ventilation
  - Symbiosys with bacterias located to the roots (Methanotrophic bacteria)
- oxygen loss from the roots

3.5 Raised bog

- high diversity (not so big plants, there is enough space)
- water table independent of ground water, -> need rain
- Restoring moore because of CO_2 sinking, biodiversity, less flooding, cooling climate-effect

Bernhard Glocker

4 Excursion: mined peat area, agricultural field experiments

All the following pictures are made by Jan Šmejkal

- Bucket experiments- water flow through the soil
  - Effect of biochars to water retention and soil exchange capacity
- Flower bed – soil formation experiment
  - Soil was removed until 1m depth and the local silt material was used as a starting point. Different crops are grown (*Trifolium sp.*, *Hordeum sp.*, grass mix, no plants) and soil properties as soil organic carbon and nutrients are observed.
  - Organic carbon content was observed since 1960.
- Organic vs. conventional farming (5 crops rotation)
  - 4 nutrients content observed, fertilized 50 – 150kg N/ha
  - Organic: manure fertilized (10t/ha), no pesticides (genetical study on weeds: biological diversity influence)
- Commercial organic fertilizers experiment
  - Granulated organic fertilizers
  - Bacterial fertilizers, fungi addition
  - Bacteria releasing phosphate or increase phosphate availability
- Long term experiment site
  - Since 1989
  - Different managements: no fertilizers, organic fertilizers only, mineral fertilizers (40 – 160 kg /ha) only or both.
  - 3 crops in rotation (potatoes, barley, wheat)
- Restored peatlands
  - The peatland we visited was mined (although according our deep soul sample, there was still over 150 cm) and restored.

Figure 4.1: Fig. 1: View of a part of the longterm field experiment site

Figure 4.2: Fig. 2: *Drosera rotundifolia* - a typical plant in the peatlands

Figure 4.3: Fig. 3: *Eriophorum ssp.* - a typical plant in the peatlands

Figure 4.4: Fig. 4: A digged hole in a peatland soil

– There were some beautiful peatland plant species for example *Rhododendron tomentosum*, *Drosera rotundifolia*, *Vaccinium oxycocos*, *Sphagnum sp.* as well as some orchids: *Dactylorhiza maculata* or *Epipactis sp.*

– The peatland is partly used for blueberry cultivation.

– We made pH measurements and first measurement showed pH of 5.5. This value is very high for this kind of area and is caused by leaching of lime from a freshly made road built from limestone. Second measurement made more further from the road showed pH about 4.5. (Fig. 1)

Jan Šmejkal

Summer School Soil & Water
Tartu 2017

Daily Report of day three

Sophie Bauer
Axel Bergeon
Bernhard Glocker

Contents

1 Litter decomposition - by Virginie Baldy

Leaf litter degradation is the principal pathway if the nutrient to return to the soil in an available form to plants. It is essential for all processes necessary for growth, reproduction and nutrition. The decomposition of leaf litter into humus or mineral matter, is managed by a lot of organism: bacteria, fungi and soil micro and mesofauna. The efficiency of this process depends meanly of environmental condition (such as temperature, soil water content. . .) and leaf litter chemistry (structure, compound, defence compound, nutrients)

1.1 Prinzipal parameter of decomposition

The efficiency of this process depends of environmental condition: habitat effect, tree characteristics, climatic conditions (such as temperature) and soil organic content.

Habitat effect: "Home Field Advantage": theory meaning than the decomposition is better at home than away. This is due to the specialized decomposers, species and the microclimate of the soil.

Tree effect: Distinct species emitted different secondary metabolite in separate way that have different effect on the litter degradation. That have an influence on biotic interaction, biogeochemical cycle etc. The global effect the distribution of species and stress plant that effect the emission of secondary metabolite, that can modify the efficiency of the decomposition.

Climatic condition and organic content: In Mediterranean areas recurrent fires degrade the soil, but also there is many environmental stress like elevated temperature, drought and anthropogenic pressure. There is a marked seasonal effect of biodegradation of leaf litter directly to water stress. Organic amendment (by compost in example) is suitable technique for accelerating the natural recovery of process of burned soil. But in general, under Mediterranean climate, the water content is more important than soil fertility for decomposition of litter because it increase the abundance of microarthropods.

Litter chemistry: The main parameters are: The water holding capacity, amount of lignin phenol, C/N ratio, plant cover, plant species and secondary metabolite. And also the composition of the soil, such as microbial, micro and mesofauna have a heavy impact on the decay. The more plants diversity there is, the greater is the number of different compounds (secondary metabolites). And a big amount of secondary metabolite permits more resources for decomposer and then increase the efficiency of the decomposition. Furthermore, some species emitted toxic secondary metabolites that may have a negative influence on the degradation such as Pinus halepensis in Mediterranean forest. Litter-mixing leaf species can affect on litter mass loss positively, negatively or have no effect.

Environmental condition: Global warming increase the frequency of dry days and heavy precipitation in several temperate regions. That impact the water availability and so the litter type, the diversity and abundance and decomposer and finally, the litter mass loss (usually negatively). An increase of plant biodiversity helps again climatic stress. That also change the structure, functioning, dynamics and biodiversity. Environmental condition and litter chemistry are interrelated.

1.2 Methods for monitoring the litter decomposition

- Litter bag used for measuring the leaf litter mass loss. This is a net bag containing leaf litter. It allows exchange between microbial, microfauna and leaf litter.
- Berlese funnel used for mesofauna extraction and identification. It is composed with a funnel containing soil that is heated by a light. Mesofauna try to escape the elevated temperature and drought and fall into a glass under the funnel.
- Ergosterol that is a molecule synthesized by fungi that permit to determine the biomass of fungi. This method need first an extraction, purification and then a quantification by HPLC.

- Biological ecoplate: indicator of microbial biodiversity with colouration of soil suspension.
- Terpenoid and phenolics extraction by Gas chromatography and mass spectrometry
- Phenolics index: total amount of phenolics (colorimetric measurement in spectrometry)

Axel Bergeon

2 Soil Zoology - by Petr Hedenec, Eva Keppner

2.1 Introduction

In the second lesson Eva Keppner told about the introduction to soil zoology. There are different ways to classify soil animals. One is the size-body width. Another way is the location/ habitat. Epidaphic animals live on the soil surface, hemiedaphic organisms in the upper layers and eudephic animals in the soil. Eva also told that the litter breakdown is enhanced by the soil fauna. The soil food web concludes 3 parties: the ecosystem engineers, the litter-transformers and the micro-food web. Another way of classification orders the organisms into Saprophagus, Mikrophytophagus, Zoophagus and Phytophagus. Then Eva talked about the soil animal's taxonomy. There are Protozoa, which include Flagellates, Amoeba and Ciliates. Another type is the Rotifera and also the Tartigrada. The soil nematodes are specialised into phytophages, microbivores, fungivores, omnivores and predators. Then there are the Annelida and also the Gastropoda (snails and slugs). The soil arthropods are concluding the Aranea, Pseudoscorpions, Opiliones, Acari, Isopoda, Chilopoda and Diplopoda. They are very diverse like the Insecta with Apterygota and Pterygota. Other taxa mentioned were the Formicidae-Ants, the Coleoptera, the Diptera and at the end the Vertebrata. To summarise, soil organisms are very diverse, well adapted to their environment and useful bioindicators.

2.2 Practical work

In the second part of the lecture Petr Hedenec told about some practical methods. Methods for studying the soil microfauna, especially the protists, are the cultivation dependent method, e.g. dilution methods, and also the cultivation independent method like DNA sequencing. For the Nematoda exists the determination according the mouthpart. The soil mesofauna can be detected by hand-sorting or tullgrens. Also the soil macrofauna can be studied by tullgrens funnels and by other methods like pitfull traps, butterfly nets for Lepidoptera's, light traps for flies, Malaise traps for flying insects and pheromone traps for bark beetles. Petr also talked about some plant soil interactions. A high C/N ratio supports the fungal energy channel whereas a low C/N ratio supports the bacterial energy channel. Some examples for these interactions are direct and indirect pathways, aambrosia beetles and fungi as well as gut microbiota. Gut microbiota are symbiotic microorganisms living in multicellular organisms. Microbiota includes bacteria, archaea, protists, fungi and viruses.

Sophie Baur

3 How to write reports and give academic presentations - by Eva Keppner

For the last lecture on this day, Eva Keppner told us how to present ourselves in Presentations and reports.

3.1 Presentations

First of all, you have to be sure about your own appearance: welcome the audience and during the whole presentation you have to keep eye-contact and speak freely. However you are not allowed to run through your presentation but to use a pointer or a stick to be sure the audience knows what you are talking about.

Power-point-Presentation: Your slides should not be overloaded with text or pictures, use simple sentences and background, the right font, size and colour and only the animations you really need.

Presentation of topics: Discuss the foregone publications, the problems they are dealing with and the methods they are using in a 10 minutes summary to show why you are interested in the topic.

Presentation of results: During your 15 minutes presentation of your results, you have to give a short introduction to the topic, methods you have used and present your results with diagrams and tables as your aid.

Last but not least: Rehearse your presentation and be prepared for questions.

3.2 Reports and protocols

Layout: You should choose an appropriate font and use list of contents, tables, figures, etc.

Daily reports: In the short reports for each day you have to summarize the main content of the lectures and what you have seen and done in the excursions.

Report of the "Mini-Research-Project": In the introduction you are supposed to summarize similar projects in a general context. Materials and Methods should be explained in a separate paragraph with all the technique dates and times of measurements. In the next step you have to show you results using tables and diagrams with captions and descriptions, so you can discuss them in the next paragraph and give an outlook to further experiments. Be sure you have no Copyright infringements in your protocol.

Bernhard Glocker

Summer School Soil & Water 2017

Day 4 – Thursday 29th June 2017
Milan Varsadiya, Alena- Maria Maidel

Lecture “Wetland ecology and carbon fluxes” (Zuzana Urbanová)

The lecture started with the Introduction to wetland ecology, the carbon cycling in wetlands, how wetlands act as a source of methane and finally wetlands and their context to the climate.

Attributes of wetlands

There are different attributes of wetlands, the permanently or seasonally waterlogged or flooded, hydrotropic vegetation and substrate saturated with water. Examples for wetlands are Peatlands, wet meadows, swamp, salt marsh, river deltas and floodplains, constructed wetlands, rice fields and mangroves. They all are close or above the surface and have a high water level. The most important drivers of wetlands functioning are the source of water (salt, freshwater; oligotrophic – eutrophic), the water regime (period of flooding), the water quality and the oxygen concentration.

Processes which are running in wetlands influence the area around them. Therefore, wetlands can be seen as a continuum between terrestrial and aquatic systems with fluxes of energy and materials.

Distribution of wetlands

Wetlands cover 6% of the Earth surface. They are also in deserts because of the high groundwater in these areas. In Figure 1 you can see the northern zone with the most wetlands.

Fig. 1: The distribution of wetlands

The Net primary production (NPP) of vegetation in wetlands can be three times higher than i.e. in tropical rain forests or temperate forests [1]. That’s the reason why there are a lot of ecological functions according to these areas. They are the most biologically productive and biologically diverse ecosystems, have an effect on water quality (living filters), climate (local and global), element cycling, flood control and are hosts for many species of plants and animals. Humans also use these areas for agriculture (rice paddies, floodplains), fishing, hunting (waterfowls), water use for drinking or irrigation, source of peat (burning, horticulture), wood (timber) and water purification (constructed wetlands).

Wetland soils

There are two different types of wetland soils, the mineral wetland soil and the organic wetland soil (Histosols) which you can see in Figure 2.

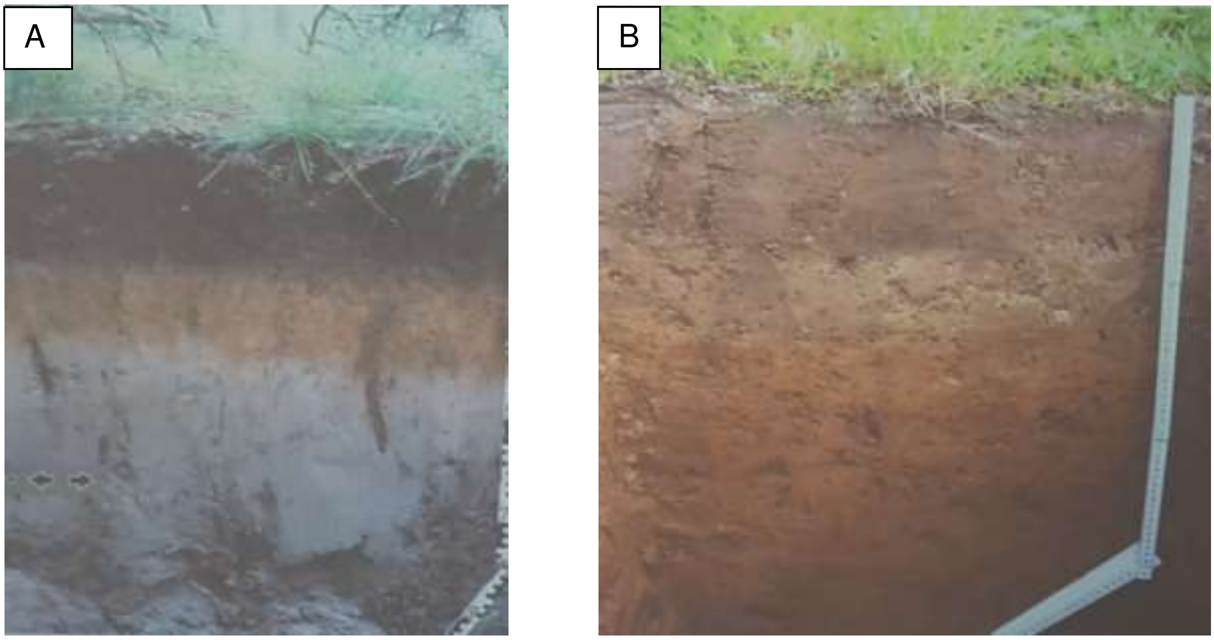

Fig. 2: The mineral wetland soil and the organic wetland soil

The picture A is the mineral wetland soil which is sandy, loamy or with a lot of clay. The part of the whole soil profile is saturated for a sufficient period of time to create distinctive gley horizons. This horizon is called the mottled zone where iron and manganese accumulate. It also consists of a mottled zone (gley horizon) and a permanently reduced zone (gray or bluish-green color). The organic matter accumulation increases in surface horizon.

Picture B is showing the organic wetland soil (Histosols) which contains more than 12% of the total carbon in the upper one-meter layer. It also consists of peat (Peatlands).

Carbon cycling in wetlands

Carbon is the basic element of life forms. There are organic and inorganic reservoirs with continuous interactions, exchange and feedback reactions. Photosynthesis and the aerobic respiration are examples. The inorganic carbon from the atmosphere reacts to organic carbon under photosynthesis. The major reservoirs of carbon are in the wetland soil. Peatlands are also important because they equal 30 – 50% of the carbon in the atmosphere. It is very high because they cover only 3 % of the Earth surface.

In wetlands the carbon comes from the photosynthesis and losses carbon by leaching, autotrophic and heterotrophic respiration. The carbon accumulates when income exceeds carbon losses. The ecosystem carbon balance is calculated with the NEP (Net Ecosystem Production) = GPP (Gross Primary Production -> photosynthesis) minus the ecosystem respiration (of plants, animals and soil microbes).

Carbon accumulates in wetlands because of slower decomposition. The decomposition rate is controlled by hydrological regime, content of O_2, temperature, quality and quantity of org. material (plant species), microbial activity, pH, nutrient content and water quality. The carbon accumulation varies between wetland types and time.

Both photosynthesis (GPP) and ecosystem respiration (RE) are controlled by many factors, which are changing in time: climate, plant species composition and hydrology. The carbon fluxes vary between years. In the winter the carbon gets lost and during summer the most carbon is stored in the ecosystem.

<u>Wetlands as a source of methane</u>

Methane (CH_4) is the end product of anaerobic decomposition under the most reduced conditions, when other electron acceptors are depleted (O_2, NO_3^-, Fe, Mn, So_4^{2-}). Methane has a 25 times stronger global warming potential than CO_2. Wetlands are one of the largest natural source of CH_4 to the atmosphere. That's the reason why wetlands have a dual impact on climate but not all wetlands are methane producing. In Figure 3 is the methane oxidation way shown.

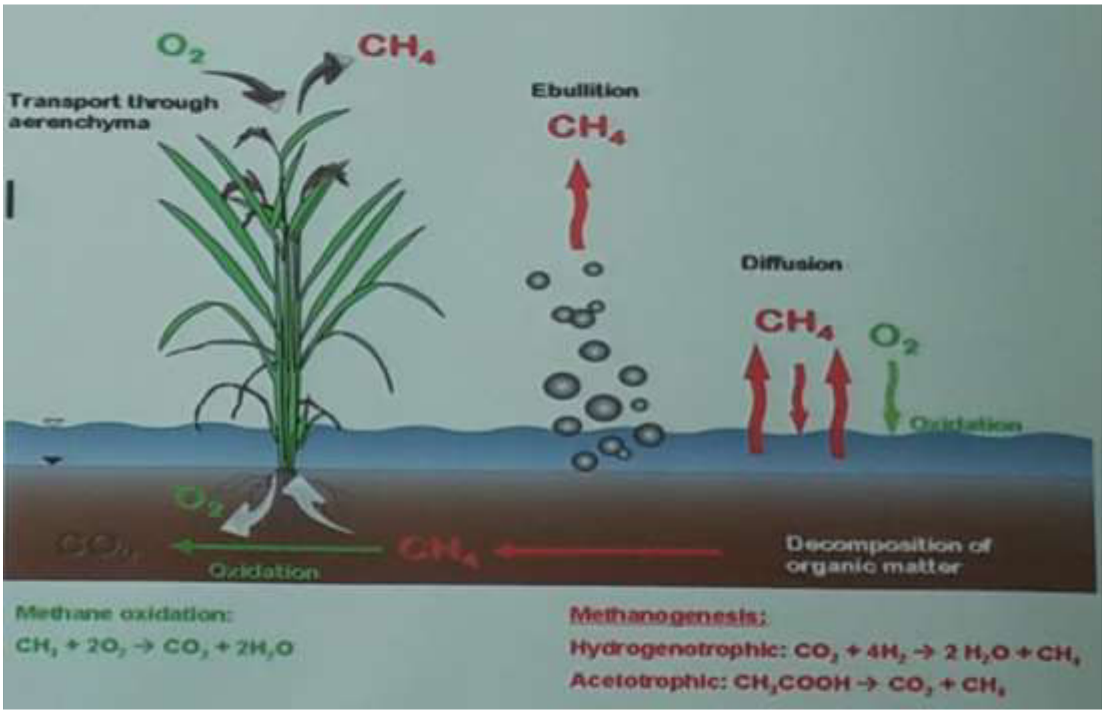

Fig. 3: Wetlands as a CH_4 source

The Hydrology, Trophic status, plant species composition and temperature are factors which are influencing the CH_4 production and emission. This production and emission varies in time and between wetland types. 3 % of the net ecosystem production (C fixation) released back to the atmosphere as CH_4.

<u>Wetlands and climate</u>

There is a feedback mechanism between climate and wetlands because of the long term storage of CO_2 and the source of CH_4. The CO_2 sequestration of carbon has a cooling and the methane emission a warming effect. GWP is the Global Warming Potential and a measure of the relative effect of a given substance compared to CO_2, for a chosen time horizon. CH_4 has a more effective thermal absorption and increased 200% over the last 200 years. The increasing concentration of greenhouse gases has an effect on the climate but what will be the impact on climate change to wetlands?

- Sea level rise → coastal wetlands
- Higher temperatures → increase in photosynthesis, respiration, biomass production…
- Changes in precipitation → hydrology, plant species composition…

Climate change is projected to be the most severe at the high latitudes where most peatlands are situated. There is also Permafrost melting in tundra.

➔ Wetlands are the most biologically productive and biologically diverse ecosystem and important for humans because of agriculture and fishing. Because of the high carbon storage, they're influencing the climate change.

[1] Table 1.7 Houghton & Skole, 1990; Schlesinger, 1997; Larcher, 2003

Lecture "Sustainable use of soil" (Alar Astover)

Soils are "non-renewable", changing in time and space and with limited quantity. The pressure on soil is increasing by the five F: Food, Feed, Fuel (bioenergy), Fibre (clothes, paper) and Fun (golf, flowers, landscape…).

There are different ways to satisfy the increasing biomass demand.

- Expanding agricultural areas (limited possibilities and not accepted by society)
- Increasing productivity/yields (intensification): Green revolution (mineral fertilizer, pesticides, irrigation, plant breeding)
- Reducing consumption and recycling (nutrients and carbon back to soil)

Think global, act local. That means you should think about aims for the whole planet and act in the local location to reach them.

There are different prerequisites for "good" land/ soil use decisions, the availability of reliable information and the ability to handle it.

1. Data i.e.: 5.1
2. Information i.e.: pH_{KCl} = 5.1
3. Decision i.e.: If agricultural soil the needs liming in most cases
4. Management action i.e.: lime fertilizer to soil
5. Result i.e.: resampling from same site and analyze pH
   ➔ Back to 1. Data

The information about soil is need to be georeferenced. Traditional ways to get original soil data with field survey and sampling for followed laboratory analysis: the soil inventory (different horizons), survey, mapping and monitoring. The difference between mapping and monitoring is that monitoring is for more fast changing soil properties. There are some new ways i.e. the Pedotransfer functions/rules (relation between soil carbon and density), remote sensing and digital soil mapping (DSM). Soil moisture, temperature, water and oxygen in soil are examples of dynamic parameters in the soil. The dynamics in time between various parameters is shown in Figure 4.

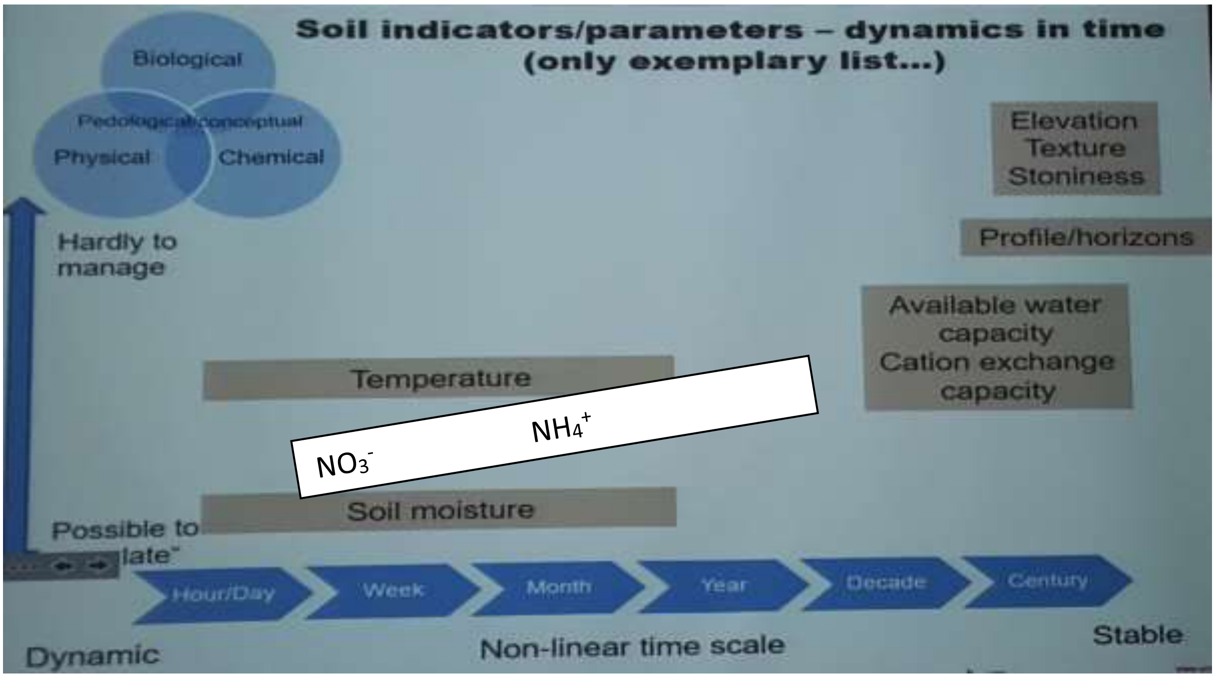

Fig. 4: An exemplary list of the soil indicators/parameters – dynamics in time

The NO_3^- form of nitrogen can change day/weak time scale because it's easy to change with mineral fertilizer. NH_4^+ is more stable because of the cations can be fixed with soil colloids with negative charge. N_{tot} stands for the nitrogen total carbon stock and is hard to change fast.

Soil quality

The soil quality is an account of ability of soil to provide ecosystem and society services through its capacities to perform its functions and respond to external influences (threats) (Toth et al 2007).

The soil quality cannot be measured with a single indicator. The selection of indicators should be based on (land use) purpose and fitted to spatial and temporal (dynamics in time) context.

There are traditional soil rating systems for agricultural soil (Typically 100-point scale, German soil rating…).

For example, in Estonia there is a lot of mineral soil which contains a lot of organic carbon. There is strong linear positive correlation between carbon and nitrogen in A-horizon of agricultural soils, the humus-rich soil contains also a lot of nitrogen. The nitrogen mineral fertilizer need depends on the soil humus concentration. With sampling and analytic methods, the agronomic optimum nitrogen rate (kg/ha) can be calculated. The soil phosphorus is difficult to measure and in Europe are more than 10 different extraction methods are in use.

In some cases, very detailed soil information is practical to generalize before land use recommendations.

- ➔ It's important to know what the soil contains and how it looks like to use the best fertilizers for the highest yield and smallest soil degradation.

A day excursion: Forest ecosystem and experiments at Järvselja

Two facilities were visited during this excursion on 29th June 2017. First one was FAHM (Free Air Humidity Manipulation) experimental site and SMEAR (Station for Measuring Ecosystem-Atmosphere Relations), we also visited a native forest at Järvselja.

Fig. 5: The entry shield from FAHM

They have 8 experimental plots with 4 control plots and they are checking the humidity effect on plants growths; Aspen (*Populus tremula L.)* and Silver birch (*Betula pendula* Roth). Every plot is separated from each other by underneath plastic. Portable systems are being used to measure all parameter at the experimental site.

Fig. 6: An experimental plot

They are analysis CO_{2}, $N_{2}O$, transpiration and photosynthesis from leaf using closed chamber apparatus.

Fig. 7: A closed chamber apparatus to analyses the different parameters

Analysis showed that soil respiration was decreased in accordance with increased net ecosystem growth. They found less P in leaves, however high N mineralization was accounted. Although, there wasn't any changes on total C budget of the system. They had another experiment site where they are testing different fertilizer effect with three plants species: *Trifolium pretense, Plantago lanceolata* and *Dactylis glomerate.* And these experiments set up are being mimicked in 8 different countries of Europe.

Our next stop was at Station for Measuring Ecosystem-Atmosphere Relations (SMEAR).

Fig. 8: The entry shield from SMEAR

Fig. 9: SMEAR station

Around the Europe, there are six SMEAR stations. In Estonia, SMEAR station was built in 2014 which has 130 m heighted tower. This tower has measuring sensors for CO2, CO, O2, SO, radiation and rain.

And at the last we visited some area of native forest from Estonia which is 10553 ha wide and out of that 6626 ha is forestland and 2723 ha is wetlands. And it is the first protected forest in Estonia. The most dominating plant species at Järvselja are swamp, *Filipendula, Oxalis-Myrtillus* and *Oxalis*. This forest is under protection since 1924. This forest has some of the highest trees of Estonia. For instance, Grey alder (31 m), Silver birch (38 m) and Aspen (41 m).

Fig. 10: A native forest of Estonia

Fig. 11: The 360 years old pine tree

At this native forest 41% is under protection and there is one single object at Järvselja is the 360 years old pine tree (Kuningamänd).

Daily Report "Soil and Water" Summer School, Estland Tartu, 2017

Friday, June 30th, 2017

Authors: Christoph Maier and Valentin Mönkemöller

On the 30th of June we had our full day excursion. First we drove to the oil shale mine and visited the power plant. After that we drove to the Baltic Sea in the city Sillamäe and village Saka. For the end of the day we ate in a restaurant a typical Estonian meal. The meal was a fish with potatoes and a blueberry cake.

Oil shale mine

Oil shale is a rock species which has an organic content about 40%. The oil shale mining can be in underground mine or in open mines which we visited. Normally the calorific value is between 3 and 8 mega joule per kilogram. In this mine the oil shale calorific value is around 15 MJ/kg. The fact they practice the open mining they need to destroy forests and the soil formation. To antagonize this effect they reforest 14 thousand hectares per one year. Important for the reforestation is to rebuild the soil formation and the groundwater level.

At the moment Estonia produces enough energy out of the oil shale mining to be independent. The mining takes place since 100 year (1916). They already exhausted 100 billion tons of oil shale which is the half of the expected sources. In this fact they have enough sources to produce the energy for another 100 years.

The whole power plant consists out of three different power units, an old one, a middle old one and a newly build one. The average efficiency of a power plant is around 30 % till 40 %. In the burning process of the oil shale remains a huge amount of ash. This ash needs to be mixed with water to get transported away. The ash is toxic because of very high ph, this is why it's called hazardous waste. For the cooling process in the power plant they use almost 90 % of the water consume all of Estonia.

Figure 1: dump truck

Some important facts:

- they work 24 hours, 5 days per week
- 12 hours working time per day
- the oil shale layer is in the depth of 30 meters
- the oil shale layer is 2 – 3 meters thick
- a dump truck needs 120 till 200 liters per 100 kilometers.
- they burn 35 000 tons oil per day
- five times more excavation material than oil shell

Figure 2: power plant from outside and inside; open mining area

Saka-Ontika Klint Plateau

After the oil shale mine we drove to the **Saka–Ontika Klint Plateau.** It's the highest cliff of Estonia. It can reach a height of 55m. Also the three highest waterfalls of the Baltic klint are located there. We visited the Saka Cascade which is 21 Meters high and has three steps. None of these three waterfalls are natural. All were formed through drainage ditch.
The steep coast represents with it different strata the layers of the age.

Figure 3: Saka Cascade

We take there a hike down to the sea through a forest with a lot of ferns and climb back up to the edge of the cliff by a steep ladder.

Figure 4: Steep ladder through a lot of ferns

Saturday, July 1st, 2017

Thomas Link-Hessing, Liisi Tõnisson

Summary of the previous excursion to the **„Narva Power Plants“** by **Marian Kazda:**

- 30 m of the layer over the oil shale needs to be removed → still energy efficient
- Power: 1300 – 1600 MW (to compare: windmills 0,5 – 1,5 MW; car 0,1 MW; biogas 1 MW)
- Energy efficiency of Narva power plants 30-40%: 40% oil shale

  10% water

  50% anorganic silica, lime
- Huge heath generation (no cooling towers; heath is conducted to rivers
- Ashes need to be mixed with water (1:20 ratio) to dispose them from the power plant
- Biggest water consumption in Estonia (90% of total water used for energy generation)

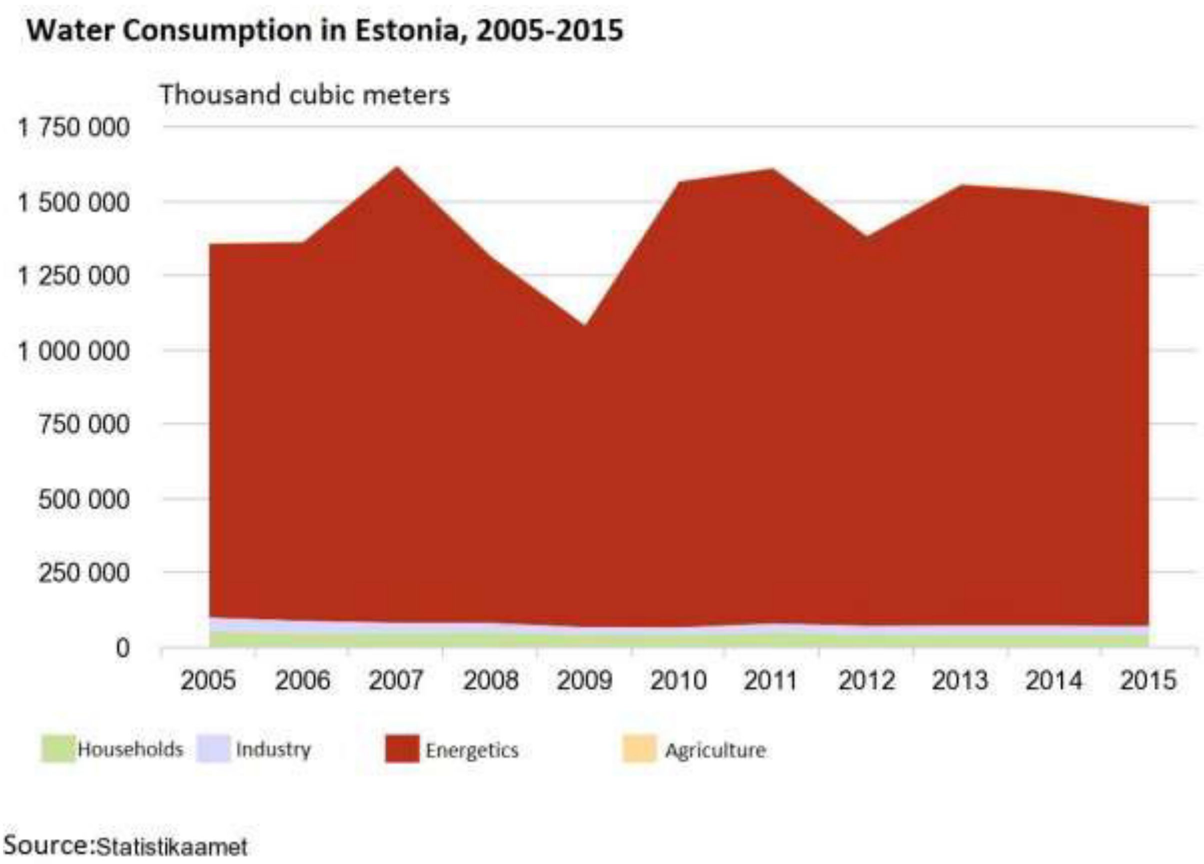

Figure 1: Estonia`s water consumption, 2005-2015. Source: stat.ee

- Water pumping for deeper mining reduces ground water level
- Reclamation of rubble piles is fast (investment in reforestation by planting trees)

- Reclamation of ash piles is slow → non-toxic lime ash (no oxygen, too high pH)
- Surface mining destroys habitats, but also generates new secondary habitats
- Energy production important for Estonia (energy security, biggest working place in the region, cheap energy)

Lecture „**Root structure and soil exploitation**" by **Marian Kazda**

Root functions:

- Water uptake
- Nutrients uptake
- Stability
- Plant anchoring in the soil
- Interactions between biotic and abiotic soil enviroment

Rhizosphere: close vicinity of roots (interactions with soil).

When root density increases the root length also increases (Comas et al., 2012). More rooting volume → the better it is for the plants.

Respiration → nutrient uptake (barrier membrane so that the plant will not take up ions that aren`t needed).

Exudation → actively excreting organic compounds.

When soil hydraulic conductivity decreases and water supply to roots also decreases then the root density is high. Nitrogen and soil nutrients also influence root distribution.

Similar species → roots clustering together.

Life more understandable on the ground because it is easy to predict gradients.

Soil → low predictability → heterogeneously distributed resources.

Root clustering → optimized exploitation of aggregated resources.

Lecture „**Experimental climate change**" by **Ilja Reiter**

Steady-state: nothing changes.

Pseudo-steady-state: in overall it remains stable, e.g. global precipitation (in the recent history).

Global change incorporates many topics such as: population, climate, the economy, resource use, energy development, transport, communication, land use and land cover, urbanization, globalization, atmospheric circulation, ocean circulation, the carbon cycle, the nitrogen cycle, the water cycle and other cycles, sea ice loss, sea-level rise, food webs, biological diversity, pollution, health, over fishing and more.

What is climate change? IPCC (Intergovernmental Panel on Climate Change) definition: „Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity."

The definition of United Nations Framework Convention on Climate Change (UNFCCC): „A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Climate change is defined through model calculations based on our current knowledge of global processes. In this context, current warming can only be explained by human-induced changes of the properties of the atmosphere.

Global warming → comparison of current temperature records to paleoclimatic temperature reconstructions.

Temperature changes are currently easier to predict than other climatic changes.

Example for experimental temperature studies : ITEX → International Tundra Experiment. Examines the responses of arctic and alpine plants and ecosystems to climate change, particularly to warming.

Figure 2: Swiss ITEX field site. (This kind of experimental field chambers are easy and cheap to install.)

http://www.slf.ch/ueber/organisation/oekologie/gebirgsoekosysteme/projekte/tundra/index_EN

By changing root temperature you change the leaf physiology.

Comment: Rooting space affects plant morphology and physiology.

Results of warming experiments: more respiration; net N mineralization ↑.

When doing different experiments on climate change, it is important to bear in mind that observations in relation to climate variability and experiments don't always match, e.g. plant phenological dates.

Atmospheric CO_2 increase

Variability in atmospheric CO_2 concentration : CO_2 decrease during summer → plants are more successful intaking CO_2 (higher sink for atmospheric CO_2).

FACE (Free Air CO_2 Enrichment) experiment: on forests and agricultural land. The technology can replicate the future concentrations of atmospheric CO_2 and scientists can study how do the changes in CO_2 concentrations affect plants.

More info: https://facedata.ornl.gov/

Elevated CO_2 effects in FACE versus chamber studies: 1) more C to the soil (due to higher plant growth) 2) huge variability in microbial communities 3) N mineralization

Free Air CO_2 Enrichment experiments provide the most realistic conditions. Chamber studies are too controlled.

Tropospheric Ozone

Controlled ozone enrichment in a canopy forest → study conducted by the Technological University of Munich.

Precipitation and humidity

Future: more rain in the higher latitudes and less rain in the lower (e.g. Mediterranean) latitudes.

O3HP (Oak Observatory at the OHP) project: how does climate change (reduced precipitation) affect Mediterranean forest?

FAHM (Free Air Humidity Manipulation) experiment in Järvselja (Estonian University of Life Sciences, University of Tartu): how increased air humidity affects different parts of the ecosystems? How do the plants and forest ecosystems adapt to increasing air humidity?

Figure 3: FAHM experimental site in Järvselja, Estonia. On the left: the air humidity is manipulated in young deciduous (silver birch and hybrid aspen) forest stands through misting water under high pressure. Such technology enables to increase air relative humidity up to 18% unit above ambient level. Photo credit: Liisi Tõnisson.

More info: http://fahm.ut.ee/main?lang=en

Multifactorial changes

Precipitation scenarios: no adequately represented biomes; the predictions aren`t accurate enough. We don`t know with high certainty how the precipitation is going to change when comparing to temperature, CO2, ozone...

All the changes are taking place at the same time → multidisciplinary challenge, many different measurements needed at the same time to understand/detect (changes in) ecosysytem functioning.

Responses to combinations of single factors differ from responses to single factors. This calls for multifactorial experimental designs.

e.g. Higher CO2 concentration → the stomatas are more closed, less pollutants like ozone get into the plant. Higher CO2 concentration can compensate effects by increased ozone on plants. Choice of the potential scenarios to simulate in experiments and multiple climate factors/drivers to consider render an exhaustive experimental approch impossible. Therefore, modelling is needed and international coordination of climate change experiments would help better intercomparison of results. We currently have many experimental data for the northern hemisphere and far less for the southern hemisphere.

Students` presentations based on research papers

(Students were divided into 6 groups, each group made a presentation about the research papers handed out by the supervisors.)

Plant stress: Water Use Efficiency

Presentation made by: Markus Hügel, Thomas Link-Hessing, Katerina Kabelacova, Claude-Eric Marquet, Patrick Waldhelm

Supervisor: Tiina Tosens

Water use efficiency (WUE): $WUE_{photosintesis} = \frac{Asimilation}{stomata\ conductance}$

$$WUE_{productivity} = \frac{biomass}{water\ availability}$$

Experiment about the WUE of different phenotypes grape vines under well-watered and water-stressed conditions.

Results:

- Water-stressed grape vines have better WUE than well watered
- Huge differences in WUE for each phenotype and species
- Water-stressed plants invest more ressources in reproduction and roots than in growth

Conclusion:

- Important for agriculture
- Climate change will increase the need for WUE research, especially for crops
- C4 plants have a higher WUE than C3 plants

Source: Hipólito Medranoa , Magdalena Tomása , Sebastià Martorella , Jaume Flexasa , Esther Hernándeza , Joan Rossellóa , Alicia Poub , José-Mariano Escalonaa , Josefina Bota (2015) From leaf to whole-plant water use efficiency (WUE) in complex canopies: Limitations of leaf WUE as a selection target. The Crop Journal 3, 220–228. doi:10.1016/j.cj.2015.04.002

Macroecological patterns in soil communities

Can changes in litter quality drive soil fauna structure and functions?

Presentation made by: Julian Fernando Cárdenas Hernandes Docente, Liisi Tõnisson, Valentin Mönkemöller, Violetta Volokitina, Paul-Loup Lecomte

Supervisors: Petr Hedenec, Eva Keppner

Macroecological patterns in soil communities

Materials: Web of Science → relevant literature (high number of citations). The author`s personal scientific database.

The scale: global and local scales.

Example: Microsite patterns and the importance of soil engineers

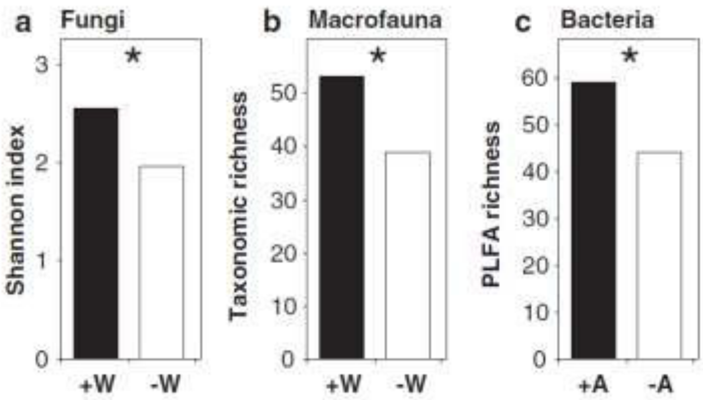

Figure 4: Diversity of different groups of soil organisms in situations with (+) or without (-) earthworm (W) or ant (A) activity: (a) fungi inside earthworm casts and in bulk soil in India (after Tiwari & Mishra, 1993), (b) macroinvertebrates below earthworm casts and in bulk soil in Colombia (after Decaëns et al., 1999), (c) microbial diversity (PLFA, Phospholipid Fatty Acid activity) in soil with or without ant activity (after Boulton & Amberman, 2006) (indicates significant earthworm or ant effects at $P < 0.05$).*

At few centimetres, the distribution of soil organisms is influenced by the soil engineers. The soil engineers impact soil heterogeneity. Earthworms create more microhabitats and the trophic resource is more available due to worms casting and burrowing activities. Ther are more nutrients in the ants` nests than in bulks soil.

Conclusions:

- Difficult to distinguish species from each other.
- When we raise the popularity and awareness of this topic, then there would be more specialists.
- Altitudinal, latitudinal and area gradients: soil and above-ground organisms have similar patterns. For example, with altitude the biodiversity generally decreases.
- Soil communities appear weakly structured by competition.
- The compact and heterogeneous nature of soils is the main factor affecting soil biodiversity. Ecosystem engineers increase this heterogeneity.

- When we understand the mechanisms influencing soil biodiversity, then we can predict how soil communities react to global changes.

Source: Decaëns, T. (2010) Macroecological patterns in soil communities. Global Ecology and Biogeography, 19, 287-302.

Can changes in litter quality drive soil fauna structure and functions?

Main idea: to determine the effects of litters of contrasting qualities on soil fauna structure and functions during decomposition.

Conclusions:

- Effects of litter quality divergence on functional groups composition.
- Different compounds in different stages of decomposition.
- Meso-/Macrodetritivores: after 11 month no difference in quality of litter.
- Fungi: Bacteria ratio depends on the hydrolytic enzyme activities.
- Divergence of litter qualities induced increasing dissimilarities in fauna composition.

Source: Bertrand, I., Brunet, N., Chauvat, M., Sauvadet, M. (2017) Can changes in litter quality drive soil fauna structure and functions? Soil Biology & Biochemistry, 107, 94-103.

The importance of long-term field experiments

Presentation made by: Christina Miehle, Alena Maidel, Christoph Maier, Liljana Schmidhaeuse, Jan Šmejkal

Supervisor: Alar Astover

Soil science

- Laboratory work: 1) cheap 2) fast 3) smaller, specific area
- Long-term field experiments (LTE): 1) expensive 2) slow 3) whole area 4) realistic

LTE

- 600 long-term experiments lasting over 20 years
- The oldest over 100 years
- Different managements
- Different conditions
- Generally acceptable statements

- But we need similar standards, new methods. Are 600 experiments enough for accurate results?

Results from 20 European long-term field experiments of the twenty-first century:
Effects of mineral and organic fertilization on: 1) Crop yield 2) Nitrogen uptake 3) Carbon and nitrogen balances 4) Soil organic carbon content and dynamics
Source:
Körschens, M. (2006) The importance of long-term field experiments for soil science and environmental research - A review. Plant, Soil and Environment, 52, 1-8.
Körschens, M. et al (2012) Effect of mineral and organic fertilization on crop yield, nitrogen uptake, carbon content and dynamics: results from 20 European long-term field experiments of the twenty-first century. Archives of Agronomy and Soil Science, 59:8, 1017-1040. DOI: 10.1080/03650340.2012.704548

Root aeration improves yield and water use efficiency of tomato in heavy clay and saline soils
Assessing the effects of initial soil characteristics, machine mass and traffic intensity on forest soil compaction
Presentation made by: Linda Ahner, Laurie-May Gonzales, Milan Varsadija, Bernhard Glocker
Supervisor: Marian Kazda
Aeration in both non-saline and saline soil environments influenced growth, development and reproductive performance of tomato in a Vertisol.
An increase in the leaf biomass, earliness of flowering, and an increase in fruit size were observed due to aeration, and they all contributed toward an improved tomato yield.
An extensive field trial was set up in eight forest stands to examine the influence of soil texture, machine mass and traffic intensity on soil compaction after mechanized harvesting.
Clay and silt to loam textures are considered to be more vulnerable to compaction than sand textures.
Source:
Ampoorter, E., De Vos, B., Hermyc, M., Van Nevel, L., Verheyena, K. (2010) Assessing the effects of initial soil characteristics, machine mass and traffic intensity on forest soil compaction. Forest Ecology and Management, 260, 1664–1676.
Bhattarai, S. P., Midmore, D. J., Pendergast, L. (2006) Root aeration improves yield and water use efficiency of tomato in heavy clay and saline soils. Scientia Horticulturae, 108, 278–288.

Composting parameters and compost quality: a literature review

Presentation made by: Arthur Naimowitsch, Donatus Mmodum, Aneta Flekalova, Laura Böe

Supervisor: Merrit Shanskiy

Composts prepared from different organic wastes differ in their quality and stability, which further depends upon the composition of raw material used for the compost production.

The literature survey showed that there are many parameters that can be considered for start-up, monitoring and quality of compost.

Composting is an exciting global process to turn wastes into resources, but it should be locally adapted taking into consideration the cost, the nature of the waste and the environmental impact of the produced compost amended to the soil.

Nutrient leaching when compost is part of plant growth media

Engineered plant growth media must support plant growth while minimizing environmental impact. To determine how different growth media influence nutrient leaching.

Source:

Azim, K., Boukhari, S., Perissol, C., Roussos, S., Soudi, B., Thami Alami, I. (2017) Composting parameters and compost quality: a literature review. Organic Agriculture, 1-18. DOI 10.1007/s13165-017-0180-z

S. D. Logsdon & P. A. Sauer (2016) Nutrient leaching when compost is part of plant growth media. Compost Science & Utilization, 24:4, 238-245. DOI:10.1080/1065657X.2016.1147398

Allelopathy

Presentation made by: Sophie Baur, Ingmar Pappel, Axel Bergeon, Nora Tomsova

Supervisor: Virginie Baldy

Definition of Allelopathy: secondary methabolites that have influence on growth, germination, reproduction and distribution of vegetation

Source:

Allelochemicals of Pinus halepensis as Drivers of Biodiversity in Mediterranean Open Mosaic Habitats During the Colonization Stage of Secondary Succession; Catherine Fernandez, Mathieu Santonja, Raphael Gros, Yogan Monnier, Mathilde Chomel, Virginie Baldy & Anne

Bousquet-Mélou; Journal of Chemical Ecology, ISSN 0098-0331, J Chem Ecol, DOI 10.1007/s10886-013-0239-6
Effect of allelopathic compounds produced by Cistus ladanifer on germination of 20 Mediterranean taxa; Jose´ M. Herranz, Pablo Ferrandis, Miguel A. Copete, Esmeralda M. Duro and Amaya Zalacaın; DOI 10.1007/s11258-005-9071-6
Differential impact on soil microbes of allelopathic compounds released by the invasive *Acacia dealbata* Link; Paula Lorenzo, Carla Sofia Pereira, Susana Rodríguez-Echeverría;

Monday, July 3rd, 2017

by Liljana Schmidhäuser,Paul-Loup Lecomte, Patrick Waldhelm.

<u>Plant stress(by TiinaTosens):</u>

- first gymnosperms appeared 300 Mill years ago *e.g. Araucaria, Cyca* at a very high CO_2-level (1800 ppm) => plants adapted to 400 ppm CO_2 today
- stress e.g. water loss or very low or high temperatures reduce the photosynthesis rate of plants, without any stress the photosynthesis rate reaches the optimum
  e.g.: plants open stomata to bind CO_2 but lose H_2O, $1CO_2$ exchanges for $500H_2O$ => stress for plants
- **forms of stress:**
  biotic stress: diseases, herbivore, competition
  abiotic stress: temperature, radiation, chem/mech influences, others
- forms of stress often appear combined, e.g. higher CO_2-level increases the photosynthesis rate, but also increase temperatures (climate change) => this leads to more water evaporation and makes water the limiting factor especially in dry areas
- plants need to adapt to the different stressfactors, time is the relevant factor for that
- adjustment in plants due to acclimation (faster, reversible) or adaption(irreversible), e.g. developing of abscisicacid (ABA) to close stomata faster,
- modular adaption: e.g. lowering the stomata density in new leafs
- evolutionary adaption: e.g. Mediterranean oak developed small hairs in front of stomata to create a humid microclimate => less transpiration

<u>Soil organic matter an indicator of soil quality/fertility (by Alar Astover):</u>

- soil forming factors:
  - abiotic: climate, topography, parental material
  -biotic: organisms, vegetation
- soil compositions: 20%-30% air <=> water 20%-30%, mineral matter 45%, organic matter 5%
- <u>SOM is the overlap of:</u>
  biological factors: energy source, nutrient source, soil plant resilience
  physical factors: structure formation, water holding capacity, thermal buffering
  chemical factors: ph buffering, cation exchange, binding pollutants
- SOM is an indicator for soil quality/fertility, climate changes, biodiversity
- Humus from the latin : ground, Earth become a basis for many words such as human…
- Importance of the soil: sinking of carbon (mineral and organic), support for plant growth, reserve of nutrient through the clay-humus complex, reserve of water…

- The old-fashioned view for components of the soil is to separate humins, fluvic acid, humic acid, but it’s not actually the reflect of realty (more complex). Because in order to separate those compounds the soil is exposed to strong chemical reagents. Probably it’s not the native soil component but its help to understand and to compare soil samples. -> Continuum model
- Methods to analyze soil samples for SOM are Thermogravimetry, Near-infrared spectroscopy (NIRS)
- Importance of the unit for the measurement of organic carbon (g/kg,%...)
- The more you have organic matter in soils the lower is the bulk density (increasing of the porosity)
- The content of Organic matter vary in the depth of the soil and the type of soil and the (e.g agriculture field 1-2 % of OM against 40% in peat land)
- As example rotation of crops and balanced fertilization helps a lot to keep and to increase the organic matter in the soil -> sustainability (more nutrients because of Clay humus complex

Tuesday, July 4th, 2017

Aneta Flekalovà, Laura Böe, Laurie-May Gonzales.

Lecture by Jordane Gavinet (8h30) and Hana Santruckova (10h30)

Secondary metabolism of plants

- Primary metabolism : Is universal, and covers all processes that are essential for growth and development.
- Secondary metabolism : High plasticity controlling functions that are under selection pressure of a continuously changing environment.
- Function of the SM : defense against biotic stress (herbivore, pathogen, competition) and abiotic stress (ex: high temperatures, UV radiations), attraction (pollinators, dispersers, herbivore predators)
- Main types of SM :
    - phenolic compounds (-OH bonded to aromatic hydrocarbon group), mainly water-soluble, from simple phenols (for example Eugenol) to polymers (tanins, lignins).
    - Terpenoides, units of 5 Carbons and generally lipophilic and volatiles.
    - Alkaloids, contain nitrogen atoms with heterocyclic ring, may also contain oxygen or sulfur, for example morphine or cocaine.
- Production, storage and release of SM
- High variation in SM production and emission: influence of genetic and environmental factors
- Cost of production, trade-off between defense and growth
- Allelopathy: definition, impact on community composition and dynamics (example of Mediterranean ecosystems)

Microbial processes in soil I

- 90% of carbon and nutrients transformations in soils are carried out by microbes (Bacteria, Archea, Filamentous bacteria, actinobacteria, fungi, mycorhizza fungi).
- Heterotrophic metabolism : heterotrophs are most abundant in soils and can live in aerobic and anaerobic conditions (aerobic is the most common type of metabolism in the soil).
- Main factors affecting microbial processes: moisture, oxygen and redox potential, temperature, soil pH and organic matter.
- The soil consists of three size classes of mineral particle.

In the afternoon we were working in groups preparing our presentation and discussing our results.

Wednesday, July 5th, 2017

Nora Tomsová, Christina Miehle, Donatus Mmodum

Lecture „Soil quality and Soil degradation“ (Endla Reintam)

- What is soil degradation?

The soil deteriorates because of human activities. That means, the soil loses its quality and productivity, to sum it up: its function.

- Why do we need to talk about soil degradation?

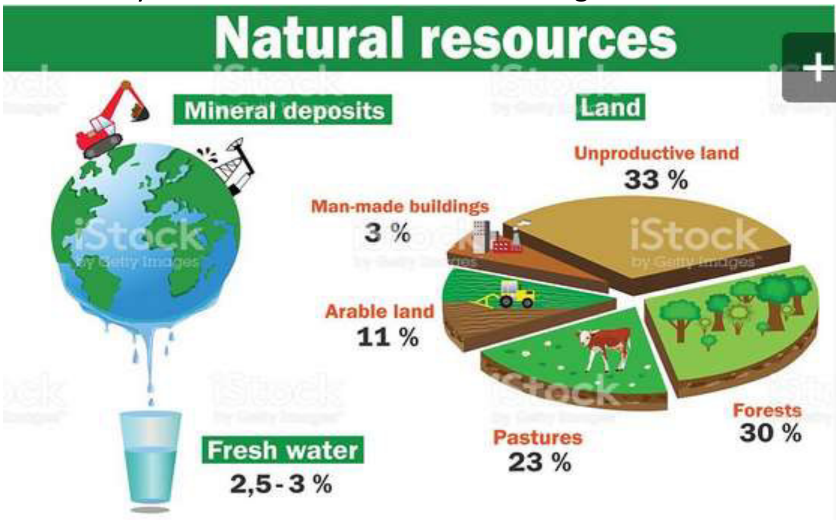

Figure 1: Natural Resources of the earth
http://www.istockphoto.com/de/vektor/nat%C3%BCrliche-umweltressourcen-vektor-infografiken-gm534001786-94666865

As the graphic shows, only a small part of our world is useable for agriculture. The other parts are water, forest, dry areas, areas which are not usable for agriculture. In addition, in the lectures before we've heard, that soil is a limited resource. Since the population number increases we need to keep the usable land to get enough food that we can survive, if we destroy it, we'll have some serious problems.

- What is soil quality?

Soil quality is the "capacity to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health." (Doran & Parkin, 1994)

- Why assess soil quality?
  - ➔ Awareness and education
  - ➔ Evaluation of alternative practices
  - ➔ Evaluation of practice effects, general monitoring, specific trouble-shooting (to understand the status of the moment)

But for who is it important to assess soil quality? The land users/owners are the ones which actually are using the land but the policy makers take the decision about it, for example they decide on the taxation. So in the end we need to do it for both groups, and they have to work together to decrease soil degradation.

- How to assess soil quality?

There are three steps needed to assess soil quality:

1. Select indicators (chemical, physical, biological)
2. Interpret indicators
3. Adjust management or policies

- Main threats to the soil

There are several threats to the soil. In the following the most important ones are mentioned.

➔ Erosion:
 - Main threat in Europe
 - Group of processes by which materiel is removed from any part of the earth's surface by water, wind, ice, snow or other agents
 - Effects not only agriculture but also cities

➔ Decline of organic matter:
 - Reduction of organic carbon content compared with earlier states
 - Can happen because of drainage or agriculture

➔ Soil contamination:
 - Mostly caused by human made chemicals or alteration in the nature soil environment
 - Examples: oil, fertilizers, factory areas

➔ Soil sealing:
 - Means the covering of the soil surface with an impervious material or the changing of its nature
 - The soil becomes impermeable

➔ soil compaction:
 - This threat is not visible from the outside
 - The soil particles are pressed together, reducing the pore space between them
 - The soil gets harder
 - Because of the use of heavy machinery the most agricultural fields are compacted

➔ Decline in soil biodiversity:
 - Less or different species in community living in the soil
 - Most times less animals, what means a loss of soil losing

➔ Salinization:
 - The salts on or near the surface of the soil get accumulated
 - Related to irrigation

- ➔ Floods & landslides

- ➔ Desertification:
  - Is the process, when a relatively dry area becomes arid, typically losing its water bodies and its vegetation and wildlife
  - Example: Aral sea

- ➔ Reacidificatin:
  - Acidification of previously limed agricultural land (soils with natural pH below 3.5)

If the soil conditions are stable, soil degradation does not happen. Examples for stable conditions: permanent forest and plant cover.

- Main causes of degradation

The main causes can be divided into two sections:

1. Natural conditions/processes: drought, heavy rain, fire
2. Human induced: Destruction of plant cover, soil covering (e.g. cities), use of chemicals (e.g. fertilization), fires, traffic on soil, industry, mining, climate change

- How can we tread soil properly?

It is important to reduce soil degradation. Here are some ideas how we can tread our soils better that degradation is not that high. For example reduce the use of chemicals or use more organic farming instead. Also we shouldn't use our best lands to build up houses, we need them to grow enough food.
It is also important that we look local what to do against degradation. For example in Estonia erosion is not the biggest problem, instead it’s the loss of soil organic matter. But in Germany erosion is the biggest thread. So we need to act different in the two countries.

- “Soil museum”

After the lecture we visited the soil museum of the university. In it, there are stored several soil types which can be found in Estonia. The museum gives the workers the possibility to compare the different types and to have the soil also during winter.
In addition, there are also stores some soil types of Europe.

Figure 2: Soil museum of the University

Lecture „Why are we so interested in soil microbial processes? "(Hana Šantrůčková)

This lecture is based on C, N and P transformation.

- C transformation:

C transformation is the basic cycle in the soil, all nutrients are attached on that cycle. Litter of primary producers is the main source of organic matter in the soil. Plant material can be divided in three groups according to decomposition rate: easily decomposable C, hardly decomposable C, resistant C. But earlier or later all organic matter is decomposed by soil biota - active soil organic matter, which is slowly changed into stable and physically protected C (particles are closed in the aggregate). Soil microbes live mainly in the upper part of the soil profile and their biomass activity decrease with soil depth, because of decrease of organic matter supply. Decomposition meant all the transformation which is going in the soil, but mineralization means respiration (CH4 production). Any decomposition can by described by exponential curve, but decomposition rate constant depends on the decomposability of material, because each material has different time of decomposing (glucose is faster than cellulose). Roots by exudation accelerate the decomposition as well. Everything connected with root activity is called autotrophic respiration, everything connected with microbial activity in free soil is called heterotrophic respiration.

- N transformation:

N is essentials element of biomass and it is also donor and acceptor of electrons in energy metabolism. Main source of N is atmosphere. Only prokaryota are able to fix atmospheric N and they need a lot of energy to split triple bond of N_2. The process is inhibited by O_2. Plants have symbiosis with bacteria on the roots. They supply bacteria by energy and protect them against O_2 and they can directly use N fixed by bacteria. In the soil, fixed N is built into microbial biomass, metabolized and either changed into dead organic matter or mineral N forms. Microbes consumeorganic matter and they release excess of N in form of NH4+ and it can be further oxidized into the NO3 (the process is called nitrification). These nitrates are assimilated by microbes or they can be used in denitrification (NO3- is changing into N2). N transformation is so complicated because N can be used in catabolic and anabolic metabolism. The oxidation state of HNO3 is +5 and NH3 is -3 and between this scale there can be so many forms of N. Microbial cell is richer in N then organic matter and C/N ratio of their biomass is much lower than that of plant material. P transformation:

P is also essentials element for biomass. The primary source of P are mineral particles in the soil (C and N2 source is atmosphere). Mineral P from soil is consumed by plants and microbiota, built into biomass and then it is changed into dead organic material and, after decomposition, it is released into mineral P, which can be eaten by microbes and plants again. P is limiting nutrient in terrestrial and aquatic ecosystems. In tropical ecosystems, P is the most limiting source. The main reason of P limitation is that P is available only on really narrow range of pH.

Excursion to Endla bog (JOVEDA)

We start off our journey after our lunch and a little break. We left from the school premises exactly 12.45pm on our way we made a five(5)minutes stop at KARDE PEACE HOUSE, This is the place Sweden and Russian made a peace treaty about 1,655 years ago.

Some of us signed in the peace book indicating that we are for peace and there we meet our guide by name ELO who works in environmental board.

BRIEF HISTORY .

This was established in 1985, it was about 10,661km. But it was taken under protection in 1985.

50% of this area is cover with forest mainly pines, The peat there started about 9,000 years ago.

There is a lake also that covers about 280 ha and about 2.4cm deep .This lake also has an island (It is called Lake Endla). The dominant tress are: PINES, PERCH and SPRUSS. BOGS are the major feature.

MY OBSERVATIONS.

We discovered one specie of plant there, CLAP MOSS (Nicopoium Arnotino)

We found ORCHID also we saw the peat especially from the ground level.

We also come across mires, Transitional mires,

We come across Raised bogs some height is up to 5.4 metres pine tress were found there there but they have stunnted growth that is as a result of Nutrient lack because the only nutrient they got is through percipitation sphagnun moss protects them from getting Nutrients from the soil.

There we saw how sphagnum draws the level of the water as it grows there by causing some stagnant water inform of lake in the Bog. Carnivores plants were also found there.

Finally we visited Endla Museum and we feed our eyes and it was so awesome, From there we headed to our Bus and we bead goodbye to our guide ELO. We drove back to school.

Awesome Experience.

Thursday, July 6th, 2017

Arthur Naimowitsch, Julian Cardenas

Supervisor: Alar Astover

In this day our journey from Tartu to Tallinn took place. We stop by Joelahtme to see the museum and also to appreciate the karst forms.

The museum was founded in a burial place from the late Bronze Age, which was found around 25 year ago; during the construction of a road. In the area is possible to observe circles of stones surrounding rectangles oriented to the north, which were used for burying the deaths. Clothes and tools made of stones and bronze were found in that place and some of them are exposed in the museum. This place is of high importance for archaeology because is the only place east of the Baltic Sea where bronze spindles have been found.

We could talk with a grower in charge of 700 Ha, producing mainly cereals and rapeseed. He expressed that one of the most difficult factors to manage in this area is the high variability of the soil. The crop production area have mineral and peat soils. In mineral soils, there are compaction problems and in organic soils (peat) the use of heavy machinery sometimes is complicated because it sinks. All the area just require 3 people with 3 tractors to make the growing activities.

Then we visited a place where the Karst forms where exposed. These formations are the result of watercourse through the limestone rock, diluting the soluble compounds and creating channels that in some cases have made the upper layers to collapse. This results in a coarse topography with exposed bedrock. The irregularity of the shapes is an example of the high diversity of the material parent composition. It can be appreciated in the pictures.

Following a list of observed grasses and herbs, in the karst area.

Grasses:

Festuca ovina and F. rubra

Phleum phleoides

Helictotrichon pratense

Dactylis gromerata

Deschampsia cespitosa

Brachypodium pinnatum

Herbs

Tragopogon pratensis

Allium schoenoprasum

Sedum acvets

Galium verum

Geranium pratense

Trifolium medium

Geum rivale

Veronica chamaedrys

Crepis tectorum

Sedum telephium

Erysimum cf. Cheiranthoidest

Galium boreale

Bunias orientalis

Alchemilla vulgaris

Veronica longifolia

Friday, July 7th, 2017

Linda Ahner and Markus Hügel

Presentations of research groups:
Stomatal kinetics in response to amount of CO_2

- Water use efficiency (WUE) = ratio of water used in plant metabolism to water lost by the plant through transpiration
- Assignments:
➔ Measuring of the stomata conductance, assimilation of CO_2 and WUE
➔ Epidermis imprinting, measuring size and density of stomata
- Methods:
➔ Measuring of the stomata conductance, assimilation of CO_2 and WUE in measuring chamber
➔ Varnish test used for epidermis imprinting, size and density results obtained via microscope
- Conclusions:
➔ Stomata can not be opened enough if plant suffer from drought
➔ Density of stomata depends on its size
➔ Smaller stomata can be easily opened than bigger ones

Soil compaction and oxygen

- Heavy machines are used in agriculture → increasing soil density → water runs away
- Hypothesis:

→ soil with organic manure has more oxygen deplet
- Methods:

→ Oxygen rate, bulk density and maximum water holding capacity in soils
➔ Samples from field with different manure and nitrogen
➔ With the FIBOX LCD measurements of the wet soil for the oxygen rate
➔ Weight of wet and dry soils
- Conclusion:
➔ Low porosity results the high bulk density, that depends on soil composition
➔ Irrespectively the soil properties, flooded soil contained the pores which trapped the air
➔ The abundance of microbes is more likely in the soil contained nitrogen with organic fertilizer. However, the change of aeration rate was not pronounced
➔ Mineral fertilizer with organic manure resulted low bulk density and high water holding capacity

Soil zoology
- Many different species in soil
- In leaf litter or upper soil
➔ Epigeic = on ground
➔ Endogeic = in soil
- 50,000 – 300,000 organisms per m²
- Hypothesis: biodiversity is higher in forest soil than in fresh cut meadow
- Aims:
➔ more practice in the identification of soil fauna
➔ More practice in fieldwork
- Methods: animas were trapped in pitfall traps
- Conclusion:
➔ Higher diversity in forest, over 6 taxa
➔ Lower diversity in fresh cut meadow
➔ Increase in fauna communities until limited due to competition
➔ Plants have specific effect on diversity
➔ Collembola: diverse functions and interactions

Land properties influenced by land use and fertilization
- Samples from grassland and soil with fertilizer and mineral fertilizer
- Different tests with the samples to check pH, soil electrical conductivity and P, K, Ca, Mg by Mehlich-3 method
- Loss on ignition and dry bulk density
- Conclusion:
➔ Not enough replicates
➔ No exact depth for humus horizon

Fast plant test with various composts
- Worldwide peat stock is decreasing
- Aim: compare and test different quality composts by using fast growing plant tests
- Methods: - in-vivo cress test

Chemical: pH, electrical conductivity, C/N ratio
Closed chamber experiment
- Conclusion
➔ Pot experiment showed positive results regarding all composts, since the seeds germinated
➔ Closed chamber had unexpected outcome
➔ pH- test in optimal range
➔ Control had the highest C/N ratio

Allelopathy experiment with Estonian trees
- Hypothesis:
➔ Macerate of leaves or needles of Estonian common trees have allelopathic effect on germination of *Lactuca sativa, Lepidium sativum*
➔ Young needless of *Picea abies* < old needless of *Picea abies*
- Methods:
➔ Leaves and needles of 3 Estonian tree species were collected and macerates were made
- Conclusion:
➔ No allelopathy effect observed in leaves leachates
➔ *Lactuca sativa* and *Lepidium sativum* are very resistant to the allelopathic effects of macerates of Estonian trees
➔ At longer term: possible effects on growth

Synthesis
➔ Discussion of the last two weeks by organizing topics of the lectures and research groups in graphs with time and spatial scale
➔ Reviewed the excursions
➔ Talk about long-term experiments

Why we should go – presentations
The students present the four different countries (Estonia, France, Czech Republic and Germany).

All students from one country presented another country.