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EDUCATIONAL NETWORK ON SOIL AND PLANT ECOLOGY AND MANAGEMENT

Summer School Soil & Water 2016

České Budějovice, Czech Republic

Daily reports

Inhalt

Monday, September 5th, 2016

Introduction by Philip von Wrangell and Marian Kazda from 8:30 to 9:00

For the participating students, this was a new environment and new synthesis of subjects. Therefore, a short introduction was given concerning the cooperation project and the involved universities. The lecturers highlighted main areas of research, such as sustainable soil management for Estonia, wetlands in the Czech Republic and Germany and the plant-soil interactions in the Mediterranean given by the French partners. The main goal of the project was highlighted as the international exchange of expertise, allowing professors and students from different regions to share their knowledge on multidisciplinary subjects.

Introduction to South Bohemia Region by Tomàš Picek from 9:00 to 10:00

- General information
  - Total area of the Czech Republic: ca. 80,000 km^2 with ca. 10.5 million inhabitants
  - Total area of South Bohemia: ca. 10.000 km^2 with ca. 640,000 inhabitants
  - South Bohemia borders Austria to the south and Germany to the west
  - Šumava Mountains national park is located in the south west
  - Average elevation in the Czech Republic is between 400 and 600 meters above sea level
  - The Vltava river has a big impact on the region of South Bohemia - almost all area is a catchment of the Vltava river
  - Many small and artificially-made lakes/fish ponds in South Bohemia, originating from Medieval times
- Geology
  - Metamorphic rocks are predominant in this part of Czech Republic
  - Granite can be found in the Šumava Mountains
  - Around Budejovice, there are many sediments originating in the ancient sea and later freshwater lakes – the landscape is flat and therefore also many wetlands are found in this area
  - Moldavites, which look like green glass and originate from a meteorite which hit in Nördlingen, Germany 15 million years ago, are often illegally mined in the forests of South Bohemia and sold as jewelry
- Soil
  - The cambisol is the most predominant and diverse soil, not found specifically on a bedrock
  - Gleysol can be found especially in South Bohemia as it is closely connected to areas of flooding, wetlands, and rivers. Its grey and red colors are caused by reduced or oxidized manganese and iron.
  - Stagnosol (also known as pseudogley) occurs in areas with seasonal flooding. Its red color is caused by oxidized iron.
  - Fluvisol can be found around rivers or lake beds and represents a nutrient-rich soil, suitable for agriculture
  - The soil in mountains is mainly podzol which needs for its development high amount of precipitation
- Land use in South Bohemia

  - 51% agriculture, 34% forest, 11% other (e.g. roads, industrial zones, parking lots), 2% freshwater
  - trends in land use: the amount of forests has increased since the 1840s; arable soil and pastures have decreased in abundance due to higher efficiency rates, “other” has increased due to the building of roads, parking lots, etc.
  - In the mid 20th century, diverse crops and small fields dominated the area, whereas now the fields are much larger and homogenous, causing a decrease in biodiversity. On the plus side, the amounts of forests have increased with time.
- Agriculture
  - 72% arable soil, 22% permanent pastures, 6% orchards and gardens
  - How crops have changed between the 1960s and now: rapeseed is the main crop grown in the region, more cereals are planted, whereas fewer fodder plants are used for feeding and fewer sugar beets and potatoes are grown.
  - Change in the use of mineral fertilizers in 1989: less nitrogen, phosphorous and potassium is used due to a sharp increase in purchasing price. The rate of nitrogen use dropped from 100 kg/ha to 60-70 kg/ha.
- Forest use and structure
  - 69% plantation, 29.8% near natural, 1.2% natural
  - More spruces are present than should be under natural conditions. This is due to the fact that this species grows relatively quickly.
  - Under natural conditions, beech, fir and oak would be the most predominant species
  - Now many scots pines are planted in order to produce timber
  - Primary forests can be found in Žofín, which is the oldest nature reserve in Europe, Boubín, which was established in 1858, and Šumava (which dominated by spruce trees)
- Wetlands
  - The wetlands are protected under the Ramsar Convention because they carry international importance
  - Šumava peatlands have a total area of 6,000 ha
  - *Třeboň transition* peatlands have a total area of 1,100 ha
  - *Třeboň* fishponds have a total area of 10,000 ha and are manmade

Introduction of Soil-Water Relations by Marian Kazda from 10:00 to 11:00

- Soil is a mix of all 3 phases: solid, liquid and gas
  - Solid phase: inorganic (e.g. sand, silt and clay) and organic matter (e.g. plant roots, animals, microorganisms, fungi, humus = a negatively charged cation exchanger which exchanges nutrients)
  - Liquid phase: water mixed with minerals and air, meaning the water contains diluted ions and dissolved organic carbon (DOC); the soil filters the water in a process called purification, causing the DOC to decrease and making the water drinkable
  - Gas: N_2, O_2, H_2O, N_2O, CH_4
- Water in the soil:
  - Unsaturated zone with all 3 phases (as mentioned above)
  - Saturated zone is missing air and is also known as groundwater
  - Water movement in humid climates is downwards (e.g. precipitation), whereas in arid climates it is upwards (e.g. driven by evapotranspiration)
- Soil water status (according to Brady 1974)
  - Saturation: 40 mL of water to 100 g of soil
  - Field capacity: 20 mL of water to 100 g of soil (maximum water saturation under natural conditions)
  - Wilting point: 10 mL of water to 100 g of soil (decreased turgor pressure)
- 340 to 1500 cm is the pressure Ψ needed to extract water, also known as plant available water
- Properties and consequences of dry soil

- When soil is very dry it also becomes more hydrophobic, making rewetting very difficult, hydrophobic substances and/or soil compaction leading to high runoff.
- Bark beetles caused dieback of trees in the Šumava Mountains because the ecosystem was weakened by droughts

Introduction to Soil Zoology by Manfred Wanner from 11:00 to 12:00

In the soil we can find different organisms, which can be classified in microflora, microfauna, macrofauna and megafauna. As a rough rule of thumb one can say the smaller the organisms (animals) the more often they can be found in the same plot. The most common structure in animals is a worm like structure which is long and round. The animals which are all living in the upper layer of the soil can although been classified in:

- Epigeic: which are living on the surface of the soil
- Endogeic: which means they are living inside the soil
- Anecic: these animals are able to switch the zones

All the organisms have evolved different ways to decompose organic material, so snails, larvae of flies and millipedes have the ability to cut through bigger material, so smaller animals can process this material.

Studying soil organisms is very tricky, because the soil is not transparent or homogenous like water. Additionally, you have the gaseous, liquid and the solid compounds of the soil.

Different organisms which live in the soil:

- Protozoa: C/N bacteria and fungi have a lot of N, so when the protozoa ingest them they have an overspill of N in their body, so they have to secret it, which fertilize the environmental soil.
- Nematoda: different mouthparts, produce also an overspill of N as in Protozoa
- Earthworms: plants use their corridors for their roots, ecosystem engineers
- Arthropoda
  - Acari - mites
    - Mesostigmatid mites - gamasina: very mobile, predators
    - Oribatid mites: very slow, vegetarians
  - Chilopoda – centipedes: predators
  - Diplopoda - millipedes: vegetarian
  - Insecta: in all terrestrial habitats
    - Formicidae - ants: ecosystem engineers, eusocial insects
    - Coleoptera - beetles: strong cuticula
    - Scarabeidae - dung beetles
    - Diptera – flies (larvae live in soil)
- Vertebrata - reptiles and mammals

When animals live on the surface layer of the soil they need to be pigmented for UV protection of the skin (and birds and other predators can’t see them). If you are living inside the soil you don’t need any pigments or good eyes for your living.

Summary:

- Soil is an important resource
  - Habitat for all terrestrial organisms (human included)

- Important for food & energy cycling – sustainability
- Soil organisms are effectively adapted to their environment
- Soil organisms are necessary for soil functioning
  - Biodiversity goes with ecosystem services

Wetland Ecology I by Tomàš Picek from 12:00 to 13:00

Definition of wetland:

- All areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt.
- *The convention set a depth of 20 feet (6m) as the limit for any water body to be included in the term wetland.* - Ramsar Convention, 1971

Locations:

- On all continents, however many can be found in North America and Northern Europe
- Peatlands in boreal climates and in Indonesia
- Deltas in Africa

Why are the wetlands important?

- Accumulation of peat, later transformed to coal
- They have ability to clean (purify) water
- Carbon sequestration
- Effect on climate (cooling effect)
- Habitats
- Source of food (e.g. rice)
- Source of timber, peat, plant biomass
- Use by human: regeneration, agriculture (e.g. rice paddies, floodplains along the Nile), fishing, hunting, water purification, irrigations, peat, wood

Peat accumulation started 10,000 years ago, meaning approximately 1 mm of peat is added per year.

Function and special features?

- Water accumulation in basins
- High productivity (primary production) because of near unrestricted nutrient or water limitations
- Wetlands may be formed by beavers, who are ecosystem engineers and have built 200,000 km^2 of wetlands in North America by damming rivers, so the water can’t flow off.
- Oceans, rivers or seas can flood nearby land, so wetlands are formed (Fig. 1)

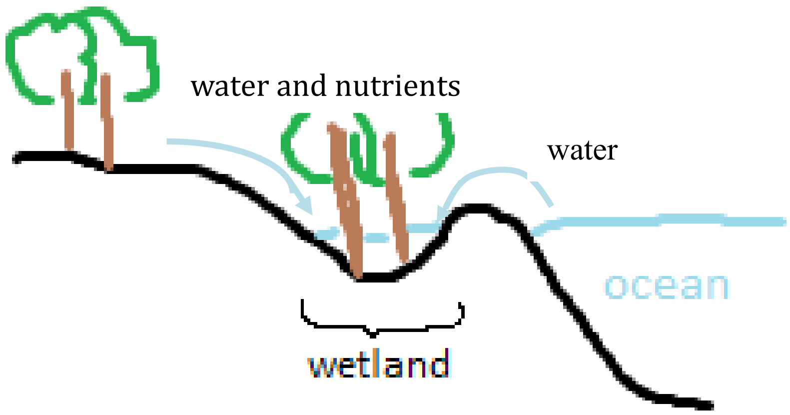

Figure 1: the water income in wetlands

The wetland produces more biomass as the rainforests, because there the plants have no limitation in water or nutrients.

Lunch from 13:00 to 14:00

Excursion to Vrbenské Ponds from 13:00 to 19:00

The Vrbenské Ponds are located northwest of Budweis in South Bohemia, Czech Republic (49°00'21.6"N 14°25'50.0"E).

Nature reserve:

- 250 ha large
- Contains 4 ponds, wetland forest, wet meadows which is the perfect habitat for birds
- Founded in 1990
- Aim is to protect wetlands and meadows
- Special habitat for birds
- Ponds created in 15th century from wet fields to make better use of land

Birds:

- Breeding site for100 bird species
- In Vrbenské there are 200 bird species in total out of 400 in the Czech Republic
- Islands in ponds are good for breeding to avoid predation, birds are only found on ponds because of these islands
- Oak trees around the ponds also good for breeding (e.g. Barrow's goldeneye, *Bucephala islandica*)
- Fish farming causes amount of birds to decrease
- Species spotted:
  - Grey goose (*Anser anser*) → hunting season starts right now, some have collars for

monitoring
- Spoonbill (*Platalea leucorodia*) → filters microorganisms out of water with its spoon-like bill, Vrbenské is only place in Czech Republic where the spoonbill breeds
- Little egret (*Egretta garzetta*) → Vrbenské is only place in Czech Republic where the little egret breeds
- Mediterranean gull (*Larus melanocephalus*) → breeds on islands without bushes and leaves the ponds afterwards
- Mallard (*Anas platyrhynchos*) → non-diving duck
- Barrow's golden eye (*Bucephala islandica*) → breeds up in trees
- Garganey (*Anas querquedula*)
- Tufted duck (*Aythya fuligula*)
  - Some ducks lay their eggs in others sucks nests besides their own nest to make sure at least one egg survives
- Black cormorant (PhalacrocoraxPhalacrocorax carbo) → does not have fat on its feathers so it has to dry once it came out of the water, has long feet to swim quite fast
- Great crested grebe (*Podiceps cristatus*) → does not have webbing between its toes, during their mating dance they run across the water
- Woodpecker → need soft wood and therefore old trees to carve their caves, black woodpecker (*Dryocopus martius*) is the biggest woodpecker, in Vrbenské there are 6 species of woodpeckers
- Bluethroat (*Luscinia svecica*) → number increases since the '80s
- European pied flycatcher (*Ficedula hypoleuca*)
- Kingfisher (*Alcedo atthis*)

Wetland:

- Ponds
  - Management is to remove mud and therefor the vegetation → no birds in one pond, because there are no islands
  - Oaks on banks stabilise the dams
  - Ponds for fish breeding, mainly carp (*Cyprinus carpio*) but also catfish (*Siluriformes*) and perch (*Perca fluviatilis*)
  - Fertilization is forbidden
  - Phosphorus is limiting factor in water, if there is to much phosphorus you'll have eutrophication
  - Species found:
    - *Phragmites australis* → often used to roof
    - *Urtica dioica* → shows presence of nitrogen
    - *Lemna minor* → shows eutrophication, smallest flowering plant on earth, is not an alga
- Wet meadow
  - Regularly mowed (once or twice a year)
  - Plants that grow there need to have aerenchyma to bring oxygen to their roots and prevent decomposition
  - Soil is mostly clay
  - Developed from historical lakes
  - Species found:
    - Meadow saffron (*Colchicum autumnale*) → is a bulb plant and toxic
    - Horsetail (*Equisetum*)
    - Common rush (*Juncus conglomeratus*)
    - Great burnet (*Sanguisorba officinalis*) / small burnet (*Sanguisorba minor*)
    - *Ranunculus*
- Wet meadow soil
  - Red colour around roots shows oxidized iron → plants need to bring oxygen down to the

roots by diffusion or actively to prevent decomposition because there is no oxygen in the soil

- Dark colour of soil shows reduced iron
- Many chemical elements exist in reduced form in oxygen-free soil, which are toxic for plants
- Gleysol → grey colour of soil, dark colour (reduced iron) with red dots (oxidized iron) in it
- Species found:
  - Purple moor-grass (*Molinia caerulea*)
  - Great burnet (*Sanguisorba officinalis*) / small burnet (*Sanguisorba minor*)
  - Various *Ranunculus* species

Tuesday, September 6th, 2016

Authors: Sabrina Tichy, Miriam Ahrens, Ricarda Jahnke, Johanna Christau

Topics: Wetland Ecology II by Tomas Picek, Constructed Wetlands by Tomas Picek and Plant-soil relationships: leaf litter decomposition, a key process for ecosystem functioning by Virginie Baldy

Lecture 1: Wetland Ecology II by Tomas Picek

1. Hydrology:

Water-balance equation:

$$S = Q + R + G_i - O - ET - G_o \pm T \ (m^3 \ year^-)$$

S = net change in storage

Q = surface inflow

R = Rainfall

G_i = groundwater inflow

O = surface outflow

ET = loss due to evaporation and evapotranspiration

G_o = groundwater outflow

T = tidal inflow (+) or outflow (-)

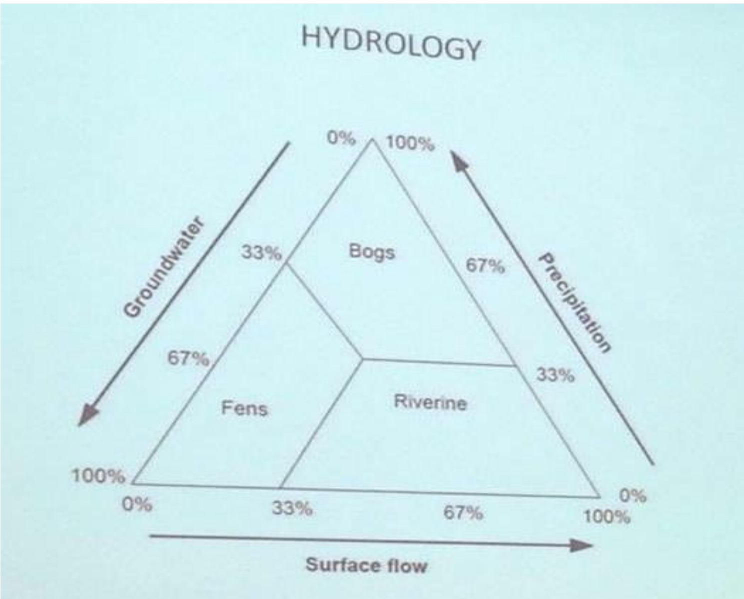

Fig. 1: Hydrology of soil

All sources of water and their increasing direction, e.g. fens are fed mostly by groundwater

2. Soils:

Two types of soils:

- organic soil: contains more then 12% of total carbon in the upper 1m layer

- waterlogged-mineral soil: water saturates for a sufficient period of time

→ gley horizon: iron and manganese accumulation

<u>3. Physico-chemical conditions:</u>

Redox potential E: tendency of a substance undergoing oxidation to give up electrons and a substance undergoing reduction to gain electrons. Organic substrate is electron donor, 0_2 is at the beginning the electron acceptor and after it is depleted there are other electron acceptors (e.g. SO_4^{2-}) → redox potential in soil depends also on light because stomata are opened under light and oxygen can be then transported to the soil

<u>4. Vegetation:</u>

- typical for wetland plants are special adaptation e.g. aerenchyma → transport of oxygen
- special plant: Sphagnum: water storage in hyaline cells, low nutrient demand and no herbivory

<u>5. Types of wetlands</u>

There are six basic types of wetlands: swamp, marsh, bog, fen, wet meadow, shallow water.

<u>6. Wetland protections:</u>

Threats for wetlands are e.g. drainage and hydrologic modifications, infilling, peat mining, mineral and water extraction, water pollution or climate change. The most important convention about wetlands protection is called Ramsar convention. Its aim is to maintain the ecological character of wetlands of international importance included in the convention.

Lecture 2: Constructed wetlands by Tomas Picek

Constructed wetlands are a type of biotechnology used for wastewater treatment which uses natural processes.

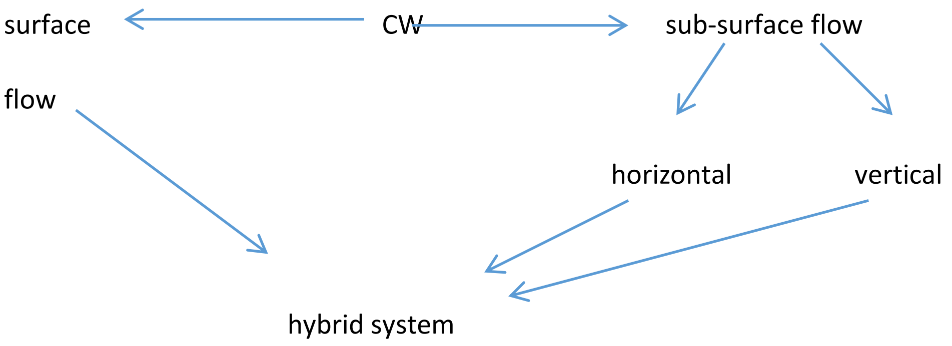

Fig. 2: Different kinds of constructed wetlands (CW)

Tab. 1: Examples of advantages and disadvantages of constructed wetlands

Advantages	Disadvantages
low maintance costs	need of large area
because of evaporation it is a cooling system for landscape	variable efficiency of nitrogen and phosphorus removal
no need of electricity or professional staff	construction costs
surviving of floods	

Lecture 3: Plant-soil relationships: leaf litter decomposition, a key process for ecosystem functioning by Virginie Baldy

Leaf litter is dead plant material such as leaves, needles or barks. Leaf litter decomposition is mainly a biological process. Nutrients return to the soil in an available form to plants.

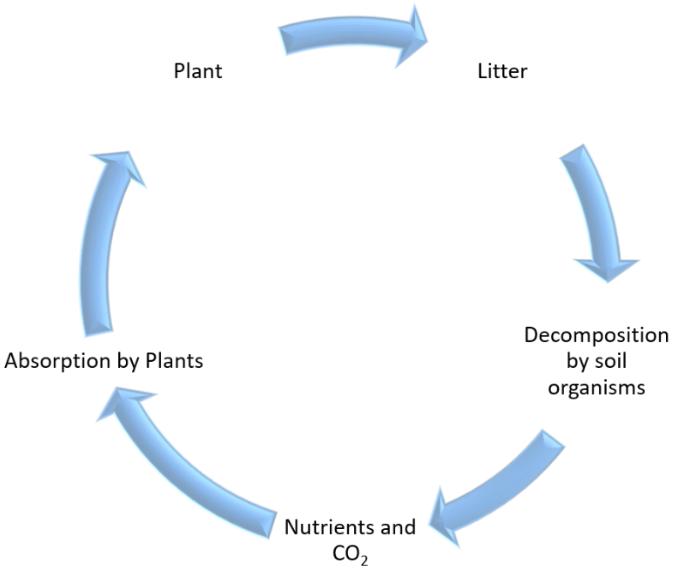

Fig. 3: Organic matter recycling

There are two main factors controlling leaf litter decomposition: environmental conditions such as temperature and soil water content and leaf litter chemistry (structure compounds, defense compounds and nutrients contents). The method to study litter decomposition is in situ-experiment by using litter bags containing a certain amount of litter and put on the field. Litter bags are collected at regular intervals for measuring the litter mass loss and chemical transformation and the decomposers associated with decomposed leaves. The decomposition rate depends on the type of litter and the environment, and for example white spruce is decomposed more rapidly in its own environment meanwhile in mixed plantations. This effect is called the “home field advantage” and can be explained by the presence of more fungi in spruce forest compared to other forests.

The age of the forest as well as tree characteristics can also play an important role in the decomposition of litter. There are three stages of forest age: colonization stage (trees~10 years old) stabilization stage (~30 years old) and mature stage (>60 years old). In between those stages the soil moisture as well as the secondary plant metabolites and the diversity, which can change and influence the decomposition. For example during colonization stage terpenoids are slower decomposed compared to phenolics and less organisms are associated to decomposed leaves. Climatic conditions show also an influence on the decomposition rate. However, in Mediterranean regions the soil water content seems to be more important than the soil fertility.

The surrounding plants have also an influence on the decomposition rate of the litter as shown in figure 4.

<u>Litter chemistry:</u>

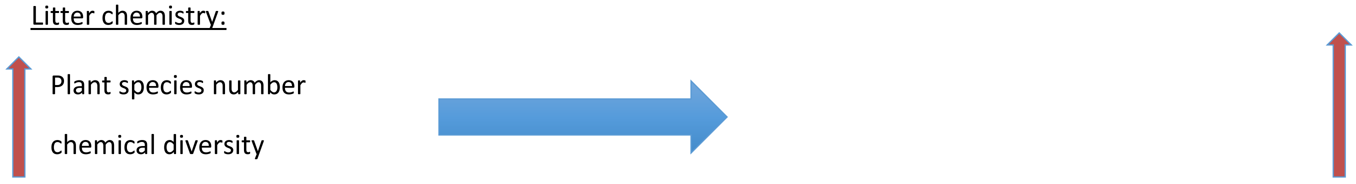

Fig. 4: Influence factors on the decomposition rate

Litter chemistry can have a significant effect in the decomposers and on the decomposition.

In the afternoon we heard a presentation on “How to write reports and give a presentation” by Philipp von Wrangell. Subsequently a short presentation of the mini projects and group formation took place.

Wednesday, September 7th, 2016

Kaisa Pajusalu, Mari Oll, Aivi Anijago, Piia Jaksi

Lecture “**Soil degradation“ by Endla Reintam**

- Soil degradation – when soil deteriorates because of human activity and loses its quality and productivity – its functions.
- We need soil for food, pure water (filtering), diversity and a solid ground to live on.
- Soil quality – sustain biological productivity, maintain environmental quality and promote plant and animal health.
- There is an idea to make an app that could easily discover the soil quality on place.
- *Arable land for one person in Western-Europe → 0.22 ha.*
- Why assess soil quality? - Evaluation of alternative practices; education; awareness.
- **NB!** We have no environmental protection for the soil because it is hard to give one number for all the different soils.
- Soil protection is very important especially for land owners and users; also for policy makers.
- *BUT HOW WE ASSESS?* – select indicators (chemical, physical and biological); interpret indicators; adjust management and policies.

- Carbon gives dark colour to the soil.
- We cannot see bacteria and fungi with our own eyes usually.
- Ecosystem services – we must think about soil functions.

- **MAIN THREATHS TO THE SOIL ARE:**
    - Pollution (oil spills)
    - Erosion
    - Decline in organic matter
    - Soil contamination
  - Soil sealing (roads and houses)

- Decline in soil biodiversity by:
  - Salinization
  - Floods and landslides
  - Desertification
  - Reacidification
- There has been a reduction of Corg content compared with earlier times.
- Soil contamination as part of land degradation is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment (nutrient depletion).
- Acid soils; ash sedimentation pools (NO SWIMMING).
- Soil compaction → occurs when soil particles are pressed together, reducing pore space between them.
- Decline in soil biodiversity – less or different species.
- Salinization → the accumulation of salts on or near the surface of the soil (occurs when there is more evaporation than rainfall).
- A landslide is a form of mass wasting that includes a wide range of ground movements, such as rockfalls, deep failure or slopes, and shallow debris flows.
- Desertification → a relatively dry land region becomes increasingly arid, typically losing its bodies of water, as well as vegetation and wildlife.
- Reacidification → acidification of previously limed agricultural land (soils with natural pH below 3.5 – 4.5).
- **Soil degradation is a global concern.**
- Reasons are water erosion, wind erosion, chemical degradation and physical degradation.
- Stable conditions – permanent frost; non-vegetated; dry land.
- Under the forest there is a litter cover which makes the land stable.

CAUSES OF DEGRADATION:

Natural conditions:

- Draught
- Heavy rains
- Fires

Human induced:

- Destruction of plant cover
- Soil covering → sealing
- Use of chemicals → pollution
- Traffic on the soil
- Fires
- Industry
- Mining
- Climate change

Lecture:“**Sustainable environmental management**“ **by Manfred Wanner.**

• We cannot produce soil in an artificial way, that is why it is so important to protect our soil.
• Soil organisms have positive impact on soil structure and are responsible for soil fertility (decomposition, mineralization of nutrients, engineering the structure).

REDUCED TILLAGE:

- Litter retention
- More substrate
- Slow but constant nutrient cycling
- Dependant on climate

PROBLEMS WITH STUDYING SOIL ORGANISMS:

- Soil is heterogeneous opaque meedium
- Pitfall traps: activity-density; statistic analyses: only non parametric

LABORATORY PROCESSES:
-Extraction of soil organisms from soil sample (e.g. soil core) by applying gradients of

- Light/darkness
- Dryness/moisture
- Cool/heat

• Disturbance/catastrophe (extreme disturbance) - a temporally limited event, no regular component of the ecosystem: there are anthropogenic and natural disturbances/catastrophes.

• MTA – military training area:
Large unfragmented areas

Small “hot spots” of activity

Providing highly dynamic habitats

• Soil organisms are important bioindicators

Excursions

Eddy covariance

Wet meadows around Trebon town is a complex of wet meadow. It is for producing hay. Measuring of the climatic characteristics started at 1977. Eddy-coveriance tower (Fig 1) was build in 2006 for measurement of gas fluxes in the ecosystem. The altitude of this area is 426, average temperature 7.7 C˚ and precipitation 607mm. At the station, there is soil and air temperature humidity, water levels, wind speed, precipitation and incoming solar energy measured.

Fig 1: Eddy covariance tower (photo by Mari Oll)

Eddy coviarance - 3D sonic anemometer instrument, analyses wind speed and air movement. Eddy covariance measures concentration of CO2, CH4 and water vapour. Based on the data, the carbon fluxes and carbon balance of the ecosystem can be calculated. The wet meadows act as a carbon sink for the most of the time, do to the high biomass productivity and decreased decomposition in water saturated soil.

The study site is also equipped by automatic chambers for CH4 measurement. This method is better for some detail understanding of relations between vegetation composition, environmental characteristics and CH4 fluxes in small scale.

Wet meadows and Rozmberk fishpond (Fig. 2)

The ponds were constructed in 1584 to 92. In this time it was twice as large it is now - 11 000 ha, but now 5000ha. Local farmers were using the area as a source of hay. In the past, it was impossible to bring the hay home during the vegetation season, because the meadows were too wet. Farmers needed to wait until winter to transport the hay when the soil was frozen. They had to build special hay house in these wet meadows where the hay was stored till winter, but many of them have not preserved till today. Nowadays the hay is more used in biogas station. A lot of wet meadows were drained for agriculture purposes, to increase productivity and facilitate the management. There is a system of drainage channels and other artificial channels which take the water to fishponds. Its lead to degradation of wet meadows ecosystem which were also strongly influenced by fertilization and their vegetation changed. The area is colonized by *Phalaris arundinacea* grass, also fox tale (*Alopecurus*).

Fig 2: Arificial channel for water regulation in wet meadows and fishponds (photo by Mari Oll)

Constructed wetlands by Tomas Picek

Slavošovice wastewater treatment was started in 2001 year and is used for municipal wastewater (from about 150 people) and surface runoff. The system does not need any extra energy as it is located on a lower side of the village and water flows to the system due to the gravity. The wastewater from the village is with a low concentration of nutrients and organic material. The water is filtrated by filters and microorganisms. The outflow water goes to the treatment bed where it is filtrated and will not cause any troubles to the local ecosystems.

There are 2 beds in the system with the length of 17m and width of 22m of each bed, the depth varies 0.8 to 0.9m. Area of one bed is $374m^2$.In the beds grows *Phragmites australis* (Fig 3). Hydraulic retention time is 14 days (18-1.5 days).

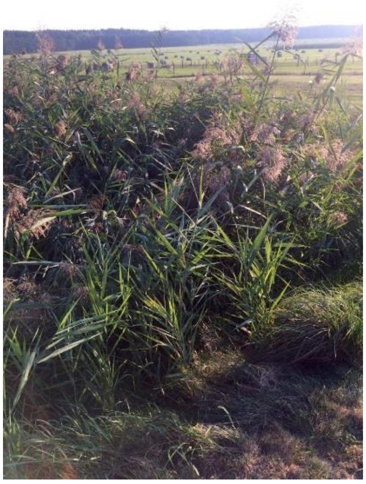

Fig 3: *Phragmites australis* in the constructed wetlands (photo by Piia Jaksi)

In the wintertime the wastewater goes under the ice and the soil will not freeze too deep because of the climate. Plants and leaf litter from the surface also isolates the soil.

The problem with small village wastewater treatments is that the water comes irregulary to the system while the plants need regular inflow for the nutrients. This system is not influenced by the problem too strongly.

Thursday, September 8th, 2016

Morning lecture : I) Wetlands and carbon fluxes

Wetland are very important ecosystems, with a lot of ecological functions and services, such as:

- Very productive ecosystems (in terms of primary production)
- Influence water quality
- Very important for nutrient cycling (accumulation, transformation, transport)
- Influence atmosphere and hydrosphere

Wetlands are also a reservoir for organic and inorganic carbon, especially peatlands, most in North East Europe. Carbon accumulates in wetlands because of the slow decomposition. Decomposition rate is controlled by:

- Hydrological regime
- Content of O_2
- Temperature
- Quality and quantity of organic matter
- Microbial activity
- pH
- Nutrient content

If wetlands are a carbon sink, they can also emit some CH_4, even one of the largest source of methane into the atmosphere. Methane is the end product of anaerobic decomposition in the most reduce conditions, and it’s produced by methanogenic archaea.

Factors that influence CH_4 production and emission:

- Hydrology (aerobic/anaerobic conditions)
- Trophic status
- Plant species composition
- Temperature

What could be the impacts of climate change on wetlands ?

- Sea level ring

- Higher temperatures
- Changes in precipitations, hydrology

→ The balance between fixed carbon (CO_2) and released methane (CH_4) is stable, but if wetlands are disturbed, the balance can change and wetland can became a source of carbon instea d of a sink.

II) Secondary metabolites of plants

In order to understand what is a secondary metabolite, it is interesting to define what is a primary metabolite first. A primary metabolites are compounds produced by plants that covers all essential processes (growth, reproduction, production of protein etc…), and a secondary metabolite is essential for the survival of the individual in it's environment (communitation, defence, adaptation…)

Production and emission

There are today thousands of known compounds, in three major types: phenols, terpenoids and alkaloids.

- Phenolic compounds : consisting of a hydroxyl group, some are volatiles like thymol, carvacrol, eugenol
- Terpenoids : generally lipophilic, they are found in essential oils and they're responsible of the odour of plants.
- Alkaloids : group that contains nitrogen. Around 20% of plants produce alkaloids. They are compounds with high biological activities (nicotine, morphine, cocaine…)

Secondary metabolites are found in every parts of plants, like flowers, leaves, roots, fruits… . Their production depends on physiological variations (age, organs, biological phases). All species in a family don't emit the same secondary metabolites, and all the individuals in a species dont have the same chemical signature : it depends on the origin of the individual.

Functions of plant secondary metabolites → attract disseminators/pollinators, protection against parasites/fungi/herbivores, Photo/thermoprotection, defence and competition.

Plant secondary metabolites can be released in the environment by fourth ways:

- Volatilization
- Leaves leachates
- Decomposition of the litter
- Root exudates

Allelopathy: any direct or indirect effect by one plant on another through the production of chemical compounds that influence the growth and the development of neighbouring plants. For some scientists, allelopathy is a part of competition.

Allelopathy is important to explain plant communities and vegetation dynamic (e.g. secondary succession in Mediterranean area. Allelochemicals of pine affect biodiversity on open mosaic areas and also regeneration in pine forest. So they are drivers on this succession. However, these chemical interactions could be modified by climate change (temperature and/or drought)

Allelopathic substances, if present in crops, could be used to reduce the use of herbicides (rice, cucuber, sorghum… are known to have allelopathic activities).

Take home message: plant secondary metabolites are important for defence against biotic and abiotic stresses, but also for plant succession and agrosystem functioning.

III) Wetland restoration

Human activities have influenced wetlands for centuries, with varying degrees of impacts :

- Mostly drained for agricultural and forestry purposes
- Wetland destruction (construction of dams, urbanization, peat extraction…)

On top of that, wetlands are also subject to many losses, around 10-20% of global wetland area is lost (especially in the tropics/subtropic). But wetland losses in Europe slowed down, because people strated to understand why it is important to protect them.

Why should we restore wetlands ?

- Water quality
- Erosion and flood control
- Carbon sink
- High biological production
- High biodiversity
- Recreation

The RAMSAR convention → international treaty for the conservation and the sustainable use of wetlands.

Basic restoration decision manual

- First: what would you like to have back (which functions?)
- Second: Is it possible to get it back? (degree of disturbance)
- Third: What do you have to do to get it back? → Aims and priorities

It is also important to think of the area, the cost of the restoration, the owner of the land, topography, and hydrology.

Main aim of restoration: increase and stabilize the water table, restore the original hydrology, restore the pH. But moreover, to revitalize a self-sustaining naturally functioning ecosystem.

Afternoon: During the afternoon we worked in our respective groups on the articles for the presentation of the subject a few days later.

Friday, September 9th, 2016

By Miguel Ballesteros, Maria Majekova and David Sednev

Summer School “Soil & Water”, České Budějovice , Czech Republic, 4th to 17th September, 2016.

Outline:

Bus transfer to Sumava.

1. Zoological material collection.

2. Guided visit to peatland and water stream restoration.

3. Guided visit to a Virgin forest reserve Boubin.

4. Presentation of workgroup topics.

1. Zoological material collection

A very short zoological collection at the beginning of our excursion yielded two species:

Arion rufus

Scarabus sp.

2. “Soumarsky most raseliniste” peatland in the Sumava National Park

Fig. 1: Guided visit (by Iva Bufkova, first from right) to peatland and water stream restoration.

General information about Sumava National Park:

Sumava National Park was established in 1990. It is the biggest National Park in the Czech Republic (total area 70000 ha). In the NP Sumava, the most protected zone is currently 15% of the area (hopefully 25% in a few years). About 30% of the National Park are wetlands and 10% are mires. The proportion of mires is relatively high (only comparable to Scandinavian countries). They are located mostly in the flood plains of the Moldava river or in the peatlands in the mountain regions (plateau about 1000m asl). Out of the more than 6000ha of mires in Sumava, 600ha have been restored and 1000 show problems.

Restoration of Soumarsky most mire: a peatbog industrially cut in the past and restored

Mire was manually cut for fuel by local people used for heating before WW2. Almost all forests were private and local people were not allowed to cut the wood and were therefore using peat as fuel. From the 60s till the 90s the bog was used for industrial peat extraction. Inventory estimated volume of peat to be extracted was one million eight cubic meters. To enhance peat extraction, the peatbog was drained in the past using a main central channel and smaller lateral channels.

In 1999 peat extraction was finished. Administration received the land and started to prepare a restoration project. Restitution law in 2000 ensured that the land in the locality was returned to the municipalities and further negotiation and agreement with the land owners was needed. The project was monitored since 1998, more in detail since 2005. The project was subcontracted and had additional aid from the volunteering program “Days for Mires”. Until now 600ha of the bog has been restored.

Main goal was to restore near natural hydrology and the original water table. Next, the dry crust left after peat extraction was covered with marsh vegetation from nearby bogs. This enhanced the hydrology and brought seed bank to help vegetation to develop spontaneously. The aim was to restore the wetland, not to restore a bog habitat. However, spontaneous succession proceeded towards bog habitat, which is also very satisfactory.

Fig. 2: Current water table and peat depth in the Soumarsky most mire.

Fig. 3: Succession over time in Soumarsky most mire.

1. Approach was to block ditches by wooden dams and block channels to stop artificial water outflow and increase water table. Water table is a very good indicator of restoration effects (vegetation takes much longer; Figure 2).

2. Cover bare peat at the beginning, it presented harsh conditions because of high fluctuation of temperature, dry surface with compaction problems and crusts limiting colonization of wetland vegetation. Peat grass during restoration was covered by mulch and the material received from mires from surrounding peatbogs and seeds to enhance vegetation cover. *Eriophorum vaginatum* tussocks served as a nurse species for recruitment of other plants (Figure 3).

3. Building shallow and quite large depressions that were filled gradually by rainwater and also represented a good environment for regeneration of wetland species (Table 1).

Monitoring shows great fluctuations of the water table since 2005 until 2008 when restoration measures took place, it only took one year (2009) to stabilise, showing a satisfactory results.

Water stream restoration

Small mountain stream regulated and straightened in the past and restored afterwards towards floodplain mosaic of fragmented and patchy habitats. We observed a clear gradient from the river to the edge of the flood plain. The closer zone is influenced by surface flood water from the river having specific dynamics and chemical conditions, minerals nutrient deposition, etc. Then the peatland mire zone: Further parts from the river with fine less permeable sediments, which were deposited in the past allowing peatbogs to form thousands of years ago. The restoration also involved the recovery of formation of meanders.

Table 1: Species than can be found in the peatland habitat.

Animal	Plant
Colias palaeno *Vaccinia optilete* *Proclossiana eunomia* *Boloria aquinolaris* *Aeshna subartica* *Pardosa sphagnicola* *Cicindela campestris* *Zooteca vivipara* *Vipera berus* *Charadrius dubius* *Tetrao tetrix* *Cervus elaphus*	*Vaccinium myrtillus* *Vaccinium uliginosum* *Vaccinium vitis-idaea* *Eriophorom vaginatum* *Eriophorum angustifolium* *Polytrichum strictum*

3. “Boubinsky prales” – Virgin forest Boubin in the Sumava NP

A National Nature Reserve declared in 1858 of beech and spruce vegetation with sycamores and firs. Strong wind storms in 1870 and subsequent bark beetle calamity led to a logging that damaged a large part of the forest and left untouched only approximately 47 ha.

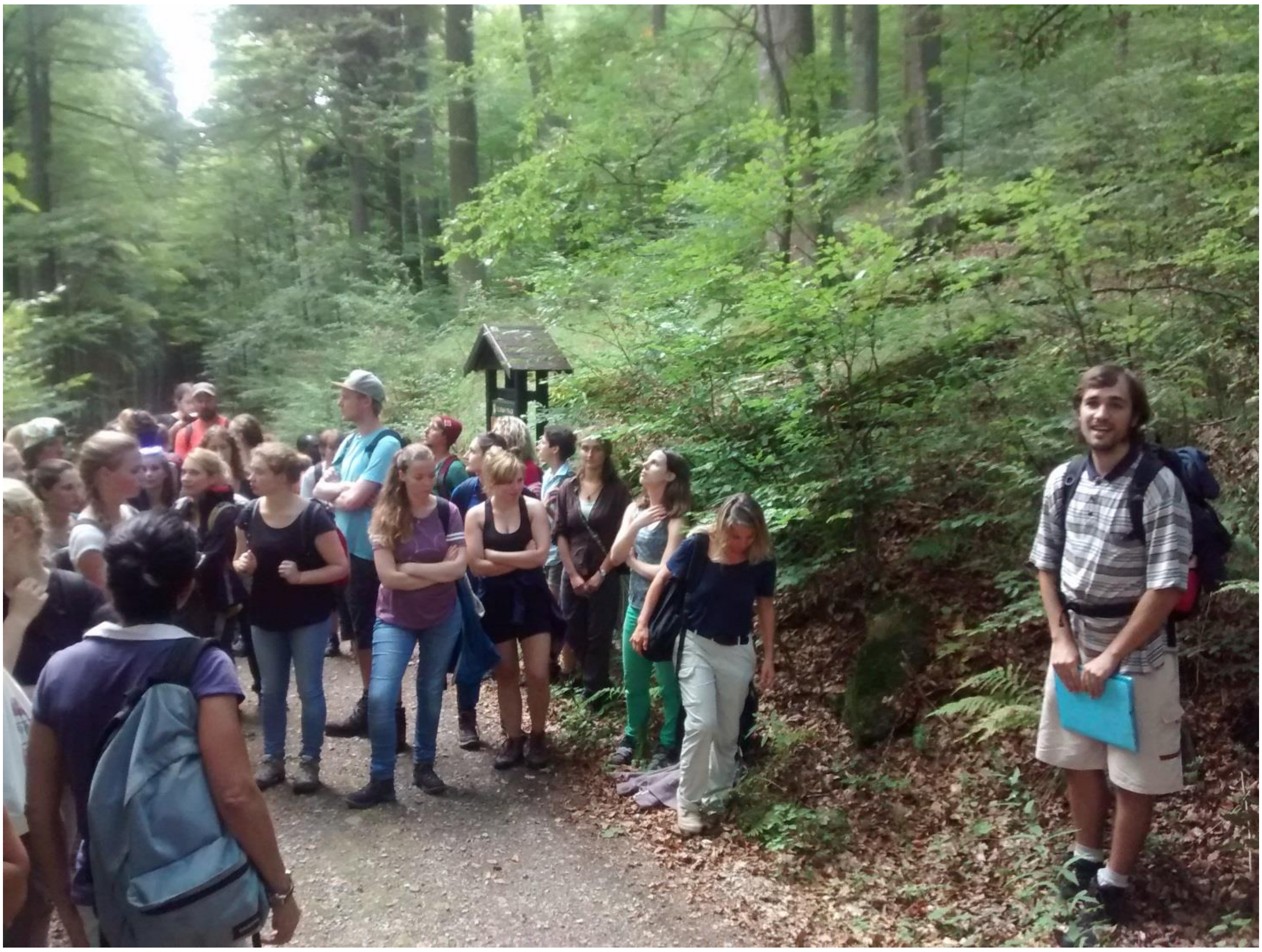

Fig. 4: Guided visit (by Vojtech Cada) to the Virgin Forest Boubin.

Natural regeneration and development of forests need a turnover of generations through the upper canopy die out which creates gaps for recruitment of new saplings. In a virgin forest we can find biological legacies that give us the information about the events forming the natural forest structure, e.g. a decomposing log, a standing dead tree trunk, a sycamore tree that points out at an upper canopy gap creation in the past or roots developed around an already decomposed log (Figure 5).

We were shown how disturbances can be tracked through time by dendrochronological research. We were shown an increment borer, a specialized tool to extract a section of wood tissue (with tree rings) from a living tree with minor injury to the plant. It is used to determine age of the tree, past growing conditions such as dry or wet years, as well as disturbances such as fires, storms, etc.

Finally, we had a demonstration of the structure of the decomposing matter in the upper soil layer (Figure 6).

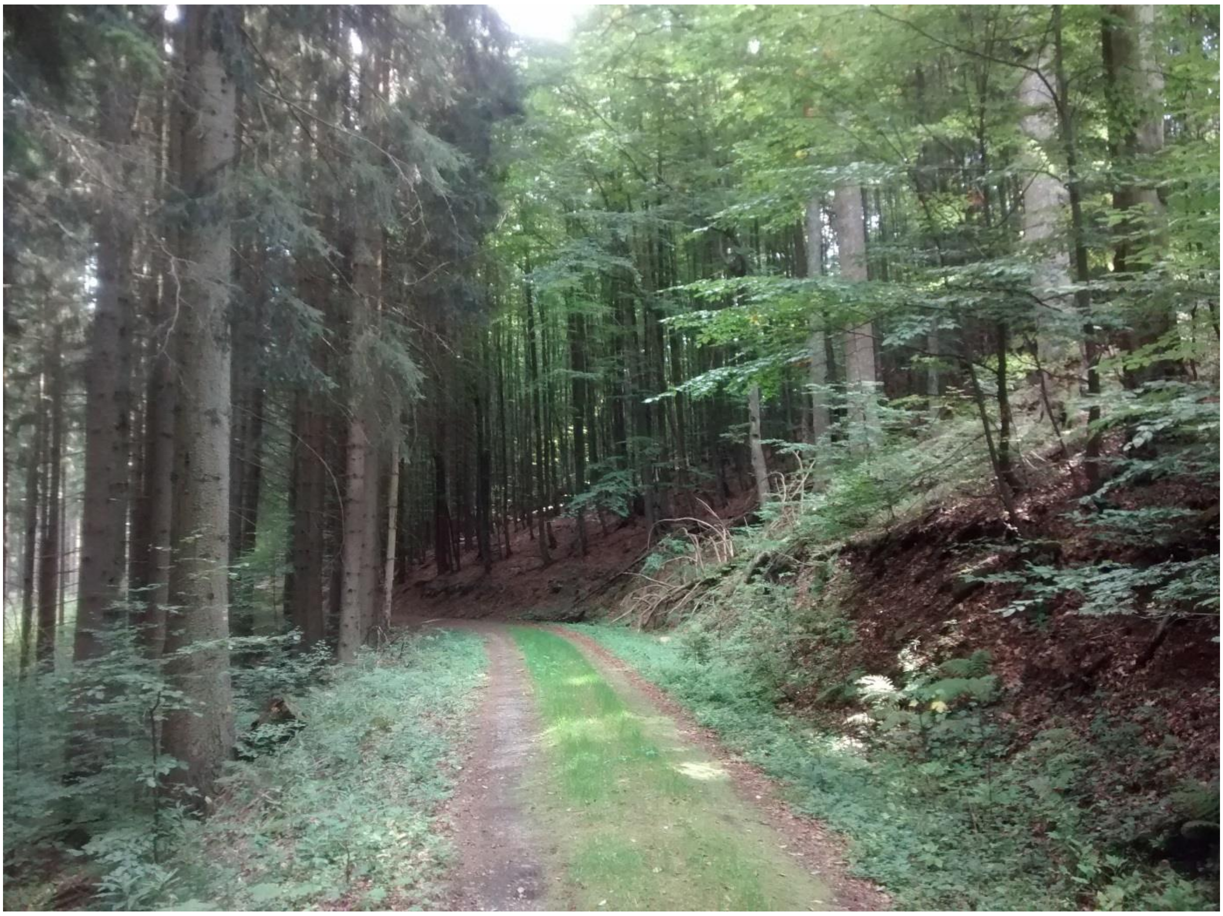

Fig. 5: Some pictures illustrating the different aspects of the forest structure. Upper: Spruce stand (left) and beech stand (right). Lower left: Dense beech canopy limiting light to reach the lower parts of the forest. Lower right: Roots developed around an already decomposed log.

Fig. 6: Virginie Baldy (AMU, France) and Endla Reintamm (EMU, Estonia) describing the O horizon in a beech forest at our site, consisting of organic material formed from the accumulation of undecomposed and partially decomposed litter of leaves, twigs, moss, etc.

4. Presentation of workgroup topics.

In the evening, each of the six groups presented some papers as background information for their respective research topics and preliminary experimental approaches for their following practical projects (10 min each group).

1. Soil zoology.

2. Litter decomposition.

3. Temperature sensitivity and soil respiration.

4. Drought stress in plants.

5. Aquatic plants as ecosystem engineers.

6. Soil physico-chemical properties.

Saturday, September 10th, 2016

WHOLE DAY EXCURSION IN THE ŠUMAVA MOUNTAINS

Darja Ashmarina, Petra Polická, Jitka Krejčíková

THE ŠUMAVA RANGE (Trojmezná-Plechý)

The excursion started at Třístoličník state border from where we followed the Czech and German border towards Trojmezí (Dreilandeck), the joint border of Austria, Czechia and Germany and then continue to Plechý (Plöckenstein). On the both Czech and German sides there is a national park (Šumava and Bayerischer Wald), whereas the Austrian part is a managed forest.

The visited area have experienced distinct disturbance in recent years. The original spruce (*Picea abies*) forest was damaged after barkbeatle (*Ips typographus*) attack and severe wind disturbations. The majority of general public and policymakers considered this event as a real disaster and wanted to save it by cutting the infected trees. Contrary to that, both German and Czech national parks decided to respect the rules of the I. zone that means not to do any actions or management of the area and let the nature do its work. In Austria, it was decided to cut the trees in the disturbed area and plant new forest.

Numerous scientific studies have taken part there. Many of them are still running and thanks to them it is already known, that the spontaneous succession is really successful and even more useful here. Nowadays, even the general public can see the results and compare the situation on both managed and unmanaged sites. The protected areas with the remnants of death wood are regenerating really well because the decomposing wood released nutrients for new tree colonizators (*Picea abies, Sorbus aucuparia*) and offer a shelter for the small trees. The another advantage is that the soil is better protected before erosion if no cutting and heavy machines are used which usually severely disturb the soil surface. The soil also does not dry up so easily as it is common in the

cleared areas and the habitat is therefore generally more resistant to the harsh climate which is characteristic for this mountain range. We can see undergrowth (e.g. *Vaccinium myrtilus, Vaccinium vitis idaea, plants from fammily Poaceae*) as well as new small trees. These trees are quite often growing in the rows which seem to be unnatural. However, this is a result of a growth on/or along a decomposing spruce trunk.

One of the crucial questions about this massive ,,dead“ forest was “What were the reasons/causes of it”? It seems that it might be a result of both natural and human impacts.

It is already known that disturbances play a vital part in virgin forest dynamics and regeneration. When old trees die, a new space is available for seeds and small trees, which have been growing in the undergrowth without sufficient space, light and nutrients. Some of the trees can wait for their chance even more than 100 years. It has been proved, that some type of a bigger disturbance has regularly appeared in natural forests through its history.

On the other hand, the spruce forest was also weakened due to human impact. Naturally, Norwegian spruce (*Picea abies*) grows only in higher elevations, or in places with higher level of ground water even in lower elevations, but because of the necessity of wood, especially for glass industry in the past, many forest in the Šumava mountains were changed to spruce monoculture, which is (as all the monostructures) more inclined to diseases and predators.

PLEŠNÉ LAKE

Another part of human impact which have weakened the trees was the acid rain induced by the chemical compounds (N_xO_x, SO_x) produced in industry and agriculture in past. These chemicals harm needles, otherwise commonly staying on the tree for more than one vegetation period.

After reaching the highest peak in the Czech part of the Šumava mountains – Plechý (Plöckenstein, 1378 m a.s.l.), we continued towards Jezerní stěna (lake wall) under which is a glacial lake called Plešné lake.

This lake was influenced by the disturbances of the forest above as well therefore offers a suitable example of soil-water interaction. After the death of spruces some nutrients including NO_3^- start to be leached out into the lake and participate in its acidification. Even more harmful for acidification were acid rains, which brought sulphates. All those events led to the changes in the chemistry of lake’s water and its biodiversity. Fish which were present (both introduced indigenous trout (*Salmo trutta*) and unoriginal American char (*Salvelinus fontinalis*)) died. The main reason of their death was the higher concentration of Al^{3+} that creates insoluble compounds on their gills. Also many species of zooplankton disappeared.

Since the 90th of 20th century the situation has started to get better – some species of zooplankton like *Cyclops abyssorum* and *Daphnia longispina* came back. But in a case of fish’s return the situation is still not good. Acidification of lake also affected population of rare plant *Isoëtes echinospora*, which is a local glacial relict.

PLEŠNÉ LAKE – NOVÁ PEC

From the Plešné Lake we followed a stony path which was occasionally lined with manmade or regulated channels previously used for the timber transport. All these trunks were cut off in the local forests and transported to the villages initially for the heating and local use. Latter the local channels were connected to the Schwanzenberg canal and the timber was transported to the wider area and the Plešné Lake was an important source of water for the wood transport.

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Monday, September 12th, 2016

1st Lecture: *Microbial processes in soil I* by prof. Ing. Hana Šantrůčková CSc.

This lecture was focused on main microbial processes in soil. The main objective of this lecture was to outline the main three groups of microbes - bacteria, archaea and fungi. First of all, we learned the basic information such as the importance of microbes - as a part of soil organic matter (e.g. 90% of carbon and nutrient transformations are carried out by microbes).

Another part of the lecture was microbial physiology and basic patterns of energy gain by microorganisms: chemoorganotrophy (use of organic compounds) and chemolitotrophy (use of inorganic compounds) The most abundant microbes in soil are *chemoorganotrophs* which use organic compounds and C and energy sources. Without microbes the ecosystem would not be properly functioning, C and nutrient transformations could not be completed and plants would suffer from nutrient deficiency. Soil microbes run plenty metabolic pathways which give them flexibility and allow them to decompose a huge variety of compounds in highly variable conditions. That is the reason why the soil needs prokaryotic microorganisms (archaea, bacteria) with their metabolic heterogeneity and flexibility.

We learned what is aerobic and anaerobic metabolism (aerobic respiration - producing only CO_2 with the electron acceptor of O_2; anaerobic respiration – producing CO_2 with electron acceptor- S^{2-}, NO_3^-, SO_4^{2-}; fermentations – producing CO_2 and organic acids, alcohols with organic molecule as final electron acceptor). Microbial respiration is full oxidation of sugars to CO_2 by one cell while –fermentations produce a lot of organic byproducts are produced besides CO_2 and they must be mineralized in sequential steps by other microbes Furthermore, we learned about the importance of many microbes that are depended on each other in wetlands, as they must collaborate with each other and are very sensitive to disturbance. As has been said anaerobic soils are more sensitive to disturbance than aerobic soils. We also learned about gaining ATP (aerobic pathway - 36 ATP; anaerobic - 2 to 4 ATP). Further the molecular composition of cell (70% H_2O; 30% chemicals - 55% protein (enzymes), 20,5% RNA, 9,1% lipids, 5,0% polysaccharides) - so the cell stoichiometry looks like this "$C_{50}O_{17}N_{15}H_8P_{2,5}$". Prof. Šantrůčková also talked about different nutrients that are limited by different processes - nitrogen is widely available in the atmosphere, but generically costly to acquire, phosphorus is rarer and locked up in mineral deposits and about enzymes, that must be released from cells to periplasm and into the soil.

The end of the lesson was devoted to main factors - texture and structure of the soil (e.g. soil aggregates stability improves - porosity, soil aeration, moisture (water-holding capacity), cation exchange capacity), soil temperature, redox potential and soil pH.

2nd Lecture: *Soil water relations II.* by prof. Dr. Marian Kazda

This was the second lecture about Soil water relations. by prof. Dr. Marian Kazda. We learnt information about texture and structure of soils. We differentiate four types of soils by sizes of soil particles:

Gravel > 2 mm (soil skeleton)

Sand: 2-0,063 mm

Silt: 0,063-0,002 mm

Clay: < 0,002 mm

We learnt about the importance of clay for soil functions. Clay is important for soil structure, water retention and cation exchange, the latter because of its negative charge.

Water supply to plant roots can be elucidated by formula, which easily demonstrates different effects:

$W = A \cdot (psi_{soil} - psi_{root}) / suma\ r$

„W“ is root water uptake, „A“ = root area, „psi_{soil}“ mean soil water potential and „psi_{root}“ = root water potential. then „Suma r“ is sum of resistance s for water movement through the soil.

If plant has not a sufficient water supply from the soil and air is dry, then plant close its stomata, because of water saving. In this case there is no transpiration of plant, as well as there is no photosynthesis, as plant do not uptake CO_2. Still there are types of metabolism of plants which can separate fixation of CO_2 and transpiration like CAM plants which are reducing transpiration in the day and are opening stomata at night.

Water supply to plant roots depends on soil hydraulic conductivity. When plant have no water for a long period, what actually depends on climate, then lack of water can cause air embolism in the water transporting vessels. Air embolisms may occur in the xylem of vascular plants, especially when plants are suffering from water stress. It is practically the blocking of a xylem vessel or tracheid by an air bubble. This phenomenon in advanced stage can cause necrosis of plant leaves and lead even to plant’s death.

Practical work in afternoon

The afternoon was devoted to a practical part for every of six groups. Group 2 (leaf litter decomposition) weighted the dried samples from the drying oven which had been drying for 24 hours to determine the water loss and the amount of decomposition. Participants wrote down the results and prepared themselves for the next day for the evaluation of the results.

Group 6 (Physico-chemical properties of soil) was outside to get sample from agriculture land with crop and then did laboratory analysis with this one sample and others from Šumava, Třeboň, Slavošovice according to prescribed procedures. We determined pH of samples in H_2O and then in KCl by pH meter. We estimated soil moisture, did direct estimation of organic matter by loss on ignition and performed extraction of mineral forms of N and available P from these soil samples. During all steps we did our notes for our protocols and wrote down the main results.

Tuesday, September 13th, 2016

Kira Steiner, Maja Mezger, Julian Müller and Julius Piller

Lecture “Soil exploitation & root architecture” by Marian Kazda

Roots can be classified in two groups. While coarse roots have a bigger diameter than 2mm, fine roots are smaller than 2 mm. The most important functions of roots are to take up water and nutrients, anchoring the plant in the soil and create an interaction with the biotic and abiotic soil environment, e.g. exudation or secretion.

Rhizosphere is an important term by reading about soil exploitation and root architecture. It means the close vicinity of the roots with different biotic and abiotic interactions. This rhizosphere can be exploited for nutrient and water uptake. The parameters for this are the specific root length [m root length/g root mass] and the root length density [cm root length/cm^3 soil volume]. For example, an extensive meadow has about 30cm roots per cm^3 soil volume. In general grass species have very dense roots.

The roots of all plants are highly associated with microorganisms. In example for wetland plants, there was a dense microbial biofilm covering the outer cells. The groups of microorganisms are interacting with soil nutrients and therefore utilizing oxygen released by plant roots (methane-oxidizing bacteria in the example).

Roots are distributed in the soil. The biggest vertical distribution of roots is in the upper layer of soil because there are more resources available. The root mass [% of total] decreases with soil depth. One reason can be drought stress. The persistence of roots depends on environmental conditions. The plant cannot always afford to build new roots.

The architecture of roots means how the root is allocated in the space. Where a lot of nutrients are provided, a dense rooting can be observed in this part of the soil.

Plants take up nutrients from such soil patches. These patches can be accumulation of organic material such as dead bodies, feces etc. If two species grow together, in most cases they both are exploiting common patches. The reason is that roots are growing in areas, where more nutrients are available. All individuals are trying to take profit from these resources.

Finally, a generalization was given regarding the resource distribution above and below ground. The natural distribution of light and CO_2 concentration which takes place in the above ground is according to predictable gradients, thus stimulating plant height growth. The allocation of roots however follows multiple gradients of soil organic matter and aggregated nutrient availability. Clusters of provided nutrients are convoyed by the preferred uptake of seepage water.

As a result: Root clustering is a rule in natural soils for optimized exploitation of aggregated resources.

Lecture “Soil organic matters” by Alar Astover

The interactions between plants and soil are varied. In particular, the mechanisms between the roots and the environment are of scientific interest. The roots can interact by diffusion or through mass flows with their environment. The ions are taken from the soil dissolved form. A special form of nutrient uptake is the Mychorrhizal symbiosis. Circa 80% of higher plants have this mechanism of nutrient uptake. Another important factor for nutrient availability is the mobility of the nutrients in the soil. Nutrients can be very mobile (e.g.: NO3-, S, B), with moderate mobility (e.g.: NH4 +, K, Ca, Mg, Mo) or relatively immobile (e.g.: P, Cu, Fe, Mn, Zn).

Very mobile nutrients can be easily dissolved in liquids. Soil collois can be divided into mineral colloid, organic colloid, and, organo-mineral 'colloid (humus). The concentration of the colloids can be described by the cation exchange capacity (CEC). Most of the soil colloids are with negative charge and thus cation exchange between soil colloids and solution is common.

The organic fraction of the soil come from photosynthesis through the plant in the ground. So that the soil formation and the growth of plants is coupled with each other. The composition of the soil depends on the following factors. The most important factors are: parent material, climate, organisms, humans and relief. A typical composition of the top soil is per volume: 45% Minerals, 5% organic material, 20-30% water, 20-30% air.

The importance of soil organic matter can be used in biological, chemical and physical aspects divided. Biological aspects are energy (carbon), sources of nutrients (N, P, S) and soil-plant capacity. Physical aspects: structure formation of the soil, water holding capacity and the thermal buffering. Chemical aspects are: pH-buffering, cation exchange and pollutant binding. From these aspects, an indicator can be formed, the (Soil Organic Matter) can be abbreviated to SOM. SOM is an indicator of soil quality, climate change and biodiversity in the soil.

However, the SOM can be measured in a destructive or destructive method. About an element analysis the wet-chemical and organic carbon can be measured.

Lecture “Role of stomata in sensing environment” by Liisa Kübarsepp

Stomata are pores with adjustable aperture that are mostly located on lower surface of leaves. They are regulating the gas exchange between the plant and the atmosphere. The stomata play an important role in the development and the life of the plant, because the cuticular layer itself is practically impermeable to gases. To reach stomata-opening the turgor in the surrounding guard cells must be increased. With the entering of ions through the corresponding channels water can enter the cell by osmosis and turgor is increasing. Two different ways of opening and closing are possible. In vascular plants a deflating cell leads to stomata-closure and an inflating cell leads to stomatal-opening. Sphagnum (and other mosses), on the other hand, close the stomata by inflating the guard cells and open the stomata by deflating them. This opposite way of regulation is due to different function of stomata in mosses – they are not for optimizing water loss but to accelerate it so that the sporangia could desiccate faster and release the spores.

Stomata can be divided roughly in two different types. Most of the plants have kidney-shaped guard cells. The more common type in grass species are the smaller and thinner dumbbell-shaped guard cells. With their smaller size, they enable a faster and a more precise regulation of aperture because the transport of water in and out of the guard cell is much faster. The stomata size is negatively related to the stomatal density on the leaf.

Stomatal conductance describes the gas exchange rate through stomata. An increasing stomatal conductance is leading to a higher photosynthesis rate till it reaches the maximum due to chemical limitations.

The main environmental factor for stomata is water availability. To understand the water conditions in plant it’s not enough to just explain the amount of available water. Water use efficiency is a measure to describe how many water molecules are lost for one CO_2-molecule fixed. Due to a low CO_2-concentration in the air and the size of CO_2-molecules, the diffusion of CO_2-molecules is way slower than the diffusion of water molecules. An optimisation of WUE can be reached by a rapid stomatal closure and a special CO_2-fixation by C_4- and CAM-plants.

The water potential shows the direction of water in plants. It is measured as a pressure gradient from high to low potential. Furthermore, vapour pressure deficit gives the difference between moisture in the air in the leaves and in the air surrounding the leaves. This relation affects the transpiration and water potential of the plant. A decrease in water content in the soil increases the danger of drying out. The dual effect of the hormone abscisic acid helps the plant to react remotely or locally to this danger. ABA leads to a decrease of stomatal conductance and stomata closure.

Another important factor is light. Light increasing leads to the increase of stomatal aperture. During midday stomata close more to avoid desiccation. An increase in the CO_2-concentration decreases the stomatal opening. The other main factors influencing stomata are VPD, temperature and nutrient availability.

In the afternoon every group evaluated their data of the practical work of the mini projects.

Wednesday, September 14th, 2016

BOZINO Delphine - REVEYRAND Laura.

Morning:

8h30 – 10h First lesson: Microbial process in soil II by Hana Santruckova.

In the part I we studied physiology, stoichiometry, soil enzymes, and effect of environmental factors on processes. In this part, the lesson explains transformations of the three most important compounds in soil.

a) Carbon (organic matter) transformation

- Carbon is a building block of biomass and donor of electron in energy source.
- Plant material is soil organic matter transformed by activity of soil biota by different microorganisms.
- At the end the organic matter is mainly used as nutrient.
- Decomposition is different from mineralisation:

Decomposition of plant is a main process of Carbon transformation in soil. It is assimilated by microbial cells which excrete enzymes.

Mineralisation is like respiration. The oxidation of organic matter product CO2 at the end of the process.

b) Nitrogen transformation

- Nitrogen is an essential element of biomass.
- The process is much more complicated than carbon cycle, because it is both donor and acceptor electron. There are different oxidation states.
- Microbes fix N for plants.
- There are different processes, depending on environmental conditions (anaerobic/aerobic): Assimilation, Nitrification, Denitrification, Ammonification.
- Mineralization and immobilization depend on stoichiometry of the cells.

c) Phosphorus transformation

- Phosphorus is an essential element of biomass.
- It is directly use for ATP.
- It is consumed only on mineral form, and is available at very narrow range of pH.

10h – 12h30 second lesson: Sustainable use of soils – from soil data into decision by Alar Astover.

Sustainable use of soils = development that meets the needs of the present without compromising the ability of future generation. The prerequisites are to think global and act local for land.

Sustainable agriculture: an agriculture that indefinitely maintains productivity. “think global, act local”

- Soils formation is a very low process. Soils are “non-renewable”, changing in time and space and with limited quantity.
- The prerequisites for good land use decision are: - availability of reliable information.
  - the ability to handle it.
- Pressures are the 5 “F”: food, feed, fuel, fibre, fun
- Nowadays the population is increasing so food demand increase too. It is a problem for agriculture lands which decrease per capita. For example, on average, arable land per capita was 0.41 ha in 1960 and 0.2 ha in 2013. It could decrease to 0.15 ha in 2050.
- We could satisfy the increasing biomass demand: reducing consumption, expanding area or with intensification.
- Today, question of “clean” agriculture.
- Soil has got an important role in ecology and socio-economy so several indicators are used to define soil quality.
- Multi- functionality of soils:
  - Ecological functions (biomass productivity environmental interaction, biodiversity)
  - Socio- economic functions
- In the seventies, soil quality concept appears: how well he can survive these pressures, how he performs its functions and respond to external influences.
- There are a lot of methods to determine different indicators of soils: LOI, plant available P, pedotransfer functions, pedometric… The spacescale and timescale are important.
- Who needs these informations? Scientists, policy makers and land user.

Afternoon:

Excursion

Main topic of the excursion – spontaneous succession of the sand pits after mining, comparison with industrial reclamation with a focus on the habitat diversity and species diversity.

First place: forestry sand pit - Cep

This sand pit is located in a forest near Cep. (2.25 ha), and it is mined only occasionally. It is part of Natura 2000. The sand pit is now dominated by woody species and some shallow lakes are changing into peatlands.

Fig. 1 : Forestry sand pit - Cep

The sandpit is home to a relatively numerous population of sand lizards, and grass snakes are common too. The pools are important mainly for the reproduction of amphibians and nesting of rare birds.

On this site we observed different species like :

- *Drosera rotundifolia, Lycopodiella inundata* (endangered species) – characteristic for very poor sites with low competition of other plants
- Pine, spruce, oak, beech, blueberry
- Dragonfly, snake, frog

Fig. 2: Frog

Fig. 3: Dragonfly

Fig. 4: Drosera rotundifolia

<u>Second place</u>: Cep II sand pit.

It is an active mining area (sand and gravel extraction) of 101 ha since 1979. This place is used for school and people sensitization to understand differences between artificial recultivation and spontaneous succession.

There are different experimental sites in the sand pits. The first site is “experimental restoration of dry grasslands”. To create the Klara Island, clay particles were extracted. The Second site is “experimental pools”, the aim is to study the impact of predation risk and habitat complexity on the dynamics of macroinvertebrate community assembly in freshwater. The last site is “near-natural restoration”. The aim is to determine which type (spontaneous succession or technical reclamation) of restoration is better for biodiversity. The spontaneous succession method is not expansive so they tested different experiments.

Fig. 6: Experimental Pools

Fig. 5: Sand pit area

Third place: “ U Dracice” sand pit (Nature reserve)

Mining of gravel – sand in the 1980s revealed bedrock of the Trebon basin. A diverse environment has been formed – bare rocks, dry sand, and semi-open grassland. To preserve the diversity, it is necessary to maintain the area free of forest.

On this site we saw species like *Carex ericetorum, Calamagrostis epigejos* (really competitive and difficult to remove), and a parasitic wasp.

Fig. 7 U Dracice sand pit

Thursday, September 15th, 2016

Gabrielle Almecija, Elodie Quer, Adeleke Oluwaseun

Experimental climate change by Ilja Reiter

The main subject of this topic was to present different experimental approaches to study the effects of climate change on the ecosystem. In particular temperature , CO2, O3, precipitations and humidity changes was developed.

Introduction:

What is climate change?

Climate change is described by an increase of average temperature, precipitation and temperature modifications. Climate change may be due to natural internal process but human activities are main causes.

What is global change?

A long term change characterized by natural internal processes or external forcings, or to persistent anthropogenic change in the composition of the atm or in land use. Climate change is multifactorial: C02, temperature, precipitation, humidity, ozone radiation are expected to change at the same time.

Temperature:

Increase of temperature are observed since last thousand years and especially in the Artic area.

Experimental methods:

- Electrical heat-resistance ground cables
- Greenhouses
- Vented and unvented field chambers
- Overhead infrared lamps
- Passive night-time warming

Ex : International Tundra Experiment (ITA)

CO_2 and ozone:

CO_2 increase since 1960 due to industrial revolution. Main CO_2 emitter per capita are USA. Many ways to increase CO_2 in atmosphere so there are many in situ experiments.

Tropospheric ozone increases since 1900 and higher concentration are reached today.

Experimental methods:

- Atmospheric CO_2 observatory
- Gases fumigation systems
- *In situ* Chamber

Ex : Mauna Loa observatory NOAA, Duke forest’s FACE, Kranzberger forest university of Munich.

Precipitation and humidity change:

Scientists are not sure about what happen to precipitation will change in intensity, frequency and duration. On a global scale precipitation will be lower except in higher altitude where it will increase. Change in distribution of precipitation are also predicted.

Experiments:

- "Static exclusion“: rain gutter type, tent type
- "Dynamic exclusion" : displaceable roof, rollable cover
- "Air humidification“: Greenhouses, Phototrons, Chamber
- "irrigation“: above canopy sprinkler, ground level drippers

Ex : LTER site jornada basin, Georgia large rainout shelter, O3HP, Font blanche, Climate, Free Air humidity Manipulation experiment (FAHM) in Estonia.

Plant stress by Tiina Tosens

The main question of this topic was plant stress and how plants acclimate and cope with environment changes?

Introduction:

- Plants have optimal temperature, radiation and humidity for growth and survival.
  => What happens if factor shift? There is a change in homeostasis which could be deadly. Homeostasis is the big balance of the organism. Metabolic reactions are very coordinated and closely associated.
- Water is important to keep plant water homeostasis and maintain cells integrity. It’s also important for cooling down.
- Biggest challenge in plant life is to keep water inside because hearth temperature increasing and it will be dryer.
- What happens if it's not regulate? If the shift is big there is bigger internal arrangement and it costs a lot of energy. Their performances are reduced by changes.
- Very important indicator of plants performance is photosynthesis
  => Photosynthesis: convert light energy into chemical energy, convert CO_2 energy into sugars
- Why plants are so important ? plants keep atmosphere CO_2 balance. They use their stomata to absorb CO_2. It's really important to maintain CO_2 concentration in mesophyll cells. =>Biggest problem is that if their closed their is stomata there will be a lack of CO_2.

Any shift in Environmental factor can cause stress:

- Biotic stressors: diseases, herbivory, competition
- Abiotic stressors : temperature (heat, cold, chemicals and enzymatic reactions), water (drought, flooding, some areas will be dryer or flooding, anoxic conditions), radiation (UV, stress oxidative reactions, photosynthetically active radiation 400nm-700nm), chemicals influences (pollutants, mineral salts),mechanicals influences (wind surface movement) other(electric fields, magnetic fields).

In natural environments plant always experience stress.

Plants responses to stress:

- Plants have 3 possibilities: resistance/adaptation/growth/survival, susceptibility/senescence/death, Avoidance/survival.
- Avoidance = plants escape from stress.
- Adaptation = long term and large scale evolution. (ex: stomata in a chamber to reduce transpiration = adaptation).
- Evolutionary adaptation: the process refers to the process of organisms changing over time in order to survive. (ex: *Populus tremula*).

Conclusion:

- Stress is abiotic and biotic factor that reduces the rate of some physiology process below the maximum rate that the plant could sustain.
- It’s important to consider specific response and plant plasticity.
- Plant adjustment to stress depends on severity and duration of stress.
- Modificative and modulative adaptation take place within a life circle.

Presentations of mini projects

1st presentation: Soil zoology

The objective of this project was to compare the mesofauna of the soil in a forest and in a wetland. They used a berleze to recuperate the invertebrate and with a binocular loupe, they identified the mesofauna.

They found that the higher diversity is present in the forest.

2nd presentation: Leaf litter decomposition

The objective of this project was to measure the additive or non additive effect of the leaves’ diversity on the decomposition
They used some litter bag to pick the litter. After heat up (105°C) during 20 hours, they weighed the litter.
Unfortunately, there were some mistakes and they were not able to have results …

3th presentation: Temperature sensitivity of soil respiration

The objective of this project was to valid (or not) two theories on the Q10 (temperature sensitivity) on the soil.

We used a soil (organic and mineral) from Sumava mountain and we added glucose and cellulose. We put the soil in different temperature (10°C, 20°C, 30°C) during 24h. Then we measured the respiration rate with CO2.

We didn’t valid any theory with our experiment.

4th presentation: How drought stress and CO_2 concentration influence stomatal conductance and photosynthesis.

Aim: To evaluate the effect of CO_2 increase and drought stress on stomata enclosure of different plants.

They use two types of plants (sedge and mint) under two treatments (drought stress or not) and under a gradient of CO_2 concentration. Then they measure stomatal conductance and photosynthesis with a Licor.

Introduction Materials and methods Results Conclusions Thank you

Hypotheses:

H1: Stomatal conductance is reduced by drought stress.

H2: When CO_2 concentration is increased stomata close and when decreased stomata open.

H3: Photosynthesis and stomatal conductance are correlated positively.

Results:

H1 was confirmed: Stomatal conductance decreased with drought stress in both species. H2 and H3 are also correlated when CO_2 concentration is increased stomata close and when decreased stomata open. Photosynthetic rates are positively related to CO_2 concentrations. Photosynthesis and stomatal conductance are correlated positively

5th theory: Effect of plants on oxygen concentrations in aquatic and wetland systems

Aim : To measure oxygen concentration variation in wetland with different aquatic plants. (lemna, potamogeton, glyceria, algae, sphagnum.

They try to answer at two hypotheses by reconstruct a microcosm.

Hypotheses:

H1: O_2 concentration are different between plants used in the microcosm.

H2: Algae will produce more algae O_2.

H3: O_2 concentration near roots depends of plants used and are correlated to plants morphology.

Results:

> H1 was confirmed but not H2 and H3. Potamogeton produces more O_2 than the other plants. There is no difference of O_2 production between plants morphology.

6th presentation : Soil physio chemical properties

The objective of this project was to measured different physical and chemical parameters (pH, humidity,%Mo,%N) in different kinds of soil.

Friday, September 16th, 2016

By Josephine Donadio, Dominik Guttschick, Simon Keck and Ädem Minat

Synthesis by Prof. Dr. Marian Kazda

The aim of this lecture by Professor Marian Kazda was to get a summary all of the main topics taught during the two weeks summer school.

Processes and cycling of elements in plants and soils (aerobic conditions)

- NPP (net primary production) → organic matter that is produced per unit area and time (year) later, it falls as litter to the ground and decomposes
  These processes were explained in relation to cycle of carbon and nutrients.
- in the air you can find
  - H_2O
  - flying animals like butterflies (after death they fall to the ground and become organic matter)
  - O_2 (Oxidative energy gain → respiration)
  - N_2
- in the soil you can find
  - H_2O
  - inorganic nutrients like phosphorus, nitrogen, potassium etc.
  - O_2 (needed for oxidative energy gain)
  - Microbes (performing decomposition → the cycling is linked to this process)
  - OM (organic matter) → OM turn-over because of microbes and soil fauna
  - fungi (important for decomposition)
- the soil is composed from
  - different layers (horizons)
  - trees and plants (after death they become OM → decomposition → nutrient release into the soil → nutrient cycle)
- roots
  - most microorganisms are concentrated around the roots, because of root exsudates, symbioses and the OM turn-over
- in relation to the described processes leaves have
  - secondary compounds
    - they taste bitter
    - they mostly slow down processes like microbial activity in decomposition
  - stomata are important
    - for photosynthesis
      - take CO_2 from air and release H_2O and O_2 into the air
    - for water regulation

During the field trips we have learned several specific features

- in the mountains are mostly small layer of soil on the top of the bedrock
- C:N:P relationship is different in organic material (plants) and microbes which leads to different stoichiometry in turnover of these elements
- In terrestrial ecosystems, O_2 is essential for oxidative energy gain (the e^- acceptor is O_2) → respiration → speeds up the circle of life (turn-over of carbon and chemical energy)

Wetlands (ecosystems with aerobic/anaerobic interface)

- wetlands are interfaces between oxic and anoxic conditions
- plants are enlarging this interactions through oxygen transport into anoxic sediments
  - plant can be in the water and on the side, release O_2 into the sediment and are providing OM to the system
- O_2 transport within the plants
- plants and animals in the water leads to organic matter accumulation because of lack of oxygen for decomposition
- slower decomposition in absence of oxygen (findings of hundreds of years old corpses or wood pieces)

Evolution history of the World

First there were only anoxic conditions, then cyanobacteria started to produce O_2 which finally led to free oxygen in the atmosphere → oxic conditions

Human impacts on ecosystems

- pollution
- agriculture
- nitrogen input to the soil
- fertilization
- importance of ecosystem services

Lecture „ERASMUS Mobility & Outlook“ by Lena John

At first, we heard about the experiences of David, Aivi and Johanna, who already took part in an ERASMUS exchange programme.

- David: ERASMUS exchange to Armenia. Good coordinators from ERASMUS, who helped. Nice experience.
- Aivi: Exchange to Prague and Slovenia; friends all over; learned much about different countries.
- Johanna: ERASMUS exchange to Finland; many courses can be assigned, also if they are not offered at the home university

Then Lena told about the advantages and the possibilities of ERASMUS:

- Advantage if you apply for a job, when you were at a ERASMUS exchange
- Student Mobility for Studies: visits of 3-12 months, regular courses are visited
- Student Mobility for Placements: traineeships for 2-12 months during or after study, practical part of a Bachelor/Master thesis can be accomplished
- Information: at International offices or on the EduSaPMan homepage

After the lecture, there was the opportunity to ask questions or just to inform ourselves at some teachers of each of the four universities, which took part at the Summer School 2016. Therefore, they had built up some information shields in front of the lecture room.

Feedback session by Dr. Ilja Reiter

In the feedback session the students got the chance to give a statement about the Summer School 2016, what they liked and things that could be improved for the next time. In the following, there is a collection of the main conclusions.

What people liked:

- the topics: wetlands, climate change, Šumava Bohemian Forest
- the expert knowledge of each university
- mixture of general and specialized topics
- the practical work so you got in touch with other students easier
- the excursions
    - local ecological issues
    - good logistics
    - the chance to explore by yourself
    - short and precise explanations

What could be improved in the future:

- better communication between the supervisors concerning the practical work
- having a first aid box on the excursions and general better organization (which clothing/ shoes are needed)
- having the topic ‘how to interact with non-scientists’
- being able to spend more time with local students (maybe same housing)
- the icebreaking party should be not on the same day like the arrival

Impacts of the Summer School on our future:

- got more confident in having lectures in English
- helped to choose (or not) a topic
- being more confident in speaking English
- We got in touch with the network (specialists, universities…)

Why should one go to…

Every nation did a short presentation about their university and country. The French students made a quiz duel with 20 questions about typical food, drinks, sights in Marseille or the landscape around Marseille. The German students showed a short video and did little acting scenes about sights and typical facts about Ulm and Ulm University. The Estonians did a presentation about Tartu and their university and talked about their land characteristics. The Czechs presented their university and faculties and thanked their research groups for their support.