Summer School

1st – 14th September, 2014

Marseille, France

Index

Work programme

date	Morning (06:00–12:00)	Lunch (12:00–14:00)	Afternoon (14:00–18:00)	Evening (18:00–00:00)
Mo 01-Sep			Arrival at the OHP "Observatoire de Haute-Provence". Accommodation on site	
Di 02-Sep	Introduction & organisation (PvW, IR); Mediterranean forests (TG); Experimental climate change (IR)	lunch OHP	OHP installations (IR); Excursion to the O3HP field site, ICOS tower, geophysical station SGM (FR)	Shopping for breakfast & supper
Mi 03-Sep	Soil water relations (MK); Mediterranean soils (TG)	lunch OHP	Practicals: Ecophysiology, Zoology	Seminars 1
Do 04-Sep	Soil degardation and compaction (ER); Secondary metabolism of plants (CF)	lunch OHP	Practicals: Ecophysiology, Zoology	Data evaluation of practicals, and conclusions
Fr 05-Sep	Wetland ecology (TP); Wetlands and carbon fluxes (ZU); Constructed wetlands (TP)	lunch OHP	Soil compaction and erosion (ER); Shopping for Picnic for students Technical meeting I for teachers	Seminars 2
Sa 06-Sep	Departure to Port Cros; Arrival in the Marine National Park "Port Cros"; Accomodation Fort de l'Eminence; Mediterranean vegetation (HM)	lunch Fort de l'Eminence	Botanical Excursion around the island	Apero & dinner F.Emin
So 07-Sep	Technical meeting II for teachers	Free day, proposed activity hiking, activity at your own risk snorkeling "marine educational path" & bathing		Transfer to Marseille
Mo 08-Sep	Soil zoology (TG / MW); Soil animals - practical exercises (VB / MW); Seminars 3	lunch CROUS	Practicals: Soil zoology; Shopping for Picnic	
Di 09-Sep	Protection & sustainable use of soils (AA); Soil degradation, ... (MK / MW)	Picnic (bring along)	Interactions in plant-soil system (AA); Feedback session; Root structure & soil exploitation (MK); Seminars 4	
Mi 10-Sep	Transfer to Montpellier; Half-day excursion to Montpellier - Eccotron	Picnic (bring along)	Half-day excursion to Montpellier - Puechabon	Transfer to Marseille
Do 11-Sep	Drought mediated constraints on plant function 1 (TT); Soil microbiology (TP); Wetland restoration (ZU)	lunch CROUS	Excursion to St Mitre	
Fr 12-Sep	Leaf litter decomposition (VB); Drought mediated constraints on plant function 2 (TT)	Picnic (bring along)	Seminars 5; Presentation results of practicals	Farewell party
Sa 13-Sep	Synthesis & Outlook 2015 (MK, PvW); ERASMUS Mobility (PvW); Research career in France (IR); Why should one go to ...	---	MuCEM museum visit	

Day 2 - Tuesday 2nd September, 2014

Hardo Becker, Kerttu Tammik

Lecture "Mediterranean Forest" (Prof. Dr. Thierry Gauquelin)

Mediterranean forests are subjected to the Mediterranean climate.

What is Mediterranean climate?
Mediterranean climate is marked by a strong deficit of precipitation during the warm period, which causes stress for the vegetation.

We learned that Mediterranean region is the major hotspot for plant biodiversity:

- 25000 plants
- 50 % endemic plants
- Main tree species in the French Mediterranean area: *Quercus ilex*, *Quercus suber* (cork oak), *Quercus pubescens* (Downy oak), *Pinus halepensis* (Aleppo pine)
- 250 tree species for the Mediterranean basin

Current and past of the Mediterranean region:

- Human impact since 8000 years
- Deforestation during the middle age
- Footprint of man on ecosystem is constant

Threats of today to the Mediterranean region:

- Fire
- Tourism, urbanisation, pollution
- Reforestation with exotic trees
- Fragmentation

Lecture "Experimental Climate Change" (Dr. Ilja Reiter) and the excursion to the OHP site

After the introduction to Mediterranean climate and forests we had a lecture about experimental climate change and the experimental installations on the OHP field site. After the lecture there was an excursion to installations on the OHP site, to visit experimental stations and to get an impression of the Mediterranean forest ecosystem.

Fig. 1. At the start of the excursion at the OHP experimental site we first got familiar with the Mediterranean climate and the oak forest ecosystem at the OHP site.

We learned that climate change is only a small part of the global change. Global change refers to the whole planetary-scale changes, which consist the changes in the cycles like nitrogen, carbon, water, atmospheric etc., but also to pollution, food stocks change, resource use with many other changing factors. Climate change is one part of the global change and it refers to a change in the statistical distribution of weather patterns when that change lasts for an extended period of time. Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions.

Various experiments are set up to predict what kind of the results the climate change has on the Mediterranean region. In the context of climate change, the OHP experiment studies the effect of decrease of rainfall on *Quercus pubescens* forest diversity and functioning from soil to the canopy without disturbing the ecosystem.

The prediction for the Mediterranean climate is that there will be a longer drought period (two months instead of one), and about 30% less precipitation. At the OHP site, there is an experimental installation to predict the outcome of above climate change in a Mediterranean forest ecosystem dominated by a deciduous oak. This is more an ecosystem-based experiment, where the results should show how plants react when receiving less water at the drought period, and what are the effects on soil-bound processes like litter decomposition, nutrient cycling and other.

Fig. 2 + 3: The rainfall manipulation experimental device. When it starts raining, the roof can be closed and this will exclude the water for the trees under the roof. There are also several different measurements done under the canopy of the manipulation experiment, like litter fall gathering or litter decomposition experiments.

There is an ICOS (Integrated Carbon Observation System) tower, which is 100 m high and is measuring the carbon fluxes at different heights (10 m, 50 m, 100 m). This is part of a European observation network to continuously analyze greenhouse gases (CO2, CO, CH4). The ICOS program is established for a long-term observations to quantify sinks and sources of greenhouse gases in the context of climate change.

Fig. 4: The ICOS tower at the OHP site.

The geophysical station “Station Gérard Mégie” at the OHP performs long-term (since 1985) tropospheric and lower stratospheric ozone lidar measurements. Continuous monitoring of the ozone vertical profile in the troposphere and stratosphere is a basic tool in present day atmospheric physics. The possible depletion of the ozone layer by catalytic chemical cycles could greatly modify the earth's environment and climate. Ozone is a constituent of the troposphere and also an important constituent of some regions of the stratosphere commonly known as the ozone layer. The troposphere extends from a certain place of the Earth to between 12 and 20 km above the surface of the Earth and consists of many layers. Ozone is more concentrated above the mixing layer, or ground layer. Ground-level ozone, though less concentrated than ozone aloft, is more of a problem because of its health effects. Health effects depend on ozone precursors, which are a group of pollutants, primarily generated during the combustion of fossil fuels. Reaction with daylight ultraviolet (UV) rays and these precursors create ground-level ozone pollution (tropospheric ozone). Ozone is known to have health effects at concentrations common in urban air like irritation and inflammation of the respiratory system. Understanding the interconnections between ozone depletion and climate change is crucial for projections of future ozone abundances. The ozone-depleting substances and many of their substitutes are also greenhouse gases; changes in ozone affect climate; and changes in climate affect ozone. An ozone layer decrease of 10% per decade has been clearly detected above the observatory. These measurements are part of the Network for the Detection of Atmospheric Composition Changes (NDACC). The lidar-laser goes up to 80 km height to analyze the ozone layer and once a week a balloon is released with an GPS, ozone, pressure and temperature sensor, which goes up to around 35 km height, where the balloon bursts. The sensors parachute back to the ground, where one of three vessels are recovered. The station also tries to figure out how, if and why the layers mix, which could provide important information for ecologist investigating climate change.

Fig. 5: Astronomical telescopes at the OHP observatory, in the middle the “193” and to the right the “152”. The numbers refer to the diameter (cm) of the main mirrors. The “193” telescope and high-resolution spectroscopy allowed to detect the first planet outside our solar system (exoplanet) in 1995.

Day 3 - Wednesday 3rd September, 2014

Jane Veski, Kätlin Smoljakova, Taavi Krusenvald

Lecture "Introduction to soil-water relation" (Prof. Dr. Marian Kazda)

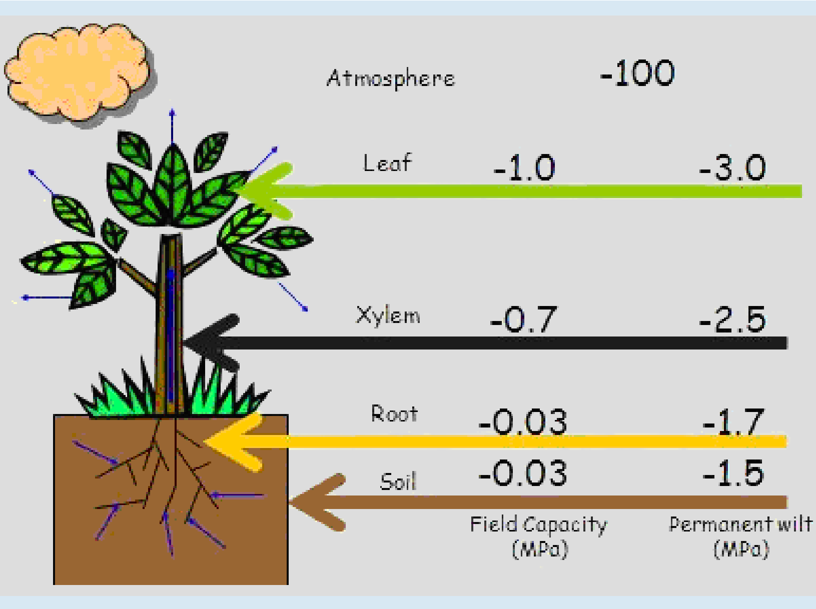


Fig. 1: Water potential

Soils can process and contain considerable amounts of water. They can take in water, and will keep doing so until they are full, or until the rate at which they can transmit water into and through the pores is exceeded. Some of this water will steadily drain through the soil (via gravity) and end up in the ground water, waterways and streams, but much of it will be retained, away from the influence of gravity, for use of plants and other organisms to contribute to land productivity and soil health.

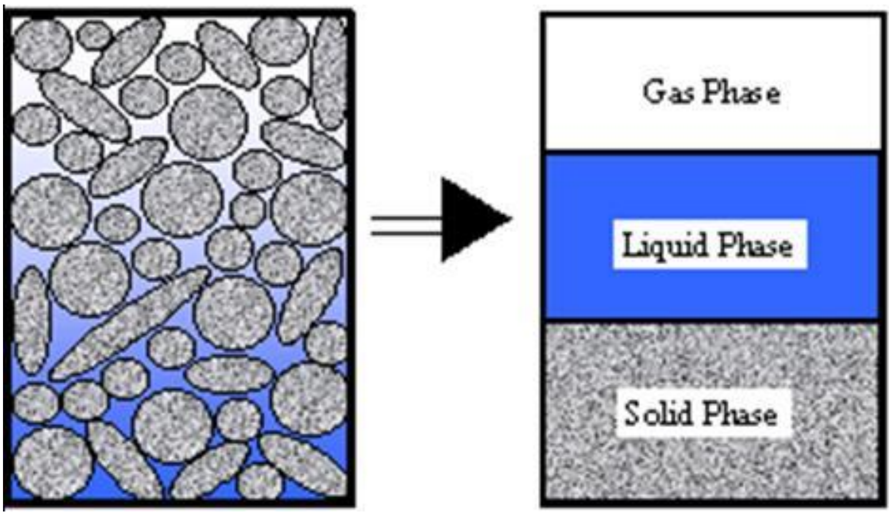


Fig. 2: Soils three phases: solid phase (humus, living part, rocks); liquid phase (water and dissolved compounds); gaseous phase

<u>Soil water retention:</u>
Saturated soil (100g; 40 ml water)
Field capacity (100g; 20 ml water + air)
Wilting coefficient (100g; 10 ml water + air)

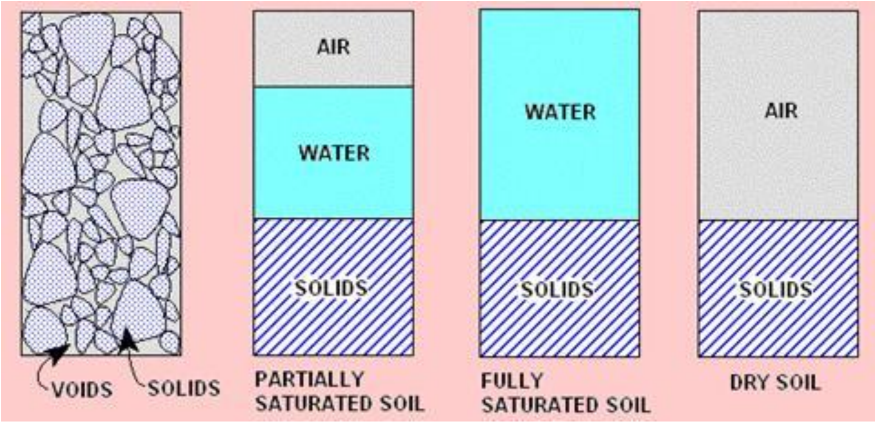


Fig. 3: In a saturated soil compared to a dry soil, the three-phase system thus reduces to two phases only

Pores provide for the passage or retention of gases and moisture within the soil profile. The soil's ability to retain water is strongly related to particle size; water molecules hold more tightly to the fine particles of a clay soil than to coarser particles of a sandy soil, so clays generally retain more water. Conversely, sands provide easier passage or transmission of water through the profile. Clay type, organic content, and soil structure also influence soil water retention.

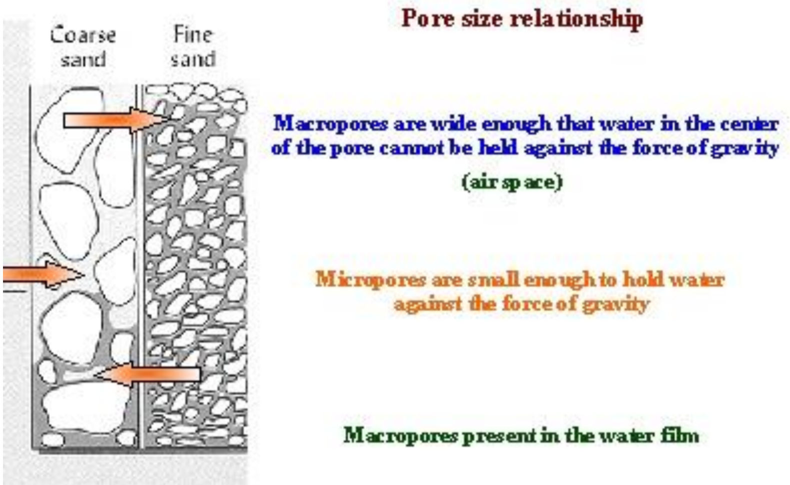


Fig. 4: Pore size relationship

The maximum amount of water that a given soil can retain is called field capacity, whereas a soil that is so dry that plants cannot liberate the remaining moisture from the soil particles is said to be at wilting point. Available water is that which the plants can utilize from the soil within the range of field capacity and wilting point.
The role of soil water retention is profound; its effects are far reaching and relationships are invariably complex. This section focuses on a few key roles and recognizes that it is beyond the scope of this discussion to encompass all roles that can be found in the literature.

Soil water retention and organisms:
Soil water retention is essential to life. It provides water to plants between periods of infiltration, so as to allow their continued growth and survival.

Soil water retention and climate:
Soil moisture has an effect on the thermal properties of a soil profile, including conductance for heat (and also gases), and heat capacity, as well as on evaporative cooling on the surface. The association of soil moisture and soil thermal properties has a significant effect on temperature-related biological triggers, including seed germination, flowering, and faunal activity.

Soil water retention, water balance, and other influences:

The role of soil in retaining water is significant in terms of the hydrological cycle; including the relative ability of soil to hold moisture and changes in soil moisture over time.

Soil water that is not retained or used by plants may continue downward through the profile and contribute to the water table (the permanently saturated zone at the base of the profile). Soil that is at field capacity may prevent infiltration thereby increasing overland flow. Both effects are associated with ground and surface water supplies, erosion, and salinity.

Soil water can affect the structural integrity or coherence of a soil; saturated soils can become unstable and result in structural failure and mass movement. Soil water, its changes over time and management are of interest to geo-technicians and soil conservationists with an interest in maintaining soil stability.

Transpiration in water-limited ecosystem:

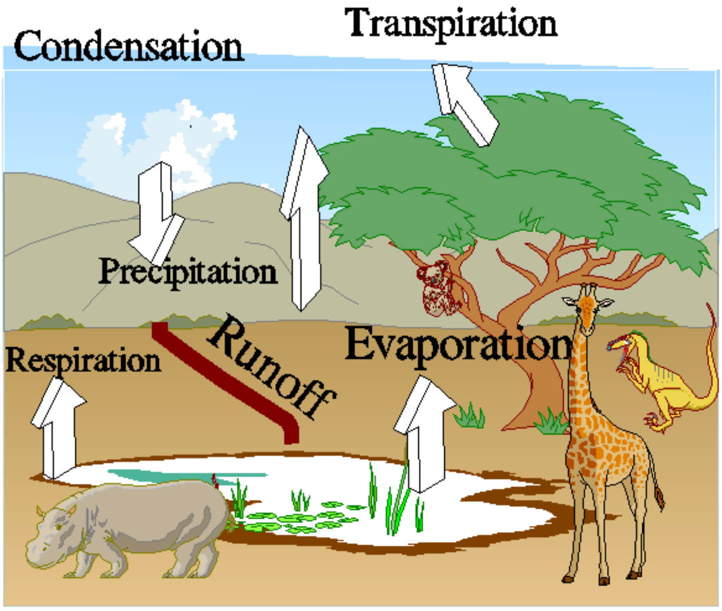


Fig. 5: Transpiration in water-limited ecosystems

Lecture "Mediterranean soils" (Prof. Dr. Thierry Gauquelin)

Fig. 6: Occurance of Mediterranean soils

Mediterranean soils form, by definition, under Mediterranean climate conditions. The main characteristic of the Mediterranean climate is that it has two well defined seasons in the year, with the rain period coinciding with low temperatures during winter, while summers are hot and often very dry. Mediterranean soils have little organic matter and are often formed on limestone.

Fig. 7: Mediterranean soil – *Terra Rossa*

Soil forming factors:

1. Natural vegetation: The natural vegetation in the areas bordering the Mediterranean Sea consists of holm oak (*Quercus ilex*), cork oak (*Q. suber*), downy oak (*Quercus pubescens*), wild olive (*Olea europeae*), carob (*Ceratonia siliqua),* lentisk (*Pistacea lentiscus*), stone pine (*Pinus pinea*) and Aleppo pine (*P. halepensis*). Degradation of the original forest often results in the establishment of a thorny xerophytic vegetation, called 'garrigue' or 'maquis' according to the density of the vegetation and the nature of the bedrock.
   The present day natural garrigue or maquis vegetation consists of a spiny and thorny vegetation with stunted evergreen oaks, and a profusion of aromatic species of lavender, myrtle, oleander and other spiny and sclerophytic shrubs able to persist heavy grazing impact on summer-dry soils and the high evapotranspiration demands in summer. Remnants of true forests are concentrated in the more rainy parts of the region, and are then often composed of trees with a deep rooting system.
2. Climate: Soil formation and weathering in Mediterranean soils is most active during the rainy winter when also evapotranspiration is minimal. The conditions are then optimal for an effective dissolution and leaching of calcium carbonate and other easily soluble elements, as well as for the migration of clay. During the hot, dry summer the soil desiccates, causing the development of red dehydrated oxidized iron compounds within the profile.
3. Bedrock: Parent material influences the formation of Mediterranean soils through its mineralogical composition, chemistry, coherence, and permeability for water. Mineralogy influences the amount, particle size distribution and type of weathering products wherein the soil profile develops; coherence or hardness determines the resistance to weathering and speed of disintegration; permeability influences the intensity of physicochemical transformations within the original rock residue.
   The variety of parent rocks in Mediterranean areas is quite large, though calcareous rocks seem to be the most extensive parent material. Around the Mediterranean Sea calcareous sedimentary rocks (limestone, dolomite, marl) with different behaviors in terms of mineralogical composition, hardness and permeability dominate. Though they have a relatively high soluble $CaCO_3$ fraction, the soils developed on them may well differ due to differences in coherence, permeability and resistance to weathering of the substratum.

The mineralogical composition of the parent material determines also the texture of the weathering product. Basic igneous rocks like basalt will decompose into fine material. They form into red clayey soils on well-drained slopes (because they contain a lot of iron bearing minerals). For carbonaceous rocks the particle size distribution of the weathering material will mainly depend on the nature and composition of the acid insoluble residue, though in most cases it will hold a clayey texture.

As a result of the intensive physico-chemical evolution of the profile the red soil material differs completely from the original parent rock. Besides a total decalcification, associated with a decrease of the soil pH near to neutrality and a tendency towards a slight desaturation of the base complex, one can observe an important enrichment of iron compounds (10% and more) and an obvious clay illuviation reflected in the presence of clay skins on the structural elements. Under oxidizing conditions, when the soils are above the water table, iron oxide (Fe_2O_2) forms in the clay. This gives it a characteristic red to orange color.

4. Biological activity and man: The areas around the Mediterranean Sea have been densely populated and intensively exploited for long periods in history, and therefore human influence on soils and soil properties is immense. The most critical actions in this respect involve crop production, deforestation, grazing and related practices.

   Massive deforestation in almost all the areas around the Mediterranean Sea is reported in almost all archives. Greece and Lebanon were major providers of timber for ship building and fuel wood in the eastern Mediterranean. Deforestation and wildfires, linked to traditional grazing practices, or modern land speculation are everyday-problems in Italy, France, Spain and Portugal.
5. Time: Physical and chemical weathering processes are often slow and it takes time before their effects become visible. Time as a soil forming factor is, therefore, closely related to the combined effect of climate, parent material and human activity. The longer the time chemical weathering, leaching and clay migration can operate in a soil, and the less the soil is affected by erosion or by man, the more advanced will be its development.
6. Topography: In contrast to climate and parent material which exercise an active role on soil formation, topography is a passive element which refrains or orients profile development within the context determined by the former factors. Moreover, the exposure of slope with respect to rainfall and sunshine interception leads to different pedoclimates and weathering conditions on sun-exposed slopes (where evaporation is more intense and less soil moisture is available for weathering and leaching) as compared to slopes facing away from the sun.

   In a steeply dissected landscape part of the rainfall runs along the slopes and creates erosion. Surface layers are removed, the deeper unaltered layers are brought nearer to the surface, and the profile is "rejuvenated". But the soil remains shallow and skeletal.

Practical work: Ecophysiology, Zoology

After lunch, we had a little excursion around the OHP. We had a walk around the observatory while the lecturers introduced the flora and soil. We also learned how to make some experiments with soil and measured the pH of OHP soil, which is very acidic (Fig. 8). Figure 9 shows horizons of organic layer.

Fig. 8: Measuring soil pH

Fig. 9: Soil of OHP

The majority of soils of Mediterranean areas belong to 4 main classes of the French CPCS system:

- Class I: which regroups recent, skeletal soils with an A-C profile, developed either on hard consolidated rocks on an erosion surface or in the lower parts of the landscape, or in aeolian accumulation zones. A fifth group characterizes the man-made soils.
- Class II: These characterize relatively young soils with an A-C profile covered by a well-developed humus layer. It includes the same 5 soil groups as described for class I.
- Class V: These are characterized by an A-C or A(B)C profile with no prominent clay illuviation, a high base saturation dominated by Ca^{2+}, and a neutral to slightly alkaline pH. Fragments of unaltered $CaCO_3$ may still be present in the profile. Most Mediterranean soils belong to subclass V-1. Soils of this class V developed under a higher rainfall regime may occasionally be classified in subclass V-2.
- Class IX: This unit groups the red, almost decalcified Terra Rossa soils with high base saturation and neutral to slightly acid pH. Two groups can be recognized: generally poorly leached and often leached.

Next we had an excursion in the research centre of OHP. And finally went to the field, where we were divided into three groups. Every group had a different experiment to make.

- Stomatal conductance
- Measurements of LAI (leaf area index)
- Water potential

One of the devices we were going to use during the fieldwork was porometer, which measures leaf conductivity.

Fig. 10: Delta T dynamic diffusion porometer

How does the porometer work?

The instrument is calibrated using a calibration plate with precisely made holes of known dimensions from which the resistance has been directly calculated by finite element analysis.

The transit time is found to depend slightly on the RH history within the cup. For this reason it is necessary to repeat the reading using a consistent cycle of humidification and desiccation until the conditions in the cup have stabilized. This usually takes about 3 or 4 cycles.

The small cup containing a relative humidity sensor is clamped to a leaf. Water vapor emitted by the leaf causes the relative humidity (RH) within the cup to rise. The instrument time how long it takes the RH to rise by small increment, of 2.3 % RH.

The cycle is produced by a pump which blows dry air into the cup after each timing measurement. It takes the RH down about 5 % RH below the set level. To minimize errors the instrument is cycled around ambient RH.

Seminars

"Recovery of forest soil from compaction in skid tracks planted with black alder (*Alnus glutinosa* (L.) Gaertn.)" (Hardo Becker)

The presentation was about a study to see if black alder would be able to grow roots through compacted soil layers and accelerated the regeneration of soil structure. The results showed that 4 plots of the experimental site were very similar in fine earth texture and among replicate samples there was also little variation over depth. The results confirmed that soil texture was very uniform.

"Changes in root system structure, leaf water potential and gas exchange of maize and triticale seedlings affected by soil compaction" (Taavi Krusenvald, Kerttu Tammik)

The study was analysing root system structure, gas exchange and relationship between leaf water potential and stomatal conductance. The results showed that growth of maize and triticale was sensitive to different levels of soil compaction and root dry mass accumulation was more suppressed than the dry mass of aboveground parts.

"Response of different crops to soil compaction - Short-term effects in Swedish field experiments" (Jane Veski, Kätlin Smoljakova)

The study was analysing the sensitivity of different crops to compaction, based on the results from short-term Swedish field experiments. The results showed that there is an optimum value of compactness for effective plant growth and the effects of compactness have generally negative affect to it.

"Application of "Clump technique" for root system studies of *Quercus robur* and *Fraxinus excelsior*" (Franziska Harlacher, Eva Keppner)

The presentation was about a method to describe spatial distribution of root-inhabited soil and describe root-inhabited soil volumes and surfaces of chole-tree rootage or of clump rootage in relationship with other tree parameters. The results showed that thicker trees have bigger rooted volume and the maximum root density is found in deeper soil layers. There was also found a correlation between DBH and the depth of the maximum root-inhabited soil density. However, many other studies have found that the highest root and rooted soil density is in close-surface layers.

Observatory

By visual observations using a telescope of at the OHP we had a chance to see galaxy and Nebula gas clouds ion the evening.

References

- Water potential theory [http://www.decagon.com.br/educacao/water-potential/, 20.04.2015]
- Physical, Chemical, and Biological Properties of MSW [http://faculty.mercer.edu/mccreanor_pt/eve420/Lesson05-Properties/Lesson05-Properties.htm, 20.04.2015]
- Three-phase System [http://nptel.ac.in/courses/105103097/5, 20.04.2015]
- Soil Water [http://www.ctahr.hawaii.edu/mauisoil/a_comp03.aspx, 20.04.2015]
- Environmental Biology - Ecosystems [https://www.marietta.edu/~biol/biomes/ecosystems.htm, 20.04.2015]
- Verheye, W., Rosa, D., Encyclopedia of Life Support Systems, Mediterranean soils, [http://digital.csic.es/bitstream/10261/38282/1/Mediterranean%20soils.pdf, 20.04.2015]

Day 4 - Thursday 4th September, 2014

Šárka Cepáková, Šárka Vlachová, Jiří Heller

Lecture "Soil Compaction" (Prof. Dr. Endla Reintam)

The first lecture started with the worldwide distribution of soil. Therefore we saw, how soil is distributed according to characters. The main focus was on forest, agriculture and built-up areas. We familiarized with soil function (food production, fluxes of chemical elements, water reservoirs, etc.).

Problem of soil loss over the past 50 years – loose fertile soil

- erosion, compaction, flood, landslides…

Soil compaction is caused by heavy agricultural machinery, but also by tourisms, herds. The main impact has agricultural machinery – tillage operations (significant impact has 3 – 4 times passing the soil). The weight of tillage machines has grown through the last 50 years.
Impacts: change in soil moisture, penetration resistance, decrease of soil aeration, water permeability, infiltration, elasticity and e.g. impact on plants – they are smaller and yellowish.

How to recognize soil compaction?
Spatula test
Crusts on soil
Water in wheel tracks

Lecture "Allelopathy" (Prof. Dr. Catherine Fernandez)

Definition of allelopathy:
Any direct or indirect effect by a plant, including micro-organisms, on another through the production of chemical compounds that escape into the environment and subsequently influence the growth and development of neighbouring plants includes both inhibitory and stimulative reciprocal biochemical interactions.

Allelochemicals: the secretions of plants are the chemical substances which can affect the growth, behaviour and population biology of other live beings

Introduction:
Secondary metabolites (SM) are chemical compounds produced by organisms (mainly sessile) that do not play a role in growth, reproduction or development.
In the history, they were firstly considered as waste products from primary metabolisms but later considered as natural products and ecochemicals or allelochemicals. The first studied and observed SM were morphine and compounds useful in medicine.

Production of SM:

- is a reaction on variations in environment (adaptive metabolism)
- serve to improve survival of fitness
- is an indicator of organism capacity to survive
- is essential for survival in the environment

Characteristic of SM:

- Low molecular weight
- High diversity (500 000 in plant kingdom)
- A lot of variation depending on the organs

SM in plant physiology:

- biosynthesis in cell cytosol, plastids, mitochondria
- sequestration in vacuoles for hydrophilic and in specialized structures as trichomes, glandular hair or resine ducts for lipophilic SM

3 major groups of SM:

1. Phenolic compounds:
    - have a functional OH group bound to an aromatic ring
    - classified as simple phenols or polyphenols based on the number of phenol units in the molecule
    - have actericid and desinfectional effects and protects against herbivores
2. Terpenoids:
    - lipophilic compounds
    - 5,10,15,20.....carbon polymerization units
    - some are volatiles (from 5 to 15 carbons), some are not volatiles and other are considered as primary metabolites as carotenoids (polymers of 40 carbon units and used in photoprotection)
3. Alkaloids:
    - basic organic compounds, which are formed from amino acids
    - always have a nitrogen in a heterocyclic skeleton
    - have often defense role and are addictive ones
    - used as medicaments
    - like all chemicals produced by living organisms their production is greatly affected by climatic factors such as: temperature, light, seasonal cycles, water availability, kind of soil, nutrition, stress intensity etc.

But also variations exist in SM production according to:

- physiological parameters (age, season, organs)
- genetic factors (chemotypes)
- geographic locations (link with others)
- biotic interaction (herbivory, pathogens)

There are different existing theories on defence production and resources:

- Resource availability hypothesis
- Carbon/Nutrient Balance Hypothesis: low nutrient soils (low N) lead to slow growth and carbon (phenolic) based defence and fertile (high N) soils lead to rapid growth and nitrogen based (alkaloid, cyanogens) defences. In this theory, generally the more nutrients are available the higher is the SM production
- Growth Differentiation Balance Hypothesis: relies on an assumed negative genetic correlation between defence and growth, and argues that growth is dominant under favourable conditions and differentiation (during which allelochemicals are produced); dominates when conditions are suboptimal for growth

Synthesis of secondary metabolites by plants may be constitutive (produced in all condition) or inducible (produced in response to severe stress).

Some interesting remarks on SM:

- they are responsible for plant-plant interaction
- they can be autotoxic
- they interact with its environment
- allelopathy - only negative effect for some authors
- allelopathy could have inhibitory or stimulative effects
- competition x allelopathy ????
- production of volatile organic compounds (VOC) in enzymatic and oxidative pathways

Practical exercises in the afternoon:

We did some practical exercises in the field (*Downy Oak* forest ecosystem) to investigate a gradient in tree height along a transect. The students were divided into three groups consisting of approximately 7 persons. In the forest, a transect had been defined from the plateau down the slope towards a valley, which was 125 meters long and along this transects we did measurements.

The first group did stomatal conductance measurements on leaves of trees (*Downy oak*) and shrubs with a diffusion porometer (AP4, Delta-T, UK; Fig. 1). The measurements were done in the sun and in the shade with five repetitions. The distances were approximately 12.5 meters along the transect.

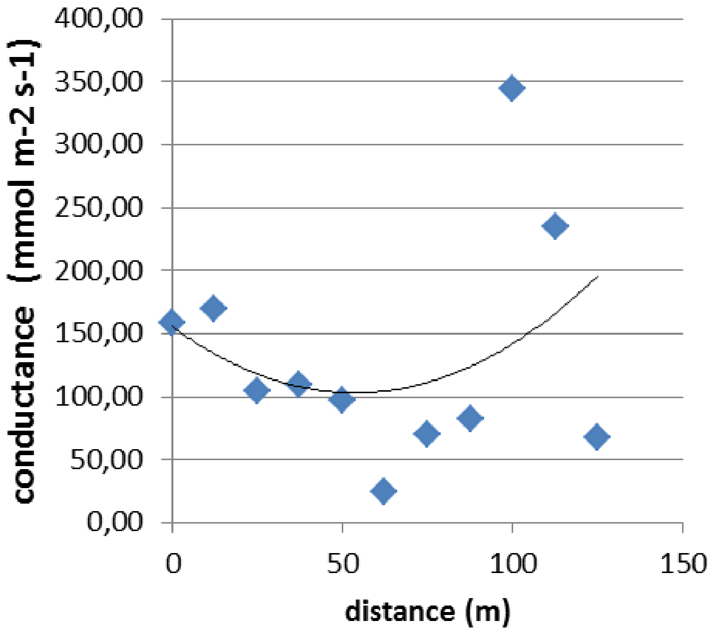


Fig. 1: Stomatal conductance measurements

The second group did leaf area index (above and below the shrub layer), tree height measurements, and observations on the plant occurrence along the transect (Fig. 2).

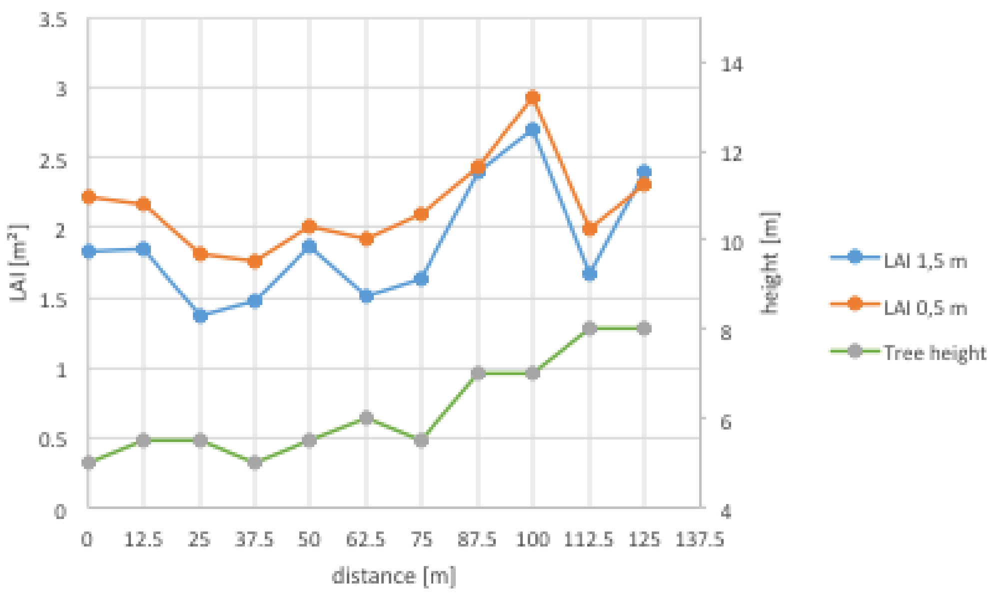


Fig. 2: Tree height and LAI below and above the shrub layer

The third group measured the water potential of the leaves (Fig. 3).

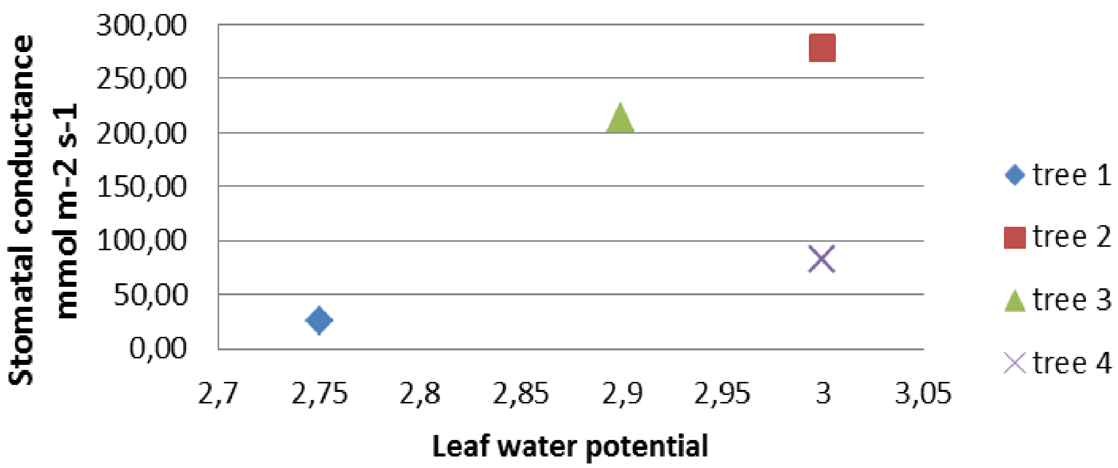


Fig. 3: Correlation between stomatal conductance and leaf water potential

<u>From our results we determined that:</u>

- there is a higher range of conductance in stomatal conductance in leaves exposed to sun
- stomatal conductance was always higher in trees than in the surrounding shrub layer (Fig. 2)
  Interpretation: Shrubs had lower water availability, more drought stress.
  Potential Causes:
  Hypothesis 1: Roots do not access as well the water-containing soil layers as the trees
  Hypothesis 2: The shrubs may have the same water availability, but close their stomata earlier (in terms of leaf water potential, or other) than trees.
- correlation between stomatal conductance and leaf water potential (Fig. 3)
- there are no significant diferences between sun and shade leaves (data not shown)
- there are no significant differences in leaf conductance between upper and lower trees along the transect on the slope (Fig. 1)

Impressions:

stomatal conductance measurements

water potential measurements

photos by Šárka Cepáková

Day 5 - Friday 5th September, 2014

(Jytte Hinrichs, Barbara Voigt)

Lecture "Wetlands" (Dr. Tomas Picek)

The definition of wetlands was made by the Ramsar Convention, 1971 and is: "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" are included in the thermal wetland. First peatlands arose 300 – 360 million years ago. Wetlands are important for several reasons: it is the most productive and biologically diverse ecosystem, they are living filters for water purification, affect global elements cycling (especially carbon), influence atmosphere and hydrosphere, control flood, cause shoreline stability and host many species of plants and animals. Wetlands are used by humans for agriculture (rice, floodplains), fishing, hunting, irrigation, peat mining, wood and biomass production and water purification. Wetlands get their water from the groundwater, precipitation or from surface waters. There are six basic types of wetlands: swamp, marsh, bog, fen, wet meadow and shallow water. Swamps are dominated by trees, rooted in hydric soil but not in peat. Marsh is dominated by herbaceous plants, usually emergent through water, rooted in hydric soil, not in peat. Bog is dominated by Sphagnum moss, sedges (*Carex*), ericaceous shrubs (*Calluna, Vaccinium, Ledum)* or evergreen trees (*Pinus, Picea)* rooted in deep peat. Fen are dominated by sedges and grasses rooted in shallow peat. Wet meadows are dominated by herbaceous plants rooted in occasionally flooded soils. Shallow water are dominated by truly aquatic plants growing in and covered by at least 25 cm of water. The fertility of wetlands depends on pH and on nutrients cycling. Plants, which grow in wetlands, have developed several adaptations. *Sphagnum* for example have a water storage in their hyaline cells, are able to adsorb cations from pore water efficiency, have low nutrients demands, prevent decay by production of organic metabolites and have no danger of herbivory. Other plants have developed special tissues like aerenchym, which allows oxygen transport to the roots. Carnivorous plants catch insects and assimilate phosphorus from their tissues. This strategy allows these plants to survive in environment with extremely low soil phosphorus concentrations (e.g. genus *Drosera* in bogs).

Lecture "Wetlands and carbon fluxes" (Dr. Zuzana Urbanová)

Carbon is the basic element of life forms. Soil have a total carbon amount of 2100 – 2500 pg, which is three time higher than in the atmosphere. One third of total soil C is stored in wetland soils. Like in other biotopes, Carbon follows a certain cycle (Fig. 1).

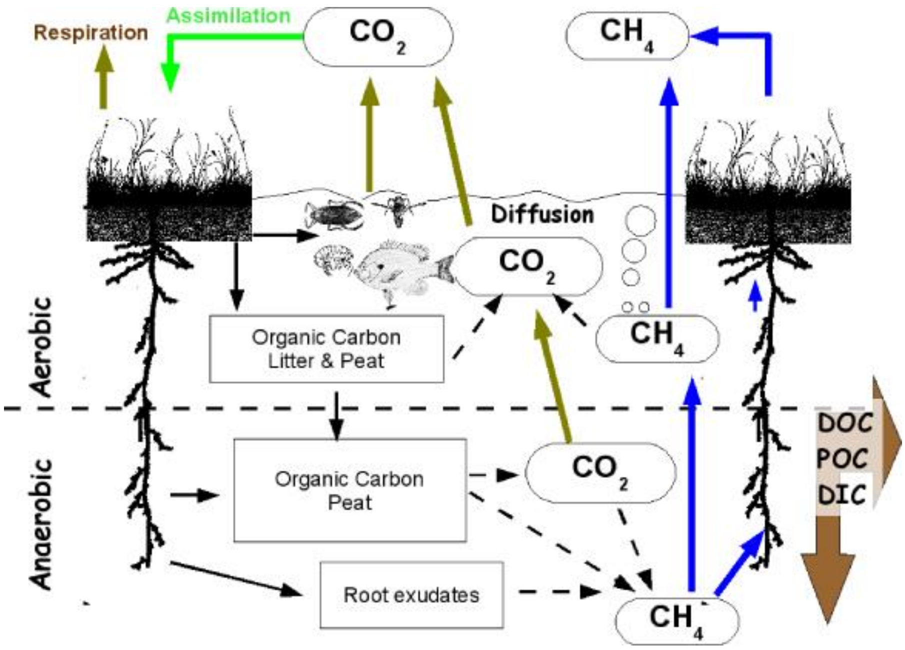


Fig. 1: Carbon cyling in wetlands

Wetlands gains carbon through photosynthesis and looses carbon through autotrophic respiration, heterotrophic respiration and leachnig. Carbon accumulates when income exceeds carbon losses and because of slower decomopsition. The decomposition rate is controlled by hydrological regime, content of oxygen, temperature, quality and quantity of organic material, micobial activity, pH, nutrient content and water quality. Even photosynthesis and respiration are controlled by many factors, which are changing in time, for example by the climate, plant species composition and hydrology. One carbon source is methane and wetlands are one of the largest natural souce of methane to the atmosphere. Methane is porduced by methanogenic archaea and transported to the atmosphere via plants, diffusion and ebullition. Factors, which influence methane production are hydrology, trophic status, plant species composition and temperature. Methane has a 25 times stronger global warming potential then CO_2. So Wetlands have a dual impact on the climate by decreasing the amount of CO_2 and increasing the amount of methane. But climate change has also an impact on wetlands. If the sea level rises, wetlands develop on coastal areas. Higher temperatures cause an incease in photosynthesis, respiration, biomass production, methane emission and changes plant composition. Changes in precipitation influences the hydrology, plant composition and other biogeochemical processes.

Lecture "Constructed wetlands" (Dr. Tomas Picek)

Constructed wetlands are systems constructed by men for (waste)water treatment by using natural processes and is an alternative to conventional wastewater treatment plants. They are used for treating of polluted waters, landfill leachates, mine leachates, farmyard runoffs, highway runoffs, industrial wastewaters and municipal wastewaters. Natural wetlands were already used for wastewater treatment in middle ages. First experiments with constructed wetlands were done in the last century in 50ties in Germany and the first functioning constructed wetland was built in Germany in 1974. Plastic-lined bed were filled with soil and planted with emergent macrophytes. Because of low hydraulic conductivity of soil, the soil was later replaced by gravel. The selection of the substrate is very important because it supports the wetland vegetation, provides sites for biochemical and chemical transformations and provides sites for storage of removed pollutants**.** The treatment of polluted water is a complex process. First suspended particulate matter settles and gets filtrated and precipitated chemically through contact of the water with the substrate, plant roots and litter. A chemical transformation, adsorption and ion exchange on the surfaces of plants, substrate, sediment and litter follow. Pollutants experience a breakdown and transformation by microorganisms. At last there is a predation and natural die-off of pathogens. As we can see, vegetation plays an important role on these processes as it removes part of the nutrients, it is responsible for the ventilation (oxygenation) of the gravel bed, and allows oxygen transportation into the roots and their surroundings, it supports microbial activities by increasing surfaces and by root exudation of easily decomposable organic substances.

Lecture "Soil compaction part 2 and erosion" (Prof. Dr. Endla Reitam)

Other effects of soil compaction are the increase of penetration resistance, reduced root growth, changes in weed coenose, nutrient loss (remains in soil) and reduced infiltration. However, soil compaction can be avoided by reducing of the pressure by increasing the contact area, sub soiling, changes in agricultural practices (using organic fertilizers), control of traffic, crop rotation and planting deep rooting plants.

The second part of the lecture was about erosion. There are different types of erosion like water erosion, snow melt, bank erosion, tillage erosion, floods and landslides, channel erosion and wind erosion. Main causes are inappropriate agricultural practices, deforestation, overgrazing, forest fires, construction activities, tourism and extreme sports. Erosion can be detected when the permanent plant cover is destroyed, at slopes over 3°, when tilled soil colour is lighter on top of the hill and water rills or sheets on soil can be seen. Any soil loss of more than 1 t ha^{-1} yr^{-1} can be considered as irreversible within a time span of 50 – 100 years. Economic losses in agricultural areas in Europe are

estimated at around 53 € / ha and costs of off-site effects on the surrounding civil public infrastructures reach 32 € / ha.
What also can be observed is a decline in soil biodiversity. Soil biodiversity is affected by all of the degradation processes. It is built on a great variety of soil organisms form bacteria to mammals that shape the metabolic capacity of the ecosystem and many other functions of soils. Main reasons of decline in soil biodiversity are soil sealing, soil contamination, salinization and desertification. What we can conclude after watching on all processes and negative effects on soil, is that plants are the best protection of the soil.

Seminars

“Plastic plants and patchy soils” (Rebecca Thom, Sarah Christmann)

Soils consist of solid, liquid and gaseous components and the most important nutrients are nitrates and phosphates, which are distributed in a patchy way. In order to get these nutrients, plants have developed several adaptations. If there are enough nutrients, plants are able to show physiological and morphological plasticity, caused by their modular root system. This phenomenon could be used for foraging to raise their amount of nutrients. They may be also able to take back resources, used for root construction and lower the overall cost for the plant. Plants are also in symbiosis with fungi, called mycorrhizal symbiosis. This association has an impact on both, plant and fungi. Fungi can compete better with other microorganisms and plants have a greater nutrient supply. This is shown by the experiment of A. Hodge, where he used for plants, two inoculated with AMF and two uninoculated, observing their root system (Fig. 2).

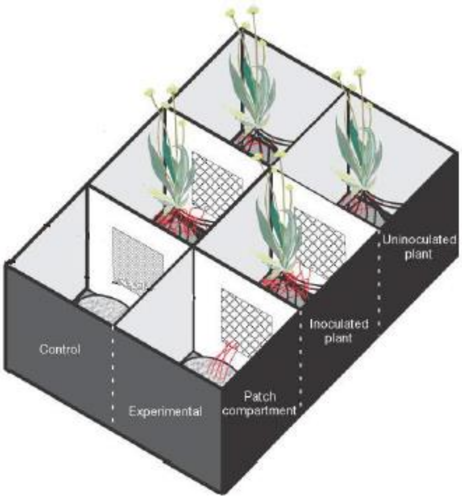


Fig. 2: Experiment with AMF, observing the root system

“Fine root dynamics in 60-year-old stands of Fagus sylvatica and Picea abies growing on haplic luvisol soil “(Toni Melzer and Florian Hipper)

The hypotheses in this paper were, that despite comparable site conditions, temporal patterns of fine root dynamics differ between *P. abies* and *F. sylvatica* and thus show different relationships to seasonal changes in the soil environment. Also it was assumed that *F. sylvatica* is characterized by lower fine root longevity when compared to *P. abies.* Minirhizotrons were used to investigate the rooting patterns of both species. Results showed that soil water content was the highest from January till April and the soil temperature was the highest at the end of August. It could also be seen that the survival probability for the fine roots of *P. abies* is higher than for *F. sylvatica*. In the paper it was concluded that environmental influence is not as big as species-specific influence and efficiency depends on soil environmental factors. Further soil temperature is more important than soil moisture and growth patterns can be counterbalanced by differences in fine root longevity in different species.

As shown *P. abies* does not show any relationship between seasonal changes and fine root mortality. Drought triggered fine root growth overcompensation.

"Advancing the use of minirhizotrons in wetlands" (Lars Seisser)

There is only a limited knowledge of root production in wetlands and the goal is to develop and communicate a methodological framework for the installation and use of minirhizotron technology to examine fine-root dynamics in wetlands. The minirhizotrons used are connected to cameras that are taking pictures of roots under the soil. A similar minirhizotron camera to this one was used in the reported study (Fig. 3).

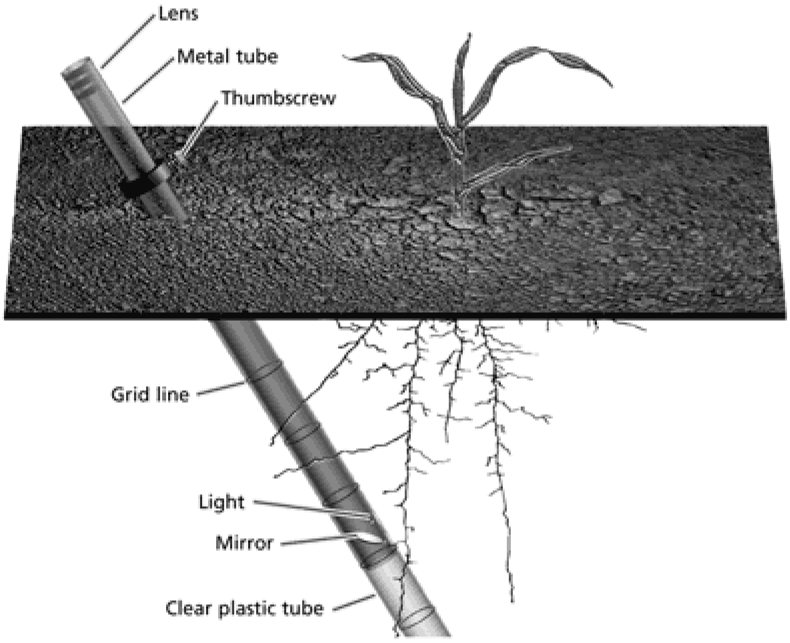


Fig. 3: Measurement with a minirhizotron camera (source: http://5e.plantphys.net/article.php?ch=5&id=44)

The advantage of using minirhizotrons is that it is non-destructive and one is able to track the growth and mortality of individual roots. For the use in wetlands, there are the following disadvantages: there are no long-term data sets from wetlands for comparison, peat levels may shift during the time, frost - heave, water condensation and very variable soil and plant characteristics. Advancing the use of minirhizotrons technology to examine relatively understudied fine-root dynamics in wetlands is important for expanding our knowledge of ecosystems carbon and nutrient cycling in these unique systems.

Day 6 - Saturday 6th September, 2014

(Kathrin Möhrle, Rebecca Höfer, Johanna Kalbantner)

We were starting the day early at 5 o'clock leaving the Observatoire de Haute-Provence taking a bus to Hyère, where we took the ferry boat to the Port Cros. Port Cros is a well-protected marine nature reserve and one of the islands of the Iles d'Or. On our half hour trip we could watch great dolphins on the boat side.

View from our ferry

After arriving at Port Cros, we had half an hour walk to the Fort de l'Eminence. Port Cros relates to the Hyèrisch islands. This islands have a magnificent, lush vegetation. Here you will find plants, flowers and trees of the most exotic and diverse nature. Port Cros is completely under nature protection.
Whilst walking, Dr. Hermann Muhle was already giving us a short introduction to the islands flora. At the Fort de l'Eminence he continued giving an introduction to the Mediterranean flora. He was talking about macroclimate of Mediterranean areas and the plant communities which depend on it. The climate is characterized by a drought period in the mid-summer which means there is more evaporation than precipitation.
Oak species are the dominant trees around the island and have special adaptations to the Mediterranean climate. The cork oak (*Quercus suber*) has a thick layer of cork, which helps it to survive when there are forest fires. *Q. ilex* has leaves which are spiny in young stages, the old leaves have no more prickles. Also have the leaves hairs on the bottom. This tree is more drought tolerant than the other species. *Q. coccifera* has spiny-serrated coriaceous leaves too, but is more shrub-like in appearance.
At about 4 o'clock we started the botanical excursion with Dr. Muhle around the island. He told us about the islands geographical background, some typical animals and more about its typical plants.

A tree-forming plant typical for the island is the tree spurge (*Euphorbia dendroides*), which can be found in the coastal heath areas.

Euphorbia dendroides

(http://www.west-crete.com/flowers/euphorbia_dendroides.htm)

However, there are not only endemic plants growing in huge numbers. Many plants live invasively in the Mediterranean climate, like the canary date tree (*Phoenix canariensis*).

Phoenix canariensis

(http://de.wikipedia.org/wiki/Kanarische_Dattelpalme#/media/File:Phoenix_canariensis_ag.JPG)

The tree heath *(Erica arborea)* is another common species on the mediterranian area.

Erica arborea

(http://www.fotoreiseberichte.de/teneriffa/teneriffa_pflanzen01.htm)

All over the island we found Aleppo pines (*Pinus halepensis),* which are the most common pines in the Mediterranean area.

Aleppo pine

(http://www.trekkingguide.de/pflanzen/pflanzen-mittelmeer.htm)

The Phoenicean juniper *(Juniperus phoenicea),* a tree species indigenous to the Mediterranean area, is a modest plant. Its wood was usually used for construction and energy source in earlier times.

Phoenicean juniper

(http://www.biolib.cz/en/image/id78191/)

The genus Arum (not shown here) has the highest species diversity in the Mediterranean region. Frequently called "arum lilies", they are not closely related to the true lilies *Lilium*

The genus Cistus is native to the western Mediterranean region, so you can find this plants on this island, too.

Cistus ladanifer

(http://www.saatgut-vielfalt.de/samen-saatgut/gross/lack-cistrose-cistus-ladanifer_01_samen_910677.jpg)

Another typical plants for this island are the orchids. In spring there are orchids all around. The orchid which is seen on the picture relates to a very specific group of plants. This plants mimic female pollinators in color, form and smell to attract male pollinators.

The sticky pollinia are fixed on the body of the pollinator.

Ophrys fusca funereal

(http://www.orchidspecies.com/orphotdir/o 1)

Oppositely arranged leaves which are connate at its lamina are typical for this species.

Lonicera caprifolium

Its leaves are churlich, white-grey and pinnated.

Senecio cineraria

It is a component of the schnapps absinth.

Artemisia absinthium

We could see many typical herbaceous plants, like rosemary (*Rosmarinus officinalis)* and lavender *(Lavandula angustifolia*).

http://www.cselandscapearchitect.com/2013/01/28/three-amazing-edible-landscape-plants-for-california-landscapes/

http://www.lavendel.net/lavandula/latifol

At about 6 o'clock, we were sitting together to have a nice "Apero" before going to supper. The Apero is a very traditional get-together in Southern France accompanied by drinks and small snacks to enjoy the last rays of the sun in a friendly atmosphere.

Group picture on top on the fort at sunset

Later, about 11 o'clock, we got the chance to join a night excursion around the fort, led by Gaultier Olphe-Gaillard. It was a zoological excursion, so we examine the fauna of the Mediterranean area. Typical animals on the island were the European leaf-toed gecko (*Euleptes europeae*), scorpions (*Euscorpius flavicaudis*), owls (*Otus scops*), rats, bats (*Plecotus austriacus*) and rabbits. Here are some impressions of the botanical partscorpions (*Euscorpius flavicaudis*), a gecko (*Euleptes europaea*), a trapdoor spider and lots of rats. As of the anthropogenic influences such as a dumping ground near the fort, the rats are reproducing very well.

Trapdoor spiders trap

We also tried to spot bats (*Plecotus austriacus*) and owls (*Otus scops*), with more luck and less wind we'll see some next time.

Day 8 - Monday 8th September, 2014

(Florian Hipper, Toni Melzer, Florian Straub)

Lecture „Soil Zoology“ (Prof. Dr. Manfred Wanner / Prof. Dr. Virginie Baldy)

- Soil definition:
  Soil is the top layer of the earth and consists of rock, minerals and organic matter. Biotic and abiotic compounds of soil forming a habitat for many organisms. The soil also contributes to the regulation of water and nutrients.
- huge amounts of organisms per m^2 (e. g. 109 bacteria, 107 algae, 105 acarians) and also very variable
- organisms live mostly in upper soil layer → organic matter
- animals → some animals have the function of bioindicators. In the case of soil-organisms such animals are very typical for special soil layers or special soil types. These organisms often have special and very important functions in the decomposition-process or other processes like soil loosening.
- soilbiota are accountable for decomposition of organic compounds as leaves or dead animals.
- habitats in the Mediterranean:
  - Highland (over 2000m)
  - Forests (oak forests)
  - Macchia (shrubland)
  - Garrigue (rigid-leaved shrubland)
  - Veld
  - Wetlands
  - Coastal zone
  - Cultivated lands
- habitats for organisms like millipedes, annelids, springtails, gastropods, rotifers, nematodes, fungi and vertebrates
- toxic soil arthropods and insects: scorpions, spiders, centipedes, butterflies (caterpillars)
-

Lecture “Methods of zoological work on soil” (Prof. Dr. Manfred Wanner / Prof. Dr. Virginie Baldy)

- field sampling and laboratory procedures
- measurement of overall biological activity:
  - litterbags
  - bait lamina stripes
  - minicontainers
- field sampling:
  - soil samples
  - pitfall traps
  - “exhauster”
  - chemical extraction
  - eclector traps
- laboratory methods:
  - dynamic extractions
  - flotation of soil samples
  - direct examination by hand
  - microscope
- litterbags with different mash to select organisms within a certain size range.

Practical work

The practical part in the afternoon started with a mixture of lecture and practical work, where we had an overview about the evolution of plants. The following pictures show some of the plants and parts of plants that were mentioned in the lectures about Pterydophytes / aquatic macrophytes and algae/ Bryophytes.
At first we took a look on Pterydophytes and their classification. Pterydophytes can be classified into 5 groups:

- fossil Rhyniophytes
- Psilotophytes
- Lycophytes
- Sphenophytes/ Arthrophytes
- Filicophytes

Fig. 1: Example of Pterydophytes. *Stigmaria pettycurense* (Rhynophytes)


Fig. 2: Examples of true fern Filicophytes (Pterydophytes). *Polipodium* sp. (left) and *Osmunda negalis* (right).

The second part gave an overview of the evolution of algae and Bryophytes.
Algae are no systematic unit and are spread across almost all orders of plants. They can be divided in three different lines:

- Green line
  - Chlorophyceae
  - Rhodophyceae
  - Glaucobiontes
- Brown line
  - Chrysophytes

  - Diatomes
  - Phaeophyceae
- others
  - Dinophytes
  - Haptobiontes
  - Cryptobiontes
  - Chlorarachnobiontes
  - Euglenobiontes

These three lines mainly differ in lifecycles, colour and structure of the algae. There are also big differences between algae of the same line.
Further there is a great morphological diversity of algae. The types of algae are reaching from unicellulars as Euglena or Diatoms over colonies as Pandorina to filamentous and complex forms e.g. Spirogyre or Chara.

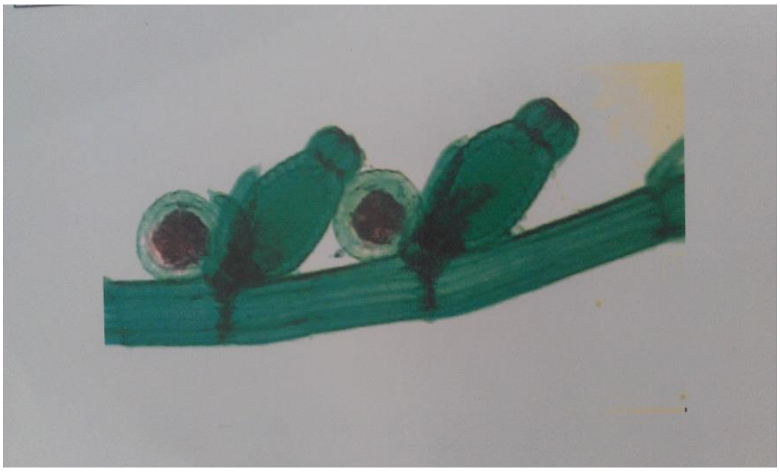


Fig. 3: *Chara* sp. (green algea), oogonia and antheridia.

Bryophytes can be divided in three divisions:
- mosses (Bryophyta)
- hornworts (Anthocerophyta)
- liverworts (Marchantiophyta)

The life cycles are determined by sexual and asexual reproduction. This is related to the type of organism (diploid/haploid).

After finishing the botanical part, we had the job to determine animals from the pitfall traps and also some pinned Insects out of collecting boxes. We determined the order of the different individuals by using an out handed identification key.
The following animals were determined from pitfall traps and are shown on the picture below:
- Diptera
- Hymenoptera
- Chelicerata (Acari, Aranea, Scorpions)
- Hexapoda (Collembola)
- Orthoptera

Fig. 4: Animals from pitfall traps of the OHP (the groups which are presented are mentioned above)

Seminars

“Macroecological patterns in soil communities” (Kathrin Möhrle, Johanna Kalbantner)

The aim of this research was to review factors that influence the distribution of soil biota at different spatial scales.
Different studies show that soil communities seem to be weakly structured by competition, but strongly by the heterogeneous structure of the soil. This is one of the most important facts out of the results of several studies. The studies also show, that at local scale most soil organisms seem not to respond similarly to regulating factors, as seasonal temperature changes and changes in precipitation, like above-ground organisms.

“Causes and consequences of biological diversity in soil” (Florian Straub, Rebecca Höfer)

The two main questions concerning this study have been formulated as follows. How is biodiversity regulated in soil? Is there a relationship between soil organism diversity and ecosystem function?
A conclusion of different studies showed, that there is no general opinion in science. Most evidence shows no relation between soil diversity and ecosystem function and resistance to disturbances is affected by soil properties. Further studies are needed.

“Environmental correlates of darkling beetle population size (Col. Tenebrionidae) on the Cañadas of Teide in Tenerife (Canary Islands)” (Kara Grudzus, Annika Herrmann)

Population size of darkling beetle *Pimelia radula ascendens* were observed by using pitfall traps. The main question was if there is a correlation between seasonal patterns in population sizes of the darkling beetle and climate?
One result is the realization that the beetle has a 2 year cycle. Further results of the study also show a positive relationship between minimum temperature and population size. That means in detail that changes in population size are strongly correlated with the minimum temperature, changes in activity density only shows small correlations with minimum temperature.

Day 9 - Tuesday 9th September, 2014

(Franziska Harlacher, Eva Keppner, Lars Seisser)

Lecture "Protection and sustainable use of soils" (Prof. Dr. Alar Astover)

Prof. Dr. Astover started with the sustainability concept in land and soil use. In this case you have to look at the sustainable development of soil in relation to social acceptance, ecology and economy. An important point is the sustainable agriculture. Agriculture maintains the productivity of the soil.
It is important for protection of the soil that you have to "think global, act local". With this sentence he emphasises the importance of the local conditions.
The second point of his lecture was the soil function. In this context he names the biomass production, transforming, buffering, filtering and storing of water, nutrients and energy, the biodiversity and gene pool and others.
He then speaks about the soil quality all over Europe, which can´t be measured with a single indicator, therefore it is a very complex topic.
The last point of the lecture was the soil information. You have to decide between static and dynamic data. Static data can be used over years and dynamic data must be measured more often. So the survey can be used after years.

Lecture "Soil degradation, disturbance and organismic succession" (Prof. Dr. Marian Kazda)

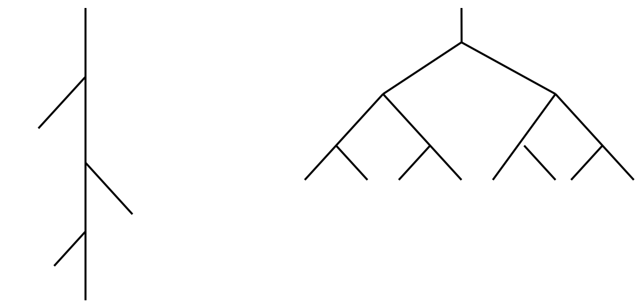
This lecture was supposed to be held by Prof. Dr. Wanner but due to his absence he was replaced by Prof. Dr. Kazda.
Soil degradation comprises of many different factors, not only concerning a loss of production efficiency but also a loss of organic carbon and an interruption of nutrient cycles. There are different factors that can cause the change of the soil environment. He mentioned disturbance and succession as two of these factors. Disturbances, like fires are in contrast to catastrophes phenomena that occur on a regular basis and can create a higher diversity in the ecosystem through the formation of new niches and lower pressure of competition.
Succession is a unidirectional process that describes the replacement of communities or species by another in a predictable manner. Disturbances in an ecosystem can create a mosaic of different successional stages.
Prof. Dr. Kazda then proceeded to the characteristics of Europe's landscapes nowadays.
Fragmentation (e.g. division between forest and agricultural land), sealed cities, intensive agricultural exploitation, intensive forest exploitation, both nutrient-rich and nutrient-poor areas are the main issues of European land use and soil protection.
Conclusively he introduced us two examples from the lecture of Dr. Wanner of disturbances in practice: mining landslides and military training areas.

Lecture "Interactions in plant-soil-system" (Prof. Dr. Alar Astover)

There are so many influences on soil and plants like organisms, climate and humans. Soil is important for water, nutrients and also root development. But the uptake of nutrients and water and also the composition of soil is a complex topic. Plants are the initial source of organic matter and are soil miners. So they take up nutrients with the help of organisms. But there are also other mechanisms of root-uptake. They use diffusion, mass flow and mycorrhizal symbiosis. There are nutrients, which are more mobile than others and is dependent on the pH-value. Finally he spoke about the importance of sustainable soil use, because soil is quite resistant, but hard to build up. The best soil indicator in his eyes is the plant and crop performance itself.

Lecture "Root structure and soil exploitation" (Prof. Dr. Marian Kazda)

Roots are the hidden part of the plant but very important. They provide anchorage, nutrient and water uptake, and the interaction with the biotic and abiotic soil environment (via the rhizosphere). Water uptake is driven by gradients in the water potential. Root distribution in soil depends on various conditions, for example the availability of water: if enough water is present, highest root density is found in the upper soil layers, in dry conditions the majority of roots grow in deeper layers. If the nutrient concentrations are high, the plant develops less roots. Also the distribution of nutrients influences the growth pattern of the roots. If the nutrients are evenly distributed, the roots' growth in the so called Heringbone type is preferential. If the nutrients are patchy, the dichotomous branching exploit such resources better, because this type can create a higher root density.



To find nutrients in the soil, roots follow a gradient of organic matter & aggregates.
In natural soils roots often form clusters. The soil is not evenly perfoliated by plant roots. Pictures of a study about root distribution show the patchy distribution of a bulk of the roots. If more than one plant (e.g. several trees) grow in close proximity, the clusters do not remain separate but combine because all plants try to exploit the patches rich in nutrients.

Seminars

"Collembola populations under sclerophyllous copices in Provence (France)" (Barbara Voigt & Jytte Hinrichs)

In this study they used litter bags on the surface of soil over 7 months and collected leave, decomposed leaves and humus. Within this they compared the conditions under two types of vegetation *Quercus ilex* and *Quercus coccifera.* It showed that the maximum density of collembola under *Quercus coccifera* occurs in June and July and the maximum density of *Quercus ilex* occurs in January and February. The most important factor regarding *Quercus ilex* were drought episodes in summer which led to water stress. The collembola under *Quercus ilex* were highly adapted to this situation. This study also revealed that the lower layers had a higher diversity of animals.

"Nutrition losses, soil properties and groundwater concentrations in a degraded peatland used as an intensive meadow" (Sarka Vlachova, Jiri Heller)

The study showed that most groundwater contains a high concentration of phosphate, but only low nitrogen concentrations. Further, nutrients interact with each other, some in positive ways, some in negative. For intensively used meadow, many nutrients get lost, but this depends strongly on the ground water elevation. The study examined as well the leaching of phosphate and nitrogen.

"Decomposition ´hotspots´ in rewetted peatland: implications for water quality and carbon cycling" (Sarka Cepacova)

Peatlands are sinks of carbon. However, during times of drainage and drought decomposition rates of the organic matter are high. In this study they performed a long term rewetting of an area. In this area they found decomposition hotspots with high concentration of many nutrients like iron, nitrogen, methane and also dissolved organic carbon (DOC). While for short-term rewetting they found the same nutrients. So in conclusion rewetting of drained peatlands produced decomposition hotspots with high carbon leaching.

Evaluation

After finishing the lecture root structure and soil exploitation, the students and teachers were ask to give their opinion about the first half of the Soil and water Summer school. Positively mentioned was that we were able to visit different and interesting study sites and institutions. Also the lectures got a positive feedback.
One the other hand some students criticized the absence of an introductional ice-breaking event in the first evening to get to know each other. In summary, the negative points were more focused on social issues than on the lecture organisation or topics.
It was emphasized by the organizers that this course provides a special opportunity to have so many different teachers from different institutes in one place and this should be well appreciated.

Day 10 - Wednesday 10th September, 2014
(Bastien Romero, Nicolas Pouchard)

Excursion to Ecotron & Puechabon Forest

We went to the Ecotron, localized on the Baillarguet campus (7 km north of Montpellier, France), an experimental research infrastructure dedicated to the study of ecosystems, organisms and biodiversity in the context of environmental changes, affiliate to the INEE/CNRS (Centre National de la Recherche Scientifique - Institute of environment and ecology). The Ecotron is one of the large instrumentations run by the CNRS, having cost 40 M€. A permanent team of 10 persons assures functioning and running of experiments.

Fig. 1: Ecotron. Macrososms

The Ecotron consists of three research platforms at contrasting scales. By confining ecosystems in chambers, it’s possible to simulate a broad range of environmental conditions and to have a good control on biotic and abiotic parameters on ecosystems like temperature, water, CO2, pollutants,...
The high measurement capacities of the Ecotron include on-line measurements of photosynthesis, respiration, the release of methane and nitrious oxide as well as the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotopes ratios of CO_2. The design of the chambers and the equipment allow to follow biogeochemical fluxes of the ecosystems (carbon and nitrogen) in relation to biodiversity.

First we visited the macrocosm, where H_2O and CO_2 gas exchange (evapotranspiration, CO_2 assimilation and respiration) is monitored and where the interaction between ozone and high CO_2 levels is tested experimentally. The material used for building the chamber doesn’t emit any volatile organic compounds (VOC), moreover the light cover doesn’t change the light spectrum including the UV. The plateau measures root development and soil respiration. With isotope technology it’s possible to separate root respiration and respiration of micro-organisms.
Microcosm chamber experiments allow to well control many environmental factors determining plant growth. A new feature are plasma lamps that emit sun-like spectrum of high irradiance. During our visit, they were monitoring C isotopes emitted by roots to compare 2 kinds of air with different atmospheric composition. At the end, we talked about the mesocosm in construction and about their potential applications: it will be possible to realize permafrost condition!

Fig. 2 : Rain-fall exclusion systems of Puechabon. Gutters (left, 30% exclusion) and a dynamic rain-out shelter (right, 100% summer-drought)

In the afternoon, we were in the forest of Puechabon and visited the experimental rainfall exclusion system. Created in 2007, it monitors the response of the forest ecosystem dominated by evergreen tree *Quercus ilex* to water stress. The records of measurement include soil and organ-level gas exchange, tree transpiration, above and belowground biomass, phenology, soil and litter biochemistry, ectomycorrhizial communities, etc.

The first researcher talked about the impacts of autumnal drought on the forest: they observed a decrease of reproductive effort and photosynthesis of oak. Moreover, with spring exclusion, a new pattern in change of C allocation was observed. This phenomena still isn't well understood, what is the process behind it?

The second researcher talked about the response to climatic change in mycorrhizal communities. According to him, the diversity is not affected by the decrease of water, but composition is affected by shift. The question is: How do species aggregate, form patches and live together? Is it competition or the environment who shape the association? We talked about the concept of "niche exclusion": in other words "2 guys living at the same place cannot have the same job!"
To conclude, soil conditions determine fungi diversity but the scale of answer is not the same for a fungi and for a tree!

Day 11 - Thursday 11th September, 2014

(Sarah Christmann, Rebecca Thom)

Lecture “Drought mediated constraints on plant function 1” (Dr. Tiina Tosens)

At 9:00, Dr Tosens from the EMU, Estonia, held a lecture about drought mediated constraints on plant function. The term “stress” is defined as “any external factor that negatively influences plant growth, productivity, reproductive capacity or survival” of an organism. The plant’s ability to structurally adapt to differing environmental conditions is called “phenotypic capacity”.

As our environment is predicted to become dryer due to global warming, recent research is highly interested in plant adaptations to drought. To prevent water loss, plants usually close their stomata so that water can’t get out. With the stomata closed, there is no possibility for CO_2-uptake anymore and so the CO_2 level inside the leaf decreases. So rubisco, the key enzyme of photosynthesis, might start to use oxygen instead of CO_2 which leads to photorespiration and inhibits the plant’s growth.

Rubisco is called the “most inefficient enzyme of earth” due to its high affinity to both CO_2 and oxygen. This inefficiency might be due to the fact that rubisco evolved when the CO_2 concentration of the earth atmosphere was many-fold higher than today. However, plant groups coping with drought, C_4 plants and CAM have evolved methods to increase their water use efficiency.

An aim of recent research is to find ways to artificially increase water use efficiency in plants in order to get “more crop per drop” in a dryer environment. Approaches to improve photosynthesis and yield can’t affect stomata but mesophyll conductance.

In nature, plants have many different short-term and long-term adaptations to cope with drought. Due to the robust structure and the low water content of drought adapted leaves, their leaf mass area (LMA) is increased compared to other leaves. In correlation to that, their photosynthesis rate and their nitrogen use efficiency are reduced. Nitrogen is mainly used for structural tissue in these leaves. The advantages of a higher LMA are the increased water use efficiency and leaf longevity that guarantee a better survival in dry conditions.

In conclusion, plants are phenotypically very plastic and adapt in many ways to stress factors.

Lecture “Soil Microbiology” (Dr. Tomas Picek)

The second lecture of the day was held by Dr. Picek from the University of South Bohemia, Czech Republic, about soil microbiology. Soil microbes are essential for terrestrial ecosystems since they play an important role in e.g. nitrogen fixation and decomposition of organic matter. Microbes can be found everywhere in the soil. Especially in the areas surrounding roots, a high incidence of bacteria, amoebae and fungi occurs. Mycorrhiza in a plant’s rhizosphere helps to protect the roots whereas other fungi may be pathogenic for plants. Microorganisms are also necessary for decomposition of organic matter and for weathering of minerals.

Soil microbes are very diverse. Most of them are prokaryotes, i.e. archaea and bacteria but there are also eukaryotic organisms like fungi. Also the functional diversity of soil microbes is extremely high. In soil microbes, any metabolic pathway can be found, even mixotrophic organisms that are able to switch from one metabolic pathway to another depending on the availability of resources.

Decomposition of organic matter is an extremely complex process involving many different organisms. Substrate which is produced in one decomposer’s metabolism can again be used by another organism. The composition of soil microbes differs between different soil horizons.

Soil microorganisms are also important for nitrogen transformation. In leguminose roots, symbiotic bacteria help the plants to take up N_2 from the atmosphere as plants are not able to do nitrogen fixation themselves.

Most soil microbes are found in the so-called rhizosphere, the soil surrounding the roots. Also fungi are frequent in the rhizosphere. Many of them are mycorrhizal (symbiotic) fungi. They are important for nutrient transport, particularly that of nitrogen and phosphorus, and also for water transport.

Regarding their many different functions in soils, it is obvious that soil microorganisms are an essential part of soils and that they are absolutely necessary to keep ecosystems running.

Lecture “Wetland restoration” (Dr. Zuzana Urbanova)

The third lecture of the day was given by Dr. Urbanova, who is from the University of South Bohemia. Humans can change ecosystems completely and so the wetlands were influenced and destroyed. Wetlands have important functions like maintain of the water quality, landscape, hydrological change, carbon sink and diversity. The RAMSAR convention has the aim to save the original wetlands and it makes an active approach to restore the destroyed wetlands. These wetlands should be revitalized to their original appearance and to be a self-sustaining system. The first step of the restoration is the re-wetting. The aims and priorities have to be clear before the project is started.

One example given in the lecture is a drained mountain bog. Before the project can be started there have to be site studies, monitoring, the identification of key species (orchids) and a reference site to control if the project was successful. This re-wetting project was successful because the water table level was 20 cm higher afterwards; the pH and the conductivity were higher, too. But there can be risks as well e.g. that the drainage is stronger than the restoration or the time of disturbance; every restoration is a disturbance, but it depends on the kind of wetland and the degree of the disturbance over the time.

The second example is a spruce swamp forest. After re-wetting there was more light and because of that the original wetland vegetation could return. To establish new plant communities it normally takes a few years.

A cut-away peatland is the third example. At first the water table was increased, but the preparation was difficult because of many ditches. Then there was shallow depression so that the heterogeneity was increased. After anti-erosion pressure grass was cut and spread together with mulch in this area. Then some trees were cut and the area was monitored. The result was that after seven years 50 percent of the area was covered with plants. The most abundant species was *Eriophorum vaginatum*.

The last example is the restoration of a stream or river. It is the most complicated demand to get a self-sustaining system again, but it is important so that human don´t have to disturb again in the future. The first task is to restore the original channel and then the natural erosion has to be supported. At last barriers are removed so that the channel capacity is restored.

Excursion to St. Mitre field site

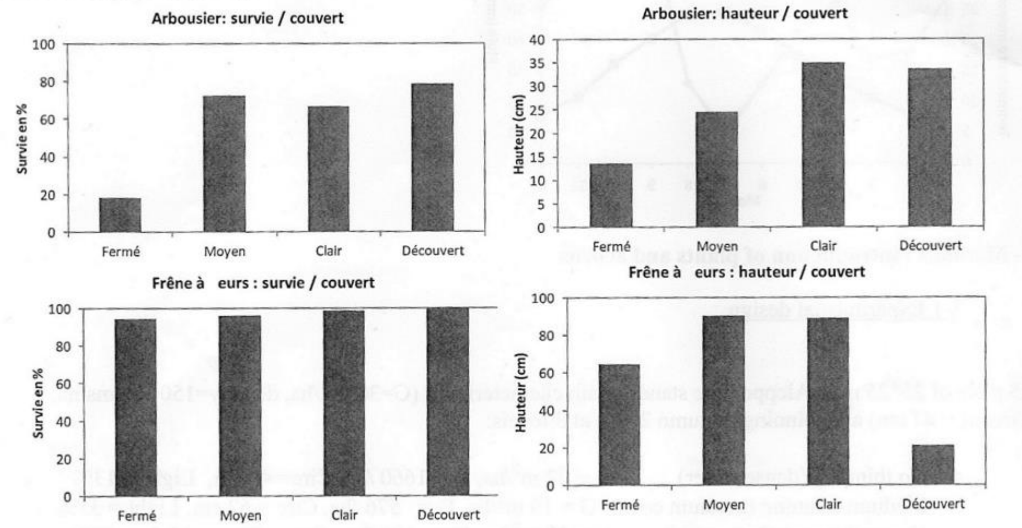
<u>Experiment</u>

The excursion was guided by two scientists of Aix en Provence from the IRSTEA (National Institute for Scientific and Technological Research for the Environment and Agriculture) research center. The aim of the experiment is to improve the diversity within this pine forest. Because of the hot and dry summer there is a drought every year and so a fire can spread easily. Fire control is an important fact in this region. 80 years ago French farmers gave up their croplands and these fields stayed abandoned. The natural succession could happen and today these fields are forests. At first shrubs cover the soil, then pines grow and in the end oaks grow slowly in these forests. Aleppo pine is a pioneer species and their seeds are wind dispersed, which explains the good distribution of these trees. Unfortunately, it is a serotinous species which means it is open fire adapted. Their cones are sealed specially and a single tree can produce more cones if there are fires frequently. Aleppo pines never grow under older Aleppo pines because they inhibit their own seedlings. Only with a disturbance like a fire new seedlings can grow. This material helps a fire to burn hot. To change the fire frequency hardwood species are planted. They do not burn so easily and they can resprout after a fire. This process influences the canopy of other species e.g. shrubs.

The experiment takes place in a protected area with three dry months. There are ten different plots which are treated differently. 90 seedlings were planted in every plot. Every first row is planted with oaks and acorns and every second row with a hardwood like *Sorbus*, *Fraxinus* or pistachio from French seedlings. The most important distinction is the coverage; a stands without thinning where the canopy is dense (for Mediterranean forests), or the seedlings are planted in stands with two different degrees of thinning. The coverage of the soil with shrubs is another important difference between the plots. With 80 percent *Quercus coccifera* is the most common shrub, *Cistus albidus* is frequent as well. Especially in full light shrubs are a shelter for seedlings. Several experiments are made there.

The first experiment shows the difference between *Arbutus* and *Fraxinus*. *Arbutus* grows better in full light which indicates it is light demanding whereas *Fraxinus* survives well everywhere with its growth being best in medium coverage (Fig. 1). This means it is shade-tolerant.

Hardwood species (2013)

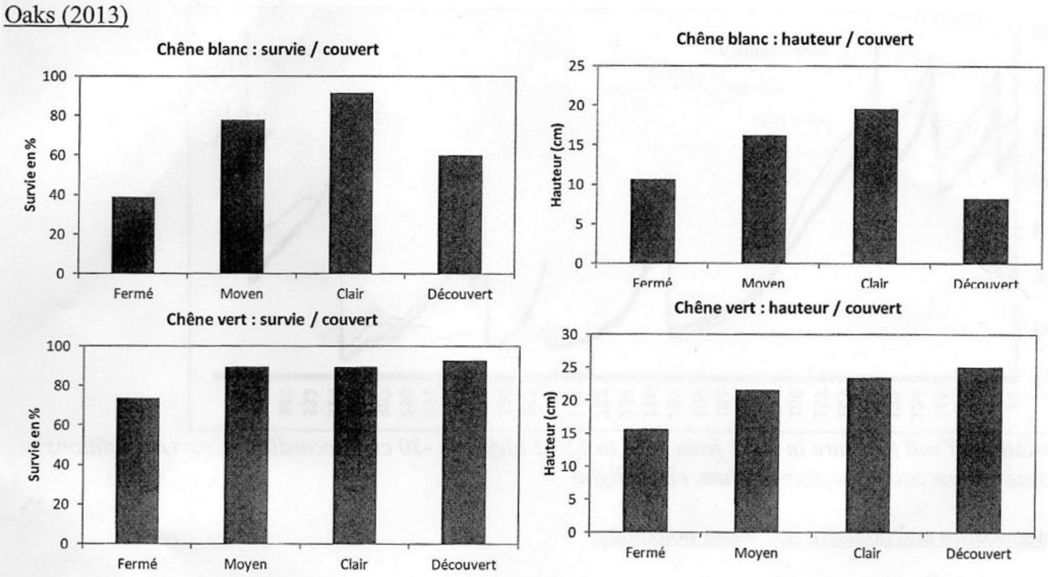


Survival and height of Arbutus (Arbousier, light-demanding) and Fraxinus (Frêne, shade-tolerant) according to cover opening (Fermé=dense cover, Moyen=medium, Clair=opened, Découvert=full light).

Fig. 1: Survival and height of *Arbutus* and *Fraxinus* according to cover opening. *Arbutus* is light demanding and *Fraxinus* is shade-tolerant.

The two oak species grow different, too. The Downy oak cannot survive well in close stands and not in full light; so it grows best in open coverage. The Holm oak is more shade-tolerant which means it survives more in every condition. With more light it can grow faster (Fig. 2).

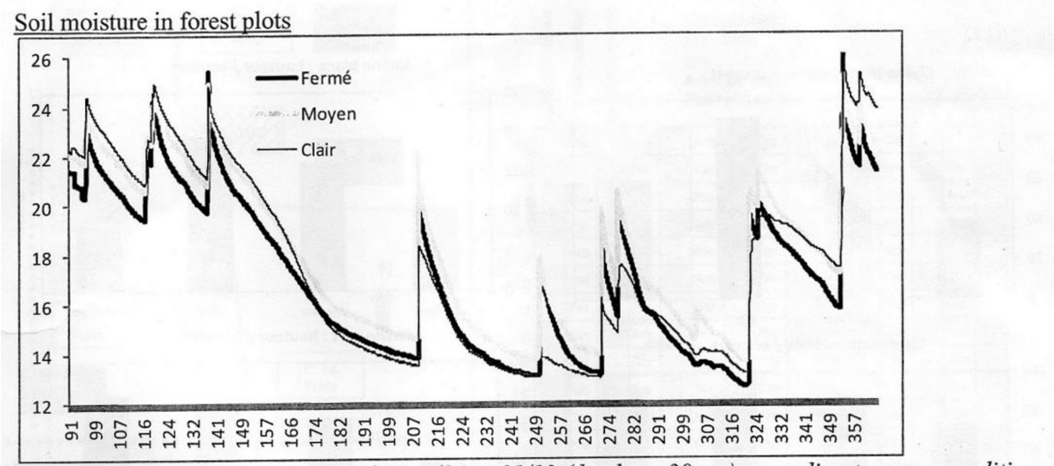
Oaks (2013)



Survival and height of Q. pubescens (Chêne blanc) and Q.ilex (Chêne vert) according to cover conditions (Fermé=dense cover, Moyen=medium, Clair=light, Découvert=full light).

Fig. 2: Survival and height of *Quercus pubescens* and *Q. ilex* according to cover conditions.

The coverage of the soil is one important point for plant growth because in a light covered part the sunlight is distributed in patches. This means that some places are more shady than others and this leads to a shrub layer which is not so divers. The highly treated plots have less moisture in the soil than the other treatments. The peaks in the graph show periods with rain and the low points show droughts (Fig. 3). The most severe consequences are in the medium treated plot because of the evaporation in the sunny patches.



Variation of soil moisture in 2013 from 1/04 to 31/12 (depth = -30 cm) according to cover conditions (fermé=dense cover, moyen=medium, clair=light)

Fig. 3: Variation in soil moisture according to cover conditions.

<u>Methods of basic tree measurement</u>

Three basic measures of trees are commonly assessed: age, height and photosynthetic activity. The age of a tree can be estimated with the help of the diameter or the curve of the stem. The precise age can be estimated with a core boring. On the core, one can count the age rings of the tree. One age ring consists of two parts: a light and a dark ring. The light ring is built in spring because then there is more stem flow and the vessels are bigger. In autumn the dark ring is built. This measurement works well for pines, however oak wood is often too hard for an extraction. In the Mediterranean region the age rings usually are rather thin as compared to temperate regions because of the growth limitations.
The measure is tree height. A receptor is fastened on the tree which you want to measure in 1.30 m above the ground. Then you are standing in some distance of the tree, which is measured optically by the measurement device, with a free view to the whole tree. The transmitter is then directed to the top of the tree. The angle between the surface and the top of the tree is measured. Then the height is calculated after Thales. The measurements are quite precise; their error is around 10 cm
The Chlorophyll Fluorometer is the third tool. The status of the photosynthetic system is measured and can be interpreted in terms of the photosynthetic stress. Principal: The system measures the variable fluorescence of photosystem II. Photons that are assimilated by the light harvesting complex transfer their energy to the chlorophyll. Chlorophyll dissipates this light energy by either driving photosynthesis, by emission of heat or by emission of fluorescence. The amount of energy directed to photosynthesis and fluorescence largely depends on the redox-state of the electron acceptors in the chloroplast membrane. The relationship of maximal fluorescence as a response to a saturating light flash, and the fluorescence emitted at a given light level (ambient or darkness) reveal information about the efficiency of light utilization by photosystem II; this data can be evaluated to quantify plant stress.

<u>Methods of light measurement</u>

Scientists and engineers of IRSTEA showed us devices for light measurement.
First, we are shown a light detector used for measuring the relative light under a canopy. Then a light detector for open field light measurement was shown to us. The third light measurement device, having 80 light sensors in one row, is used for measuring light interception under a canopy. Finally, a camera having 185° field of view was presented (see photograph below). It is used to take hemispherical images to determine canopy structure and leaf area index by a method evaluating the “gap fraction”, i.e. the relation between bright parts (sky) and dark parts (vegetation). It is used only once per year on St. Mitre field site. Then, up to 20 images are taken in the morning or in the afternoon.

Appendix


The scientist explains the experiment and shows the field site.


The field site with the Aleppo pines, shrubs and the planted seedlings.


Core extraction


Tools for light measurement

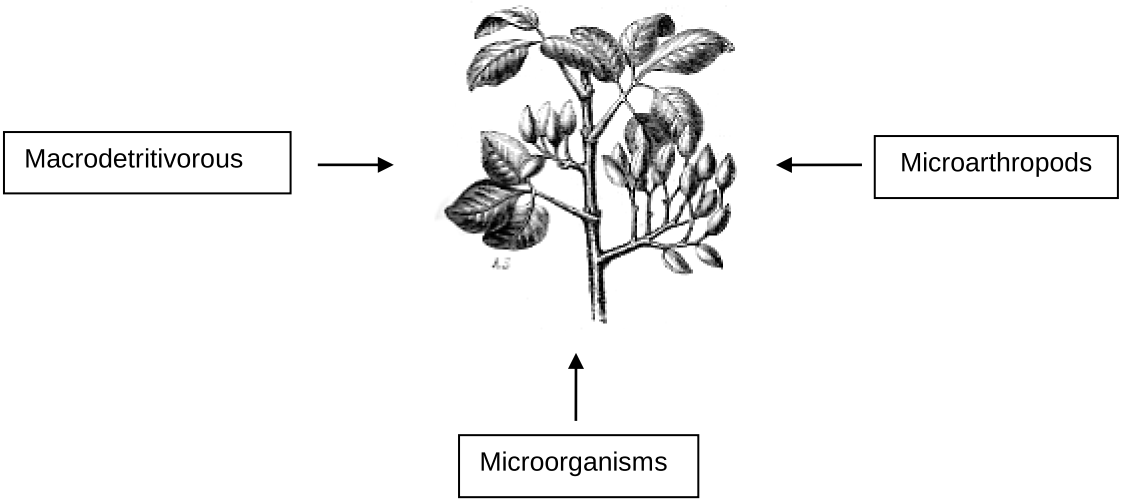

Camera for measurement of density of the canopy, used for “gap fraction”

Day 12 - Friday 12th September, 2014

(Roxane Kermarec, Rania Besbes)

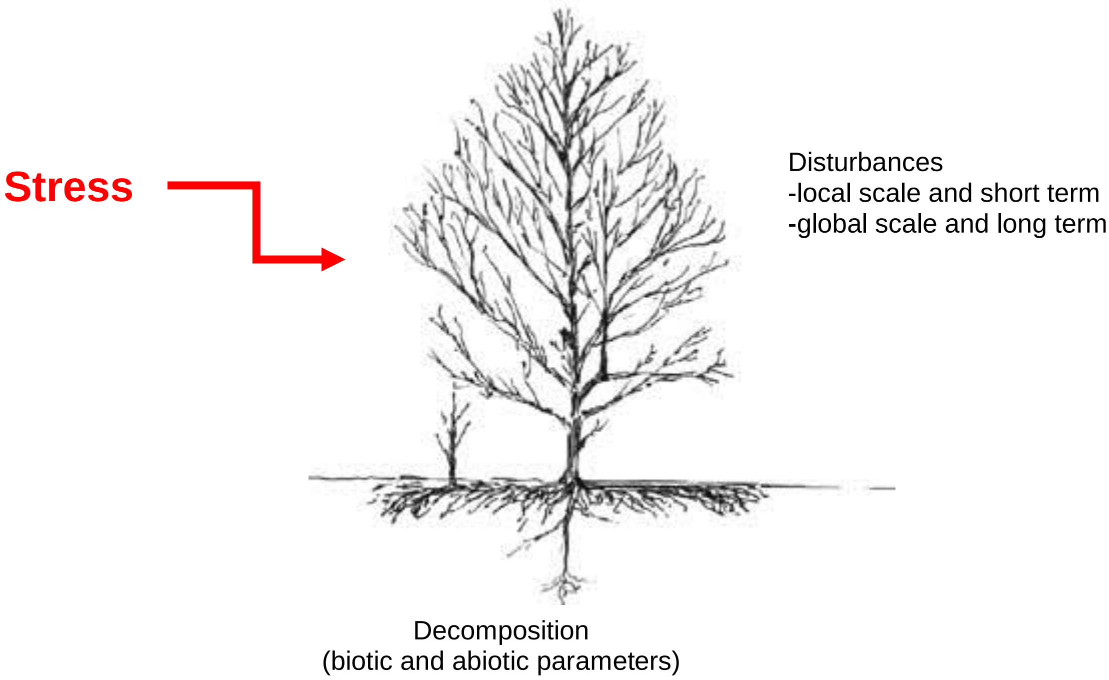
Lecture “Leaf litter decomposition: a key process for ecosystem functioning” (Prof. Dr. Virginie Baldy)

The main messages from the presentation are:
Decomposition → mainly a biological process



Leaf litter decomposition is controlled by two types of factors:

1. Leaf litter chemistry (structure and defense compounds, nutrients)
2. Environmental conditions (humidity, temperature)



<u>STRESS: context</u>

Mediterranean terrestrial ecosystem:

- climate characterized by a hot dry summer
- low annual rainfall
- violent rainy and windy events
- recurrent fires
- soils often shallow: a lot of rocks
- old anthropogenic pressure
-

This conditions leads to resistant plant species:

- morphology: sclerophyllous
- physiology: secondary compounds production (phenolics and terpenoids)
-

To study the dynamic of leaf litter decomposition, firstly leaf litter was placed in litter bags, and put on the ground. After a certain period, litter bags were retrieved and in laboratory, leaf litter mass loss, litter chemical transformations [follow terpenoids and phenolics extractions], functional and specific diversity [BIOLOG ecoplate] and activity of decomposers associated with decomposed leaves were followed.

The results of this study show that:

- The decomposition is long and not continuous. During the summer, there is no decomposition. The decomposition starts when soil water content is sufficient.
- During the summer, there is no ergosterol [fungal biomass] production and no mesofauna
-

→ In temperate forests there are continuous leaf mass loss, continuous increase of decomposers biomass, with microarthropods coming after fungi.

→ In Mediterranean terrestrial ecosystems there are discontinuous dynamisms depending on the drought periods.

Lecture "Drought mediated constraints" (Dr. Tiina Tosens)

Photosynthesis depends of stomata conductors. CO_2 is used in photosynthesis inside chloroplasts.
CO_2 enters leaves through stomata, long way across until chloroplasts. The diffusion of CO_2 is done through mesophyll conductors and should be fast.
CO_2 enters in stomata: [CO_2] ↘
[CO_2] chloroplast < [CO_2] stomata

Photosynthesis limitations:

1. Biochemical (not so variable)
2. Diffuse: stomata conductance (highly variable) and mesophyll conductance

Mesophyll conductance:

- gas exchange
- transpiration
- anatomic
-

Two parameters are limiting the mesophyll conductance:

- Smes: mesophyll photosynthesis cells area
- Tcw: diffusion of CO_2 in mesophyll conductors

Stomata conductance: stomata closure efficiency helps to reduce the water loss from plant. Photosynthesis depends on stomata conductance.

Seminar

"Variations in Allelochemical Composition of Leachates of Different Organs and Maturity Stages of *Pinus halepensis*" (Roxane Kermarec, Rania Besbes)

Plant secondary metabolism produces chemicals that help plants to survive in the environment but is not necessary for plant growth (primary metabolism). Secondary metabolism facilitates the primary metabolism in plants.
Plant secondary metabolites affect Ecosystems processes and Biodiversity. They are a driver of biotic interactions; through their input in the environment via:

- Litter decomposition
- Vaporization
- Root exudates
- Leaching from plant parts to the soil
- Protection against soil-borne pathogens

This is the allelopathy mechanism.
Allelopathy role is to regulate plant diversity, to establish invasive species and dynamics in arid environments.
The article studied the role of *Pinus halepensis* in plant secondary succession. The results show that:

P. halepensis forests:

- accumulate thick needle layers below their canopy
- have the potential to influence biotic interactions in litter and plant dynamics through allelopathic interactions and mechanical effects.

P. halepensis synthesizes a rich phenolic and terpenoid mixture during early stages of colonization → confer a competitive advantage in the competition among plants or pathogens
The effects of leachates are:

- Function in the defense of one plant against another
- negative impact on wild plants
- Influencing directly microbial activity

Presentation of practical work at the O_3HP site

Study of a tree height gradient along a transect on a slope exposed to the east

Students were asked to develop hypothesis on what was driving this gradient: changes in microclimate (light, wind, humidity, temperature), soil water availability, nutrient availability, belowground space availability, erosion and nutrient leaching, soil characteristics, plant age, silvicultural treatment, effect of the understory,… were put forward (not exhaustive).
Three groups had been formed for practical studies: (1) optical measurements of leaf area index (LAI) and tree height, along with observations on the occurrence of plant species (2) measurements of leaf water potential using a pressure bomb, and (3) stomatal conductance measurements by porometry.

Results:
Tree height increased from the top (5 m) to the bottom (8 m) of the slope. There seemed to be a higher LAI (close to 3 $m^2\ m^{-2}$) associated with higher tree height, however, the increase was not steady showing a minimum (1.8 $m^2\ m^{-2}$) in the middle of the transect. The LAI of the understory shrub and tree species was up to 0.5 $m^2\ m^{-2}$, and had a tendency to be lower for the lower part of the slope (Fig. 1).
In the lower part of the slope a maple species (*Acer opalus*) occurs, which is not present on the upper part of the slope and the whole of the plateau. This tree species is expected to be more demanding in terms of water and/or nutrients. Also *Vibornum lantao* and *Sorbus aucuparia* appear in the lower part of the slope (Table 1).

Stomatal conductance of the oaks was generally high between 100 and 300 mmol m^{-2} s^{-1}, whereas the understory around the oak trees showed low conductance of around 50 mmol m^{-2} s^{-1} i.e. stomatal closure due to water limitations. (Fig. 2)
Stomatal conductance was generally higher in sun compared to shade leaves in trees and in the shrubs surrounding the oak trees that were measured. Shrubs had a lower stomatal conductance than the trees, indicating that had less water availability, or stomata more closed for other reasons (Fig. 2).
The difference in stomatal conductance between shade and sun leaves was more marked if the mean stomatal conductance of an individual was higher (Fig. 3).
Along the transect, stomatal conductance varied similarly to the leaf area index, i.e. had a tendency to be higher in the lower part of the slope (Fig. 4).
The leaf water potential during the day was between -2.8 to -3 MPa, which shows a low but not very low water availability. Water potential did not vary much, and was not different between the upper and the lower part of the slope. Also there seemed to be no sensible correlation with stomatal conductance (see Fig. 5, i.e. higher stomatal conductance with more negative leaf water potential).

Conclusions
→ The tree size gradient is somewhat correlated to the leaf area index
→ The stomatal conductance and leaf water potential are likely not to be closely coupled in Downy oak.
→ At the 'same' water potential, stomatal conductance seems higher at the bottom of the slope, which indicates a stomatal behaviour adapted to better water availability, which could explain higher carbon gain and better growth at the lower part of the slope.

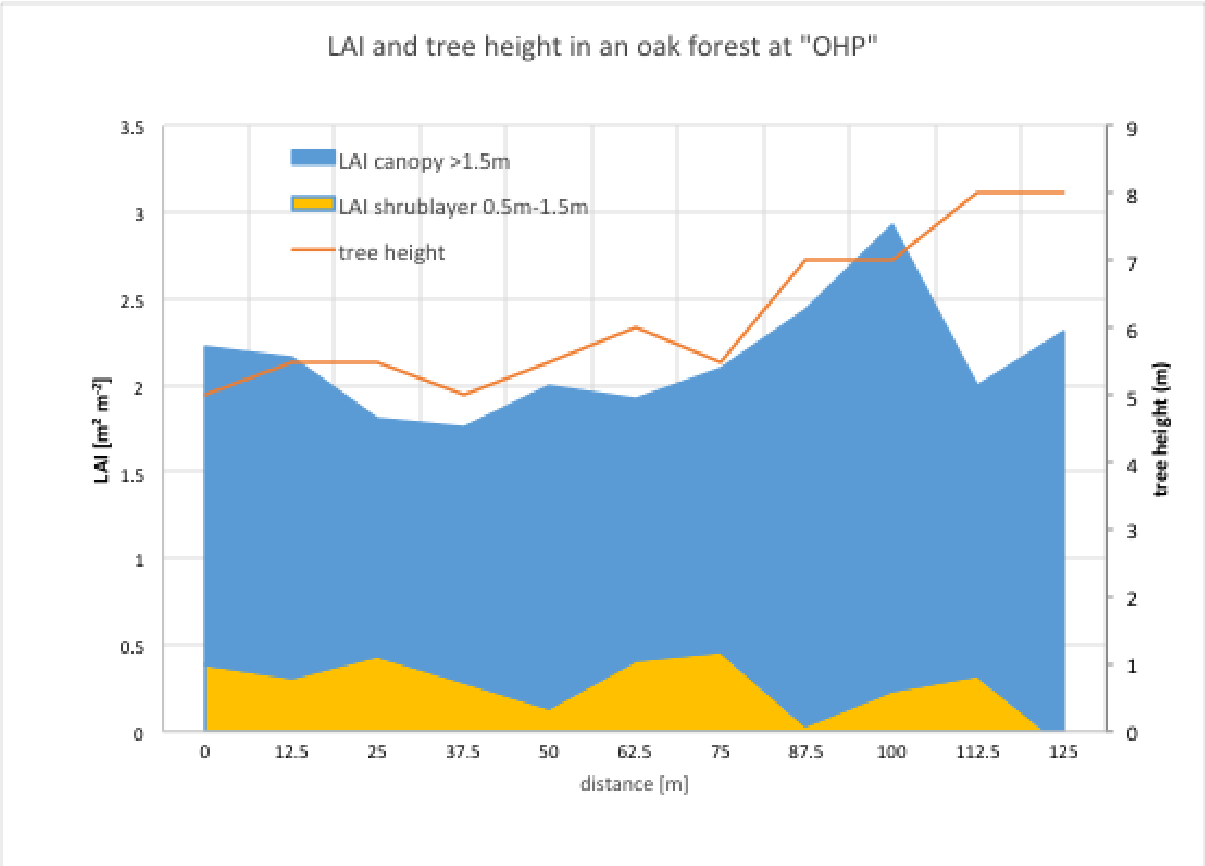


Fig. 1: Leaf area index (LAI) measurements for the shrub and canopy layer, and tree height along the 125 m transect. « O » denotes the top of the slope

Table 1: Occurrence of plant species along the 125 m transect

Plotnumber	1	2	3	4	5	6	7	8	9	10	11
Tree layer (height)	5	5.5	5.5	5	5.5	6	5.5	7	7	8	8
Quercus pubescens	x	x	x	x	x	x	x	x	x	x	x
Acer opalus											x

Shrublayer 0,5-2,5m											
Cotinus cogyggria	x		x	x	x	x	x	x	x		
Acer monspessulanum	x	x		x		x		x			
Anulachier	x	x	x	x			x	x		x	
Sorbus aria	x					x			x	x	x
Prunus spinosa		x									
Cytisus sessiliferus		x	x		x		x		x		
Sorbus terminalis			x		x	x				x	
Prunus mahaleb				x							
Cornus mas					x			x			
Vibornum lantano								x			x
Acer opalus									x		
Sorbus aucuparia											x

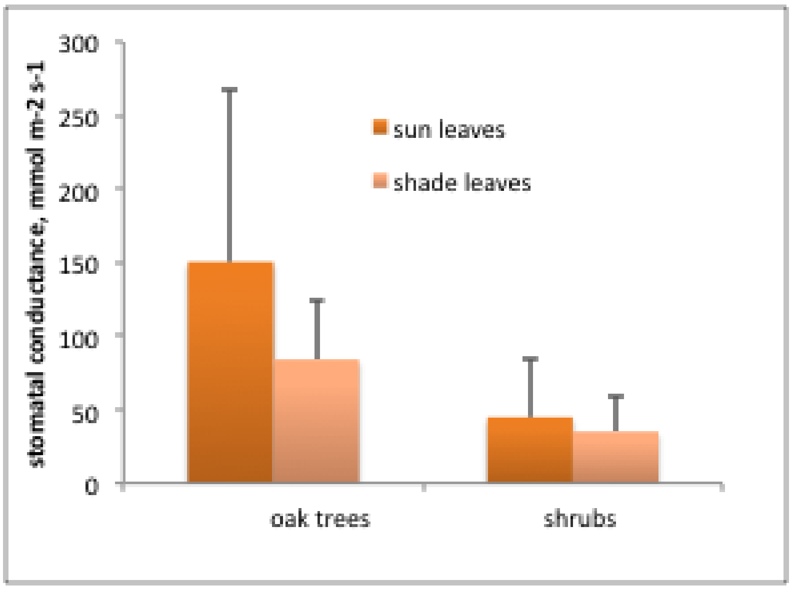


Fig. 2: Stomatal conductance for oak trees and surrounding shrub species. Bars denote means, error bars means standard deviation.

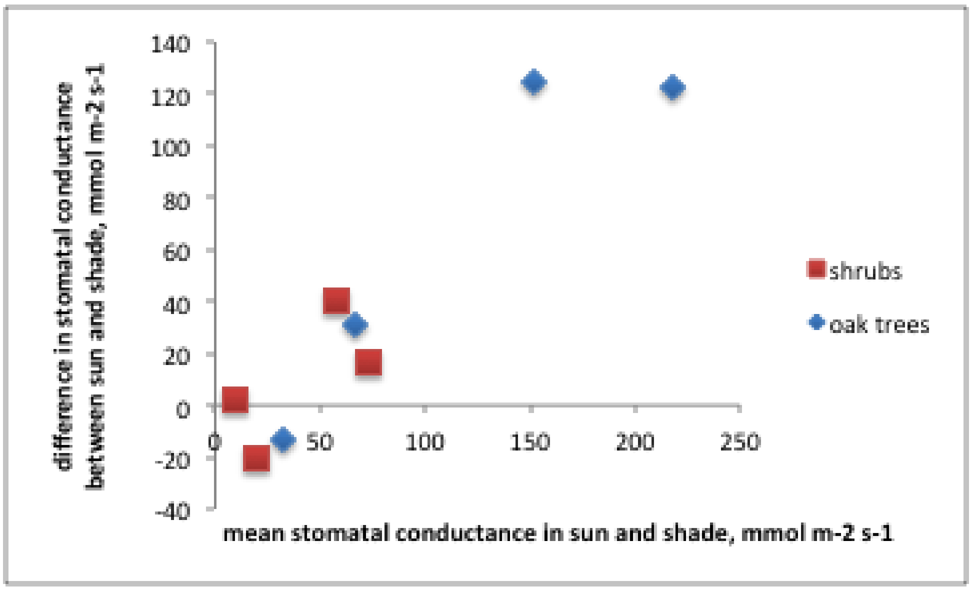


Fig. 3: Relationship between mean stomatal conductance of a tree or shrub individual, and the mean difference between the stomatal conductance of sun-shade leaves.

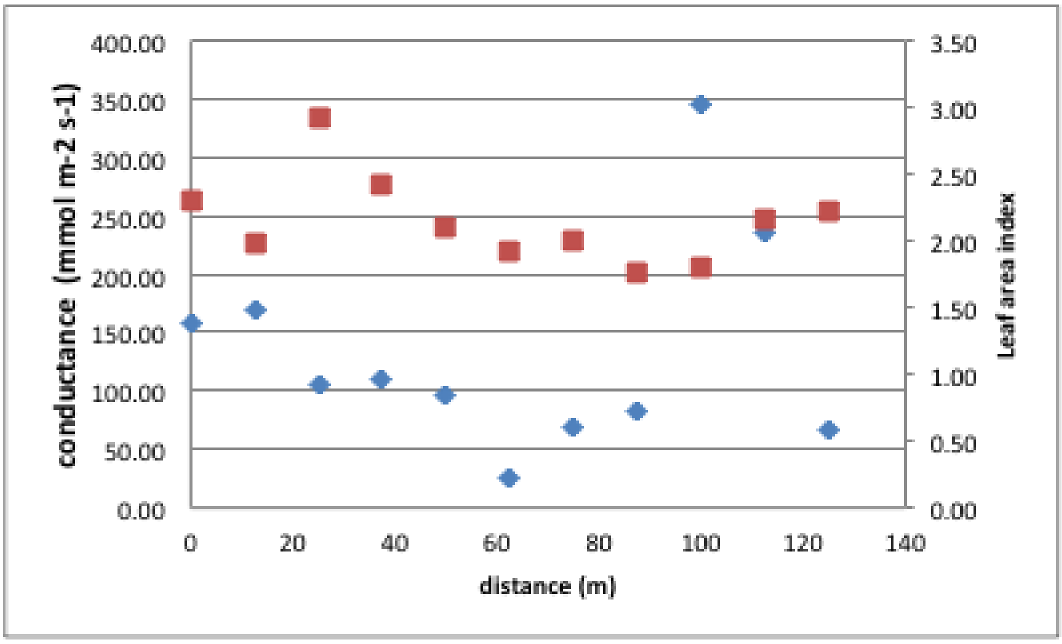


Fig. 4: Stomatal conductance and Leaf area index along the transect. « Here « 0 » denotes the bottom of the slope.

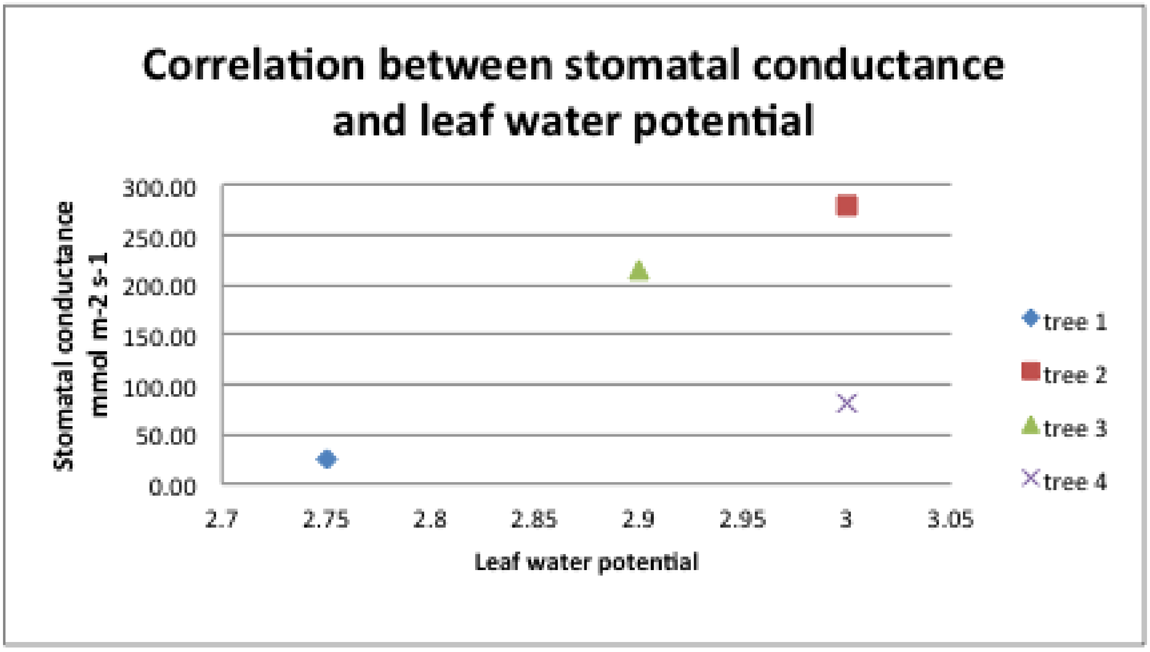


Fig. 5: Correlation between stomatal conductance and leaf water potential measurements performed on the same trees. Trees 1 and 2, and trees 3 and 4, were measured on the upper and the lower part of the transect respectively.

Day 13 - Saturday 13th September, 2014

(Annika Herrmann, Kara Grudzus)

Presentation "Outlook" (Dr. Philipp von Wrangell)

During the outlook Dr. von Wrangell gave a summarized return on the previous two Summer Schools. The good things that have been approved and the issues which had been improved. The program tries to cover a wide range of topics in the lectures given by the professors of the summer school. For the summer school of this year they added more practical work for the students in order to give them the opportunity to also gain some practical experience, and to find a better equilibrium between lectures and activities which demand more active participation by the students.

Presentation "Erasmus Mobility Options 1" (Dr. Philipp von Wrangell)

Dr. von Wrangell informed us about the ERASMUS program and emphasized the importance of planning ahead and being on time with your application when you intend to study abroad. You should plan at least half a year ahead. All the information you need concerning the ERASMUS program you can find in the International Office. There are also other projects you can use for studying abroad, these are also made available through the International Office. PROMOS is one example and "general practical work" in a company abroad is another just to name a few.

Presentation "Erasmus Mobility Options 2" (Dr. Ilja M. Reiter)

Dr. Reiter talked about the future life prospects of finding a job in science, and particularly in the French system. He advised us to think about foreign countries and complementary activities in order to distinct oneself from run-of-the-mill students. He also advised us to choose a PhD with an innovative topic. He presented us some organizations situated in France which could be an interesting option for our future work place. For example CNRS, INRA, CEA, IRSTEA, IFREMER and INSERM. There is a lot of information about these organizations to be found online.

Presentation of participating countries "Why should one go to...?"

- Germany
- Estonia
- Czech Republic

The students were presenting a short overview of their university and city including cultural and night life aspects.