2nd International Scientific Conference

QUO VADITIS AGRICULTURE, FORESTRY AND SOCIETY UNDER GLOBAL CHANGE?

From understanding past and present Earth's processes to adaptations for the future.

Velké Karlovice, Czech Republic | 19th–21st September 2022

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Book of Abstracts

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Freshwater ecosystems in the era of global change: perspectives from freshwater crayfish

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Freshwater ecosystems and their biota face multiple threats, including climate change and invasive species introductions. These ongoing processes will be exemplified during the presentation, using warm-water invasive crayfish species as amodel group. Besides their introduction pathways and roles in the freshwater ecosystems, the contribution will focus on perspectives of their distribution in Europe, overwintering under conditions of temperate winter, as well as burrowing and reproduction abilities under severe droughts. Native and invasive crayfish species will be contrasted in these regards.

Acknowledgements

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THROUGH UNDERSTANDING THE PAST AND PRESENT PROCESSES TO ADAPTATION FOR FUTURE

Rural sustainability pathways: Adaptation to climate change in Czech agricultural areas

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Climate change poses a crucial challenge for European rural landscapes. Across different types of land uses, rural landscapes face the need to adapt to climate change, which is particularly tangible in the agricultural sector. However, while adaptation planning has become amainstreamed effort in rural and agricultural landscapes, low attention has been paid to the social and cultural barriers and opportunities for implementing adaptation measures across different European contexts.

In this contribution, we combine the results of two recent projects focusing on Czech agricultural landscapes to illustrate (a) potential agricultural adaptation pathways for the Czech context, and (b) social, economic and cultural factors underlying barriers and opportunities for different adaptation pathways in Czech rural landscapes. In particular, we present the SustES agricultural adaptation pathways developed in an expert-based setting and incorporating the combination of land-based, technological and soft adaptation measures, together with insights gained through qualitative research (interviews, field observations, participatory workshops and science-art co-production) carried out in a case study under the JPI Climate Just Scapes project.

The SustES adaptation pathways designed for the Czech agricultural landscapes span from conventional pathways relying on state-of-the-art approaches to pathways based on extensive technological advances and/or scaling the application of sustainable agricultural practices. However, the implementation of such adaptation pathways across scales from individual to national requires various levels of changing legal, economic, socio-cultural and behavioural patterns through agradient between incremental and more profound transformative changes in rural landscape management. Thus, the second part of our results puts the adaptation pathways into a context and illustrates which barriers to climate change adaptation are perceived in Czech rural landscapes by various types of actors and which root causes they identify for such barriers. Finally, we illustrate the key role of justice towards different societal groups in selecting and adopting different types of adaptation measures and pathways.

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Just Scapes – Environmental justice analysis to advance rural landscape transformations in the face of climate change (8F20015)

Forest growth responds more to air pollution than acidification or climate change

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The forests of central Europe have undergone remarkable transitions in the past 40 years as air quality has improved dramatically. Retrospective analysis of Norway spruce (Picea abies) tree rings in the Czech Republic shows that air pollution (e.g. SO_2 concentrations, high acidic deposition to the forest canopy) plays adominant role in driving forest health. Extensive soil acidification occurred in the highly polluted "Black Triangle" in Central Europe, and upper mineral soils are still acidified. In contrast, acidic atmospheric deposition declined by 80% and atmospheric SO_2 concentration by 90% between the late 1980s and 2010s.

In this study we observed that annual tree ring width (TRW) declined in the 1970s and subsequently recovered in the 1990s, tracking SO_2 concentrations closely. Furthermore, recovery of TRW was similar in unlimed and limed stands. Despite large increases in soil base saturation, as well as soil pH, as aresult of repeated liming starting in 1981, TRW growth was similar in limed and unlimed plots. TRW recovery was interrupted in 1996 when highly acidic rime (originating from more pronounced decline of alkaline dust than SO_2 from local power plants) injured the spruce canopy, but recovered soon to the pre-episode growth. Across the long-term site history, changes in soil chemistry (pH, base saturation, Bc/Al soil solution ratio) cannot explain observed changes in TRW at the two study sites where we tracked soil chemistry. Instead, statistically significant recovery in TRW is linked to the trajectory of annual SO_2 concentrations or sulfur deposition at all three stands.

From aerosols, through the air humidity to the climate change

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The climate change and air quality significantly influence human health and living conditions. Atmospheric aerosol (AA) affects climate directly (by scattering and absorbing of radiation) and indirectly (alters albedo and lifespan of clouds). Both aerosol direct and indirect effect alter radiative balance of the Earth and represents one of the greatest uncertainties in estimation of climate models. One of the key parameters regulating aerosol optical properties (AOP) is relative humidity (RH). Hygroscopicity is aerosol ability to bind air humidity. This changes their shape, size, AOP such as refractive index and scattering coefficient and thus influences climate and human health.

The main objectives are to study the hygroscopicity of AA generated in laboratory and in the real atmosphere; relationships between the chemical composition of the particles, RH, and AOP of dry and wet particles; interaction of aerosols with solar radiation; long-term characterization of aerosol light scattering properties at NAOK with source apportionment.

A seven-years based (2012–2019) characterization of aerosol light scattering properties with nephelometer at National Atmospheric Observatory Košetice (NAOK), with the special focus on temporal variability and source apportionment was performed. Alongside, climate relevant variables, radiative forcing, influence of meteorological conditions, size distribution of aerosol and chemical composition have been investigated.

To study the hygroscopic properties of ambient aerosol, nephelometer was adjusted to have two different sampling pathways – one for dry aerosol (less than 40% RH) and one for humidified aerosol (80–95% RH). The experimental outcome is enhancement factor, ratio of scattering properties under wet and dry conditions.

The aerosol mixtures with known composition relevant to atmospheric aerosol will be generated in the laboratory and their hygroscopicity will be studied using HTDMA (Hygroscopic Tandem Differential Mobility Analyser). The experimental outcome is growth factor, ratio of particle diameter under wet and dry conditions.

The preliminary results showed decreasing trend of aerosol scattering properties, indicating decreasing aerosol concentration from 2012 to 2019. However, other climate relevant parameters showed the light scattered back to the space has become bigger fraction of total scattering, thus cooling effect of aerosol has become stronger. SO_2 and NO_x concentration correlated with scattering properties confirming high scattering potential of sulphates and nitrates particles.

Relative shift from smaller to bigger particles was observed throughout the period and with decreased concentration of AA indicates effectiveness of air pollution policies. To sum up, shift in size and concentration of particles could lead to improved air quality related to respiratory diseases. In addition, long-range transport of aerosol particles may have become amore significant source at NAOK.

Acknowledgements

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Long-term rainfall exclusion versus extreme seasonal drought – effects on transpiration, radial growth and water use efficiency in Picea abies grown outside ecological optimum

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Norway spruce (*Picea abies* [L.] Karst.) is one of the most important tree species for forestry in Europe. However, it is also considered as the one with the highest number of various health and growth problems that appeared in the last decades, caused by the shift of climatic conditions and frequent planting outside its ecological optimum. Nowadays, the Czech forestry faces enormous problems with health condition and stability of spruce stands due to combined effect of abiotic and biotic stressors.

The objective of the study was to evaluate the effect of long-term reduction in water availability on Norway spruce water use and growth dynamics. The study was conducted in two pure Norway spruce stands, approximately 35 years of age, located on sub-optimal sites for cultivation of this species at altitude of 440 m asl. In the first stand (PE), space between tree rows was covered by plastic foil 1 meter above the ground, which excluded about 25% of precipitation. The plot was established in 2007, so trees grew seven years with reduced water availability prior to our measurements. The second stand was the control plot (PC) without foil coverage. Tree transpiration (sap flow), stem radial increment, tree water deficit and water use efficiency were monitored in two consecutive growing seasons: 2015–2016 with contrasting hydro-climatic conditions. In 2015, long-term and severe drought with four intensive heat waves occurred, while 2016 was considered as normal without distinct soil water stress.

In dry year 2015, trees growing under precipitation exclusion treatment (PE) reduced transpiration sooner than control, minimizing excessive water loss due to high evaporative demand. However, during dry and hot July, trees in both PE and control group reduced their transpiration rates, reaching close to null values and thus exhibited strong stomatal control. Sap flow rates remained very low during the whole drought period, even during hot waves. In both stands, radial growth was significantly reduced and control trees did not differ in radial growth in comparison with PE treatment. However, in more favourable year 2016 with high precipitation levels, stem radial increment was higher in control group but transpiration rates were the same.

Therefore, the long exposure of Norway spruce to water deficit reduced its recovery ability after substantial drought event. The results are striking as the stand was of relatively young age. Drought hardened population showed no acclimative response to water deficit stress and this maladaptive behaviour might lead to accelerated decline of Norway spruce forests at lower altitudes.

Climate change in the Czech Republic with a focus on the urban heat island

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Changes in meteorological characteristics since 1961 have been analyzed in several recent studies (Brázdil et al. 2021, 2022; Zahradníček et al. 2020, 2022). The most visible change is the increase in air temperature and related indices (heat waves, tropical and frost days etc.). On the contrary, overall changes in precipitation are rather masked due to the large temporal variability. The long-term average remains unchanged, but the distribution and character of precipitation show a certain shift compared to the past. Future climate development is analyzed using a wide range of climate models and emission scenarios, which rather point to the fact that the current acceleration of observed changes is greater than was assumed by the climate models (Štěpánek et al 2016, 2019). A specific topic is climate change in the urban environment. The increase in air temperatures here is usually higher than in the surrounding areas, especially at night. The majority of the Czech population lives in towns and cities and is therefore most affected by the phenomenon of climate change and the urban heat island.

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The impact of climate changes on water balance in the Dyje river basin – aplication of 3D hydrological fully distributed model

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The Dyje basin is among the Czech basins with the most significant ongoing negative impacts of climate change and the greatest vulnerability of water resources. Currently, awhole spectrum of adaptation measures are being planned or being executed to limit the negative impacts of climate change. These adaptation measures have either natural character and/or are mainly technical. However, for arealistic assessment of the effectiveness of these measures and their interrelationships, integrated tools with the ability to accurately quantify the water balance of the basin and capture key biophysical processes are needed. In addition, all this needs to be addressed in the context of climate change and the development of the needs for the future use of water resources. The presented contribution is focused on the application of the detailed hydrological and hydrodynamic 3D simulation tool for water balance analysis in the River Dyje Basin and its use for the evaluation of proposed adaptation measures under climate change conditions with the impacts on all three segments of users – agriculture, forestry, and water management utilising MIKESHE and MIKEHYDRO tools provided by DHI. The tool will serve for fast, comprehensive, independent decision-making on the necessity, effectiveness and interaction of adaptation measures in watersheds under conditions of climate change. It therefore indirectly assesses the possibilities of strengthening water resources while maintaining the principles of sustainability for both groundwater and surface water resources. Detail result's analysis points to some well-known problems of the water management within the application of the Water law from the point of view of the balance of water discharges mainly from WWTP and withdrawals for water users. Balance models should work in adaily step, and many data is only available in amonthly step. Another problem of balance models are urbanized basins, which have a significantly different character of surface runoff and infiltration compared to rural areas, mainly due to the drainage and water redistribution systems in these urbanised basins. The paper introduces to the audience the current state of the simulation tool and wide range of its outputs. The team of authors analyses the problematic areas form the point of view of water balance in adetailed simulation tool, assesses the input data sets that are available and indicates the trends of the development of the water balance in aspecific hydrological basin of the River Dyje and in greater detail of the River Svratka for the upcoming period of app 100 years, which will be clearly influenced by the climate change. For such conditions, the team has been evaluated number of alternatives with adaptation measures suggested by Water Authorities and other relevant stake holders in water management and is ready to present aselection of the output, some partial results and some reasoning about climate change impacts on water balance in the specific basin of interest.

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Controls on Pb mass balances in headwater catchments in light of changing environmental and climatic conditions

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Lead is anon-essential and toxic element for the environment and human health. Its natural geochemical cycle has been substantially changed by human activities. In Central Europe, Pb emissions reached a maximum during 1980s, due to coal burning, former using of leaded gasoline, base-metal smelters and the chemical industry as the most important pollution sources. Pb emissions are removed from the atmosphere via dry and wet deposition to the pedosphere and hydrosphere. In Central Europe, forested headwater catchments are an important source of drinking water. GEOMON monitoring network of 15 forested catchments was established in 1994 to evaluate hydrochemical fluxes of major elements. Since 1996, fluxes of lead and the other toxic metal(oid)shas been measured as well. Catchments are situated along a north-south pollution gradient and include different bedrock types with contrasting contents of environmentally relevant elements and weathering rates. The aim of this ongoing study is (i) to process the long-term Pb concentration data and to evaluate Pb input and output fluxes and their changes between 1996–2019, (ii) estimate Pb soil pools and its availability to be removed from the soil pools, (iii) quantify the contribution of geogenic and atmospheric Pb to catchment runoff, and (iv) specify important hydrochemical and soil parameters controlling Pb retention/release and assess their possible impacts on Pb budgets during ongoing recovery from acidification and changing soil parameters due to climatic warming.

Monthly sampling of open-area precipitation, throughfall and runoff water at GEOMON catchments enable to estimate annual input and output Pb fluxes for 24 consecutive years (1996–2019) for all monitoring catchments. Preliminary data showed that across the sites, the mean of annual input Pb flux was 14.8 g/ha Pb (with a maximum of 49.5 and a minimum of 4.3 g/ha), whereas the mean annual output Pb flux was 6.2 g/haPb (with a maximum of 30.4 and a minimum of 0.6 g/ha). At each site, three soil pits were sampled in depths of 0–10 cm, 10–20 cm, 20–40 cm and 40–80 cm, they were analyzed for water-soluble, bioavailable, and total Pb concentrations (H_2O extracts, EDTA, and HF digestions, respectively). Across the sites, the overall mean water-soluble Pb pool was 0.17 kg/ha (with aminimum of 0.04 and amaximum of 0.32 kg/ha), the mean bioavailable Pb pool varied from 22 to 84 kg/ha, with the mean of 42kg/ha and the total Pb storage ranged from 65 to 481kg/ha, with the mean of 210 kg/ha. On average, almost half of the water-soluble Pb storage and more than 40% of bioavailable Pb pool were located in the uppermost layer of the mineral soil (0–10 cm). On the other hand, more than 40% of the total Pb pool was in the deepest sampled layer (40–80 cm). A further systematic analyzes are in the progress.

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Effect of no-till, nitrogen fertilization, external carbon amendment, and drought on soil CO_2 efflux from the crop field

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Agriculture faces increasing food demands leading to anegative impact on the environmental quality. Different practices are applied to increase food production but also to improve soil properties, decrease greenhouse gas emissions and resist changes in climate (e.g., frequent dry periods). We investigated the effects of no-till (adaptation tillage technology), nitrogen fertilization, external carbon amendment (biochar, compost, and composted biochar), and drought on soil CO_2 efflux (Rs) from a crop field during three growing seasons. While external carbon amendment had no significant effects on Rs, N fertilization with the medium fertilizer dose tended to increase Rs compared to the control at the beginning of the growing season, followed by Rs decrease later in the season. On the other hand, fertilization with the maximum fertilizer dose mostly decreased Rs throughout the whole growing season. Adaptation tillage technology had a variable effect on Rs through the three growing seasons. One-month drought reduced Rs by up to 50%. Application of adaptation tillage technology has a small effect on the magnitude of Rs after one-month water deficit compared to the conventional tillage technique. On the contrary, microbial carbon and dehydrogenase activity and their response to drought depended on the tillage technique. After the end of the water deficit period, Rs recovered fast while recovery of microbial biomass and dehydrogenase activity was more variable. In general, better recovery of soil activity was observed under adaptation tillage technology.

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Soil carbon balance in a Middle-Hungarian crop rotation system

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Long term flux measurements are needed to improve our understanding of the carbon balance of arable lands. The objective of our study was to determine the seasonal dynamics of carbon cycling in aHungarian cropland and to examine the effect of crop rotation on net ecosystem exchange of CO_2 (NEE), furthermore to assess the influences of C outputs and inputs derived from lateral fluxes on soil organic carbon (SOC) stock.

The experiment began in 2017 and crop rotation of the measured field consisted of winter wheat (2017–2018 and 2019–2020), rapeseed (2018), sorghum (2019) and sunflower (2021). CO_2 fluxes and annual net ecosystem exchange (NEE) of CO_2 were measured by a field-scale eddy covariance (EC) station at aCentral Hungarian cropland site. Both vertical and lateral C fluxes were taken into account when calculating the net ecosystem carbon budget (NECB).

The largest sink activity was observed in the sorghum season (-277 g C m^{-2} from sowing to harvest). The cropland acted as asource of CO_2 during the rapeseed season (140 g C m^{-2}) due to incomplete germination caused by extreme autumnal drought.

We found that during the study period both meteorological variables and lateral carbon fluxes such as C inputs derived from seed and crop residues and outputs (harvest) had significant influence on the C dynamics. The higher temperatures and precipitation amount that characterised the fall of 2019 caused large differences in NEE dynamics for winter wheat when compared to 2017. The impact of climatic factors could be seen in the sunflower period since lack of precipitation in 2021 led to remarkably low carbon uptake.

Fallow periods in total covered a relatively long period of time (approximately 1 year out of the 4 year long study period). These fallow periods had a significant effect on NECB values due to immense C loss. During the four years of our experiment cumulative NEE was -222 g C m^{-2} and NECB was 726 g C m^{-2} as carbon loss during fallow periods (437 g C m^{-2} in total) and carbon export through harvest (964 g C m^{-2} in total) counterbalanced the crop'sCO_2 uptake.

We can conclude that while this Hungarian cropland was a sink of carbon it could not maintain the soil organic carbon content as it was not able to sequester enough carbon to do so. Cover plants and crop residue retention could be asolution to reduce the risk of soil carbon stock depletion but further studies are needed in the field of soil management practices.

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Drought-induced reductions in yield formation parameters among selected winter rye and winter triticale genotypes

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Rye belongs to crops with high adaptation to drought and other adverse environmental conditions. Triticale is the result of interspecific hybridization of wheat and rye to combine the high yield potential of wheat and the tolerance to abiotic stress of rye. Therefore, both rye and triticale are potential candidates for cultivation under changing climate with increasing frequency and severity of drought episodes. The cereals are generally most sensitive to drought and heat stress during transition from the vegetative to the generative stage, particularly at the stage of anthesis. Hence, this study is focused on the comparison of drought-induced effects on yield formation in winter triticale Agostino, and winter rye genotypes Gonello and KWS Binntto. The plants were cultivated in 3L pots filled with Luvic Chernozem from the Polkovice experimental site under ambient weather conditions in a vegetation hall of Mendel University in Brno (Czech Republic). The plants were regularly irrigated, treated against pests and diseases, and fertilized (69 kg N ha-1 per vegetation). The plants were transported at the beginning of the stem elongation (DC 30 according to Zadoks decimal codes) to the PlantScreenTM Modular System of Photon Systems Instruments, Ltd. in Drasov. The control treatments (5 pots of each genotype) were maintained at 70% of the maximum soil water content (SWC). The drought stress treatments were irrigated every 2–3 days to the SWC of the pot with the highest soil moisture to ensure the same rate of drying across all replications of drought stress treatment. The continual drying of drought stress treatments, simulating natural drying, to the 15% SWC (permanent wilting point of this soil) lasted 32 days (DC 65). Then, the pots were irrigated to 70% SWC and left for recovery for 17 days (DC 75). Then the pots were transported back to the vegetation hall and manually harvested at the fully ripe stage (DC 92). Grain weight per the main spike (GW), grain number per the main spike (GN), thousand grain weight, and harvest index (HI) were determined after drying for 12 h at 105°C in an automatic drying oven. ANOVAs with Tukey's HSD tests ($n \geq 4$, $\alpha = 0.05$) revealed that genotype and treatment are statistically significant but not their interactions. The highest and the lowest mean drought-induced reductions of GW were observed in rye KWS Binntto (80%) and triticale Agostino (45%), respectively (74% in rye Gonello). Agostino and KWS Binntto reached the highest and the lowest HI, GN, and GW, respectively, in both treatments. Agostino showed the best results and hence, it seems that hybridization of rye and wheat is not negatively affecting the drought tolerance coming from rye and triticale can provide potentially even higher tolerance to drought than rye.

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Interception loss affects water availability in forested catchments under changing climate

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Climate warming is having pronounced effects on the hydrological cycle by increasing atmospheric demand, changing water availability, and snow seasonality. Interception loss in forests represents an amount of precipitation that evaporates directly from tree canopies and do not reach the ground. It is typically considered as a part of evapotranspiration however its role in rainfall-runoff analysis is quite often underestimated and underrated. Study site Lysina catchment (50°03‘N, 12°40‘ E; area 0.25 km^2, 829–949 m a.s.l.) is a part of network of small catchments (GEOMON) established in 1994. belongs to several international monitoring networks, International Cooperative Programme (ICP) on Integrated Monitoring of the international network of forested sites, ICP waters, International Long-Term Ecosystem Research (ILTER) network. The Lysina catchment is also one of the four Critical Zone Observatories of Europe in the framework of the SoilTrEC project. We applied two versions of a deterministic, process oriented, lumped parameter hydrological model Brook90 that runs on daily time step. The original version and the upgraded version LWFBrook90R that was fully transformed to R environment. Our main aim was interception simulation. Both model versions performed well on historic streamflow and in agreement with each other according to the catchment water budget. The average air temperature was 5.9 °C in the period of 1994–2019 and varied between 3.7 °C (1996) and 7.3 °C (2019). The mean annual precipitation measured on catchment for the same period were 989 mm. The annual precipitation were between 685 mm (1997) and 1285 mm (2002). The mean interception was 255 mm with a range between 169 mm (2011) and 444 mm (2000). It represented an average interception loss of 26%. The mean seasonal interception from May to October was 173 mm and varied between 108 mm (2008) and 308 mm (1995). It corresponded to mean seasonal interception loss of 31%, nevertheless the ratio varied notably from 20% (2007) to 56% (1997). Both model simulated satisfactorily observed runoff. However, the simulated interception was notably lower that the observed ones. The LWFBrook90R performed much better with an interception of 14% compared to only 1% of interception in the original Brook90 version. Our preliminary results show aparametrization model importance in order to correctly capture complex hydrological processes such as interception loss in forested catchments. Interception affects the water availability for trees and its importance will increase under the changing climate.

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Characteristics of sun-induced fluorescence in monocot and dicot crop patches with different NDVI and canopy closure

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Rapidly developing technical advances have now made it much easier for agriculture to monitor the health of crops in field and define possible stress factors. These developments (remote and proximal sensing) can be exploited to look for correlations between satellite imagery and developmental changes induced by various physiological processes. In Kartal, Hungary, measurements of the physiological performance of plants were carried out in crop fields in two consecutive years on five clearly discernible spots; in May 2020 on winter wheat and in June 2021 on sunflower. GPS coordinates were used to identify the five patches that showed different NDVI values and/or canopy closure in the satellite images. The following parameters were measured or derived: soil moisture, leaf area index (LAI), sun-induced fluorescence (SIF), vegetation indices (FCVI, PRI, MTCI, WI, NDRE), plant water, chlorophyll, and carotenoid content. To quantify the latter, three leaves from the plants on each patch were processed. Our aim was to look for differences in the function and condition (stress state) of plants in patches that were markedly different. Field observations reflected the results of our instrumental measurements. For example, the average LAI values of the patch with the apparently tallest and greenest, i.e. most vital wheat plants, were more than twice as high as those obtained from patches that were visually either nutrient deficient or stressed (low and yellow plants). Similar conclusions could be drawn from the PRI values. The lowest value (-0.063) was derived from the patch with yellowish plants, while the highest (0.0235) was in the greenest patch. Principal component analysis (PCA) of the variables reflected slight differences between the two observed stands as well because yellowish, stressed vegetations were not found in the sunflower stand, even though the canopy closure was markedly different. PCA loadings for SIF B (at 685 nm in the O_2 B-band) oriented in the direction of scores from the yellow plant patches, while SIF A(at 761 nm in the O_2 A-band) oriented in the direction of scores from the healthy, green plant patches in the wheat stand, reflecting potential reabsorption by chlorophylls in healthy, larger canopy patches. Loadings of the two SIF metrics did not differ in orientation in the sunflower stand, both of them oriented in the direction of smaller canopy closure and smaller physiological activity plots, that is, plots characterized with a larger share of the excitation energy loss as fluorescent light emission. Moreover, the SIF values measured with the Piccolo Doppio spectrometer were compared with the values obtained by using radiative transfer model simulations with the Soil-Canopy Observation of Photochemistry and Energy fluxes (SCOPE) model. By comparing our data with a simplified test condition, we can draw conclusions about the sensitivity of the model for aset of input parameters.

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Determination of isotope composition in archaeological charred grains

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The isotopic composition of plants reflects the environmental conditions during the growth (temperature, precipitations) as well as the physiological ability of plants to cope with such an environment (e.g., adjustment of water use efficiency). Therefore, stable isotopes represent an important proxy data of past climate and are often used in paleoclimatic or archaeological research. The crop remains retrieved from archaeological sites are often preserved by charring. However, the effects of charring on the composition of stable isotopes and thus the interpretation of isotopic signals are not fully understood.

This experiment aimed to determine the representation of stable isotopes in artificially carbonized grains and compare these to isotopic signals from archaeological grains. We focus on the following questions: What is the effect of charring on elemental contents (C, N, O) and their isotope abundances? Are there any shifts in signals due to the charring process?

We have used grains of ancient wheat cultivars (einkorn and emmer) and precisely documented archaeological (charred) samples. The grains were carbonised in a muffle furnace at two temperatures (250 and 300 °C) and two atmospheric conditions (aerobic and anaerobic). While the grains were left free on the Petri dish to achieve aerobic conditions (O_2 of ca. 21%), these were inserted in the sand and wrapped in aluminium foil to achieve anaerobic conditions (O_2 less than 2%). All samples were heated for 2, 4, 8, 16 and 24 hours. After that, samples were homogenized and weighted (approximately 1.5 mg). Isotope ratios were measured using the elemental analyser (varioPYRO cube) coupled to a continual flow isotope ratio mass spectrometer.

The morphology of grains exposed to anaerobic conditions at 300 °C for 16 and 24 hours was similar to those from archaeological findings. All elements/isotopes tested were detectable in artificially charred grains as well as in the archaeological remains, including nitrogen. Charring had only minor effects on $\partial^{13}C$ values (statistically non-significant increase by 1.5–2.5%) but reduced $\partial^{15}N$ values by 6–11.4%. Noticeably, enhanced $\partial^{15}N$ values were found in modern wheat varieties with high protein contents likely due to the loss of lighter ^{14}N via N-containing volatiles. On the contrary, $\partial^{18}O$ values depend on charring conditions and decrease with the time of exposure to high temperatures. Values of $\partial^{13}C$ and $\partial^{15}N$ ratios determined in the archaeological samples (3000 BC-year old) are comparable to those determined in artificially-charred grains, but it is not true for $\partial^{18}O$ values.

We conclude that carbon and nitrogen isotopic compositions are not substantially altered by the charring process and the original environmental signal is preserved. Charred remains of cereal grains thus represent a suitable material for paleoenvironmental and archaeological reconstructions. However, the interpretation of $\partial^{18}O$ signal is unclear and needs to be further investigated.

Acknowledgements

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What are the new approaches and technologies at aunique infrastructure of tall tower?

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The atmospheric station Kresin u Pacova is a part of unique infrastructure of National Atmospheric Observatory Kosetice (NAOK). The station, which consists a 250 meter-high tall tower, serves as a Czech national monitoring point for the measurement andidentification of long-range transport pathways and potential sources of greenhouses gases, mercury and other selected chemical compounds and atmospheric aerosols including organic/elemental carbon aerosols. Cloud cover mapping and meteorological characteristics analyze belongs to basic scientific domain of NAOK as well.

Two such important pan-European research infrastructures as the Integrated Carbon Observation System (ICOS) and the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) were established at this background site, which enable free-access to high-quality long-term atmospheric data. The research and monitoring activities are connected to other significant projects and programs like Global Atmosphere Watch (GAW), European Monitoring and Evaluation Program (EMEP), Global Mercury Observation System (GMOS), Global Observation System for Mercury (GOS4M) and Aerosol Robotic Network (AERONET).

It'simportant to note that all of measured data is open and it seeks to find current answers to the causes and effects of global climate change in connection with the level of pollutants in the environment, their long-range transport and their vertical distribution.

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Atmospheric mercury monitoring in the Czech Republic

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Mercury (Hg) is a significant persistent, toxic and bioaccumulative pollutant. It can be transported in the atmosphere over long distances, contaminate water and soil up to thousands of kilometers away from the source of pollution. As a naturally occurring element, Hg can be released into the environment from several natural sources – such as weathering of mercury-containing rocks, forest fires, volcanic eruptions or geothermal activities – but also from human activities [1]. Since 2013, the anthropogenic sources of Hg are regulated by an international treaty called the Minamata convention.

A challenge facing research and policy communities is that Hg transport, dispersion, reactivity, speciation, and methyl-Hg biomagnification are chemical, physical, biological, and ecological processes sensitive to ongoing global change, including climate change.

Synergic effects of raising global temperature, permafrost thawing, sea ice melting, deforestation, biomass burning, land cover change, shifts in fish population, changes in transport patterns etc. are causing net combined impacts hard to predict. However, recent studies indicate both future increase in Hg released into the global cycle and simultaneously its decrease with carbon neutrality effords [2, 3].

This poster summarizes the Hg monitoring efforts in the Czech Republic undertaken by CzechGlobe in order to fulfill the obligations arising from the Minamata Convention.

The atmospheric station Křešín u Pacova located at the National Atmospheric Observatory Košetice in the Czech Republic ensures measurements of total gaseous mercury (TGM) as a long term continuous observation at the rural background conditions. Since 2012, two automated Tekran 2537B (or 2537X, respectively) devices were measuring both at the ground level and since October 2013, they have been measuring parallely at the ground level and at the level of 240 meters of the Křešín tall tower. Hg levels at this location correspond to northern hemispheric average (1.2–1.8 $ng.m^{-3}$) [4–6]. Since November 2020, the measurement was extended to include gaseous oxidized mercury (GOM) and particulate bound mercury (PBM) determination.

Apart from this active measurement, there is no continuous air pollution monitoring of Hg concentrations in the Czech Republic, resp. amonitoring network that assesses the risks associated with possible Hg contamination at background, urban or industrial sites. A pilot study was conducted to determine the level of mercury air pollution at 29 carefully selected locations by using the MerPAS passive samplers from Tekran Inc. (Toronto, ON, Canada). Samplers were deployed for one month, from 28.4. to 26.5.2021 (± 2 days at some sites) in order to identify sources of mercury within the Czech Republic.

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Cleaner air reveals growing influence of climate on dissolved organic carbon trends in northern headwaters

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Surface water browning, the result of increasing concentrations of dissolved organic matter (DOM), has been widespread in northern ecosystems in recent decades. Here, we assess adatabase of 426 undisturbed headwater lakes and streams in Europe and North America for evidence of trends in DOM between 1990 and 2016. We describe contrasting changes in DOM trends in Europe (decelerating) and North America (accelerating), which are consistent with organic matter solubility responses to declines in sulphate deposition. While earlier trends (1990–2004) were almost entirely related to changes in atmospheric chemistry, climatic and chemical drivers were equally important in explaining recent DOM trends (2002–2016). We estimate that riverine DOM export from northern ecosystems increased by 27% during the study period. Increased summer precipitation strengthened upward DOC trends while warming apparently damped browning. Our results suggest strong but changing influences of air quality and climate on the terrestrial carbon cycle, and on the magnitude of carbon export from land to water.

FROM MOLECULES TO LANDSCAPE: EXPERIMENTAL AND OBSERVATORY STUDIES FOR THE FUTURE CLIMATE CHANGE

Importance of ebullition for methane fluxes from alowland stream

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Streams and rivers are a well-recognized source of methane (CH_4) characterised by high spatiotemporal variability. According to recent estimates, they account for 8–17% of CH_4 fluxes from freshwaters (lakes, reservoirs, ponds, rivers). However, CH_4 release in the form of bubbles (ebullition) is not fully included in current estimates of CH_4 emissions from these ecosystems, mainly due to scarcity of measurements. Considering the highly variable contribution of CH_4 ebullition to its total fluxes (0–99%) reported in recent studies, further quantification of CH_4 fluxes from these ecosystems, including the contribution of different emission pathways, is strongly required. Hence, our study aimed to determine the importance of individual emission pathways (diffusion and ebullition) for total CH_4 fluxes from alowland stream and reveal the potential link of ebullition to environmental variables. In 2021, we measured CH_4 fluxes by diffusion and ebullition from a stream flowing through the lowland broadleaf mixed temperate forest at Lanžhot in the Czech Republic (Central Europe). For this purpose, 18 bubble traps were installed at three stream sites and periodically sampled for gas volume and its CH_4 content from April to December. Diffusive CH_4 fluxes from water were measured at 14 days intervals with a floating chamber connected to a portable GHG analyser. We found that the investigated stream was a significant source of CH_4 (mean 260 ± 107 mg CH_4 m^{-2} day^{-1}) with ebullition as a dominant pathway (55 – 85%) of CH_4 release throughout the whole monitored time period. Considering the high global warming potential of CH_4, it was an important part of CO_2 equivalent emission from the river (~35%). In accordance with other studies, we found that the CH_4 ebullition rate was correlated with the water temperature. Moreover, we found large spatial heterogeneity of CH_4 ebullition despite the relatively homogenous sediment conditions. Our results suggest that this large spatial variability is driven by a complex combination of factors when we found asignificant negative correlation of CH_4 ebullition with water depth and flow velocity, explaining part of this spatial variability. Based on our results, estimations of CH_4 fluxes omitting the ebullition can lead to a strong underestimation of total CH_4 fluxes from lowland streams. Further investigation linking the measured CH_4 fluxes from aquatic habitats with CH_4 exchange on the forest ecosystem scale using the eddy covariance method should answer the question of how the relative proportion of water surfaces and related CH_4 emission corresponds to whole ecosystem CH_4 fluxes.

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Contribution of remote sensing for assessment of forest ecosystems

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Climate change have contributed to increasing pressure on the Central European forests, their functioning and service provision. To understand the response of forests to increasing pressures, various monitoring, measurement and modelling schemes are needed and remote sensing can provide valuable data for forest research. This contribution presents four examples of different proximal and remote sensing observations from individual tree to stand level and their contribution to the assessment of forest ecosystems vitality and structure.

Terrestrial laser scanning (TLS) can capture unprecedent details in tree structure and architecture. We use TLS tree scans to reconstruct individual trees and build virtual 3D forest scenes. These are then used for 3D modelling of forest radiative budgets (using Discrete Anisotropic Radiative Transfer model DART), allowing to assess the impact of different forest characteristics on canopy reflectance, and even on subtle signal of sun-induced chlorophyll fluorescence (SIF). SIF can be nowadays retrieved globally from satellite remote sensing and it is a novel measure of vegetation photosynthetic activity. However, our simulation study shows that SIF signal is largely influenced by different forest structures.

Airborne remote sensing data help us to develop new methods, validate satellite-based products and study ecosystems at the local scale with high spatial detail. Airborne data allow to analyse individual trees, as well as entire stands. Airborne laser scanning data are extremely valuable for estimation of forest inventory parameters including above ground biomass as a proxy of carbon storage capacity of forests. Airborne hyperspectral data (in visible, near or short-wave infrared) enable to derive spectral proxies that can be link with forest vitality and help to detect early stages of bark beetle infestation on Norway spruce trees.

Last but not least, satellite remote sensing observation allow for long-term and regular monitoring of large-scale areas. We present here how fusion of Landsat 8 and Sentinel-2 data can help to study seasonal patterns of forest biochemical traits (such as leaf chlorophyll, carotenoid and water content) that are indicators of forest vitality. Those could be further related to environmental variables and assess e.g., the response of forests to drought periods.

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The role of macrophytes in carbon sequestration in wetlands and standing waters

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Data on the biomass and net primary production by aquatic macrophytes, which had been collected in Central and Eastern European standing waters since the 1960ies, have been evaluated from the viewpoint of the organic carbon accumulation in those macrophytes. The macrophyte habitats are classified according to their nutrient status into oligo- meso- and eutrophic ones. The macrophyte life forms are classified as emergent, natant (either rooted or free-floating) and submerged (either rooted or not rooted). Within each macrophyte life form, the medium-term to long-term accumulation of carbon is inversely proportional to the trophic status of the respective macrophyte habitat. Macrophytes from eutrophic habitats, which are richly supplied with plant nutrients, retain their photosynthetically assimilated carbon for the relatively shortest times, and vice versa. Discussed is also the importance of the macrophytes' net primary production and carbon accumulation for the whole aquatic and wetland ecosystems. Where applicable, the carbonate encrustations of the macrophytes are also taken into consideration.

Seasonal dynamics of methane emission from stems of European beech and its contribution to ecosystem exchange.

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Recent research has revealed that not only soils and herbaceous plants but also woody plants can be significant sources of atmospheric methane (CH_4), an important greenhouse gas. The trees' capacity to exchange CH_4 shows high intra- and interspecies and temporal variability, which is unfortunately not well understood. Still little is known about the seasonality of the tree stem CH_4 fluxes, particularly for the dormant winter season, and impact of environmental parameters on these stem fluxes. These uncertainties prevent correct estimation of net annual tree and forest ecosystem CH_4 fluxes.

Therefore, we investigated seasonal dynamics of CH_4 fluxes of mature European beech stems (Fagus sylvatica) and adjacent soil plots in a temperate montane beech forest of White Carpathians, Czech Republic, over a period of one year, using the static chamber methods and gas chromatographic analyses. The forest site is characterized by high spatial heterogeneity in soil water content, and is, therefore, most appropriate to test the hypothesis whether soil water content affects CH_4 emission by trees. We studied the tree stem fluxes' contribution to forest CH_4 exchange and the impact of important environmental parameters on the gas exchange.

We found beech stems to be net annual CH_4 sources, whereas the soil was anet CH_4 sink. High tree CH_4 emitters showed clear seasonality in their stem CH_4 emissions that followed stem CO_2 efflux. The fluxes of CH_4 peaked during the vegetation season, and remained low but significant to the annual totals during winter dormancy. The "winter" stem CH_4 emissions contributed up to 21% to the annual totals. At the annual scale, the beech trees substantially offset the soil CH_4 uptake by up to 47%.

The detected high spatial variability in stem CH_4 emissions could be explained by neither soil CH_4 exchange, nor by CH_4 concentrations, water content or temperature in soil profiles near each measured tree. We therefore assume a connection of stem CH_4 emissions to internal wood'sCH_4 production.

In Central Europe widely spread beech trees markedly contribute to seasonal dynamics of forest CH_4 exchange and significantly offset the soil CH_4 uptake. We conclude that clarifying their role in CH_4 exchange of typical beech forests is the prerequisite for correct estimations of the ecosystem CH_4 budgets and therefore global greenhouse gas flux inventories.

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CO_2 sources and sinks in fertilized boreal pine forest

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Nitrogen (N) fertilization causes distinct changes in stem growth, aboveground net primary production (ANPP), soil organic carbon content, and carbon (C) sequestration in boreal forest ecosystems by shifting belowground partitioning, carbon-use efficiency, and gross primary production (GPP). We combined state-of-the-art chamber measurements and C–pool change estimates with ecosystem-scale eddy covariance (EC) measurements to quantify the C balance and its partitioning in along-term N-addition experiment in northern Sweden. We compared two uniform 13-ha forest plots with EC flux towers in the center of each. On one plot, N was added annually at 50 to 100 kg N ha^{-1} yr^{-1} for fifteen years; the other plot was left as a reference. After five years of fertilization, the fertilized plot had reached new steady-states in leaf area index (LAI), litterfall, stemwood production, and net ecosystem production. Fertilization increased GPP on average by 12-13%. Soil organic carbon accumulation increased by 104 g C m^{-2} yr^{-1} on the fertilized plot. Fertilization increased all other flux components proportionally, except for fine root and exudate production, which declined from 39% to 14% of GPP. Aboveground carbon-use efficiency (ANPP/(ANPP + aboveground respiration)) increased on the fertilized plot from 0.45 to 0.49. Although estimates of GPP by the two methods agreed well, estimates of ecosystem respiration (Reco) diverged, increasing by 102 g C m^{-2} yr^{-1} in the EC data, but decreasing by 80 g C m-2 yr-1 in the component fluxes. The observed increase in stemwood production following fertilization was caused by the increase in GPP (32%), the increase in CUE (10%) and the shift in partitioning away from fine root and exudate production (58%). These results place the long-term carbon sinks in the context of ecosystem fluxes, allowing us to understand gains and losses in carbon partitioning under extreme N-fertilization.

Characterizing the impact of Covid-19 lockdowns on carbonaceous aerosols at European rural background using the vertical distribution

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The novel Coronavirus Disease 2019 (Covid 19) has emerged in China in late 2019 and became worldwide outbreak in early 2020. Like in many countries, a series of preventive and control measures have been implemented by Czech authorities to prevent the spread of the epidemic, including the city lockdown, and restrictions of traffic and most of the economic activities. Elemental (EC) and organic carbon (OC) are one of the key components of ambient aerosols arousing an increasing interest due to their adverse effects on human health, atmospheric visibility, and the climate forcing. In this study, we analyse the vertical distribution of carbonaceous aerosols to investigate the impact of Covid-19 lockdowns at European rural background.

Ground based (4 m a.g.l) long-term monitoring of EC and OC has been carried out since 2013 at the National Atmospheric Observatory Košetice (NAOK; 49°35´N, 15°05´E), central Czech Republic. From December 2019 to Jun 2021, measurements were simultaneously performed at the ground and at 230 m a.g.l of a 250-m tall-tower with a 4h time resolution using a semi-continuous OCEC analyser (Sunset Laboratory Inc., USA).

In this study, EC and OC at 4 m and EC at 230 m displayed a similar seasonal pattern with higher values in winter, whereas OC showed an opposite behaviour with slightly higher values in spring and summer likely associated to the enhanced contribution of secondary organic carbon (SOC). The concentrations of EC and OC were generally higher at the ground level suggesting a larger influence of local sources at the near-surface, whereas measurements at 230 m could be more impacted by aged, and long range transported aerosols.

To investigate the impact of the Covid lockdowns, the levels OC and EC measured at the ground during the pre-Covid period (2017–2019) were compared to the values recorded during the Covid period (2020–2021). The results show that the restrictions during the Covid lockdowns did not systematically result in a decreasing of OC and EC levels at the rural background site. This is especially the case during the second lockdown for EC in spring and for OC in all seasons. The impact of Covid lockdowns could be better observed by inspecting of the correlation of EC and OC between 4 m and those at 230m. Indeed, the correlation coefficient which was very weak (around 0.20) during the pre-lockdown especially for EC, steeply increased during the two controlled periods (up to 0.85 and up to 0.70 during lockdown 1 and 2, respectively). The enhanced correlation during the lockdown periods suggests that the aerosols collected at 4 m and 230 m were influenced by common sources and/or transported simultaneously at the sampling site. The Covid restrictions resulted in reduction emissions of air pollutants from most kind of anthropogenic sources, there was less influence of local sources at the receptor site. As a consequence, the measured aerosols were mostly affected by long distance transported aerosols.

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About the importance of greenhouse gas exchange of tree stems from various forest ecosystems around the globe

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Forests play an essential role in the global carbon cycle, regulating climate and climate change by contributing to the methane (CH_4) and nitrous oxide (N_2O) exchange with the atmosphere. However, the complexity of various climatic zones, forest ecosystem types, tree species and their physiological dynamics cause a challenge to identify and quantify the processes and pathways behind the fluxes.

We hypothesize the high relevance of soil water conditions to determine the specific role of CH_4 and N_2O fluxes from tree stems in two temperate riparian forests in Estonia, a floodplain forest in the Danube River basin (Austria), a tropical palm swamp forest in Amazonia (Peru), and a tropical rain forest at the volcanic island of La Reunion. Further, the temporal flux dynamics of these forest ecosystems and the impact of altering water tables on the fluxes are examined.

Enhanced CH_4 and N_2O emissions at higher soil water content were found in temperate forests, especially at the lower segments of the tree stems. The investigated species (grey alder, poplar, ash) demand stable hydrological regimes to form and maintain aerenchyma to exchange gas between the tree above the water and the submerged tissues. Consequently, seasonal adaptations were identified, although diurnal changes of CH_4 and N_2O fluxes were not found. Observations in the tropics revealed the relevance of specific physiological and morphological parameters in trees' role as a source or sink of CH_4 and N_2O.

A limited number of studies in different forest ecosystems show high spatial and temporal variability of CH_4 and N_2O exchange between tree stems and atmosphere. In some forests, tree stem fluxes can even dominate the ecosystem budgets of these gases. Therefore, further complex interdisciplinary investigations are required to better understand these relationships. Identifying microorganisms connected with gas turnover and biochemical pathways is evident for reliable estimation and further modelling of the gas exchange dynamics

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Long-term soil methane uptake trend in aconiferous boreal forest: vegetation vs non-vegetation period

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Terrestrial ecosystems play an important role in regulating the atmospheric concentration of greenhouse gases. For example, forest ecosystems covering a large part of the biosphere are significant global methane (CH_4) sources and sinks. The atmospheric concentration of this trace gas has increased rapidly at the present rate, highlighting the importance of understanding its sources and sinks to help forecast and manage the effects of CH_4 on the global climate system. However, the processes influencing the balance in soil CH_4 fluxes, the competing interactions between CH_4 production and oxidation by the microbes, are highly variable in space and time, forming substantial uncertainty in the CH_4 fluxes from terrestrial landscapes to the atmosphere. Furthermore, long-term studies on the impact of main environmental drivers are scarce.

We conducted a long-term study (from 2013 to 2021) in a 60–230-year-old coniferous upland forest of Scots pine *(Pinus sylvestris)* with the second layer of Norway spruce grown on loose sandy soil in the Soontaga Research Station (58°01'N 26°04'E) in Estonia. The soil CH_4 samples were collected biweekly using manual static soil chambers (n = 6) and analyzed using gas chromatography. In addition, the environmental parameters such as air temperature and humidity, precipitation, and soil moisture and temperature (10 cm depth) were measured, and the correlation with soil CH_4 flux was calculated.

The mean hourly CH_4 uptake varied from −158.95 to −5.66 µg m^{-2} h^{-1} over the whole study period. The highest CH_4 uptake was observed in July 2021, the warmest and driest month of the year. The variation of annual uptake between the investigated years was low; on average, the forest soil was anet annual sink of CH_4: −7.56 ±0.88 kg ha^{-1} y^{-1} (mean + SE). CH_4 uptake correlated positively with soil temperature (r^2 = 0.60, $p<0.01$) being significantly higher during the vegetation (Apr-Sept; −4.52 ± 0.41 kg m^{-2} h^{-1}) than during the non-vegetative seasons (Oct-Mar; −3.04 ± 0.56 kg ha^{-2} y^{-1}). As the soil moisture variation was small, the correlation with CH_4 uptake was weak (r^2 = 0.20, $p < 0.05$). However, the CH_4 flux was affected by precipitation. This indicates that in cold and wet conditions in winter, the CH_4 uptake decreased with increasing precipitation. In contrast, in dryer conditions in summer, an increase was observed.

Atool for evaluation of target area homogeneity at ecosystem stations employing eddy covariance method

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Our understanding of the carbon and water cycle was greatly improved through application of eddy covariance measurements in recent decades. Though powerful, this micrometeorological approach relies on anumber of assumptions that can be affected by a selection of station location. Most importantly, terrain of the target area should be flat, target area should be homogeneous and adequate air mixing should be achieved. Although possible shortcomings can be reduced by careful site inspection before tower installation (flat terrain) or can be corrected for during data post-processing (filtering of periods with low mixing), preliminary assessment of target area homogeneity is difficult as well as correction of its impacts afterwards. The influence of such inhomogeneities can lead to a bias in the flux annual sums but also abias in their relationships with environmental variables. Certain solutions were already proposed, but their validity should be further tested. Here we aim to provide asuit of software tools that build on the existing software packages (REddyProc, openair, openeddy) and allow easy diagnosis of the situation at the given ecosystem station. We provide directional analyses of variables of interest. This allows to identify the wind sectors that show large deviations from the mean value of the whole target area. The assessment will attempt to distinguish the effect of seasonality (wind directions associated with certain wind flows with contrasting properties in time) from the footprint inhomogeneities tied to given wind direction.

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Light quality trigers system-wide resource allocation shifts in cyanobacteria

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Cyanobacteria have been forming the biosphere for more than 3.7 billion years. Cyanobacteria have made Earth'satmosphere oxygenic, they contributed to our present oil reserves and today, as an essential part of phytoplankton, transform substantial part of solar irradiance into forms of chemical free energy that are accessible to other forms of life including humans. Phytoplankton is a unique driver of global geochemical cycles that captures approx. 2000 million tons of carbon annually more than is released from the ocean by respiration and decomposition. Cyanobacteria also hold great potential for sustainable green biotechnology. Compared to heterotrophic microorganisms, however, the cellular economy of phototrophic growth is still insufficiently understood. During our more than 10 years' work, we collected comprehensive dataset that allows for detailed evaluation of both light quantity- and quality-driven resource allocation shifts in cyanobacteria. Using a reproducible quasi-continuous (turbidostatic) cultivation setup, we initially characterized photoautotrophic growth of amodel cyanobacterium *Synechocystis sp.* PCC 6803 under white, red and blue lights. Identifying red light as optimal for *Synechocystis* growth, we further quantitatively analyzed (red)light-limited, saturated, and inhibited growth with the emphasis on proteome allocation, and we interpreted the results in the context of photoautotrophic growth laws. Following the detailed red-light analysis, we further studied effect of other wavelengths (in range 435 – 687 nm) on resource allocation and energy capture efficiency in *Synechocystis*. We found that light quality has substantial effect on electron transport rates (linear, cyclic, respiratory), metabolite sinks (glycogen, carbohydrates, lipids, proteins), pigments concentration (both light harvesting pigments and carotenoids), and redox state of plastoquinone (PQ) pool. Our results show wavelength-dependent plasticity of cyanobacteria metabolism and energy management, and point to a central role of the redox state of PQ pool in the light quality sensing. The results provide understanding of underwater photosynthesis limitation, where the light spectra shift according to presence of organic substances.

Do tillage and biochar management practices influence Soil CO_2 emissions from asugar beet field?

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Improving agricultural practices have great potential to increase the amount of carbon sequestered in cropland soil. By the adoption of recommended management practices, agriculture contributes not only to soil conservation and water quality goals, but also to enhancing the amount of soil organic carbon and to mitigate carbon dioxide (CO_2) emissions affected by climate change. A promising approach in recent years is biochar application; there has been a significant interest in biochar for various environmental applications, e.g., pollutants removal, carbon sequestration, and soil amelioration.

Measurements of soil CO_2 efflux from asugar beet were carried out during the growth period 2021 (June till October) in order to quantify the influence of different management practices on CO_2 emissions. The sugar beet field (located In Polkovice, The Czech Republic) was divided into four identical plots (rectangular shape – 252 m x 150 m) with two different management practices. The first management practice was related to tillage: In two plots, conventional tillage was realized, and in the other two plots, no-tillage was done. The second management practice was related to biochar application: Biochar was added only to two plots (one for the tillage and one for the non-tillage management). Measurements of soil CO_2 emission were carried out every two weeks at five positions at each studied plot; at the same time, soil temperature (at 1.5 cm depth) and soil moisture were measured. Here we presented the preliminary results of soil CO_2 emissions of asugar beet field under four different management practices. All the investigated management showed a good correlation with soil temperature and soil moisture. The highest soil CO_2 emission rates (about 6.3 μmolCO_2 $m^{-2}s^{-1}$) were measured in the no-tillage plot with biochar application plot in June, and the lowest rates (about 1.4 μmolCO_2 $m^{-2}s^{-1}$) in no-tillage without biochar plot in October. Nevertheless, the Kruskal-Wallis test did not reveal astatistically significant difference between the treatments.

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Influence of gross primary productivity and soil carbon content on soil CO_2 efflux in dry grasslands

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Soil respiration of grasslands is spatio-temporally variable reflecting the changing biological activities and carbon input of the soil. The aim of this study was to describe the effect of gross primary productivity (GPP) and soil organic carbon content (SOC) on soil respiration under varying environmental conditions. We made spatially explicit measurements of variables including soil respiration, aboveground biomass, green vegetation index, soil water content, and soil temperature during an 8-year study in the vegetation periods at a dry pasture in Hungary. Altitude, slope, and soil organic carbon were used as background factors at each sampling position. Site-level GPP data were derived from eddy-covariance measurements and used for the estimation of GPP at every sampling position as a weighted metric on the basis of the biomass and green vegetation index of the positions. Sampling was conducted 23 times in 80 x 60 m grids of 10 m resolution with 78 sampling points. Data were analyzed using generalized additive models (GAM). Soil respiration had negative correlation with soil temperature, altitude and slope, while it was positively correlated with soil water content, aboveground biomass, green vegetation index and SOC. Soil respiration was significantly different between SOC groups (low-medium-high carbon content), mean soil respiration increased with soil carbon content. According to the GAM analysis the shape of the GPP response was almost linear in each SOC groups and GPP had a strong influence on soil respiration in all of the groups besides temperature and soil water content.

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Forest aboveground biomass estimation using remote sensing methods

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Aboveground biomass (AGB) is one of the key forest inventory characteristics, which is critical for estimating carbon stock and its changes over time and space. Remote sensing-based AGB estimation can provide apractical and economical approach to forest surveys and ensure the spatial integrity and time consistency of data with high accuracy on various scales. We propose three remote sensing methods for biomass estimation covering three scale levels: individual tree, stand, and regional level.

Individual tree, stand, and regional AGB estimates were tested on several forest sites in Czech Republic which differed in species composition, age, and canopy density. Accuracy of estimates, provided below, correspond to the conditions of Central European forest ecosystems.

Individual tree AGB estimation is based on tree species classification from airborne hyperspectral imagery, identification of tree position from airborne laser scanning (ALS) data, and tree allometry. The method can provide spatially explicit AGB distribution of each tree species (average R^2 = 0.85 and nRMSE = 26%).

Stand AGB estimation is based on area-based approach, which is commonly used for biomass modelling from ALS data. Parameters of the ALS height distribution and also parameters related to the canopy density are used as metrics in models. Ground plot measurements are used for model validation and verification. The method estimates forest biomass with a high accuracy (average R^2 = 0.90 and nRMSE = 18%) and it can be used to assess biomass increment.

Regional AGB estimation is based on combination of satellite optical and radar data. These data are used as predictors together with field observations as aresponse variable are used for biomass modelling performed with machine-learning algorithms. The method allows estimating AGB for coniferous, deciduous and mixed types of forest (average R^2 = 0.62 and nRMSE = 28%).

The proposed remote sensing methods for AGB estimation can be used in forest inventory, and contribute to climate and environmental models on various scales.

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Effects of katabatic flows: analysis of the eddy-covariance data from Trebon CZ-wet site

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We developed a data-filtering procedure that addresses environmental-condition effects on eddy-covariance (EC) data processing at a sedge-grass marsh (CZ-wet ICOS code) (Trebon, Czech Republic, 49°1´ N, 14°46´ E) in the context of annual-carbon balance. The procedure is based on three thresholds: stationarity test < 5 from 9 by Foken (2004); stability threshold u_* > 0.1; high-RH threshold RH > 95%. The annual carbon-balance inaccuarcy for the 2014 year is being reduced from 182 (234) ±10 gC m^{-2} for the initial best-quality (good-quality) data to 39 (44) ±10 gC m^{-2} for the RH 95% filtered data and to 24 (26) ±10 gC m^{-2} for the further u_*=0.1 filtered data. The chosen year of 2014 can be considered a standard year characterised by a stable water table without any significant floods and drought events minimizing the soil-CO_2-efflux effects on the measurements. The distinguishable katabatic drainage flows from the nearby Třeboň-town direction generally occur at nights and account for up to 9.5% of the positive shift in the sedge-grass marsh annual carbon balance. The distinguishable high-RH conditions account for up to 27% of this shift. In addition, both conditions together (undistinguishable) account for up to 67% of the identified carbon balance change. The poster provides and validates aprocess that could apply to other EC measurements conducted at different wetland or terrestrial ecosystems with similar conditions.

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Continuous monitoring of CO_2 concentration gradient in the lower troposphere – dependence of its local changes on the atmospheric boundary layer height and thermal stratification

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The vertical stability of the troposphere and the atmospheric boundary layer (ABL) height diurnal variation are significant factors which affect diffusion of greenhouse gases (GHGs) in the environment. Both these factors also have an effect on the level of concentrations measured at the location of the receptor which is important for correct evaluation of the total amount of GHGs in the atmosphere and its future development prediction.

The different atmosphere stability situations with varied dispersion conditions is possible to distinguish on the basis of the vertical temperature gradient. The Pasquill Atmospheric Stability Classes system used in this study divides these situations into seven stability classes, where three classes are stable, one normal and three unstable. The stability decreases from the class G called "Extremely Stable", when the diffusion of pollutants in the air is very small or almost negligible to "Extremely unstable conditions" in which case the dispersion conditions are the best. The several remote sensing methods can be used for ABL height determination and structure diagnostic. In this study data obtained by a ceilometer, device based on the lidar (Light Detection And Ranging) technology, are used for this purpose in combination with commercially available software and manual post-processing evaluation.

The continuous monitoring of CO_2 and other GHGs concentrations at several height levels is one of the main research programs at the Atmospheric station Křešín uPacova (AS Křešín). This station was built as part of ICOS (Integrated Carbon Observation System) Atmospheric Measurement Network which associates over 149 greenhouse gases measuring stations over Europe to ensure long-term harmonised measurement of GHGs concentrations and the dynamics of their flows. AS Křešín is located in the central part of the Czech Republic and its 250 m tall mast is one of the essential parts of the infrastructure, which creates The National Atmospheric Observatory (NAO) Košetice. Since 2016 the greenhouse gases have been measured here at four height levels (10, 50, 125 and 250 m). From the data obtained so far, an increasing trend is clearly visible for all 4 levels. Measurement of the ABL height at the station is provided by the Vaisala CL51 ceilometer. Also air temperature is measured at the several levels of the mast

Aim of this study was to determine how the characteristic values of the ABL height and temperature stability classes affects CO_2 concentrations measured at the mast at the several height levels. For this purpose, all data from the two years period (2019–2020) was aggregated for 30 minute averages for presented results.

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Patterns in stream water dissolved organic carbon concentrations and fluxes

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Long-term monitoring of element concentrations and fluxes aids our understanding of ecosystem processes. Dissolved organic carbon (DOC) is an important component of forest ecosystems and has been increasing in surface waters of Europe and North America in the last three decades. DOC is often referred as "humic substances" and characterized by colored compounds, mostly brown. Weekly monitoring in small upland catchments with prevailing Norway spruce (Picea abies) forests situated in western Czechia underlain by contrasting substrates in the Slavkov Forest started in the period of 1990–1992, on two instrumented catchments with V-notch weirs and water-level recorders (Lysina, LYS and Pluhův Bor, PLB) and on one non-instrumented catchment (Černý Potok, CEP). DOC measurements of stream water started in 1993. Streams on leucogranite/Histosol (CEP, Hruška et al., Water Resources Research, 1996), leucogranite/Podzol (LYS) and serpentinite/Stagnosol (PLB) (Krám et al., Biogeochemistry, 1997) were sampled mostly in weekly intervals. In 2019 stream probes were installed to measure several parameters in-situ at a 10-minute interval frequency, including fluorescent dissolved organic matter (fDOM), to improve our understanding of hydrologic processes and conditions for aquatic biota and calculate element fluxes more precisely. The stream at CEP affected by Histosol from ombrotrophic peat bog exhibited much higher DOC concentrations (mean 50 mg/l) than streams draining mostly mineral soils at LYS and PLB (mean DOC 12 and 17 mg/l, respectively). Shallow flow paths through organic soil horizons during high-flow conditions generated DOC stream water peaks up to 61 and 46 mg/l, respectively in stream water at LYS and PLB, catchments with prevailing mineral soils. However, deep layers of peat at CEP generated the highest DOC concentrations during low-flow conditions (up to 120 mg/l). Long-term increase of stream water DOC was observed at all three sites, the most significant at PLB (0.4 mg/l/yr, $p<0.001$). Stream water mean output fluxes of DOC available from the two instrumented catchments are very high: 88 kg/ha/yr (±31 kg/ha/yr), at PLB and 81 kg/ha/yr (±30 kg/ha/yr), at LYS in the last decade (2012–2021). These values are 2 to 6 times higher than mean values reported from 426 European and North American headwaters examining similar time period (de Wit et al., Environmental Research Letters, 2021). The highest recorded DOC fluxes in the Slavkov Forest were recorded in years with large floods, at LYS in 2002 (217 kg/ha/yr) and at PLB in 2013 (156 kg/ha/yr). Depending on future hydrometeorological and hydrological factors (Zheng et al., Hydrological Processes, 2021) and also acidic atmospheric deposition in the Slavkov Forest, different proportions of the DOC mobilized from organic forest soils will be exported to stream waters, degassed directly to the atmosphere or retained in local mineral soils and weathered bedrocks.

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Multi-annual greenhouse gas flux measurements in ariparian forest highlight the impact of extreme events

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Riparian forests are important carbon (C) and nitrogen (N) cycling ecosystems and reply sensitively to climatic variability. However, only few studies worldwide investigate the greenhouse gas exchange from soil, tree stems, and above canopy (eddy-covariance) simultaneously. Here, we report highlights of continuous, multi-annual measurements of methane (CH_4) and nitrous oxide (N_2O) fluxes in atemperate riparian Alnus incana forest in Northern Europe.

High-frequency measurements from soil and ecosystem and manual chamber measurements from tree stems were used to investigate (I) the impact of extreme events (flooding, dry periods, freeze-thaw events) to the gas exchange of forest compartments, (II) the inter-annual ecosystem flux dynamics, and (III) their potential drivers such as soil water content.

There were significant differences in CH_4 fluxes between wet and dry periods. In dryer periods, the soil consumed CH_4 while the exchange from tree stems was very low. In contrast, during wetter periods, tree stems were the most relevant emitters within the ecosystem, peaking under flooded soil conditions.

The investigated Alnus incana forest is, according to the eddy-covariance measurements, a modest source of N_2O. Although extreme events of N_2O emission (hot moments) lasted a quarter of the study period but contributed more than half of soil fluxes. Spring and freeze-thaw periods were hot moments with rapid water content change. The intermediate soil moisture determined the elevated soil emissions. Moreover, high soil emissions of N_2O do not "escape" the ecosystem but are processed in the canopy. Most likely, photochemical reactions and dissolution in canopy-space water act as N_2O reduction mechanism.

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Non-photochemical quenching in *Arabidopsis thaliana* natural accessions during acclimation to suboptimal temperatures

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Plant'scold acclimation, initiated by dynamic regulation of light and non-freezing low temperatures, helps them to better survive at subzero temperatures. We compared the effects of two weeks of acclimation to suboptimal temperatures, at 10 °C (AC10) and 4 °C (AC4), with non-acclimated (NAC) *Arabidopsis thaliana* natural accessions, grown at 21 °C, on their growth measured by rosettes area, chlorophylls and epidermal flavonols, CO_2 assimilation rate, and their quantum yields of photochemical and non-photochemical quenching processes. Two weeks of acclimation to low temperatures ceased the plants' growth with decreased rosettes areas as well as chlorophyll contents, but increased flavonols accumulation. We report a significant increase in an additional non-regulated non-photochemical quenching (NPQ), $\Phi_{f,d}$, a significantly lower Φ_{PSII}, and marginally differed Φ_{NPQ} for AC4 accessions as compared to their NAC and AC10 counterparts. We further studied components of Φ_{NPQ}, e.g., pH regulated fast energy dissipation, Φ_{qE}, state transition component, Φ_{qT} and photoinhibitory component (Φ_{qI}), from induction and relaxation kinetics of chlorophyll *a*fluorescence measurement. We found that plants acclimated to 10 °C predominate energy-dependent fastest NPQ, Φ_{qE}, caused by ΔpH across the thylakoid membrane in the presence of PsbS and zeaxanthin; however, those acclimated with 4 °C promote state transition quenching, which caused reversible phosphorylation of light-harvesting complex of PSII (LHCII). The two-week acclimation to 10 °C or 4 °C decreased photoinhibition in all accessions except for cold tolerant accession, Te, in which Φ_{qI} for AC10 was higher than that of their NAC counterpart. These results provide new insights on the effects of non-acclamatory, at 10 °C, and cold acclamatory, at 4 °C, reactions for the regulation of molecular mechanisms of NPQ in *Arabidopsis thaliana* natural accessions.

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Implications of mistletoe parasitism for the host metabolome: anew plant identity in the forest canopy

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Mistletoe-host systems exemplify an intimate and chronic relationship where mistletoes represent protracted stress for hosts, causing long-lasting impact. Although host changes in morphological and reproductive traits due to parasitism are well known, shifts in their physiological system, altering metabolite concentrations, are less known due to the difficulty of quantification. Here we use ecometabolomic techniques in plant-plant interaction, comparing the complete metabolome of the leaves from mistletoe *(Viscum album)* and needles from their host *(Pinus nigra)*, both parasitized and unparasitized, to elucidate host responses to plant parasitism. Our results show that mistletoe acquires metabolites basically from the primary metabolism of its host, and synthesises its own defence compounds. In response to mistletoe parasitism, pines modify aquarter of their metabolome over the year, making the pine canopy metabolome more homogeneous by reducing the seasonal shifts in top-down stratification. Overall, host pines increase antioxidant metabolites, suggesting oxidative stress and also increase part of the metabolites required by mistletoe, which act as a permanent sink of host resources. In conclusion, by exerting biotic stress and thereby causing permanent systemic change, mistletoe parasitism generates a new host-plant metabolic identity available in forest canopy, which could have notable ecological consequences in the forest ecosystem.

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Dissolved and gaseous nitrogen losses in forests controlled by soil nutrient stoichiometry

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Global chronic nitrogen (N) deposition to forests can alleviate ecosystem N limitation, with potentially wide ranging consequences for biodiversity, carbon sequestration, soil and surface water quality, and greenhouse gas emissions. However, the ability to predict these consequences requires improved quantification of hard-to-measure N fluxes, particularly N gas loss and soil N retention. Here we combine a unique set of long-term catchment N budgets in the central Europe with ecosystem ^{15}N data to reveal fundamental controls over dissolved and gaseous N fluxes in temperate forests. Stream leaching losses of dissolved N corresponded with nutrient stoichiometry of the forest floor, with stream N losses increasing as ecosystems progress towards phosphorus limitation, while soil N storage increased with oxalate extractable iron and aluminium content. Our estimates of soil gaseous losses based on ^{15}N stocks averaged 2.5±2.2 kg Nha^{-1} $year^{-1}$ and comprised 20±14% of total N deposition. Gaseous N losses increased with forest floor N:P ratio and with dissolved Nlosses. Our relationship between gaseous and dissolved N losses was also able to explain previous ^{15}N-based N loss rates measured in tropical and subtropical catchments, suggesting a generalisable response driven by nitrate (NO_3^-) abundance and in which the relative importance of dissolved N over gaseous N losses tended to increase with increasing NO_3^- export. Applying this relationship globally, we extrapolated current gaseous N loss flux from forests to be 8.9 Tg N $year^{-1}$, which represent 39% of current Ndeposition to forests worldwide.

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How can stable isotopes contribute to plant eco-physiological studies and paleoclimatic reconstructions?

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Values of stable oxygen ($\delta^{18}O$; $^{18}O/^{16}O$) and carbon ($\delta^{13}C$; $^{13}C/12C$) isotopes in plants are modulated mainly by physiological processes associated with photosynthetic CO_2 uptake and transpiration of water. Similarly, nitrogen isotope ratio ($\delta^{15}N$; $^{15}N/^{14}N$) provides apowerful tool to assess N cycling in terrestrial ecosystems as it integrates the signals associated with isotope fractionation during various transformations (e.g. nitrification, denitrification, mycorrhizal N transfer). These processes are often influenced by environmental perturbations and/or changes in weather and climate including changes in temperature, relative humidity, precipitation, and/or light availability. Accordingly, isotopic compositions of plants, particularly those of tree rings, are important archives for climate reconstructions and/or ecosystem disturbances. Moreover, isotopic ratios have numerous advantages compared to traditional dendrological parameters like tree-ring width (TRW; Rybníček et al., 2021).

Here we bring several achievements of the laboratory of stable isotopes at Global Change Research Institute, Czech Academy of Sciences. Among others, we have shown that annually-resolved and absolutely-dated $\delta^{18}O$ and $\delta^{13}C$ measurements of 21 living oak trees from the Czech Republic exhibit significant coherency across species, locations, and tree ages and can be combined into robust chronologies for multi-millennial climate reconstructions (Urban et al., 2021). Based on these findings, we have reconstructed the central European summer hydroclimate from 75 BCE to 2018 CE showing adrying trend over the past two millennia (Büntgen et al., 2021).

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Eddy Covariance station in flooded rice filed in Vietnam: preliminary results

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Vietnam ranked 15th for the largest population in the world, with more than 97 million of the population in 2020 (Worldbank, 2022). Rice export is the strength of this country, with the 3rd position globally in 2016 (after Thailand and India) (Kea et. al., 2019). In particular, the largest amount of rice production in the country is in the Mekong Delta area, in the South. And according to the third biennial updated report of Vietnam to The United Nations framework convention on Climate change (UNFCCC), the total greenhouse gas (GHG) emissions of Vietnam in 2016 was 316 million ton of CO_2 equivalent (CO_2eq), in which rice cultivation placed the second position and contributed 11% emission of CO_2eq (Ministry of Natural Resources and Environment, 2020). This report was made based on the general approach proposed by IPCC, using the emission factor, and this might affect the accuracy, due to the differences in local climate environment as well as the farming process and habits of farmers might be varied. Therefore, in 2019, under the cooperation agreement between the Global Change Research Institute CAS (CzechGlobe) and the University of Science, Vietnam National University – Ho Chi Minh City (HCMUS, VNU – HCMC), an ecosystem station was established for GHG measurements (CO_2 and CH_4) in flooded rice paddle field area at the Mekong Delta area in Vietnam The station is fully equipped with state-of-art equipment for CO_2 and CH_4 gas exchange and micrometeorology measurements. These measurements are important to improve our knowledge about greenhouse gases exchange in this region and to investigate the factors influencing carbon cycling and sequestration in these types of ecosystems. The signature of the station is that it was constructed as a floating pontoon during the flooding season. Here, we present the infrastructure set-up of this flooded rice ecosystem station and some preliminary results on CO_2 and CH_4 gas exchange.

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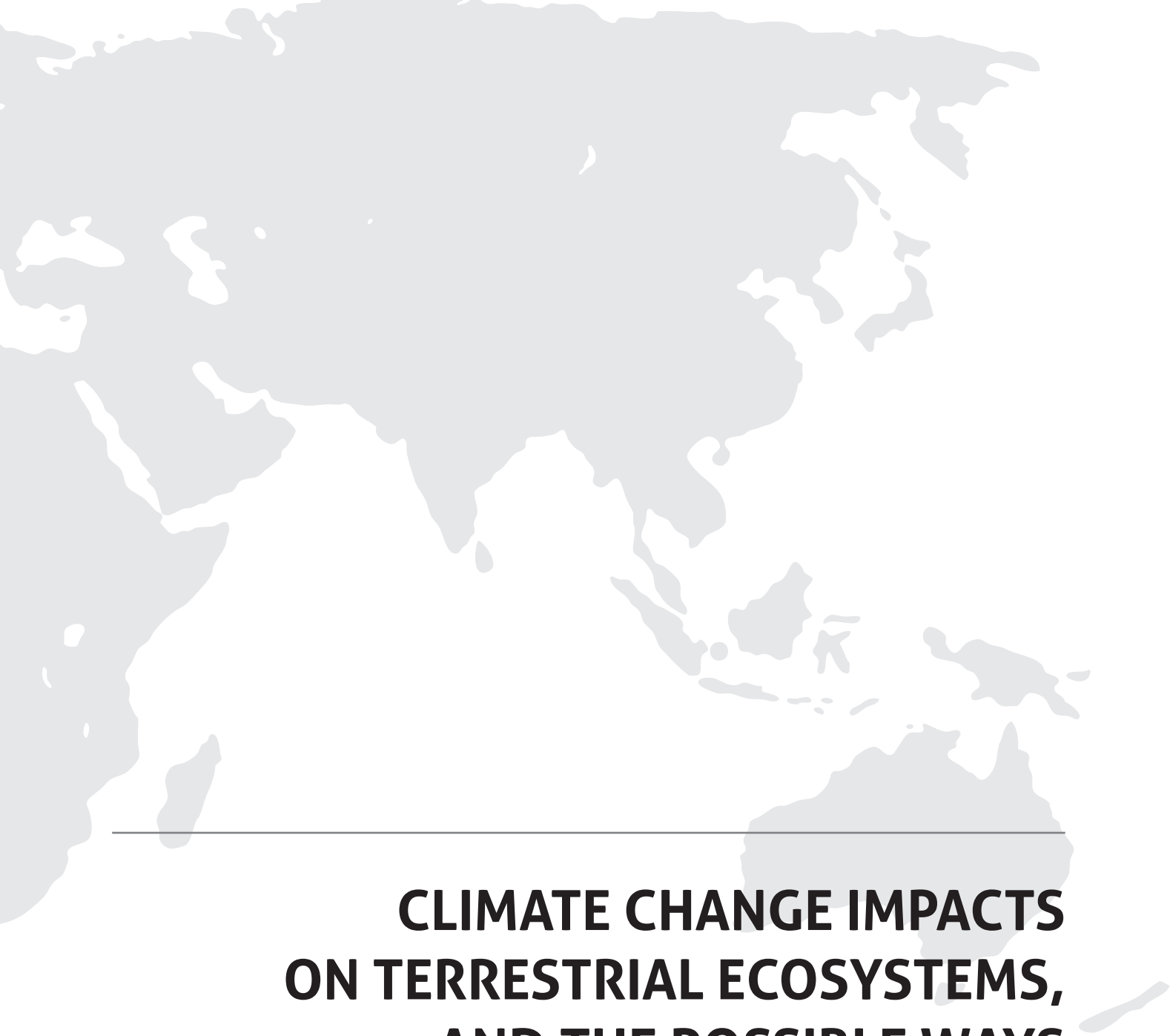

CLIMATE CHANGE IMPACTS ON TERRESTRIAL ECOSYSTEMS, AND THE POSSIBLE WAYS FOR THEIR ADAPTATION AND CLIMATE CHANGE MITIGATION

Stomatal and non-stomatal ozone fluxes during drought conditions in amountainous spruce forest

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The European summer drought in 2018 was unprecedented for more than two millennia (Büntgen et al.: Nat. Geosci. 14, 190–196, 2021), and therefore represents a unique opportunity to investigate responses of ecosystem behaviour. The presented study was designed to describe stomatal and non-stomatal ozone fluxes during the unprecedented drought period in 2018. The measurements were performed at Beskydy Mts. (900 m a.s.l.), NE of the Czech Republic, Central Europe. An eddy covariance technique consisting of fast ozone chemiluminescence detector (Enviscope, Germany) was deployed together with slow-response (APOA-370, Horiba, Japan) ozone analysers. Subsequently, the single-layer resistance model based on the Evaporative/Resistance method (Turnipseed et al.: Agric. For. Meteorol. 149, 1447–1459, 2009) was applied to investigate the stomatal and non-stomatal components of the ozone flux. Ecosystem transpiration was calculated based on sap flow measurements, which were scaled to the ecosystem level based on different classes of stem diameters and compared to water vapour flux measured by eddy covariance. Moreover, the 5-layer MEGAN 2.1 model based on measured basal emission factors was applied to predict isoprene and monoterpenes fluxes.

Averaged (March-November) daily maxima of total ozone flux reached similar values of 6.8 and 6.5 nmol m^{-2} s^{-1} during noon time hours of a moist (VPD <800 Pa & soil moisture at a depth of 22 cm >16%) and a dry period (VPD>800 Pa & soil moisture <16%), respectively. In contrast, the stomatal ozone flux reached 5.3 nmol m^{-2} s^{-1} during the moist period, while it amounted to only 3.4 nmol m^{-2} s^{-1} during the dry period. The stomatal flux thus formed 65.8% of the total ozone flux during the moist period but it represented only 46.8% during the dry period. This suggests that a significant portion of the total ozone flux was caused by processes other than direct stomatal uptake. Accordingly, we tested the hypothesis that non-stomatal ozone deposition is driven by its chemical oxidation with volatile organic compounds.

Over the moist period, monoterpene fluxes modelled by MEGAN were dominating (daily average of 0.5 nmol m^{-2} s^{-1}) followed by isoprene fluxes (0.12 nmol m^{-2} s^{-1}). However, these fluxes increased to 1.18 and 0.35 nmol m^{-2} s^{-1} during the dry period. Such increase was particularly caused by continuous drought stimulating the production of isoprenoids The calculated non-stomatal chemical ozone sink was as much as 1.5 nmol m^{-2} s^{-1} and amounted only to 0.86 nmol m^{-2} s^{-1} during dry conditions representing thus 48.7% of non-stomatal ozone sink. Effect of stomata modulation during dry conditions, separation of the dataset to Spring, Summer and Autumn as well as alternative hypotheses of non-stomatal ozone flux will be presented.

Acknowledgements

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Plant and ecosystem responses and adaptation to climate change: the role of interactions and response non-linearity

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Due to the increasing variability and extremity of the weather, with many combinations of weather factors, the few emissions, and following climate change scenarios are splitting into hundreds of potential weather scenarios that ecosystems will experience in the near future.

The situation in estimating the climate change impacts on ecosystem functions is further complicated by the fact that the plant responses to environmental factors are generally not linear but usually have a sigmoidal or peak character. For example, an increase in the photosynthetic performance with a slight increase in temperature is followed by a rapid drop in high temperatures. It is also quite common that low intensities of an environmental factor otherwise widely considered to be negative, have a stimulatory effect on growth and yield (for example UV radiation) mainly due to the effect on the induction of protective mechanisms in plants, such as the production of antioxidants or osmolytes, or by stimulating the development of root system. This effect, which is referred to as hormesis, can also be considered an important element of plant acclimation to adverse conditions accompanying climate change. Thus, its study is crucial not only for understanding and utilization of the potential adaptation mechanisms.

In addition to the response nonlinearity, the complex interactions between two environmental factors are complicating the understanding of the ecosystem responses to the ongoing climate change, modelling future impacts, and finally also designing possible adaptation pathways. It is common that not only additive interactions (the simple sum of the effect of two factors), but also synergistic (higher than additive) or antagonistic (lower than additive) interactions are reported as a result of the action of two or more environmental factors.

This wide range of interactions is basically the result of the nonlinearity of the responses to the combined environmental factors but also originates from the internal molecular mechanisms in the plant, which can either alleviate or amplify the negative effects of another factor. In the vast majority of cases, however, the intensity of a particular factor is crucial, while the mitigating effect of its low intensities usually turns into an aggravating one at the higher intensities.

Experiments in which the possible interactions of the effect of two or more factors associated with climate change are evaluated, and primarily the regression type of experiments in which the response is evaluated at a range of intensities are absolutely essential for understanding the impacts of the future climate on ecosystems.

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DendroNetwork – Bio-monitoring of the present and the future state of the forest in the Czech Republic

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Only vital forest ecosystems contribute to the mitigation of climate change. Therefore, understanding and monitoring the dynamics and the state of forests under conditions of climate change are of urgent social need. Current forest monitoring networks are based on traditional growth measurement (e.g. National Forest Inventory) or crown condition assessment (e.g. ICP Forests). These approaches are based on manually recorded long-term data with a frequency of measurements varied from annually to 10 years time step and thus are not capable of providing sufficient and continuous information about the state of the forest ecosystems. DendroNetwork fills the gap and generates near-real-time indicators of the forest state. Possible applications of this network range from monitoring of vulnerability to tree mortality and forest die-off, assessment of the probability of bark beetle attack to quantification of important ecosystem functions such as climate effect or production function.

DendroNetwork is a research and monitoring network that aims to collect and analyze datasets of tree growth and water deficit with high temporal and spatial resolution. The DendroNetwork has been established for the biological monitoring of drought and production in forest ecosystems in 2016 in the Czech Republic. It covers 86 sites and main tree species across a large climatic gradient in the Czech Republic. The study site locations include evergreen coniferous and broadleaf deciduous trees commonly found throughout Europe: Picea abies, Pinus sylvestris, Fagus sylvatica and Quercus ssp. In parallel with the measurement of microclimatic characteristics (air temperature and relative air humidity), soil water content and combined sensor of soil temperature and soil water potential, the monitoring is based on direct observation of the growth and stress response of trees in real-time (based on the stem dendrometer reading (DR26P, EMS Brno, Czech Republic)). To obtain information about trees and stand reactions in the past, we took wood core samples at each DendroNetwork site during the years 2021 and 2022. Data from cores not only provide information about the growth of trees in the past but also monitor changing environmental conditions. This allows abetter understanding and interpretation of current measurements in terms of astress response.

The uniqueness of this network is not only in the spatial scale and frequency of measurements (i.e. every 30 min) but based on the automatic data collection and online data transmission. It allows us to combine real-time measurements with modelling for the assessment of the current situation in the forest ecosystems of the Czech Republic and to provide information in near real-time for a wide audience. Moreover, this unique forest network and data sets could bring novel insight into the dynamics of European forests.

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Assessing changes in service provision in the Bia-Tano forest reserve for sustained carbon mitigation and non-timber forest products provision

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The Millennium Ecosystem Assessment (2005) defined ecosystem services as "the benefits people derive from ecosystems". Besides provisioning services or goods like food, wood and other raw materials, plants, animals, fungi, and micro-organisms provide essential regulating services such as pollination of crops, prevention of soil erosion and water purification, and avast array of cultural services, like recreation and asense of place. Forest ecosystems also provide numerous services, benefits, and goods that benefit human wellbeing and mitigate carbon emissions. In many developing countries, forest ecosystem services serve as a vital means of providing food, reducing poverty and creating employment. This study aims to assess the changes in forest ecosystem services in the Bia-Tano forest reserve from 1990–2020 using GIS and satellite images. The purpose was to ascertain how human interventions and activities have contributed to the decrease in the service provision of Bia-Tano forest reserve'secosystem services. In all two sets of Classified Land Use Land Cover Images (CLULCI) covering the years 1990, 2000, 2011 and 2020 for Bia-Tano forest reserve and surrounding areas and CLULCI for the actual forest reserve using the same years. The findings further revealed that the fringe community's livelihood activities have contributed to the decrease in the quality and quantity of the forest reserve over the past 30 years, with closed forest decline, while built-up areas, barren areas, planted/cultivated areas and open forest continue to increase. Furthermore, the excessive exploitation of natural resources from the reserve, coupled with illegal encroachment, and frequent access to timber and fuelwood, threaten the conservation of the reserve's biodiversity and sustainability of ecosystem services.

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Two different approaches of the phenological observation in afloodplain forest

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Phenological observations play important role as indicators of global warming and as estimation tools for the terrestrial carbon balance in vulnerable ecosystems, such as the last fragments of floodplain forests Lanžhot in the Czech Republic. The aim of this study was to compare two different approaches of the phenological observations: 1) ground-based phenological observations 2) canopy development monitored by phenological cameras. There were observed eight phenophases on three dominant species Hornbeam, Oak and Ash. The images were taken by phenocameras mounted on a meteorological mast. The thresholds were estimated according to the seasonal trajectory of the greenness index (Gcc). The average annual air temperature in the studied years 2014–2021 was 1.3°C higher than the long-term average, and the precipitation deficit reached ⅓ of annual rainfall. We found a high proportion of above-average warm days in the warmest part of the growing season. Above-average air temperatures significantly accelerated the onset of budbreak in ash. In 2017, rapid cooling after exceptionally warm temperatures at the onset of spring had adetrimental effect on the stand productivity and showed amarked effect on the phenological shifts. The period when leaf area developed was in the range of DOY 66–210 for hornbeam, DOY 81–246 for oak and DOY 92–246 for ash in 2014–2021. The seasonal trajectory of Gcc showed differences between tree species that corresponded to the dynamics of the onset of phenophases observed in the field. The best match between both used methods was observed for greenup and foliage formation 50% for hornbeam (av. diff. 0.4 day). According to image analyses, the phenophase of greenup and maturity for hornbeam and ash had minimal uncertainty. In contrast, the uncertainty was high in the determination of phenophases for oak. Our observations show that the modern method of phenological observation by phenocameras is suitable for mixed forests, but classical ground-based observations by a phenologist are still crucial in order to verify the results.

Molecular insights into wheat'sresponse to climate change

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Objective: Investigation of future climate effect on crop is complicated because of the potential of multiple interactions between underlying factors. These combinations could trigger unique morpho-physiological and molecular responses. Hence, the objective of this study was to identify the key alternations in the crop traits impacted and possible mode of action under the multiple factor combination scenarios.

Methodology: In this study, we exposed four winter wheat cultivars to 8 different climate setups comprising of elevated temperature, drought and CO_2 levels (3 individually and 5 combinations) corresponding to years 2020 and 2100. The morphological (growth and biomass), physiological (gas exchange) along with the transcriptional (RNA-seq) and metabolic profiling (Mass spectroscopy) were performed to identify the key alteration in the targeted traits.

Findings: Individually, each factor affects morpho-physiological traits and gene expression; however, their combinations lead to a unique response. Alterations in the critical traits such as flowering time and crop maturity, spike/seed morphology and water use efficiency were observed. The interactive effect of climate variable caused unique shifts in transcriptional profile. Noticeably, we found that CO_2 concentration and temperature have major effect on the gene expression than drought. Signature changes in the transcriptional pattern of genes, leading to specific acclimation responses, were mainly conferred by the antagonistic response mode of individual climate variables under the multi-factor interactions.

Significance: These results shed light on the molecular mechanisms of plants under multifactorial combinations and are anticipated to progress towards a more effective approach to offset the adverse impacts of changing climate.

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Learning from nature – importance of long-term observation for understanding natural processes in forests under climate change

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Climate change affects forest ecosystems at all levels. Our working group focuses on ectomycorrhizal (ECM) fungi, which form asymbiosis with most of the temperate and boreal tree species and functionally connect individual trees with an extensive network of mycelia. Although ECM symbiosis is crucial in nutrient cycling, water management and tree defense and affects many organisms associated with them, there is no method to study the whole system in its complexity. We study manifestations of ECM fungi – ectomycorrhizas, fruiting bodies and analyzing the DNA of fungi in the soil in nature.

In the Giant Mts., four permanent plots have been studying since 1999. We monitor the regeneration of ECM species assemblage following serious air pollution in the, 80´s and 90´s. In addition, we have three gradients of permanent plots at the treeline ecotone, where Picea abies mountain forest changes into Pinus mugo shrubs. We found the majority of ECM fungi form a symbiosis with both tree species and the possible shift of the treeline due to climate change will not be hindered by the absence of suitable ECM symbionts.

In the Tatra Mts., we monitor the regeneration of forest stands after damage caused by awindstorm and subsequent bark beetle infestation. We found that in naturally regenerating stands, the ECM community is more similar to mature forest than in logged and artificially planted stands. However, these differences are not reflected in seedlings, because they form ectomycorrhizas mainly with ECM species adapted to disturbances. The dominance of such adapted species in regenerating stands is probably the reason, why there is no difference in potential to form ECM networks with different regenerating tree species.

Environmental changes more likely affect sensitive rare species than the common ones. Whether this is happening and what are the consequences is one of the goals of our future studies.

Verification of having drought reporters estimate soil water content and drought impacts in Central Europe

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Monitoring drought impacts is currently a crucial issue since drought is one of the major consequences of climate change. Within the Czech Republic, we monitor the impacts of drought on agriculture through the voluntary cooperation of reporters (farmers) who complete an online questionnaire weekly with information about the soil water content and the impact of drought on yield within their farms. The results from the questionnaires for individual farms were averaged on the area of districts and those with a continuous number of reports were further elaborated. Reporter´s data about soil water content and drought impacts on yield were compared and validated with four other tools and methods for drought monitoring, i.e. the SoilClim model, the AVISO model, the Soil Water Index (SWI), and the Evaporative Stress Index (ESI). The number of received reports increased from (on average) 50 reports in 2015 to 400 reports in 2018 since the drought has become a major problem in agriculture. There was a significant correlation between the reporter´s estimated soil water content and the outputs of the SoilClim model for soil depths between 0–0.4 m (r = 0.67) and the SWI (r = 0.68). The estimated impacts of drought on yield by reporters are highly correlated with the AVISO model (r = 0.74), with ESI (r = 0.67), and the SoilClim model at soil depths of 0–1.0 m (r = 0.66). Our main finding is that the drought monitoring based on the reporters is usable and reliable. It brings information about the impacts of drought in real-time from given sites and it serves as a robust informative and validation tool.

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Carbon sequestration at single tree level in relation to groundwater modification in South Moravia

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Floodplain ecosystems are facing increasing stress from climate change effects and turn out to be one of the planet'smost vulnerable ecosystems. On the other hand, floodplain forests are rich in diversity and play a vital role in the global carbon budget. Recent studies found that changing water balance can significantly moderate the carbon sequestration of the ecosystem. South Moravian floodplain forests faced Intense anthropogenic effects such as river regulation and ground water extraction though the impact of it on biomass allocation is not yet well understood. In this context, we have performed the study to evaluate the carbon sequestrations of Pedunculate oak (*Quercus robur* L.) and Narrow-leaved Ash (*Fraxinus angustifolia* Vahl.) trees of age approximately 120 years from dominant and co-dominant layers. Two sites with different groundwater status have been chosen for the study, where one site had stable, higher groundwater levels and the other had declining and deeper groundwater levels. We hypothesized that the biomass allocation would be less in the site with deeper groundwater.

To confirm the hypothesis, FieldMap technology was used, and parameters such as tree DBH (diameter at breast height), height, crown length, and crown width were measured. Allometric equations suggested by Krejza and colleagues in 2017 were used to calculate the DBH-dependent biomass of leaf, shoot, branch, stem, root, total aboveground biomass and total biomass in tree level. Though the equations were for *Quercus robur* and *Fraxinus excelsior* in the original publication, here *Fraxinus angustifolia* was evaluated using the same equation as both the species have a similar habitues. This study will provide insights to the forest management plans to have better strategies for all alternatives actions centred on the goal of increasing forest resilience and resistance.

The effect of atmospheric CO_2 concentration and light intensity on response to drought and heat stress in spring barley

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Climate change brings new challenges to crop breeding and food production. Our future crops must be more resilient to drought and heat as their occurrence is predicted to continue to rise in the future. Moreover, the stress factors often occur together and their interactions result in different responses. Knowing and understanding these responses is crucial for effective breeding for climate-resilient crops.

In this study, we compared the effect of heat, drought or combined heat and drought stress in two varieties of spring barley under three different concentrations of CO_2 (low – 200 ppm, ambient – 400 ppm, elevated – 700 ppm) and two light intensities (low light, high light). Gas exchange measurements were used to evaluate the stress impacts on plants. Combined heat and drought stress induced more negative changes in gas exchange than each of the stress treatments individually. On the contrary, heat stress displayed a stimulating effect on gas exchange in part of the treatments. The least negative changes were found for plants grown in low CO_2 concentration, while plants grown in ambient CO_2 showed the biggest reduction in gas exchange under combined stress. The concentration of various metabolites such as tryptophan, phenylalanine, salicylic acid or γ-aminobutyric acid was affected by different CO_2 concentrations and light regimes before the stress onset. Nevertheless, no compound associated with subsequent performance under the stress treatments was found.

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Spatio-temporal patterns of plant species and diversity in a Hungarian sandy pasture

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Occurrence, distribution, and relative importance of species within an ecosystem show large spatio-temporal variability related both to the relatively invariant terrain features of the habitat and many more quickly changing environmental and plant species-related factors. Furthermore, in Hungary, climate change is accompanied by an increased probability of droughts and heat waves which may cause increased alterations in the long-term equilibrium of the community and a potential shift to anew one.

The finely undulating (no more than 1.5 m elevation differences within the study site) surface in our sandy grassland study site was formed through the combined effects of wind, water erosion, and drought, and resulted in uneven soil nutrient and water distributions. We surveyed the vegetation of an ~ 1 ha area along 15 campaigns covering spring, summer, and autumn aspects for 7 years in 80 × 60 m grids where the surface cover of plant species within 78 patches of 0.5 × 0.5 m quadrates was recorded. The large spatial and temporal dataset (n=78 × 15=1170 quadrates with an overall species number of 117) enabled us to follow both species-wise (abundances) and community level (e.g., diversity) patterns along with different terrain attributes for years.

During the study period, the grassland functioned as acarbon sink with abalanced physiological performance with year-to-year variability. The yearly sum of precipitation was very variable without any statistically significant change since the establishment of the study station (2002); however, significant warming was observable since then.

Within the study area, vegetation differentiation was detectable along with the terrain attributes. This vegetation differentiation was temporally variable following the patterns of how species with different environmental requirements split available places/resources through time. At hotter, dryer, more elevated positions, and more on the ridges, we could differentiate a larger ratio and diversity of agroup of species favoring such conditions, while another group was more abundant in areas with opposite conditions. The presence of such different species groups and functional types within this relatively small area with a slight surface undulation may have been responsible for the observed balanced physiological performance of the grassland. However, although the diversity of the community as awhole didn't change significantly during the study period, one of the ecological group diversities, that of species favoring cooler, wetter positions, decreased. So, not only temporal variability but also trend-like shifts were observable in the vegetation composition through time, and the stability of the diversity was found to show aterrain-related pattern.

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Refuges of epiphytic lichens in the era of climate change: the role of forest structure and potential microhabitats

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Forest management and amplification of natural disturbance regime due to ongoing climate change can lead to substantial changes in forest structure in the next several decades. Epiphytic and epixylic lichens belong to highly sensitive organisms to the changes in habitat conditions. Hence, we evaluated species richness and composition of epiphytic and epixylic lichens in relation to the forest structural characteristics of various types of temperate forests in the Czech Republic. Particularly, we recorded data about occurrence of microhabitats that are potentially suitable for epiphytic and epixylic lichens. We surveyed ten pairs of 1-hectare forest plots located in unmanaged and adjacent managed forests. The plots were distributed in ten distinct regions in the Czech Republic and covered main types of forest vegetation and altitudinal gradient.

Forest structure and abundance of microhabitats were similar in unmanaged and managed forests while species richness and species composition of lichen communities differed significantly. Species richness in unmanaged forests ranged from 119 to 174 species, in managed from 54 to 126 species. Averagely, almost 20% of the species were occurred only in one plot whereas only less than 4% in managed forests. The main gradients of spatial turnover in lichen communities were associated with altitude, spatial distance and forest type (managed vs. unmanaged stands). In terms of forest structure, spatial turnover in lichen communities was supported by higher contribution of the trees and deadwood objects with microhabitats and diameter > 40 cm. On the contrary, high number of trees with diameter between 40 and 80 cm indicated plots with rather shade homogeneous structure and more nested lichen communities.

On the basis of our results, we documented (1) irreplaceability of the old-growth forest stands without forest management for maintenance of species-rich lichen communities in central Europe, (2) balanced importance of various types of temperate forests along the altitudinal gradient for species diversity of epiphytic and epixylic lichens, and (3) limited ability of both forest structure and abundance of microhabitats for prediction of species richness of lichen communities in temperate forests.

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Nitrogen leaching depends more on climate than fertilization in winter wheat

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Wheat is one of the most important food crops, providing about 20% of proteins and the total dietary calories consumed per-capita. With climate change mostly manifested by an increasing temperature and uncertainties in precipitation patterns increasing heat and drought stress, food security become more vulnerable than in the past. Drought periods following by heavy rainfall may result in increasing nitrogen (N) leaching from the soil. The risk of N leaching is also growing with increasing N depositions, which in some regions can exceed the critical loads of plants. As aresult, ecosystems are losing stability due to increased leaching of N from the ecosystem and subsequent increase of nitrate content in drinking water sources. This study aimed to evaluate effects of changing climate parameters and N fertilization on winter wheat production, grain N uptake and N leaching during four growing seasons. At two experimental sites near the town Březová nad Svitavou where there are sources of drinking water for Brno region, the effect of N fertilization was studied on three levels: 0,70, and 140 kg N ha^{-1}. Climatic data including the daily average, maximum, minimum air temperature, and precipitation were collected from the close meteorological station. In our study, PCA separated experimental years, particularly the wettest growing season 2014 and on aless scale also growing season 2013 were more associated with climatic parameters in comparison with drier seasons 2015 and 2019. We found strong associations between climatic parameters and N leaching to the soil. On the other hand, increasing N fertilization significantly enhanced all wheat production and N parameters, however no effect of N fertilization on N leaching was observed. We conclude that changes in climate, particularly predicted higher occurrence of drought periods following by heavy rainfall can have higher impact on N leaching from agricultural ecosystems than the effect of the different N doses.

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Acclimation of Norway spruce to different light intensity leads to adifferent lipid composition of the thylakoid membrane affecting low salt-induced thylakoids unstacking

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Norway spruce photosynthetic apparatus revealed several specific features differing from typical land plants. Absence of lhcb3 and lhcb6 proteins in photosystem II (PSII) light-harvesting complexes (LHCII) was found in the gymnosperm genera Picea and Pinus (family Pinaceae) resulting in different PSII supercomplex structure (Kouřil et al. 2016, New Phytologist) and macro-organization (Karlický et al. 2016, Photosynthesis Research). Further, a substantially different composition of lipids of spruce thylakoid membranes could contribute to observed increase of PSII thermal stability (Karlický et al. 2016, Photosynthesis Research). Recently we have shown that spruce seedlings employ largely different regulatory mechanisms in the adjustment of their photosynthetic processes to changes in growth light intensity as compared to *Arabidopsis thaliana*, amodel angiosperm plant (Štroch et al. 2022, Photosynthesis Research). High-light acclimation of spruce involves the disruption of PSII macro-organization, reduction of the amount of both PSII and PSI core complexes, synthesis of stress proteins, and formation of "locked-in" quenching centers within uncoupled LHCIIs (Štroch et al. 2022, Photosynthesis Research).

In this work, we focused on studying the properties of the thylakoid membranes of spruce acclimated to different light intensities in order to shed light on the unusual acclimation mechanisms of spruce. We found that the lipid composition of spruce thylakoid membranes was significantly changed after high-light acclimation, which is unusual in plants. Strongly reduced macro-organization of PSII-LHCII supercomplexes in thylakoid membranes of high light-acclimated spruce was accompanied by unchanged chlorophyll fluorescence emission ratio of PSI/PSII and absorption cross-section of PSII and PSI after unstacking. This indicates a suppressed lateral segregation of both photosystems. We hypothesize that a considerably reduced content of non-bilayer lipid monogalactosyl-diacylglycerol (MGDG) and increased content of bilayer anionic lipid sulfoquinovosyl-diacylglycerol (SQDG) in high light-acclimated spruce thylakoid membranes contribute to reduced flexibility of grana stacking/unstacking in vitro due to electrostatic repulsion of membrane layers enriched in negatively charged SQDG.

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Differences in the physiological response of two Maize and Barley varieties to drought, temperature stress, and elevated CO_2 concentrations

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Climate change is changing a number of environmental conditions for growing crops, including a combination of long-term trends (mainly elevated atmospheric CO_2 concentration (EC) and a gradual increase in average temperatures) and the increasing frequency of weather extremes (especially droughts and heatwaves). Understanding the mechanisms of plants' response and acclimation to these conditions is crucial for predicting the expected climate change impacts, planning the proper adaptation strategy, selecting suitable species for future conditions, and breeding resilient genotypes. The most significant differences in response to changing environmental conditions are reported between plants with C3 and C4 photosynthetic metabolism, as they show a different response to EC, fundamental differences in water use efficiency, and also a different temperature optimum. Therefore, amanipulation experiment in growth chambers FS-SI-3400 (PSI, CZ), that allows the control of most environmental factors including atmospheric CO_2 concentration, air temperature, and relative air humidity was conducted. This was done to investigate the physiological response of the two varieties of maize (C4) and two varieties of barley(C3) and compare the differences in responses between varieties and also the comparison of C3 and C4 responses to the manipulated environmental conditions. Physiological measurements of photosynthetic parameters, stomatal conductance, and transpiration using the gas-exchange method were performed at the end of the experiment, as well as an In-vivo measurement of chlorophyll, flavonoids, and anthocyanins and chlorophyll fluorescence imaging.

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Global Change Research Institute of the Czech Academy of Sciences
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Crown reduction as simple drought stress-response reducing treatment

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European forests are facing widespread disturbances and are greatly endangered by rapid and severe climate change effects. Thus, it is crucial to preserve their existence. Preservation of forests does not only concern existing forest stands but especially the youngest tree stages, within reforestation or afforestation. Seedlings and young trees are the most sensitive and vulnerable to extremes and rapid changes in climatic conditions. Thus it is essential to test potential treatments, possibly increasing seedling's vitality in order to cope better with severe droughts periods.

In our 2-year study, composed as Ph.D. students project, via MendelGlobe cooperation. We focused on two tree species – Norway spruce (*Picea abies* (L.) H. Karst.) as the most distributed tree species in the Czech Republic and Sessile oak (*Quercus petraea* (Matt.) Liebl.) as species believed to be a great fit in future climatic conditions. We evaluated their response to selected combinations of artificially induced factors. By these factors, we mean (i) tree species, (ii) an effect of reduced precipitation (drought), (iii) crown reduction, and (iv) the effect of hydrogel application (EscubeTM). The study design used the infrastructure of CzechGlobe in Brno, where 72 seedlings of Norway spruces and 72 Sessile oaks were planted in pots (20 l volume) separately. The main objective of this study was to understand the morphological and anatomical response of different organs and trees as awhole to the combination of treatments mentioned.

Our study is designed to perform a destructive analysis at the end of vegetation season 2022. Preliminary results confirm that Norway spruce has a more significant response to drought than Sessile oak. Hydrogel addition shows no significant effect on the tree morphology of both studied tree species. However, crown reduction in Norway spruce helps the trees to improve vitality. It is apromising method mainly for its simplicity and low-cost character.

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Molecular adaptations studied by Raman spectroscopy: Lessons from the extreme survivors in the Atacma Desert

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Algae and cyanobacteria have found a way to prosper in one of the most challenging environments on Earth, the hyperarid Atacama Desert, Chile [1–3]. The extreme dryness of this area is caused by location between two mountain ranges, Andes to the east and Coastal Cordillera to the west. Importantly, the conditions may be described as "polyextreme". Apart from the extreme lack of water, extreme sun irradiation (including UV), substantial diurnal temperature oscilations and osmotic stress due to "salty" environment also occur in the area. Various model situations of adaptation strategies to survive in such a harsh polyextreme environment are presented, based on Raman spectroscopy and imaging as a principal non-destructive technique. Protective biomolecules from the families of carotenoids and phenolics are the key players in this story. In addition, relation and comparison of biomolecular responses observed within phototrophs from different families and environments is discussed.

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Light drives and temperature modulates: Variation of the phenolic compounds profile in coordination with photosynthesis in spring barley

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Irradiance and temperature are among the most important environmental drivers that influence the rate of photosynthesis, primary assimilates and biomass production. Low or high temperature may act synergically with high irradiance to increase the susceptibility of photosynthetic apparatus to photoinhibition. On the other hand, the light may serve as an effective protector against heat-induced inactivation of PSII. Considering this, it is worthy to study various combination of these two factors to assess their possible physiological consequences as they often co-act under natural conditions. Thus, we investigated, how low (LI, 50 μmol m^{-2} s^{-1}) and high (HI, 1000 μmol m^{-2} s^{-1}) irradiance in combination with low (LT, 12°C), normal (NT, 20°C), or high (HT, 35°C) temperature modify the profile and total amount of photosynthetic pigments, phenolic compounds as well as other important physiological characteristics (photosynthetic assimilation rate, content of non-structural carbohydrates, or antioxidant activity) in 2-weeks old barley seedlings (*Hordeum vulgare*, L. cv. Bojos). The analysis revealed expected positive effect of irradiance and negative effect of high temperature on photosynthetic CO_2 assimilation and production of non-structural carbohydrates. Besides that, irradiance and temperature caused changes in the metabolomic profile of phenolic compounds. The most pronounced accumulation due to high irradiance acclimation exhibited B-dihydroxylated flavonoids LUT, HFG, and HSG that were considerably less abundant in LI acclimated plants as compared to B-monohydroxylated FLVs. On the other hand, the effect of temperature on the total FLV content was ambiguous. The total FLV content was the highest at LT whilst at NT and HT was rather equal. This accumulation of total FLV in plants acclimated under LT could be attributed mainly to increased content of SAP and IFG. Intriguingly FLV acylated by sinapic acid exhibited opposite trend at HI conditions and were accumulated mainly under HT. The changes in FLVs profile are related to variations in demands on antioxidant protection induced by co-action of irradiance and temperature.

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Role of public greenery in urban space and its human perception

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The outdoor comfort of urban residents is negatively affected by many factors such as air pollution, noise, more frequent and severe heatwaves, etc. Urban greenery plays an indispensable role in mitigation of these effects. Here we present approaches and results of two interdisciplinary projects related to urban greenery.

The objectives of the first one focused on the assessment of five ecosystem functions (EF) and services (ES), namely cooling effect, carbon sequestration, capture of harmful substances, traffic noise mitigation, and aesthetic/recreational function. Physically and biochemically based models of each function enable us to quantify the contribution of the EF to the performance of an urban ecosystem in physical units. The ES derived from the results of the EF express monetary value of the functions. There are two main outputs: 1/methodology and 2/software. The software is accessible on www.ekobenefity.cz. It enables to public to get more complex view on the importance and the value of greenery in urban ecosystems and even calculation of the EF/ES of their own grassland, bush or tree.

The second project aimed at assessing of outdoor thermal perception and comfort during heatwaves that are becoming still more frequent and severe with the ongoing climate change. As such, the assessment of outdoor perception and comfort has become an important element of successful urban adaptation strategies. The assessment combines features of currently used approaches (i.e., use of rating scales of thermal perception, use of surveys, and the use of photographs representing places) with remotely sensed data. This study provides some preliminary validation of this approach. Specifically, across three studies conducted in two Czech cities, we show that long-term thermal perceptions for a large sample of 1,869 urban places can be elicited in a large sample of city residents (total N = 1,877) using rating scales in off-site surveys complemented with visual representations of the target locations (street-view photos). In Studies 1 and 2, we partially validate this approach by showing that such long-term thermal perceptions can be traced back to average surface temperature, sky-view factor, and the presence of blue and green infrastructure, all factors that the literature relates to thermal perception. Moreover, we show evidence that observers can reliably glean these properties from the visual representation of places. In Study 3, we provide additional evidence of the predictive validity of such long-term thermal perception by showing that it coincides with place-related activities (waiting and walking) and the place preference of people participating in survey more than one year later. Thus, this approach to the measurement of long-term thermal perception related to heat waves can be auseful addition to currently used approaches.

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CREATING THE TRANSFORMATION: POLICY, PRACTICE AND PROGRESS

Towards an integrated understanding of the trade-offs in Czech Agricultural adaptation pathways

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As current research continues to assess the impacts of climate change and the urgent need for adaptation in the agricultural sector, it remains crucial to understand the trade-offs of the national adaptation policies in an integrated manner, including its impacts on food security, markets, and food prices. While a comprehensive agricultural adaptation strategy is frequently comprised of actions aimed at increasing the resilience of national food systems, the linkages between global drivers, local responses, and feedback can dampen the domestic efforts to adapt to climate change. This contribution investigates the economic impacts and trade-offs of three adaptation pathways (‚Hold the ground,' ‚Make the best of the Climate,' ‚Outside the limits') in the Czech agricultural sector over the medium and long term. Three adaptation pathways were co-designed with Czech experts as part of the project ‚SustES Adaptation strategies for sustainable ecosystem services and food security under adverse environmental conditions as a result of multidisciplinary and collaborative work. The pathways were parametrized based on three main dimensions: adaptation approach, technological development, and prioritization of ecosystem services, which described the future agricultural landscape in the Czech Republic. This study considers changes in land and crop management practices, domestic consumption patterns, and the production of agricultural products. The ‚Hold the ground' pathway depicts a future in which adaptation measures with immediate effects are preferred and rely on compensation for losses caused by adverse climatic conditions. The ‚Make the best of the Climate' pathway seeks to optimize land use and land management to provide abalanced supply of ecosystem services through landscape diversification and natural resource protection. The ‚Outside the limits' pathway encourages diverse, climate-resilient agricultural systems that maximize the provision of ecosystem services. We used the GLOBIOM-CZE, aglobal agroeconomic model tailored to the Czech agricultural context, to conduct our forward-looking assessment of the adaptation pathways trade-offs. The EPIC crop model was used to project the climate change impacts on agriculture using the latest climate scenarios from the CMIP6 protocol and incorporated into GLOBIOM. Then we explore further the response of climate change and adaptation pathways on land reallocation across the main essential crops and livestock, the effects on food prices, self-sufficiency, production, trade, and consumption in the Czech Republic.

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Climate change risk perception as behavioural change to sustainability

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Climate change represents one of the main challenges and global problems of the 21st century. This ongoing phenomenon causes awhole range of negative impacts on society, the economy and the environment. The impacts of climate change are manifested in cities and in rural regions, which are characterized by the dominant presence of forest ecosystems. The key is how the current generation perceives this problem and how they are willing to change their behaviour towards sustainability. In the context of climate change, one of the main challenges is finding ways to motivate people to change their behaviour and lifestyle, which is comfortable for the individual, but not sustainable for the preservation of the environment and ecosystems for future generations. Heads of state and experts have been discussing this problem at international summits for years, but so far the negative trend has not been stopped or slowed down to the desired extent. The measures taken to mitigate the negative impacts prove to be insufficient and are not sufficiently implemented in the policies of individual states as well as in the daily decisions of individuals. We observe that we can´t solve this problem only by managing from above, and it is necessary to start at the local level – this shows the potential of social change starting at the local (community) level with the potential of society-wide change.

The perception of climate change risk was one of the main activities of the cross-border (SK-CZ) INTERREG project: Restoration of biodiversity and ecosystem services of forests threatened by climate change in the Beskydy region (INTERREG V-A SK-CZ/2016/04, project code NFP304020D067). The degree of perception of the key actors of the management of the marginalized region Beskydy was determined through semi-structured guided interviews. Moderately pessimistic scenarios of the development of climate change were interpreted by actors from the field of forest management, local governments, nature protection and tourism. It is precisely in marginalized regions that people need an impulse and ahigher level of enlightenment, as they also face several social challenges and problems (lack of job opportunities, conflicts of interests, segregation, leaving of qualified labour force, ...). However, if aleader is found in the community who will be properly motivated, the disadvantage of marginalization can become an opportunity to innovate social practice and improve the quality of life.

Implementing local circular solutions into the packaging industry – areal life example

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It might seem that today the conditions for implementing innovative circular solutions are just right. The policies are on the table, the public understanding of the necessity and value of transition towards circular economy is increasing. Yet still, innovations offering functional alternatives to linear production processes and products based on fossil sources struggle finding support in development, implementation or scale-up. Still, there are knowledge gaps and lack of understanding or will on the side of investors and decisionmakers.

Myco s.r.o. is alocal innovative start-up company producing compostable alternatives to plastic packaging materials. Their products utilize fungal mycelium as abinding agent in composite materials made from agriculture or woodworking waste. They offer acircular, locally sourced, and fully-biodegradable solutions to packaging substituting standard materials such as polystyrene foam.

After two years of existence Myco succeeded to get the initial funding. To get to this point, they had to find away how to communicate their innovation and vision to investors and potential clients who could not think outside the current production lines and technologies used for plastics. Obstacles identified by Myco on the way towards getting funding and how this start-up managed to make their way through can serve as an illustration of the current situation in the field of circular solutions implementation.

The use of the Environmental Sensitivity Assessment Index (ESAI) as astep to prevent and reduce land degradation in the Czech Republic

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A large part of the Czech territory is affected by land degradation, which is aggravated by increasing anthropogenic pressure and climate change. It is manifested mainly by the loss of soil productivity and the consequent loss of other ecosystem functions and biodiversity. Areas most at risk are those where several negative factors coincide, such as a dry climate combined with strong anthropogenic pressures and low soil quality.

The ESAI (Environmental Sensitivity Assessment Index) is atool developed in the Mediterranean region to combat desertification. It is a composite index that groups the individual drivers of land degradation into four thematic categories: i) human pressure and intensity of land use, ii) soil quality, iii) vegetation quality, and iv) climate quality to identify areas vulnerable to land degradation. This method was adapted to the conditions of the Czech Republic, where it was applied at adetailed scale suitable for application in individual municipalities with extended power (MEPs).

Aframework for using ESA indices for land use, restoration, and mitigation planning was then proposed. The first step is to provide amap with the calculated average ESA index for each MEP, showing the relative land degradation risk in its area. If the average value of this index exceeds the risk threshold, more detailed maps are available, namely (a) maps of individual thematic groups of drivers and (b) detailed 1:10,000 scale maps showing the specific location of risk polygons and the drivers/parameters that contribute most to the overall risk of degradation in individual cadastres. Groups of limits, mitigation, and restoration measures are then recommended to address the specific causes. In this way, the quality of spatial and landscape planning can be greatly improved and the effectiveness of mitigation and restoration measures increased.

Strengthening the international development cooperation through participatory social-ecological knowledge production

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The design and implementation of development cooperation projects focusing on sustainable livelihoods is contested by multiple issues, ranging from questioning the past and recent development paradigms and the fundaments of development cooperation itself, to projects' intended and unintended consequences, including sealing power disbalances. Many of these issues have stemmed from (a) the lack of acknowledging complex social-ecological links between societal and environmental dynamics, and (b) gaps in robust and legitimate processes to co-produce knowledge on these links by multiple actors in international development cooperation, including citizens, experts, policy-makers and researchers in both the "donor" and the "recipient" countries.

In this contribution, we will introduce and discuss interim results of project Coop4Wellbeing, which aims at strengthening Czech international development cooperation (CIDC) through the integration of social-ecological research in target countries. We will specifically focus on the process of participatory social-ecological knowledge production within current practice CIDC. The process consists of collaborative knowledge flows identification and social-ecological mapping with two groups of actors: (1)CIDC actors who are the designers and implementors of sustainable livelihood-oriented development projects; (2) and local actors in the Mongu district, Zambia, spanning from local citizens and experts to representatives of customary and statutory governance structures.

The interim results illustrate that the understandings of social-ecological realities differ along several dichotomies, among others, between international development actors and local actors, and between holders of power and disempowered actors. In particular, we identify mismatches between how different actors reflect on the role of customary and statutory governance processes in the recipient areas, and what role is assigned to knowledge coming into and existing in Mongu district. One of the major barriers to filling this gap was related to the processes of knowledge co-production and creating spaces for sharing and operationalizing social-ecological knowledge in framing, designing, implementing and assessing development projects.

Our research shows the importance of capturing similarities, discrepancies and blind spots in perceptions and interpretation of social-ecological linkages across scales and knowledge systems, allowing for design and implementation of development projects anchored in mutual understanding. To this end, bringing together realities of diverse actors in robust participatory social-ecological knowledge production is key for strengthening recent practice of CIDC.

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Climate change as athreat to the forests – forest manager'sassessment (results from survey)

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Researchers from 15 European countries analysed forest manager'sresponses to application of Climate-smart Forestry (CSF) as its definition and list of indicators were already published in 2020. CSF currently shares similar objectives of adaptation and mitigation of Greenhouse Gases (GHGs) through carbon sequestration, substitution of fossil fuels and effective species mixtures that optimise growth, diversify timber products and increase biodiversity and resilience. Attention around CSF has grown in recent years, however work has mainly focussed upon the role of carbon sequestration and storage, and wider GHGs emissions reduction strategies. To date, there has been little work on social-ecological elements of CSF that engages forest managers, which highlights the disconnect between policy, science and practice interface. Forest managers have key role in implementation of forestry goals and adaptation to climate change which is a complex task requiring better knowledge transfer to bridge the gap between knowledge and action. The goal of our survey was to engage forest managers in defining relevant indicators potentially linked to aset of tools to support management plans and regular monitoring activity.

Forest managers perceive climate change as a high or critical threat to their forests. Established indicators of CSF were viewed as comprehensive but too numerous to integrate into management activities. Indicators ´Tree species composition´, and ´Erosion protection and maintenance of soil conditions´ were rated highest. Slenderness quotient was considered as the least important indicator of sustainable forest management for all (state, private and National Park) managers. And further, provisioning of food, pharmaceuticals and bio-chemicals were stated as the least important ecosystem services indicators. In analyse of potential future use of tree species, the most cited was Douglas fir (central and northern European countries) following with Red oak and Sweet chestnut (western Europe). Finally, training activities and communication programmes are recognised as key tools for increasing awareness and acceptance among forest managers. These will enhance managers' ability to adapt to and anticipate climate change impacts with greater ease and collectively develop and promote climate-smart forests.

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Managing global change in education for sustainability transition

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The emphasis on climate change in educational process at universities is limited at present and possibilities for integration of knowledge about climate change and its impacts in the curriculum are often overlooked. And thus, SlovakGlobe and CzechGlobe together with University of J. E. Purkyne research team lecturing at Slovak and Czech universities decided to prepare atextbook for university students studying economics and management for business as well as anyone who is interested in the issue.

The approach how to write the textbook makes it unique because it combines the experts´ views from several disciplines. The textbook explains the process of globalisation resulting not only in awide range of biophysical, ecosystem and socioeconomic changes that influence the functioning of the Earth, but also in apolitical dimension with aglobal reach, which significantly complicates rational decision-making.

The first volume of textbook, which is in the publishing process and consist of 10 chapters, is focused on the interactions between ecosystems and anthroposphere and the adaptation and mitigation capacity of landscape as socio-ecological system to the global changes. In addition, the policy challenges and moral aspects as a new phenomenon of global change are discussed. To foster critical thinking of students, after theoretical introduction of topic and several practical examples, authors prepared several questions for students to think about the discussed topic in the end of each chapter.

Furthermore, the aim of authors´ team is to prepare the second volume of textbook in 2023 that will be focused more on innovative approaches and potential solutions to overcome the challenges of managing the global change. It will be focused on collective resource management, multilevel decision-making, incentive tools to support the ecosystem services provision and transformation to low carbon economy.

Authors are opened to discuss with conference participants about their recommendations what other critical and key aspects of global change should be included in textbook to reach really wide-spectral understanding of global change and connected environmental and socioeconomic challenges. We believe that a comprehensive and critical view of climate change and its impacts based on the transfer of current professional knowledge to the younger generation is the key to address these challenges

Tools and approaches supporting the transformative change in the management of river landscapes

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River landscapes are among the most dynamic, productive and threatened ecosystems performing awide range of functions and services in the form of benefits for people. Since it is an ecosystem that concentrates substance and energy flows from the entire catchment areas, it is obvious that the ecological condition of this, often not very large part of the landscape, can significantly affect the quality of life in places far from water bodies. Unfortunately, it is an environment that has very often come under considerable pressure as aresult of agricultural cultivation of the landscape or the development of industrial and human settlement activities. These interventions are subsequently reflected not only in the reduction of biodiversity, groundwater recharge, carbon sequestration and flows of sediments and nutrients, but in general also in the limitation of the water retention function, which leads to an increased risk of extreme hydrological events (drought episodes and flash floods). The assessment of the overall ecological status of river landscapes is therefore an important source of information for the needs of water management and landscape planning, the aim of which should be to maintain the good status or improve the currently unsatisfactory status of these ecosystems.

The aim of this contribution is to present approaches and methods by means of which it is possible to quantify the provision of functions at the level of the riverbed, riparian zones and the whole river landscapes. Special attention was paid to the riparian zones, which are the key element directly affecting the quality of contact of the water bodies with its surroundings. For example, under optimal conditions, they provide the functions of non-point source pollution control and biodiversity support. In the Czech Republic, these ecosystems occupy approximately 4.25 % of the area of the entire country and their importance is significant especially in agricultural areas. The importance of riparian zones and their ecological status for the transfer of pollutants from agricultural production is continuously monitored and evaluated in several experimental sites, where partial outputs will also be presented. Another issue, the solution of which could enable the transformative change in the management of water-related ecosystems, is the implementation of nature-based solutions in floodplains and their social acceptability. For along time, floodplains in the Czech Republic generally faced the fact that their legal protection was difficult to implement, both due to the lack of documentation for their spatial delineation and insufficient justification of protection in the case of partially degraded ecosystems. An approach enabling the protection of floodplains in the Czech Republic, which supports the eco-stabilization function, is currently being developed and selected aspects will be presented.

NEW APPROACHES AND TECHNOLOGIES FOR CLIMATE ADAPTATION AND MITIGATION SOLUTIONS

Potential of airborne remote sensing to monitor municipal solid waste landfills

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Landfilling is a relatively low demanding and prevalent method of municipal solid waste (MSW) disposal in most European countries. According to current data (Waste Management Plan 2014, Kubal et al. 2021), more MSW is disposed of in landfills than is recycled in the Czech Republic. Landfilling raises a number of issues harmful for the environment, such as discharge of leachate from the landfill body, release of methane from the ground surface, and settling and instability of landfill body. The use of airborne remote sensing technology to study landfill state has high potential to perform accurate area analysis and advance in exploring and studying landfill state indicators.

The study explored the potential of FLIS– Flight Laboratory of Imaging Spectroscopy (CzechGlobe, https://olc.czechglobe.cz/) to extract and analyse the landfill parameters on three sites in South-Moravian region of Czech Republic. Airborne hyperspectral and laser scanning data were acquired in June 2021 and repeated data acquisition took place in December 2021. Laser scanning data were used to perform a change detection analysis, when normalized digital surface models were calculated from two lidar point cloud data sets. The map of changes over aperiod of 6 months contained both positive and negative pixel values demonstrating landfill parts with increasing waste deposition and landfill parts with waste subsidence. Hyperspectral (VNIR and SWIR) data were used for landfill land cover classification, where four main types of waste (plastic, wood, construction materials, and metals) and four vegetation classes (trees, shrubs, grass, and grass with waste) were identified. Hyperspectral (TIR) data were used for mapping of landfill surface temperature to identify the thermal anomalies which potentially can be related to the emission of warm landfill gas.

The study demonstrated that airborne remote sensing has a potential for a significant advancement in landfills mapping and analysis of landfill state indicators.

Digital platform for distributed optimization of sustainable production and mitigation capacity of microalgae – optimALga

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In this presentation, project concept, a case study and selected features of adigital platform for geographically distributed data acquisition from microalgal cultivation devices (bioreactors), centralized data processing, and automated analytics will be discussed.

The activity aims at systematic categorization of experimental data that could be used for optimization of microalgae culturing (enhanced by various methods of AI) and validation of predictive ecosystem models that would describe the influence of aquatic ecosystems to terrestrial ones and vice versa.

In this context, we mainly focus on microalgal biotechnological solutions that address global issues of eutrophication (nitrogen and phosphorus), contaminants (hormones, antibiotics, colorants), and marine waste residues (microplastics) as well as stimulation of atransformational change through acircular economy.

The digital platform includes:

- An infrastructure to data acquisition from user endpoint devices.
- A digital environment for storage and distribution of aggregated data for data analysis.
- Maintenance and distribution of created analytical models.
- Interactive web-based frontend for monitoring of selected indicators and models management.
- Development of communication protocols to secure data transfer among the infrastructure components / nodes.

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Synthesis of airborne remote sensing data for urban environment description

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The Flying Laboratory of Imaging Systems at CzechGlobe is capable of imaging in the visible, near-infrared and thermal parts of the electromagnetic spectrum. Together with alaser scanner that produces a3D surface map, it is possible to produce complex analyses showing deeper relationships of geometry, materials and temperatures in the area of interest. In this contribution we focuse on urban environment and present the current state of data fusion that allows estimating approximate air temperature in the street level based on the surface temperature of photosynthesizing vegetation obtained from the airborne thermal data. Further synthesis of air temperature, surface temperature and the geometry allow to estimate expected thermal tranquillity or stress perceived by residents o the streets. The values estimated based on airborne remote sensing datasets are within reasonable agreement with ground measurements with potential for further improvement of the accuracy.

Opportunities for biogenic carbon to decarbonise the construction industry

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In this presentation, we will explore how biogenic carbon (forestry, plant biomass, and algae) can replace fossil-derived carbon components of awide array of construction products. The construction industry is amongst the most significant contributors to the climate crisis and can become one of the leading sinks of atmospheric carbon. Developing carbon product footprint systems will encourage manufacturers to preferentially replace fossil carbon with biogenic carbon rather than opting for forest offsetting as the easiest method of achieving net zero. The goal is to develop technology that delivers carbon capture and use (CCU) rather than the current carbon capture and storage (CCS) approach. When wastewater is used in aCCU system, this offers an example of acircular bioeconomy.

Application of enzyme activity profiling for cell physiological phenotyping of climate change impacts: abiotic and biotic stress responses and adaptations to pedoclimatic conditions

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High-throughput profiling of key enzyme activities of carbon, nitrogen, and antioxidant metabolism (1,2) is emerging as a valuable approach to integrate deep cell physiological phenotyping into a holistic functional phenomics approach (3). Through a meta-analyses of enzyme signatures we show how enzyme activity profiling contributes to the mechanistic understanding of development and response to abiotic stress and pathogen attack (4). Notably climate change related abiotic factors such as drought, heat stress and elevated CO_2 are reflected in distinct enzyme activity signatures. In addition, the assessment of multilocation field trials of different crops revealed that different pedoclimatic conditions are also reflected in distinct enzyme fingerprints. This was verified by assessment of the effect of the corresponding soil types also under control conditions. In addition, the determination of such biosignatures may complement the classical developmental or morphological parameters to monitor climate change related impacts. However, the analyses of the large datasets generated by this method represent a bottleneck, often keeping researchers from exploiting the full potential of their studies. These limitations are addressed through the exemplary application of a set of tools for data evaluation and display within a case study. This includes the introduction of multivariate statistical analyses, which can easily be implemented in similar studies, allowing to extract more valuable information to identify enzymatic biosignatures. The high robustness of the distinct enzymatic biosignatures observed during developmental transitions and under stress conditions underpins the enormous potential of enzyme activity profiling for future applications both in basic and applied research. Enzyme activity profiling will complement molecular omics approaches to contribute to the mechanistic understanding required to narrow the genotype-to-phenotype knowledge gap and to assess genotype x environment x management interactions of crops. Such robust biosignatures generate a basis to identify predictive biomarkers for plant breeding, for the development of climate-resilient crops and the assessment and monitoring of climate change related impacts.

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AlgaeScreen – Complete Automated Algal Phenomic Platform

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Rapidly growing human population requires innovative approaches in dealing with urgent resource shortage and the consequences of our global activities. Algae are the diverse group of organisms that are emerging as next-generation resources with potential to produce awide range of highly valuable products (e.g. pigments, unsaturated fatty acids or bioactive compounds) and as asustainable alternative to feedstocks or renewable fuel production.

The biotechnological exploitation of algae is critically based on the concepts of screening. The typical tasks comprise mutant screening, searching optimal conditions for end-product production, bioprospecting and others. These tests are traditionally performed by trained lab technicians and are time and labor consuming. Photon Systems Instruments developed AlgaeScreen, the Automated Algal Phenomic Platform. The fully automated system allows high-throughput non-destructive monitoring of the microalgae growth and production of biomass, evaluating its physiological state and biochemical composition.

The AlgaeScreen platform is versatile for many microplate formats. It is modular, it allows to combine various modules so that acomplete workflow is established for the desired process including a sample preparation, cultivation and 27/4 monitoring, to sterile samples disposal. The full list of existing modules comprises: algae hotel for microplate incubation, liquid handling unit for sample preparation and treatment application, hyperspectral unit for OD monitoring and detection of absorbance spectra, chlorophyll fluorescence imaging unit for probing photosynthetic performance. In addition, the supporting modules such as automatic microplate stackers were developed and the concept of the AlgaeSceen system enables integration of third-party instruments. The aim of the presentation is to introduce the new AlgaeScreen platform and discuss a range of potential applications.

Self-growing functional materials from mycelium – development, optimization and properties investigation

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The growing urgency to tackle the increasing greenhouse gas emissions and our dependence on fossil fuels together with the need for more effective waste management in the transition towards circular economy, and the degradation issues of synthetic plastics are some of the major challenges that humanity faces nowadays.

In response to that and besides the necessary and crucial mitigation actions, new adaptation approaches also need to be developed. In the field of functional materials one example which addresses all the above-mentioned issues are mycelium-based materials.

Mycelium is the lower vegetative part of fungi. It is a natural polymeric material, a fibrous composite composed of chitin, cellulose, and proteins. Fungi produce enzymes that decompose lignin and cellulose molecules and that allows them to feed on plant structural biomass. These mycelial properties are being exploited in the development of new, self-growing functional materials. Because the production is a low energy biofabrication process upcycling locally sourced waste or side-products from agriculture and woodworking, mycelium-based materials aspire to be asustainable low-cost alternative to foams, timber, leather, and plastics [1,2]. No harmful chemicals need to be used in the production process and no waste is produced as aside product. Such materials are 100% biodegradable in soil or a compost heap and the decomposed matter can serve as a fertilizer. The potential application spans widely from fields such as construction to e.g., food packaging, fashion or even coffins [1–4].

That is why the Department of Adaptive Biotechnologies teamed up with the startup company Myco to work on the optimization of mycelial growth and investigation of the functional properties of mycelium-based products.

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Development of breeding methods for increased lipids accumulation by marine microalgae using fluorescence-activated cell sorting

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The marine microorganism belonging to the family Thraustochytriidae are group of non-photosynthetic marine protists. These unicellular, heterotrophic eukaryotes are commonly found in seawater and sediments, with the highest abundance in nutrient-rich areas, such as mangrove forests. Thraustochytrids are reported to be efficient producers of polyunsaturated fatty acids (PUFA) including the n-3 series, such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). These organisms are considered as one of the potential alternative sources of PUFA for commercial and industrial exploitation.

We developed advanced cultivation strategy and breeding method, and applied them on one particular Thraustochytrid strain Schizochytrium AN4 for optimisation of lipids accumulation.

The breeding method aims for selection of the hyper producing sub-population using high-throughput fluorescence-activated cell sorting (FACS) in combination with imaging flow cytometry (IFC) and multiparametric discrimination the cells with both high lipid content and metabolic activity. The method was tested for negative influence on post-sorting cell viability possibly caused by the sorting technique procedure (e.g. high pressure, laser beam exposure, electro-magnetic field, toxic effects of both fluorescent marker and fluidic system medium composition) with no effect compared to non-sorted control sample.

The results show that the breeding method in combination with advanced, highly reproducible, cultivation strategies leads to development of a novel strain, producing more than double content of lipids per cell under the same conditions as untreated original strain.

We expect that an additional outcome of the method and the cultivation strategy will be a set of identified genes and/or complex metabolic adaptations that contribute to increased lipid accumulation and can be taken as aclue for enhanced genetic manipulation.

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Exploring remediation capacity of living factories: adaptive evolution toward efficient phenolic compounds degradation in *Chlamydomonas*

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Water bodies phycoremediation, i.e. using microalgae for pollutants removal, is intensively investigated as a potentially highly efficient and sustainable approach. To this end, scientists either seek for optimal species and growth conditions, or engineer model species to contain transgenic enzymes, often with evident drawbacks such as limited use in the external environment and/or GMO restrictions. An appealing option is to increase cells removal capacity by an adaptive laboratory evolution (ALE) which offers an advantage of multiple parallel non-intuitive mutations compared to targeted engineering, and the resulting strains are not necessarily GMO. So far, ALE has been only used for increasing specific production, not for remediation or degradation processes.

Here, we want to examine for the first time the potential of ALE for increasing pollutant degradation efficiency. As a model pollutant, we chose phenol and several related phenolic compounds (PhC), as many PhC are designed as priority pollutants for which better remediation approaches are intensively sought for, including phycoremediation. Among microalgal species, we chose *Chlamydomonas reinhardtii* (Cre) due to its versatile PhC degradation process. To facilitate automatic selection during ALE, we prepared several strains with variants of a fluorescent biosensor which should reflect the quantity of a PhC degradation intermediate (CCM). Of these strains, we will select the one with the clearest responsiveness (linearity, dynamic range) to CCM and phenol, and we will subject this strain to the ALE process. During this iterative selection process, cells capacity to degrade PhC and the occurrence of degradation intermediates in the cells and media will be regularly controlled using HPLC. After obtaining a stably bred strain with significantly higher PhC degradation efficiency, we will scrutinize its adaptation mechanisms at the molecular, metabolic, and physiological levels. Besides exploring a new approach to increasing bioremediation efficiency, we wish to reveal degradation capacity bottlenecks that might be addressed in future research.

Impact of artificial polyploidization in *Ajuga reptans* on content of selected biologically active glycosides and phytoecdysone

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Artificial polyploidization in plants is a breeding technique used to modify the genome, mainly by doubling (and occasionally further multiplying) chromosome sets. Polyploidization techniques are experiencing a renaissance. One of the reasons could be that this approach is not classified as genetic modification, therefore is increasingly being incorporated into the breeding programs of many interesting crops and aromatic and medicinal plants. One example of such perspective medicinal plant, which is known for its biologically active substances, is *Ajuga reptans* (blue bugle), belonging to the family Lamiaceae. Plants from the genus *Ajuga* have a wide variety of biologically active substances, such as phytoecdysteroids, anthocyanins, carotenoids, diterpenes, and phenylethanoid glycosides. Extracts from this plant species contain two glycosides: trans-teupolioside and trans-verbascoside. Several studies have demonstrated the potential anticancer, anti-inflammatory, and antioxidant effects of this species, which could, therefore, have cosmeceutical and food production applications. E.g. the Italian company ABResearch produces, on the basis of plant cell culture, the substance Teupol 10P containing mainly trans-teupolioside which was proven to be effective in:

- Bening prostatic hyperplasia (BHP)
- Crohn´s syndrome and gastro-intestinal chronic diseases
- Improving the functionality of microvasculature

In addition, *Ajuga reptans* contains also 20-hydroxyecdysone belonging to the class of phytoecdysteroids which have antifeedant effects on herbivores and suppress insect molting suggesting the possible use of *Ajuga* extract as a botanical pesticide.

The plants from the Crop Research Institute (CRI), Prague-Ruzyně, Czech Republic, were used for the extraction. The extracts were analysed using HPLC, LC-MS and LC-NMR. The most affected compound by polyploidization was trans-verbascoside, the content of which was higher in tetraploids compared with diploid progenitors. The nearly two-fold higher trans-verbascoside content in tetraploids, compared to the diploid progenitors, observed in this study indicated that such A. reptans could be used in the pharmacological industry.

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Laser dendrometer

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We developed an electronic non-contact dendrometer, adevice for measuring log thickness (diameter at breast height), as an alternative to the standard forestry caliper. The classic forestry caliper does not contain an electronic part for recording measured data. It is necessary to write this data, usually done manually on paper, and then rewrite it into acomputer and process it. More modern and more expensive forestry calipers are equipped with an electronic recording device. However, working with them still involves several mechanical operations (stretching the measuring jaws, placing them in the desired position, pressing the measuring jaws, writing), which represent obtaining only a single value. For more accurate measurements, it is advisable to repeat the measurement at the same height but measure the diameter perpendicular to the first measured diameter. The device developed by us, unlike the forestry caliper, has no moving parts. The actual measurement is performed by laser sensors, which when moving the device perpendicular to the longitudinal axis of the stem, back and forth, scanning its surface. The data is recorded in the memory of the control mobile phone (control console) and then it is possible to transfer it to a personal computer for detailed processing. From the values obtained (many tens, depending on the size of the trunk), the on-site control console calculates the trunk diameter, its circumference and the cutting area. After transferring the data to acomputer, it is possible to construct the cross-sectional shape of the trunk at the measuring point and to calculate many other data.

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Potential of airborne spectroscopy for asbestos-cement roofs mapping

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Until the 1980s, one of the most common uses of asbestos in homes in many countries was as roofing material. Although asbestos has insulating properties which are highly useful in the construction industry, and it is outstanding in resistance to acids and alkalis and in fire resistance, asbestos fibres inhalation significantly increases the risk of developing asbestos-related diseases (Abós-Herràndiz et al. 2017, Furuya et al. 2018, Janošíková et al. 2020).

The aim of the study was to identify asbestos-cement roofs using airborne hyperspectral data (400 – 2500nm, https://olc.czechglobe.cz/) acquired for two Czech municipalities of Vysoké Popovice and Šošůvka. The first approach was the Spectral Analyst method where spectra of building roofs from airborne data were compared with laboratory spectra from a specific sample with an unknown curve. The result was a probability value of the asbestos-cement spectrum occurring in the image pixel. The asbestos-cement roofing material was identified with a91% probability of asbestos occurrence. The result was validated using ground truth data.

The second approach was a supervised classification. We used Registry of territorial identification, addresses and real estate (RUIAN) data, which was validated over the orthophoto of the State Administration of Land Surveying and Cadastre (ČÚZK) to create roofs mask. The process of airborne hyperspectral data normalization and residual noise reduction was performed using Minimum Noise Fraction (MNF) transformation. Then, the pixel spectra of pure materials were found using pixel purity index with asetting of 10,000 iterations and athreshold of 2.5 standard deviations. Next, we selected end-members as inputs to the classification with the Spectral Angle Mapper (SAM) method followed by accuracy evaluation using ground truth data. The accuracy of asbestos-cement roofs identification was 68 %.

Study results can be interesting for organizations involved in the improvement of settlements, in architectural planning and environmental protection. Potentially, results can help in planning to use modern insulation roof materials to contribute to adaptation/mitigation environmental programs.

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