

ODBORNÝ SEMINÁR • ZVOLEN • 22. OKTÓBER 2024

Zborník posterov z odborného seminára

KLIMATICKÁ ZMENA V NAŠICH REGIÓNOCH 3.0

Ekosystémové služby v podmienkach meniacej sa klímy



Katedra prírodného prostredia Lesníckej fakulty Technickej univerzity vo Zvolene a odborní partneri pripravili seminár zameraný na aktuálne výsledky ekologického, bioklimatologického a hydrologického výskumu dopadov klimatickej zmeny v stredoeurópskej krajine.

MIESTO

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Študentská 2117/27, Zvolen

DÁTUM

22. október 2024

Ekosystémové služby × bioklimatológia × hydrológia × fyziológia drevín

Výskum, meranie a adaptačné súvislosti klimatickej zmeny

Odborný program

- Klimatická zmena v našich regiónoch
Bernard Šiška
- Experimentálna hydrológia, jej význam a budúcnosť
Miroslav Tesař
- Lesy, ich ekosystémové služby a meniaci sa klíma
Viliam Pichler
- Meteorologické požiarne nebezpečenstvo horských smrečín v Západných Tatrách
Jaroslav Škvarenina
- Fenologická odozva buka lesného na suchu a horúce vlny
Veronika Lukasová
- Reakcie a adaptácie stromov na meniacu sa klimatickú situáciu
Jiří Kučera
- Sekvestrácia uhlíka v lesoch s rôznym stupňom prirodzenosti
Michal Bošeľa
- Fyziologické aspekty prežívania drevín v podmienkach sucha
Daniel Kurjak
- Separácia tokov CO₂ a H₂O nad lesným porastom
Peter Fleischer

Posterová sekcia

Štyri príspevky v pôvodnej grafickej úprave

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Effects of drought and disturbance on the CO₂ and CH₄ fluxes in a mixed forest and spruce monoculture

Michal Bosela¹, Peter Marcis¹, Dominik Poltak¹, Jerguš Rybár¹, Peter Fleischer¹, Erika Gömöryová¹, Jaroslav Vido¹, Paulína Nalevanková¹, Boris Tupek², Aleksi Lehtonen², and Raisa Mäkipää²

¹Technical University in Zvolen, Faculty of Forestry, T.G. Masaryka 24, 96001, Zvolen, Slovakia

²Natural Resources Institute Finland (Luke), Latokartanonkaari 9, FI-00790 HELSINKI

Test site Dobroš, Slovakia
Elevation: 970 m asl

Species:
Spruce: *Picea abies*
Mixed: *Fagus sylvatica*, *Fraxinus excelsior*, *Acer pseudoplatanus*, *Abies alba*, *Picea abies*
Soil type: deep Cambisols

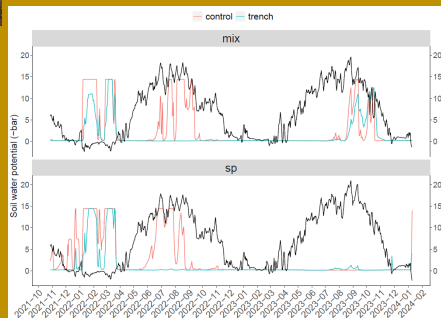
Mixed stand: 150-yr-old in a buffer zone of the Dobroš primary forest (no intervention)
Spruce stand: 65-70 years old spruce monoculture, barkbeetle outbreak, clear cut in Sept 2023



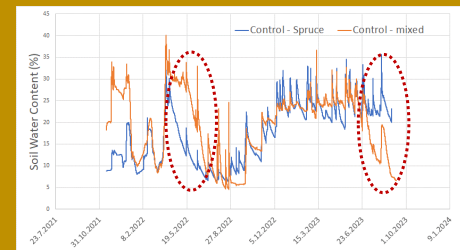
2023 clear-cut following bark-beetle outbreak



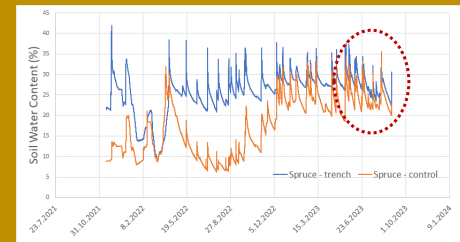
Soil microclimate



Control plots – spruce versus mixed stand



Spruce stand – trench versus control plots



Motivation

- Spruce monocultures have been intensively planted across a wide area of Europe
- Evidence suggests that trees in monocultures may not be as resilient to drought spells and heat waves as mixtures of two or more species
- It remains unclear how drought events, heat waves and disturbances affect carbon sequestration in the soil and how it differs between mixed forests and species monocultures

Methods

- Monitoring of soil CO₂ and CH₄ using LI-COR LI-7810 Analyzer since August 2021
- Trenching plots to separate heterotrophic (trench) from the total forest floor (control) respiration established in May 2021
- Continual measurements of soil water content, soil water potential, and forest microclimate
- Continual measurements of tree radial changes (tree water deficit) using band dendrometers
- Tree ring samples to quantify long-term tree and stand growth and resilience to climate events

Results

Results

- Total root biomass is similar in spruce and mixed stand, but the proportion of fine roots is higher in the mixed stand.
- Carbon stock in above-ground biomass as well as in the soil is higher in the mixed stand.
- In general, CO₂ fluxes were higher in the mixed stand than in the spruce stand.
- CO₂ fluxes were significantly lower in the spruce stand during the drought periods.
- CO₂ fluxes significantly differed between spruce and mixed stand when the soil was warmer than 12°C.
- Heterotrophic CO₂ respiration was more soil-moisture-sensitive in the spruce stand at higher soil temperatures.
- Methane is oxidised to CO₂ in the soil, however, the it is significantly reduced after the clear-cut following the bark-beetle disturbance in 2023.
- We found a long-term decrease in above-ground biomass increments in the spruce stand, while no change in the mixed stand.
- Spruce was far more sensitive to the 2022 drought than silver fir and European beech.

Above-ground (AGB) and below-ground (BGB) biomass

Site	C of AGB (t/ha)	Density (trees ha ⁻¹)	AGB incr (t ha ⁻¹ yr ⁻¹)	C AGB+BGB (t ha ⁻¹ yr ⁻¹)
Spruce	180	433	6.9	9.6
Mixed	233	278	6.5	8.3

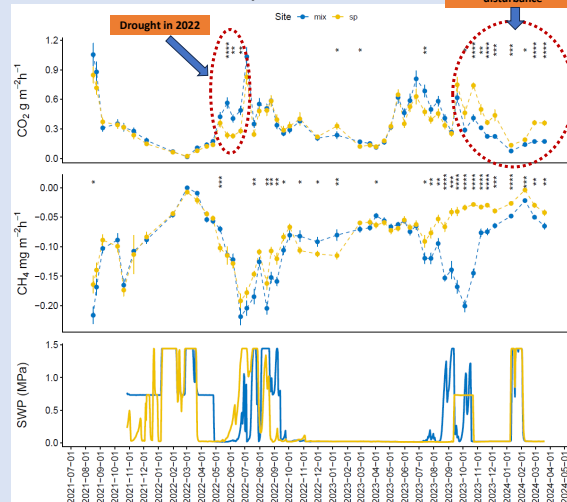
Biomass of roots in a depth of 50 cm

Site	Total weight (t ha ⁻¹)	Share of fine roots (%)
Spruce	12.36	15
Mixed	13.81	28.5

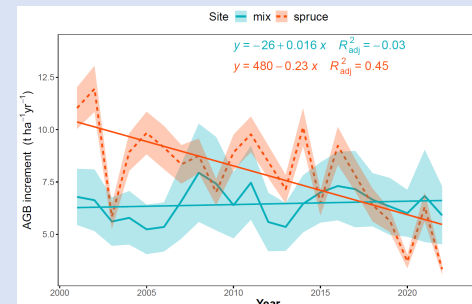
Soil carbon stock in 80 cm depth

Site	C soil (t ha ⁻¹)	% of AGB
Spruce	126	59
Mix	135	46

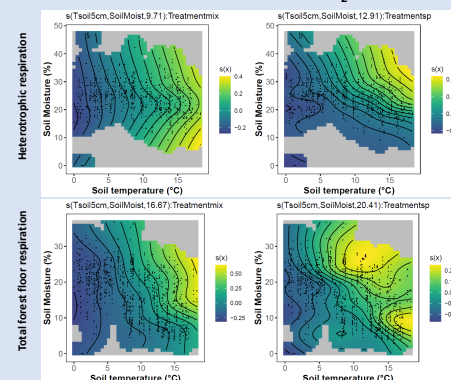
CO₂ and CH₄ fluxes – total forest floor respiration



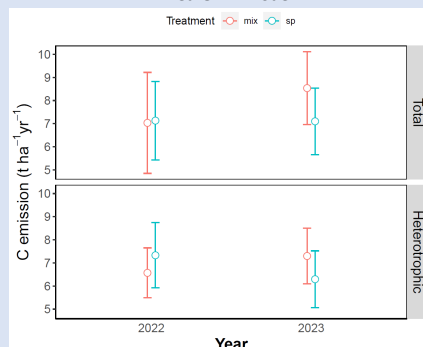
The trend in the above-ground biomass increment



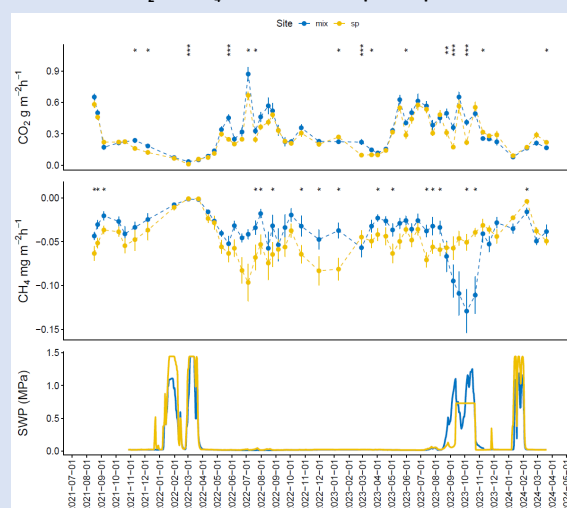
Mixed-effects GAM model of CO₂ fluxes



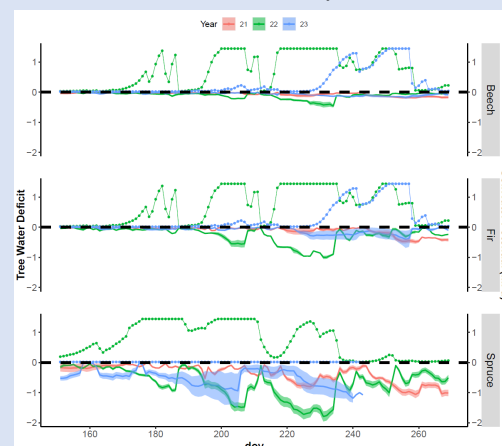
Total annual carbon emissions as modelled by the mixed GAM model



CO₂ and CH₄ fluxes – heterotrophic respiration



Tree Water Deficit measured by dendrometers



Acknowledgement

The work has been supported by the grant Holistic management practices, modelling and monitoring for European forest soils – HoliSoils (EU Horizon 2020 Grant Agreement No. 101000289) and the Slovak Research and Development Agency via project No. APVV-19-0183



Helping humans to adapt honeybees to climate change:
A new ecological approach to master this challenge

Michaela Korená Hillayová, Ľubomír Korený, Ján Holécý, Jaroslav Škvarenina
Technical University of Zvolen, Faculty of Forestry



One-way humans can help bees adapt to climate change is to reduce the use of „hard“ chemicals in beekeeping. Using organic preparations to prevent and treat bees from deadly diseases such as varroosis benefits sustainable beekeeping, a higher yield of quality bee products, and reduced operating costs.

Varroosis is the most devastating honeybee disease worldwide, causing more damage and higher economic costs than all other known beekeeping diseases. In bee colonies attacked by *V. destructor*, there will be an overgrowth of parasitic mites and, if untreated, the entire bee colony will eventually collapse. That is why successfully controlling Varroa mites should be a natural part of every beekeeper's activity. Currently, total control of varroosis is demanded worldwide, which includes beekeeping management without the use of antibiotics and harsh chemicals, which is included in the concept of organic beekeeping and leads to a decrease in the percentage of mortality of individual bee families after the winter period. In the research, we focus on expanding knowledge about the effectiveness of managing bee colony treatment against varroosis using environmentally safe preventive means. Methodically, we propose and test the use of a combination of chemical (phytotherapy), mechanical (use of varroa board in the hive) and hygienic (disinfection of hives with fire and subsequent application of propolis tincture) methods of varroosis control, which we compare with the use of a preventive veterinary agent for the treatment of varroosis and acarapidososis. The results of our study show that using locally growing plants to treat varroosis is a suitable way to reduce infestation in bee colonies in the long term. The management of beekeeping we designed has achieved, in the long term, a highly significant decrease in infestation in monitored beehives with a multi-year application of herbal decoctions.

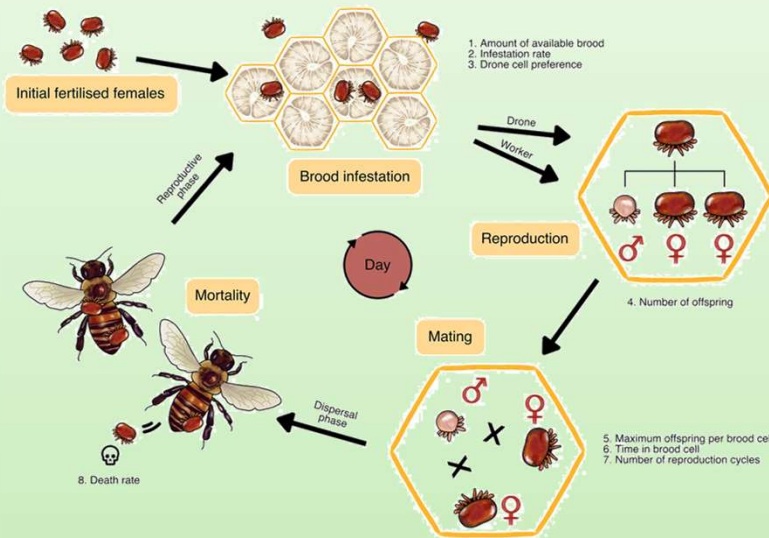


Figure 1. A gene drive in populations of the honey bee parasite *Varroa destructor* (Source: Faber et al. 2021). *Varroa destructor* is an insect parasite growing to an average size of 1.5 mm. Females are larger than males and have round, flat bodies of brown colour. Males have a longer and slimmer body. Both sexes have eight legs and are covered with fine hairs.

It works even without "hard" miticides!

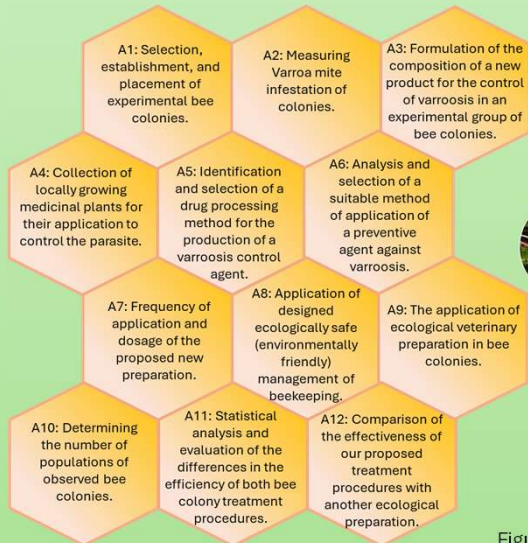


Figure 2. Methodical procedure for achieving ecologically friendly beekeeping. By following these methodological procedures, the incidence of *V. destructor* can be reduced to a minimum infestation below 0.1%.

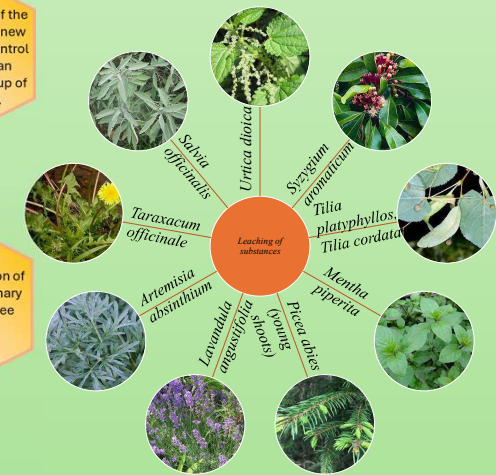


Figure 3. Identification and selection of plants with proven content of organic compounds against varroosis. These plants grow gradually throughout the entire beekeeping season in the territory of central Slovakia. They contain active substances to reduce the mite population.

The part of the plant used / The period of decoction application	March	April	May	June	July	August	September	October	November
Urtica dioica	The whole plant								
Tilia	Flower								
Mentha piperita	Leaf and stem								
Syzygium aromaticum	Flower								
Picea abies	Young shoots								
Artemisia absinthium	Leaf								
Lavandula angustifolia	Flower								
Salvia officinalis	Leaf								
Taraxacum officinale	Flower and leaf								

Figure 4. Combinations of plants for decoction in a given month according to growth and flowering in the locality of central Slovakia. The correct combination and application of plants in the decoction can prevent varroa resistance.

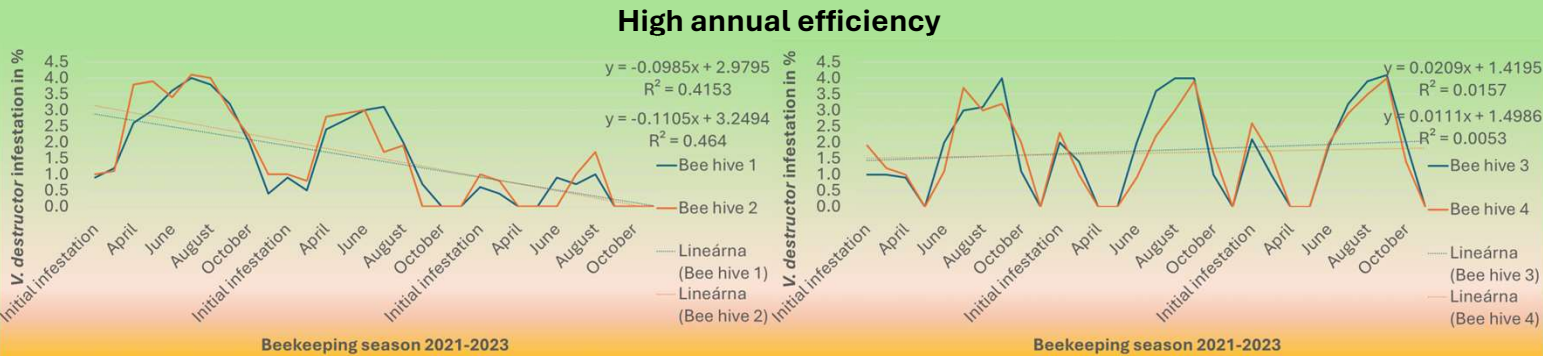


Figure 5. Development of the time trend of interannual infestation in the monitored groups of bee colonies. The figure on the left shows that the treatment of bees against varroosis we proposed is more effective in the long term than treatment with common ecological preparations (Ekopol, Bisanar, etc.).

VPLYV MENIACICH SA PODMIENOK PROSTREDIA NA VODNÝ REŽIM BUKA A SMREKA V JEDĽOVO-BUKOVOM LESNOM VEGETAČNOM STUPNI

Nalevanková P., Popadič P., Střelcová K., Vido J., Technická univerzita vo Zvolene, Slovensko

Úvod

Vplyv zmeny klímy na lesné ekosystémy sa v posledných desaťročiach značne zintenzívňuje. Jej dôsledky, najmä zmena v distribúcii zrážok a zníženie ich dostupnosti v rámci vegetačnej sezóny sprevádzané dlhými vlnami horúčav, negatívne ovplyvňujú vitalitu a tiež samotné prežívanie jedincov drevín, ale aj celých porastov, ktoré ináč plnia významnú stabilizačnú funkciu krajiny. Znížená dostupnosť disponibilnej vody v pôde a vysoké evaporačné požiadavky ovzdušia drevinám spôsobujú stres, ktorý ovplyvňuje životne dôležité fyziologické procesy a často priamo alebo sekundárne spôsobuje ich úmrtie. Bezprostredné reakcie stromov na meniace sa podmienky prostredia alebo na extrémne meteorologické udalosti dnes dokážeme pozorovať prakticky „v priamom prenose“ prostredníctvom monitorovania fyziologických procesov a ich prejavov. Intenzita transpiračného prúdu a tiež jemné zmeny obvodu kmeňov stromov (vrátane odvodených ukazovateľov) nám poskytujú informácie o hospodárení jednotlivých druhov drevín s vodou a tiež o ich vodnom statuse. Vieme skúmať ich zmeny ako odozvu na vplyv podmienok prostredia a na základe toho ich modelovať v budúcich podmienkach. Štúdium reakcií našich významných drevín na meniace sa poveternostné podmienky a rôzne úrovne zásobenia vodou, či rôzne teplotné extrémy má význam pre predikciu dopadov zmeny klímy na ich rozsiahle spoločenstvá, ale aj pre plánovanie budúcich lesníckych opatrení rešpektujúcich predpovedaný zmenený režim environmentálnych faktorov. Zmeny vo fyziologických procesoch zároveň môžu byť spoľahlivým skorým indikátorom pôsobenia rôznych stresových faktorov ohrozujúcich ich vitalitu, zdravie a prežívanie.

Materiál a metódy

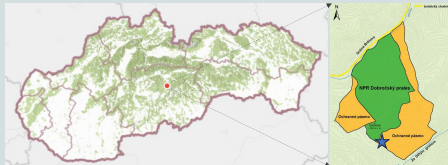
Výskumná plocha sa nachádza v tesnej blízkosti NPR Dobročský prales, v strednej časti Veporských vrchov, v jedľovo-bukovom LVS. Horniny – hlbinné granitoidy s ich metamorfným plášťom. Pôdy – kambizeme, hlboké až veľmi hlboké, s vysokým obsahom humusu. **Vzorníky** pre monitorovanie transpiračného prúdu a zmien obvodov kmeňov – 2 dospelé buky (*Fagus sylvatica* L.) v ochrannom pásme NPR, zmiešaný les, $d_{1,3}$ 50 cm a 45.5 cm a 2 dospelé smrek (*Picea abies*) v blízkom hospodárskom lese, $d_{1,3}$ 41.7 cm a 40.4 cm.

Meranie podmienok prostredia: globálna radiácia, teplota a vlhkosť vzduchu – RTHi sensor (EMS Brno, CZ).

Zrážky – Pronamic Pro gauge (200 cm²) doplnený o Minikin ERI datalogger (EMS Brno, CZ). Sýtosťný doplnok a potenc. evapotranspirácia odvodené z meraní.

Vodný potenciál pôdy (10, 25, 50 cm hĺbka) – MicroLog SP3 (EMS Brno, CZ) + sadrové bločky(Delmhorst Instrument, U.S.A).

Sap flow a zmeny obvodu kmeňov: Sap flow system EMS81 (THB method) a dendrometer DRL26E (EMS Brno, CZ).



Výsledky

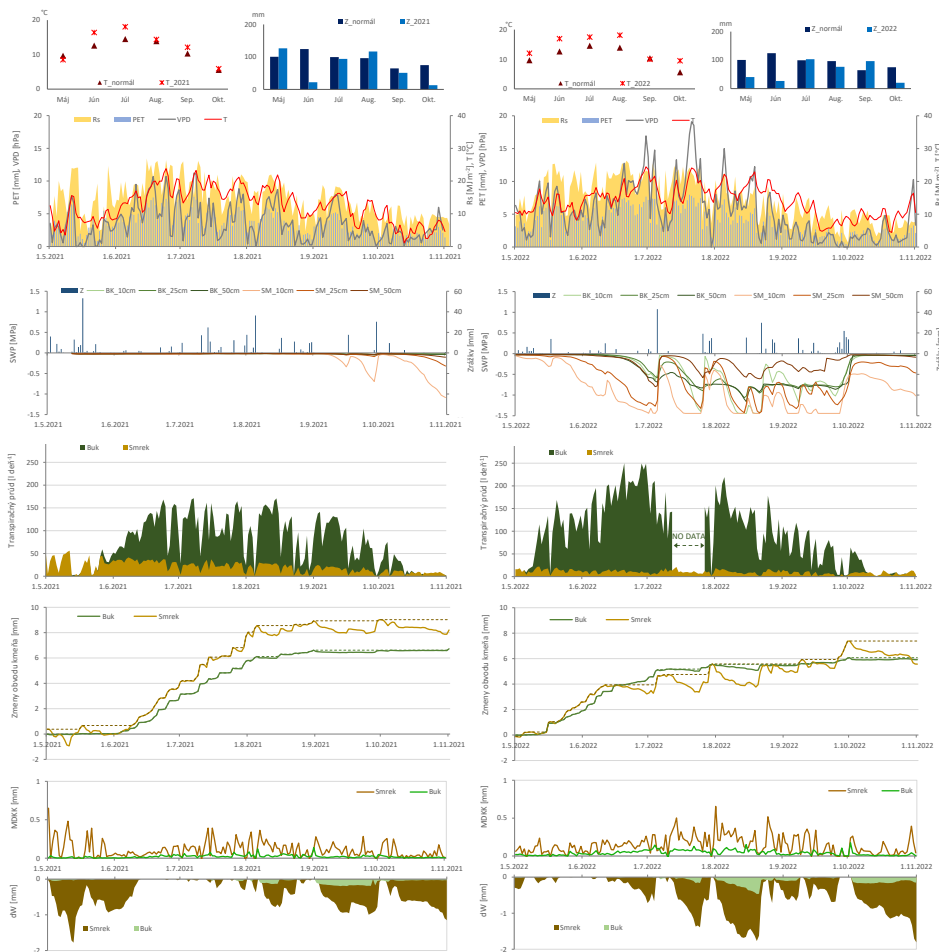
Merania sa realizovali v priebehu vegetačnej sezóny (01. 05 do 31. 10) rokov 2021 a 2022. Zo študovaného obdobia bola práve vegetačná sezóna 2022 charakteristická priemernými teplotami výrazne prevyšujúcimi normál (okrem septembra). V danej vegetačnej sezóne bol zároveň zaznamenaný vysoký zrážkový deficit (196 mm), ktorý sa prejavil výskytom období so zníženou dostupnosťou pôdnej vody.

Dynamika vodného režimu smreka obyčajného a buka lesného je výrazne ovplyvnená meniacimi sa podmienkami prostredia, najmä dostupnosťou pôdnej vody a meteorologickými extrémami. V mimoriadne suchom roku 2022 bol aj v nadmorskej výške viac ako 900 m n. m. zaznamenaný výrazný pokles intenzity transpiračného prúdu a tiež stagnácia narastania obvodov kmeňov. Merania na kmeni stromov detegovali pôsobenie stresu suchom, výraznejšie u smreka. Odzrkadlilo sa to na výraznej limitácii procesu transpirácie (v sezóne 2022 napríklad celková transpirácia u smreka bola o 52 % menšia ako v predošlej sezóne) a rovnako kumulovanom zmršťovaní obvodov kmeňov stromov, znížení celkového sezónneho prírastku na obvode. Buk jednak vďaka hlbšej koreňovej sústave, ale predpokladáme, že aj vďaka prírodnému lesnému ekosystému (zmiešaný porast), ktorého je súčasťou (ochranné pásmo NPR, lepšia úroveň SWP), preukázal vyššiu odolnosť voči nedostatočnej distribúcii zrážok v danej lokalite. Spolupôsobenie stresu suchom a vlny horúčav sa pravdepodobne podieľali na oslabení smrekových jedincov do takej miery, že v nasledujúcom roku podľahli napadnutiu lykožrúta smrekového a v júly 2023 boli vyťažené. Sucho sa stalo predispozičným faktorom pre následné zničenie porastu iným škodlivým činiteľom.

Analýzou údajov sme ďalej potvrdili štatisticky významný vplyv faktorov prostredia na mieru transpiračného prúdu, pričom sme však v roku 2022 oproti roku 2021 zaznamenali pokles v tesnosti týchto vzťahov. Daný jav pripisujeme práve abnormálnym podmienkam prostredia nastoleným v roku 2022 – enormný deficit zrážok, vysoké teploty a evaporačné požiadavky ovzdušia.

Všeobecne, výška transpirácie bola u dreviny buk násobne vyššia ako u smreka. V optimálnych podmienkach pretranspiroval buk 250 l/deň, pričom zaznamenané maximum smreka bolo 56 l/deň.

Výsledky výskumu zdôrazňujú dôležitosť monitorovania fyziologických reakcií stromov na meniace sa klimatické podmienky, čo môže byť kľúčové pre efektívne riadenie a adaptáciu lesných ekosystémov v kontexte prebiehajúcich klimatických zmien.



Priebeh transpiračného prúdu (SF), zmien obvodu priemerného kmeňa a vodného deficitu kmeňa (dW) buka lesného a smreka obyčajného (stredná časť), zobrazené s globálnou radiáciou (Rs), sýtosťným doplnkom (VPD), potenciálnou evapotranspiráciou (PET), vodným potenciálom pôdy v jednotlivých hĺbkach (SWP) a dennými úhrnmi zrážok (P) v roku 2021 (vľavo) a 2022 (vpravo)

TREE SAP FLOW AS AN IMPORTANT COMPONENT OF FOREST ECOSYSTEMS' EVAPOTRANSPIRATION IN THE CONTEXT OF CHANGING ENVIRONMENTAL CONDITIONS: MONITORING AND USE OF ONLINE TRANSMISSION IN THE EDUCATIONAL PROCESS



Nalevanková Paulína¹, Hanzelová Miriam¹, Lukáčik Ivan², Vido Jaroslav¹



¹Dep. of Natural Environment, Faculty of Forestry, Technical University in Zvolen, T.G. Masaryka 24, 960 01 Zvolen, ²Arborétum Borová hora, Technical University in Zvolen, Borovianska cesta 2171/66, 960 01 Zvolen, Slovakia

With this contribution, we aim to present a newly built on-line biometeorological laboratory, that through a web application in a user-friendly way depicts or/and examines the response of physiological processes of plants (biological component of the landscape) and soil moisture characteristics to changes in environmental conditions (abiotic component) and its interactions in-situ in real time. The project bring modern live streaming of processes taking place in woody plants – sap flow and stem circumference changes – and in the environment, as well as their reactions to changing atmospheric conditions directly to user's mobile phone and computer. The main advantage of the online educational laboratory is the possibility to display and analyze current data, as well as the ability to work with historical data in a cloud environment without the need to install additional software. This makes the laboratory a unique interactive education tool for students and also for the public users. Interactivity, online and cloud accessibility allow the high usability of the biometeorological laboratory in distance education, which significantly increases the efficiency and accessibility of the educational process, improves the level of awareness of functional relationships between physiological processes in the country and the weather, thus supporting system education.



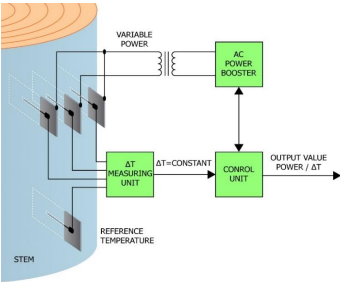
◀ Location of the area of interest – Arborétum Borová hora
Meteorological station ABH ▶



All measurements for the needs of **on-line Biometeorological Laboratory** are carried out in the “Arborétum Borová hora (ABH)” arboretum, which is an organizational part of the Technical University in Zvolen. ABH is located in the Middle Hron basin, and the territory has the character of a hilly area with an altitude range from 291 m to 377 m. Climatically ABH belongs to a warm area - a warm, slightly humid district with a cold. The long-term mean annual air temperature and annual sum of precipitation are 7.9 °C and 651 mm, respectively. **Sap flow** is measured on *Betula Pendula* tree trunk by Sap flow system EMS 81 developed by Environmental Measuring Systems (EMS), Ltd. (Brno, Czech Republic). The system uses a tissue heat balance method (THB, Kučera et al., 1977; Čermák et al., 2004) based on volume (three-dimensional) heating of the stem segment to measure the values of volumetric sap flow directly in kg of water per a specific period and per one centimetre of stem circumference. The Sap flow system is supplemented with the dendrometer DRL26E (EMS, Ltd., Brno, CZ). DRL26E records reversible changes in stem circumference, which reflect the tree water status and are closely related to the transpiration process.

Meteorological variables are measured within an open area by an automatic meteorological station situating near the sample tree. The station is equipped with an air temperature and relative humidity sensor (both 0,5 m and 2 m above ground) and a global radiation ($W\ m^{-2}$; 10 m above ground) sensor (2x EMS33S and EMS11S; (EMS), Ltd., Brno, CZ). Wind speed ($m\ s^{-1}$) and direction is monitored using an ultrasonic anemometer Atmos 22 (Meter Group, Inc. Pullman, WA, USA) at a height of 10 m, and precipitation (P, mm) is measured using a rain gauge Pronamic Pro (Pronamic ApS, Skjern, Denmark; 1 m above ground). Soil temperature in two depths (0,15 and 0,3 m) is measured via RTDx2/S sensor manufactured by EMS Brno (CZ). In addition, derived parameters such as vapor pressure deficit (Pa), potential evapotranspiration (mm), Dew Point (°C), water balance PET 30D (mm) and fire index are listed.

The data is stored in 10-minute intervals to the N2N datalogger and are transferred to the cloud storage using a GPRS modem. All measured (physiological & meteorological) and derived data are **visualized** on the Technical University in Zvolen web site ▶ **Biometeorologický monitoring** and are available to students and the general public 24 hours a day, 7 days a week.

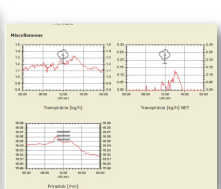
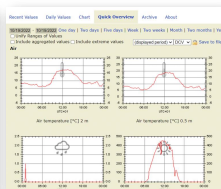
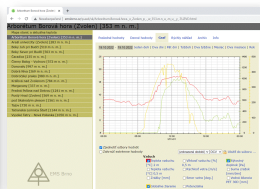


Sap Flow System produced by Environmental Measuring Systems, Ltd. (Brno, Czech Republic) installed on the tree trunk and the flows chart of measuring process.
Sap flow values are calculated directly from the P/dT ratio (Nalevanková et al. 2020)

Meteorological station ABH and sample tree, students during lesson

The project of online BioMeteorological laboratory focuses on the relationships in the soil-water-plant-atmosphere system. The main theme is the process of transpiration as a main part of potential evapotranspiration influenced by the synergistic action of internal but mainly external factors. Modern methods of physiological and meteorological monitoring and data transferring bring us the possibility to observe or/and examine the response of physiological processes of plants (biological component of the landscape) and soil moisture characteristics to changes in environmental conditions (abiotic component) and its interactions in-situ in real time. In-situ measurements of tree sap flow enable the analysis of derived forest transpiration and also the water state of the entire ecosystem, . The process of water transport (by sap flow) and transpiration through vegetation organisms are strongly influenced by the synergistic effect of numerous external factors, some of which are predicted to alter due to climate change. Therefore, there is currently a great emphasis on understanding the response of the physiological processes of individual tree species to changing environmental conditions and especially to extreme events (drought, heat waves). The online BioMeteorological Laboratory makes it possible to detect, display and analyze the relationships between environmental weather conditions, soil temperature and the physiological response of selected (measured) trees in real time.

Users can choose any combination of variables for online display, they can download data from the cloud and work with it further, including in the Mini32 software (EMS, Ltd., Brno, CZ), which is an irreplaceable tool in the analysis of meteorological data, sap flow and data from dendrometers. Interactivity, online and cloud accessibility enable a high degree of use of the biometeorological laboratory in higher and especially distance education, which fundamentally increases the efficiency and accessibility of the educational process, also improves the level of awareness of functional relationships of the interconnectedness of physiological processes and the weather, thus supporting systemic education. The next step will be to improve the visual interface and create a separate application that will integrate all available measurements with online transmission in a user-friendly and user-attractive way, and to increase the usability of the application. We also plan to extend the measurements to other individuals and different types of trees with various requirements for environmental conditions and reactions to extreme events. At the same time, we plan to add soil water potential measurements to the presented monitoring system to show a soil water regime, because water availability is the limiting factor of physiological processes.



Biometeorological Laboratory URL ▶
Web visualization of data ◀