



6. DWB Student Conference 2021: Forest and Soil Science *update*

Book of Abstracts

17. May 2021, Vienna



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Masterseminar 910301, and

Dissertantenseminar 910400

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Program

The **6th DWB Student Conference 2021: Forest & Soil Science *update*** takes place on **May 17th, 2021 (1-6 pm CEST)**. Presentations are given **ONLINE (ZOOM)** in **2 parallel sessions** due to the restrictions during the COVID19 pandemic situation.

Participants are kindly asked to check their presentation before the conference or during breaks with a host / co-host for functionality. Please use a headset or mute yourself if not talking. If your internet connection permits, we kindly ask you to keep your webcam on, enhancing communication. Participants are strongly encouraged to comment on other presentations during the conference (if time permits), or later via email, or by any other means. Please *keep the given time limits* strictly!!

Posters are available on <https://boku.ac.at/wabo/departmentskolloquium> (after login) until further notice. Poster can be presented by any means (original pdf of Poster, 3-4 pptx slides etc.).

Session 1 (IFE, IBF) ZOOM link (from 12.40 noon):

<https://bokuvienna.zoom.us/j/7926628609?pwd=eXh5NjNDSONTOGxmK1BHRk9PMmNWdz09>,
Meeting ID: 792 662 8609, Passcode: 359643

Time	Presenter	Title
13.00	<i>IFE - Matthias Steinparzer</i>	Mixtures matter: Integrating tree species identity and diversity on PM absorption
13.15	<i>IFE - Anne C. Fitzky</i>	Constitutive VOC emissions of four common European tree species
13.30	<i>IBF - Raphael Vetter</i>	Estimation of greenhouse gas emissions of a cropland in the pre-alpine region: A modelling approach
13.45	<i>IBF - Nathalie Triches</i>	Effects of soil temperature, soil moisture and topography on CO ₂ , CH ₄ and N ₂ O fluxes from a temperate upland forest soil
14.00-14.30	Poster Session 1.1 & Coffee Break	<p><i>IFE - Maximilian Behringer.</i> The influence of forest site preparation on soil functions of an alluvial forest in the upper Rhine valley, Vorarlberg</p> <p><i>IBF - Ulises R. Esparza Robles.</i> Understanding the role of agricultural soils in meeting societal challenges outside Europe as a reference framework on climate-smart sustainable management</p> <p><i>IBF - Lauren Herold.</i> Effect of hedge rows on soil properties and functions</p> <p><i>IFE - Anna Schrötter.</i> Morpho-functional classification of humus forms using the TerrHum-App: correlation of morphological indicators and standardised laboratory analysis parameters</p>

Program

14.30	<i>IBF - Philipp Steiner</i>	The potential of pioneer management systems to improve soil organic carbon
14.45	<i>IBF - Andreea Spiridon</i>	Phytosiderophore release of contrasting barley (<i>Hordeum vulgare</i>) cultivars grown in Zn and Cu deficient soils
15.00	<i>IBF - Julia Fohrafellner</i>	Cover crops affecting pool specific soc sequestration in european cropland – A meta-analysis
15.15	<i>IFE - Robin M. Kotsia</i>	How do ectomycorrhizal decomposition traits change along a chronosequence of two different tree hosts on an afforested area?
15.30	<i>IBF - Christoph Noller</i>	Effect of EDTA-soil washing on the microbial community and mesofauna
15.45-16.15	Poster Session 1.2 & Coffee Break	<p><i>IBF - Uxue Otxandorena Iregi.</i> The mystery of root exudation: Do sampling conditions affect observed root exudation?</p> <p><i>IBF - Frederik Philipssen.</i> A SOC Hedgerow Model: Assessing effects of hedgerows on C-fraction dynamics and sequestration potentials in cropland soils of Lower Austria</p> <p><i>IBF - Philipp de Jong.</i> Potentials and limits for an increase of soil organic carbon (SOC) stocks in arable fields under different crop residue and tillage management</p> <p><i>IBF - Gabriela Villalba.</i> Methanotrophic Soil Microbial Communities under extreme weather events and enhanced N inputs</p> <p><i>IBF- Ara Bitar.</i> Determination of multielement and isotopic patterns by mass spectrometry to trace the origin of primary agricultural products</p>
16.15	<i>IFE - Alexander Dovas</i>	Comparison of water absorption and release properties of natural, hybrid and synthetic hydrogels and their potential as soil amendments
16.30	<i>IBF - Mike Rohling</i>	Influence of ammonium fertilization and clay amendments on caesium dynamics in the soil
16:45	<i>IBF - Anna Carolina de Azevedo Barbosa</i>	Understanding of adsorption and degradation of halogenated hydrocarbons at mineral surfaces
17:00	<i>IBF - Christina Hummel</i>	<i>In situ</i> visualization of phosphorus mobilizing processes in the rhizosphere of <i>Zea mays</i> L. in the field
17.15	<i>IBF - Theresa Ugochukwu Ukwamedua</i>	Development of physical-biological filter for groundwater remediation

17.30-18.00	Poster Session 1.3	<p><i>IBF - Celia Fernández Balado.</i> Conducting microcosm experiments to select suitable combinations of biochar and pollutant-degrading microbial consortia</p> <p><i>IBF - Tobias Kloimböck.</i> Phytosiderophore release and Fe-uptake during plant development in barley lines differing in micronutrient efficiency</p> <p><i>IBF - Henning Schwalm.</i> The role of rhizosphere traits in phosphorus efficiency of upland rice</p> <p><i>IBF - Usama Rahman.</i> Quantifying the involvement of microbial processes in the phosphate turnover in the soil system using a ¹⁸O-PO₄ labelling approach</p>
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Institute Abbrev.: IBF, Soil Sciences; IFFFF, Entomology; FT, Forest Technology; Waldbau, Silviculture; WAFO, Forest growth; IFE, Forest ecology

Session 2 (FT, Waldbau, WAFO, IFFF) ZOOM link (from 1 pm):

<https://bokuvienna.zoom.us/j/97472951852?pwd=L2VzNIN3Y0p4RVhsVFVlVDJnTmF1UT09>,

Meeting-ID: 974 7295 1852, Passcode: 250483

Time	Presenter	Title
13.00	<i>FT - Stephan Böhm</i>	A comparative view on cable-yarding productivity
13.15	<i>FT - Alexander Vilsmeier</i>	Assessment catalogue for the comparison of relevant cable yarder parameters
13.30	<i>Waldbau - Werner Toth</i>	Development and application of IT-supported collaborative planning methods considering uncertainty for advising sustainable development
13.45	<i>FT - Jana Pirolt, Markus Pirker</i>	Einsatz eines personengetragenen Laserscanners zur automatischen Detektion und Vermessung von Forststraßenquerprofilen
14.00-14.30	Poster Session 2.1 & Coffee Break	<p><i>WAFO - Markus Tonner.</i> Development and evaluation of automatic algorithms for the dynamic measurement of wood chip stockpiles using different terrestrial laser scanning systems</p> <p><i>WAFO - Stephan Außerwöger, Matthias Stelzer.</i> Heizwertzuwachs und Trockensubstanzverlust durch Lufttrocknung von gelagertem Rundholz</p> <p><i>FT - Lukas Weigl.</i> Fossil-free forestry: Utopia or a way out into the future?</p>

Program

14.30	WAFO - Jakob Seywald	Vermessung liegenden Holzes mithilfe terrestrischer Laserscans
14.45	WAFO- Sabine Schweitzer, Martin Winder	Digitale Waldinventur mit dem iPad-Laserscanner
15:00	WAFO - Manuel Wessely	Evaluierung des Einsatzes videogrammetrischer Punktwolken zur Positionsbestimmung und Durchmesser-messung von Bäumen im Vergleich zu PLS-Daten
15.15	Waldbau - Sophia Gruber	Genetische Untersuchung der Artidentität und Autochthonie ausgewählter Stieleichenbestände im Kamptal in Niederösterreich
15.30	Waldbau - Urban Ammerer, Alfred Eisner, Sander Hommes	Entwicklung einer Douglasienaufforstung auf Kalk
15.45-16.15	Poster Session 2.2 & Coffee Break	<p><i>Botanik - Greta Dobetsberger.</i> Wachstum von Bäumen auf einer Wiederbewaldungsfläche einer Finca der Tropenstation La Gamba, in der Region Puntarenas, Costa Rica</p> <p><i>Waldbau - Martin Eder, Hubert Goldberger.</i> Waldbauliche Analyse von Fichten-Lärchenwäldern aus Hochlagenaufforstungen beim Murursprung (Lungau /Salzburg)</p> <p><i>Waldbau - Mathias Klien, Michael Klien.</i> Vergleich der heimischen Weißtanne mit Provenienzen aus Südosteuropa anhand eines regionalen Provenienzversuches in Vorarlberg</p> <p><i>IFFF - Dragana Petrovic.</i> Untersuchungen zu etwaigen non-target Effekten an landwirtschaftlichen Nutzpflanzen durch das <i>Verticillium nonalfalfae</i> - Isolat Vert56</p>
16.15	Waldbau - Stella A. Waszilovics, Mirijam Zimmermann	Waldbauliche Analyse einer Zirbenaufforstung in Winklern/Kärnten
16.30	WAFO - Tina Annett Grätz	Evaluation of reforestation in high altitudes
16.45	WAFO - Florian Welser	Intra-annual radial tree growth of Norway spruce (<i>Picea abies</i>) and Swiss stone pine (<i>Pinus cembra</i>) at high elevation sites in Tyrol
17.00	IFFF - Lukas Vonmetz	Spatial spread of the <i>Wolbachia</i> strain wCin1 in <i>Rhagoletis cingulata</i>

17.15	<i>IFFF - Abdelhady Elshal</i>	<i>Wolbachia</i> dynamics in the invasive American cherry fruit fly, <i>Rhagoletis cingulata</i>
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Table of Content

Oral presentations.....	9
Poster presentations.....	11
Abstracts.....	13
Institute of Forest Ecology.....	13
Institute of Soil Research.....	19
Institute of Forest Engineering.....	40
Institute of Silviculture.....	44
Institute of Forest Growth.....	50
Institute of Forest Entomology, Forest Pathology and Forest Protection.....	57
Other BOKU Institutes.....	60
Index of contributors.....	61

PRINTING: Please note that the document has been optimized for duplex mode / printing on both sides.

Oral presentations

(in Alphabetical order (last name), Institute - first author(s))

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IFE - Alexander Dovas. Comparison of water absorption and release properties of natural, hybrid and synthetic hydrogels and their potential as soil amendments

IFFF - Abdelhady Elshal. *Wolbachia* Dynamics in the Invasive American Cherry Fruit Fly, *Rhagoletis cingulata*

IFE - Anne Charlott Fitzky. Constitutive VOC emissions of four common European tree species

IBF - Julia Fohrafellner. Cover crops affecting pool specific SOC sequestration in European cropland – A meta-analysis

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Poster presentations

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FT - Lukas Weigl. Fossil-free forestry: Utopia or a way out into the future?

Abstracts

Institute of Forest Ecology

Poster presentation

The influence of forest site preparation on soil functions of an alluvial forest in the upper Rhine valley, Vorarlberg

Maximilian Behringer^{1*}, Klaus Katzensteiner¹

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Abstract

Alluvial forests are changing drastically in their hydrological regime, vegetation composition and structure, and disturbance dynamics. This occurs as a consequence of river regulations, historic land use and recent forest management practices and introduced species such as the cause of ash dieback *Hymenoscyphus fraxineus* or *Solidago canadensis agg.* Early effects of climate change increase the scale of these changes. As an effect of this, older stands dominated by *Picea abies* or *Fraxinus excelsior* had to be cleared in advance of regenerating forest stands. In order to achieve a tree species composition which is adapted to the altered site conditions and still economically desirable, tree planting in a larger scale is inevitable. Due to the strong competing vegetation (e. g. *Solidago canadensis agg.*, *Clematis vitalba*) site preparation was deemed to be necessary. Before planting, the sites were mulched and the lines for planting were prepared with a rotary tiller. As this is an abrasive preparation method, criticism arose. Based on this conflict, the aim of this master's thesis is to assess the long-term (≥ 5 years) effects of the site preparation on soil functions. To assess this, a chronosequence approach was chosen. The sampled areas represent five different age groups: (1) mature forest stand, (2) fallow area, (3) area treated 1 year ago, (4) area treated 2-3 years ago and (5) area treated ≥ 5 years ago. For the two main soil types in the area, alluvial soils and (para-)rendzinas, two repetitions per soil type were performed. For evaluating the habitat function of soils, vegetation analysis, earthworm sampling and measuring microbial biomass are planned. Additionally, the effect on water storage, carbon pool and nitrogen will be assessed to draw conclusions towards the storage, cycling and regulating function of the soil.

Oral presentation

Comparison of water absorption and release properties of natural, hybrid and synthetic hydrogels and their potential as soil amendments

Alexander Dovas^{1*}, Pavel Tlustoš², Hans Sandén¹

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Abstract

In recent years hydrogels have been used as soil amendments in order to increase water holding capacity of soils. Most traditionally used products are based on synthetic, hardly biodegradable polymers. Therefore, products created from natural, easily biodegradable polymers could present a valid and environmentally friendly alternative. A fully synthetic hydrogel (Stockosorb[®]) was compared to a hybrid hydrogel (Polyter[®], based upon cellulose and synthetic polymers) and to two newly developed products made of cellulose and lignin respectively. The aim was to assess the potential of natural and hybrid hydrogels as an alternative to synthetic hydrogels. Free swelling capacity, swelling velocity, the effect of mono- and divalent salt concentrations on swelling capacity, and the change in water holding capacity over several wetting and drying cycles in soil were measured parameters. Furthermore, the efficiency of water release to drying soil was assessed by combined measurement of soil respiration and soil drying rate. Overall results indicate a high suitability of Polyter as an alternative to Stockosorb. Free swelling capacity of Polyter and Stockosorb was similar, whereas Cellulose, and especially Lignin, absorbed less water than abovementioned products. The effect of salt concentration on swelling capacity was much more pronounced for Stockosorb and Polyter, compared to natural hydrogels, with decreasing absorption at increasing salt concentration. Exposure to soil and wetting/drying cycles resulted in an initial decrease in water holding capacity for Stockosorb and Polyter, before absorption capacity stabilized during subsequent measurements. Cellulose was very unstable, dissolving in water and being completely lost from the soil. All hydrogels released nearly all of their absorbed water to surrounding soil when the soil dried out. Results show a high suitability of Polyter as an alternative to synthetic hydrogels. Cellulose proved to be unstable, dissolving into water and losing its structure. Lignin absorbed too little water to be considered a valid alternative.

*Oral presentation***Constitutive VOC emissions of four common European tree species**

Anne Charlott Fitzky^{1*}, Arianna Peron², Lisa Kaser², Thomas Karl², Martin Graus², Danny Tholen³, Mario Pesendorfer¹, Maha Mahmoud³, Hans Sandén¹, Boris Rewald¹

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Abstract

Volatile organic compounds (VOCs) emitted by plants constitute for a broad range of different gases, which serve the purpose protecting against herbivores, communicating with insects and neighboring plants, or increasing the tolerance to environmental stresses. Constitutional emissions give insight in species-specific stress tolerances and are an important first step linking metabolism and function of combined emitted VOCs, which are still poorly understood. To investigate the diversity of co-occurrence of BVOCs across species, we recorded the fingerprint of VOCs for four common European tree species, *Quercus robur*, *Fagus sylvatica*, *Betula pendula* and *Carpinus betulus*, and highlight interdependencies between VOCs emission rates within the blend. As expected, VOCs of *Q. robur* and *F. sylvatica* mainly emitted isoprene and monoterpenes, respectively. *B. pendula* had the highest sesquiterpene emissions compared with other species; however, it made up only 1.7 % of its total emissions while the VOC spectrum was dominated by methanol (~72 %). *C. betulus*, a purported close-to-zero VOC emitter, was emitting similar amounts of VOCs as *F. sylvatica* and *B. pendula*; and should thus be reclassified as a methanol and low monoterpenes emitter. A principle component analysis (PCA) of proportional emissions among species revealed a classification of co-regulation between the dominant compounds. However, the PCA indicated new links between pathways and catabolites, as we found indications for aligned emission rates of methanol, sesquiterpenes of the mevalonate (MVA) pathway, and green leaf volatiles (GLVs) emitted by the lipoxygenase (LOX) pathway. Further, acetone emissions correlated with VOCs from the Shikimate pathway, a relationship which has not been described before. Our results indicate that different VOCs must be interrelated within species. Therefore, it is important to understand the whole blend of VOCs, rather than just the dominant emissions. Future work should investigate physiological links such as transcriptional factors or common derivatives to also understand their function as environmental stress responses.

Oral presentation

How do ectomycorrhizal decomposition traits change along a chronosequence of two different tree hosts on an afforested area?

Robin M. Kotsia^{1*}, Rasmus Kjøller², Douglas L. Godbold¹

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Abstract

Ectomycorrhizal (ECM) fungi play an important role in the carbon (C) cycle because they receive a large proportion of atmospheric C assimilated by plants some of which become sequestered in soil. However, we know little about the decomposition rates of ECM in general and different ECM species in particular and thus their contribution to soil C storage over time. This should be directly linked to the decomposition traits of the ECM found in association with the tree hosts and to temporal changes in the community as such. Additionally, the decision of the Kyoto protocol to investigate the effects of land-use and land-use change in the global C budgets has made it interesting to study the shifts in the soil C storage in afforested areas. A broader understanding of the dynamics and drivers of ECM morphotype variability and their decomposition traits will provide valuable insights for predicting long-term C storage and the effect of climate change on C fluxes. In this master thesis, I explore changes in ECM morphotypes and their decomposition traits following afforestation of former arable land and along a chronosequence of two tree host species, oak (*Quercus robur* L.) and Norway spruce (*Picea abies* (L.) Karst.). The chronosequence is composed of six stands of each tree species ranging between 24 and 52 years. Soil and root samples are collected to 10 cm depth for analysis. Root samples are analyzed under a stereomicroscope for separation into morphotypes and trait analysis. The analysis of the mycorrhiza will involve measurements of morphological attributes, C:N ratio, melanin content and the fungal biomass, as well as the identification of the ECM through sequencing. Question 1: Does biodiversity increase along the chronosequence? Are there more ECM morphotypes in the older stands? Question 2: As spruce is introduced and oak is naturally occurring in Denmark, I am interested to see whether oak will have associations with more morphotypes compared to spruce. Question 3: Do ECM from older and less nutrient rich stands decompose slower? Do we identify traits that indicate slower decomposition? (higher melanin and C:N ratio)

*Poster presentation***Morpho-functional classification of humus forms using the TerrHum-App: correlation of morphological indicators and standardised laboratory analysis parameters**

Anna Schrötter^{1*}, Michael Englisch², Klaus Katzensteiner¹

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- 2 BFW - Austrian Research Centre for Forests, Department for Forest Ecology and Soil, Subdivision Site and Vegetation

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Abstract

As the most dynamic part in soil, humus forms are an integrative indicator for decomposition processes in a forest ecosystem. The TerrHum App provides a digital field manual for classifying terrestrial humus forms. This common morpho-functional classification system categorises the organic & organo-mineral topsoil based on morphological characteristics detectable with the naked eye in the field and links them to biological soil functioning. In the present study we investigate, how practicable the TerrHum-App is as a tool and how well the morphological-functional field indicators correlate with standardized laboratory parameters (chemical and soil microbial properties) which are used to characterize litter decomposition. The field survey comprised 30 ForSite plots (Forest Site Classification Styria 2019) in the Bruck-Mürzzuschlag district, stratified by substrate, climate and vegetation. Humus forms at three microsites per plot (erosive, intermediate and accumulating) were described using the TerrHum App. Area representative, volumetric samples were taken from the organic layer and topsoil horizons at the intermediate plot. In addition, sufficient amounts of samples were taken in all relief-positions, homogenised and sieved in the field and stored within few hours at -20°C. We analyzed C_{org} & N_{org} (Elementary analyzer), pH-value and C_{inorg} (Scheibler, in case of calcareous A-horizons) as well as soil microbial biomass, C_{mic} and N_{mic} (fumigation extraction method). The temperature and moisture response of heterotrophic respiration R & Q_{10} are analyzed on a subsample of representative humus profiles. We will use correlation analyses, analyses of variance, multiple comparisons as well as multivariate statistics (cluster analyses, PCA) in R in order to test the hypothesis: 'We are able to predict indicators of SOM turnover based on a morphological description of humus forms'.

Mixtures matter: Integrating tree species identity and diversity on PM absorption

Matthias Steinparzer^{1*}, Douglas L. Godbold¹

1 Institute of Forest Ecology, Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna, Austria

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Abstract

Ambient air pollution is linked to a plethora of human health problems and is one of the leading five health risks worldwide. Air pollution exposure leads to over 4.5 million premature deaths every year, of which 400,000 occur in Europe. Particulate matter (PM) is a major air pollutant, the toxicity is dependent on size and composition. Particles with aerodynamic diameter $\leq 10 \mu\text{m}$ (PM₁₀) enter the respiratory system and can be absorbed in the body.

Vegetation is a countermeasure against PM exposure, acts as a natural filter, and is known as a relatively low-cost and sustainable form of phytoremediation. Trees provide a vast bandwidth of ecosystem services and are well-suited for air purification. The foliage surface provides an absorptive area, which is quantifiable as the Leaf Area Index (LAI). The air cleaning effect of trees depends strongly on leaf and canopy structure, and although this differs between species, the influence of species and architectural trait diversity on PM absorption is largely unknown.

We investigated four broadleaved species (*Acer platanoides* L., *Tilia cordata* Mill., *Quercus robur* L., *Carpinus betulus* L.) along a species diversity gradient within in the B-Tree experimental site at Tulln, Austria – which is part of the worldwide largest biodiversity network TreeDivNet. Leaf samples for PM fractionation and weight determination were taken from the upper crown layer. For upscaling the absorptive area, LAI was directly estimated via leaf litter traps. The highest amounts of PM₁₀ cm⁻² leaf area were bound to leaves of *C. betulus*, and considerable species identity effects were shown. At a plot level, a tendency to a greater PM absorption was found in mixtures compared to the monocultures. This greater binding was linked to a higher LAI in mixtures and species leaf traits. Our results suggest that due to a combination of leaf traits and increased LAI, higher tree species diversity and the resulting canopy structure enhances total PM binding.

Institute of Soil Research

Oral presentation

Understanding of adsorption and degradation of halogenated hydrocarbons at mineral surfaces

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Abstract

The number of dangerous compounds in soils and water sources that originate from human activities has rapidly increased. Whilst most of the examples of soil pollution are related to metals or other inorganic pollutants, there has been an increasing concern over the last few decades regarding organic contaminants. For example, chlorinated hydrocarbons (CHCs), such as PCE (perchloroethylene), TCE (trichloroethylene), and DCE (dichloroethylene), severely affect the well-being of humans and wildlife. There is a systematic effort to eliminate these pollutants from the environment. In this scenario, adsorption and degradation by low-cost materials distinguish itself as an effective and economical method. The application of nanoparticles based on zero-valent iron (nZVI) and its chemical modifications are at the centre of the intensive research. It is of outmost importance to understand the mechanism of surface processes of these nanoparticles at a molecular scale. Nanoparticle surfaces can be represented by surfaces of the iron minerals such as iron (oxy)hydroxides (e.g., Fe(OH)₂, Fe(OH)₃, goethite (α -FeOOH), lepidocrocite (γ -FeOOH), and hematite (Fe₂O₃)), iron sulphides (e.g., mackinawite (FeS) and pyrite (FeS₂)), and iron nitrides (e.g., roaldite (Fe₄N)). Thus, the main objective of this work is to provide a molecular scale understanding of the nature and mechanism of interactions between the selected organic contaminants such as CHCs and minerals previously mentioned by using the methods of computational chemistry. The Fe(OH)₂ structural models were already created using crystallographic databases. The surface was defined. The models were fully relaxed and, the most stable structure was obtained. The adsorption studies of TCE at the bare surface are ongoing.

Determination of multielement and isotopic patterns by mass spectrometry to trace the origin of primary agricultural products

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Abstract

The determination of the elemental and isotopic composition of soils and plants by inductively coupled plasma mass spectrometry (ICP-MS) is a promising analytical approach to determine the geographical origin of primary agricultural products. The objective of this thesis was to further investigate the suitability of multielement (i.e., Mn, Ni, Cu, Zn, As, Sr, Cd, Pb) and multi-isotope ratio (i.e., $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{207}\text{Pb}/^{206}\text{Pb}$) analysis in soil and corresponding plant samples as a robust method for crop provenience analysis. To this end, three different plant species of agricultural importance (i.e., *Triticum aestivum*, *Lactuca sativa*, *Raphanus sativus*) were cultivated in pots filled with five soils of different geographic origins under controlled greenhouse conditions. The soils differed in their elemental composition and physicochemical characteristics (i.e., pH, CaCO_3 , CEC, organic matter). Plant tissues were harvested between 30 and 52 days after planting and subsequently prepared for multi-element analysis by quadrupole ICP-MS following microwave-based acid digestion. Digests of *Lactuca sativa* were further processed for isotope ratio analysis by (multi collector (MC)) ICP-MS via simultaneous separation of Sr and Pb from matrix elements using an automated low-pressure ion-exchange chromatography procedure. The analysis of elements in soil and plant samples showed that multielement pattern can be used as a site-specific fingerprint, which is, however, dependent on soil characteristics and plant-specific uptake processes. To further assess the discriminative power of the approach, multivariate statistical analysis will be applied. Analysis of Sr and Pb isotope ratios in leaves of *Lactuca sativa* showed no significant isotopic fractionation as compared to bioavailable (i.e., NH_4NO_3 -extractable) fractions in soil, although precise determination of $^{207}\text{Pb}/^{206}\text{Pb}$ remains challenging under non-contaminated conditions. The combination of the isotopic signatures of both Sr and Pb enabled robust discrimination of *Lactuca sativa* grown on soils with different geographic origins.

*Poster presentation***Potentials and limits for an increase of soil organic carbon (SOC) stocks in arable fields under different crop residue and tillage management**Philipp de Jong^{1*}, Michaela Dippold², Heide Spiegel³, Walter Wenzel¹

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Abstract

Utilizing optimised management practices on arable fields is considered for climate change mitigation through CO₂ sequestration. As arable soils are largely depleted in SOC compared to former land uses like forest, a large potential to sequester C is attributed to them (e.g., by the 4‰ initiative).

However, to achieve a consistent C sequestration on a global level a better understanding of SOC stock determination based on either direct bulk density and C concentration measurement or their derivation from pedotransfer functions is required. Additionally, the degree of stabilization and saturation of C in soils is of importance for assessing the climate change mitigation potential of a particular soil under certain climate and management practices.

The aim of this thesis is to increase the understanding of SOC stock characteristics under different crop residue management or tillage systems. Crop residue incorporation is compared with removal combined with P fertilization and conventional tillage is compared with a reduced and minimum tillage variant. The tested management varieties are implemented on long-term field experiments run by the Austrian Agency for Health and Food Safety (AGES).

For this we apply a range of methods including bulk density (BD) sampling with a continuous core down to 75cm and comparison of measured BD to BD derived from a selection of pedotransfer functions. SOC stocks were recalculated based on equivalent soil masses in the tillage treatments, to account for potential errors leading to an overestimation of SOC stocks comparing treatments affecting bulk density. Quantification of stabilization and saturation of C is done by physical soil fractionation into four particle size fractions and C measurement in each fraction. Furthermore, amorphous Fe and Al oxides are extracted to quantify their impact on C stabilization in organo-mineral complexes and the specific surface area is estimated.

Poster presentation

Understanding the role of agricultural soils in meeting societal challenges outside Europe as a reference framework on climate-smart sustainable management

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Abstract

Soil management practices can determine whether the carbon sequestration rate counteracts greenhouse gas contributions in agriculture. The potential of soil to provide this function usually depends on the pedoclimatic conditions, creating diverse challenges that can also bring different solutions across the globe. The aim of this thesis is the exploration of potential innovative sustainable soil management practices outside Europe to identify needs, challenges, knowledge gaps, and the role of soil management as a tool to overcome them. It will also be tested how organic additions and crop rotations modify the resilience to drought by the increase of carbon stocks. A global survey composed of 22 main questions was answered by a total of 169 participants with soil management experience, from which many belong to research institutes and universities in India, Mexico, Argentina, Chile, USA, Brazil, Australia, among other countries. Their responses were analyzed grouping trends by continent or country, climate, major stresses, soil group, or field of expertise. As a further step, a sensitivity analysis in the simulation program APSIM will be used to test agronomic performance in soils of Kenya, South Africa, India, and México with 2 locations with contrasting conditions per country. Modeling scenarios of crop rotations will also be evaluated. Out of 24 land stresses, the two most common selected by respondents were low soil organic matter (71%) and low moisture and nutrient status (42%). Regarding climate, the three most typical selections were: tropical monsoonal, warm semi-arid, and temperate with dry summer; and concerning soil, the three most common groups (Soil Taxonomy) were Vertisols, Alfisols, and Inceptisols. These answers are just an example of how diverse the conditions can be and the urgency of creating and implementing proper management practices to increase levels of soil organic carbon.

*Poster presentation***Conducting microcosm experiments to select suitable combinations of biochar and pollutant-degrading microbial consortia**

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Abstract

Perchloroethene (PCE) is an organic compound widely used as a solvent in the industry such as in dry cleaning of textiles and metal degreasing. It is recognized as one of the most ubiquitous groundwater contaminants and, together with its metabolites, is known to be toxic and carcinogenic. Different techniques involving sorption (e.g. activated carbon and biochar), chemical degradation (e.g. nanoscaled zero valent iron) and microbial degradation exist for remediating PCE contaminated groundwater. This master thesis aims to combine the anaerobic dechlorination performed by organohalide-respiring bacteria (OHRB) with the sorption to biochar. Non-obligate (Proteobacteria, Firmicutes) and obligate (Chloroflexi) OHRB perform reductive dechlorination of PCE in which chlorine are replaced by hydrogen and a kinetic isotope effect is appears. This is done by the reductive dehalogenase in the electron transport chain using the PCE as terminal electron acceptor and producing different metabolites until the harmless ethene. Biochar produced from agricultural and forestry-by products presents in general a high sorption capacity for PCE and additionally can act as the habitat for the OHRB biofilm. The methodology to establish this PCE degradation and sorption consist in incubate microbial consortia (Bioclear, BOKU consortia) with a mixture of PCE containing water and biochar in a microcosm study. Microcosms are prepared under anoxic conditions at -250 mV and pH 7 in a Glovebox. Liquid samples are measured weekly for concentration and isotope ratio of all detectable chlorinated ethenes using GC-IRMS. Up to the present moment the degradation performance of the OHRB consortia is being investigated. Results show incomplete degradation in the first trial. A second trial with a larger inoculum is currently tested and the use of alternative microbial consortia (KB1) is considered.

Oral presentation

Cover crops affecting pool specific SOC sequestration in european cropland – A meta-analysis

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Abstract

The “4 per mille Soils for Food Security and Climate” initiative proposes that by increasing the global soil organic matter (SOM) stocks by 0.4 percent (4 permille) per year, the global anthropogenic greenhouse gas (GHG) emissions could be offset. Especially croplands are usually low in soil organic carbon (SOC) and by enhancing the SOC levels in these soils, GHG emission can be partly compensated. This can be achieved by adopting SOC enhancing land management practices, as the cultivation of cover crops.

There are several meta-analyses which already assessed the positive effects of cover crops on SOC globally and in the Mediterranean climate. To the knowledge of the authors, no systematic, quantitative analysis of the effects on SOC pool level has yet been done for Europe. The objective of this research is therefore to conduct a meta-analysis on the effects of cover crops on selected SOC pools in European cropland soils. Several databases will be systematically searched for relevant literature, which will then be screened and critical appraised. Lastly, necessary data will be extracted from the final study set in order to conduct a meta-analysis. The pools chosen for this analysis are the microbial biomass carbon (MBC), the free particulate organic matter (fPOM), the occluded particulate organic matter (oPOM) and the mineral associated organic matter (MOAM) pool, as well as total SOC. Alongside, the influence of cover crops on SOC sequestration throughout soil depths (0-1 m) and the effects of pedo-climatic factors and management practices (tillage, residue management, irrigation, fertilization) on SOC sequestration in European cropland soils will be studied. Cover crop characteristics, such as depths of root systems, shoot-to-root ratio and legume vs. non-legume crops will be specifically analysed. Overall, this meta-analysis will provide guidance for future research in sustainable management of agricultural soils.

*Oral presentation****In situ* visualization of phosphorus mobilizing processes in the rhizosphere of *Zea mays* L. in the field**

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Abstract

Understanding phosphorus (P) dynamics in the soil-plant system is crucial for sustainable crop production. To investigate the effect of root hairs and soil texture on the spatial distribution and intensity of P mobilizing processes, we applied 2D chemical imaging methods to visualize soil pH (planar optodes), phosphatase activity (zymography) and labile P and Mn fluxes (Diffusive Gradients in Thin films) in the rhizosphere of two maize genotypes (wildtype WT and root hair defective mutant *rth3*) grown in two soil substrates (loam, sand). Root windows installed in the field allowed non-destructive application of these imaging techniques.

Image analysis revealed a strong patchiness for pH and labile P while phosphatase activity and Mn flux were more homogeneously distributed along the roots. Acidification extended up to 1.5mm into the rhizosphere and was more pronounced in sand due to lower P availability and lower buffer capacity compared to loam. Acid phosphatase activity on the root surface was similar for both genotypes and substrates. P flux showed no clear trend and depletion zones were rather indicative. Irrespective of genotype and texture, elevated P flux was observed at root tips. Acidification was stronger around young growing tips than older sections which was even more pronounced for WT and co-localized with high phosphatase activity, P and Mn flux.

Our results suggest that proton extrusion was linked to root growth and created a pH optimum for P solubility, P uptake and acid phosphatase activity, *i.e.*, transformation of organic P to phosphate especially at the tips and the elongation zone which are the major sites of P uptake. Combined with the generally higher P availability in loam and the higher absorption surface of root hairs, these rhizosphere processes jointly contributed to a more efficient P uptake of WT compared to *rth3* and better performance in loam compared to sand.

Poster presentation

Phytosiderophore release and Fe-uptake during plant development in barley lines differing in micronutrient efficiency

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Abstract

Iron (Fe) uptake in grass species is based on the release and reuptake of phytosiderophores (PS). These root exudates form stable metal complexes with Fe in soil facilitating the uptake of complexed iron and other micronutrients. Most of our knowledge about the role of PS in plant nutrition is based on hydroponic studies and only little information about PS release under natural soil conditions is available. Furthermore, little is known about qualitative and quantitative differences in PS release by different grass crops. In this thesis, we investigated whether higher phytosiderophores exudation during plant development correlates with higher Fe shoot and/or seed uptake by barley (*Hordeum vulgare*) when grown in Fe deficient soil. Four barley lines differing in micronutrient uptake efficiency were grown in an iron deficient and an iron fertilized soil in a pot experiment and Fe shoot and seed content, as well as PS exudation rates and PS-related gene expression were analyzed. Additionally, we investigated PS release by different grass crops (*Hordeum vulgare*, *Secale cereale*, *Avena sativa* and *Sorghum bicolor*) grown hydroponically under Fe deficient and sufficient conditions to compare species specific exudation patterns and link our results to previous studies. Our results will provide a better understanding of micronutrient uptake mechanisms in grasses and help improving the selection of highly efficient cultivar lines for micronutrient deficient areas.

*Poster presentation***Effect of hedge rows on soil properties and functions**

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Abstract

Hedge rows are established to decrease wind erosion and improve the microclimate in agricultural landscapes. To this end, the Lower Austrian Land Reform Authority has been planting hedge rows since 1958. Additional to these main aims nowadays ecosystem services like the provision of goods, cultural benefits and especially regulating effects get more and more important. The latter include carbon storage, regulation of greenhouse gases, erosion and flood protection, filtration of nutrients, organic plant protection and increase of biodiversity.

This master thesis investigates the effects on sequestration of organic carbon, on pore space and soil structure. Furthermore, the resulting ecosystem services including water retention and storage, water infiltration and the storage of nutrients and pollutants are estimated using pedotransfer functions.

Based on data obtained from the Lower Austrian Land Reform Authority, 150 hedge rows of differential age, ranging between 1 and >70 years were selected on Chernozems and Phaeozems in the districts Hollabrunn, Mistelbach, Gänserndorf, Bruck an der Leitha and Baden. Soil samples were collected to 40 cm depth in the hedge row and the adjacent cultivated soil using a split-tube corer. For description and soil analysis, the mineral soil was split into two depth increments) (0-20 cm and 20-40 cm), and where present, the organic surface layer was collected separately. A detailed description of soil structural characteristics was conducted according to the German guidelines. Further, the textural class, bulk density, nitrogen and carbon concentrations were determined. Based on the field and analytical data we determined temporal changes of soil carbon stocks and related soil functions in response to turning cultivated land to hedge rows. The results provide information on the long-term dynamics of changes in soil structure and carbon stocks after turning cultivated land into perennial woody vegetation.

Oral presentation

Effect of EDTA-soil washing on the microbial community and mesofauna

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Abstract

The importance of soil conservation and remediation is an important component in the fight against continuing loss of arable land and are needed to succeed in the aims of the new European Green Deal. Soil washing technologies can provide an efficient solution to reduce plant available heavy metal concentrations (e.g. Pd, Cd, Zn) in private gardens to background levels. The impact of such invasive technology on other chemical physical and microbiological characteristics is not documented yet and requires fundamental investigation.

Two trials were set up using highly contaminated soil (total: 795 Pb, 4.47 Pb, 484 Zn mg kg⁻¹) and two washed variants (total: 189 Pb, 2.36 Cd, Zn 373 mg kg⁻¹), one amended with 2.5 %wt vermicompost and 2.5 %wt biochar with reduced metal content. To understand the impact of soil washing on the N/C nutrient cycle and the soil food web, ¹³C and ¹⁵N labeled plant material was applied to the soil treatments in an outdoor (raised beds) trial. Gas and soil samples were taken on 10 consecutive dates. In a greenhouse trial, pots were inoculated with a mesofauna and managed and kept with a crop cover for 6 months. 4 weeks before extracting the mesofauna, maize straw, highly labeled with ¹³C was applied to the pots. Stable ¹³C and ¹⁵N isotopes were measured for PLFAs, NH₄ and NO₃ (Microdiffusion) and CO₂ gas samples in raised beds and Mesofauna FA in the pot trial to investigate the nutrient cycle.

First results show differences for microbial and mesofauna composition between the contaminated and washed soils. In respect to the NH₄ and NO₃ microdiffusion measurements, mineralization seemed to be the predominant process in the untreated soil. In EDTA washed soil nitrification, immobilization or NH₃ volatilization seemed to have a greater effect. First results on PLFA/FA composition of soil and mesofauna will be presented.

*Poster presentation***The mystery of root exudation: Do sampling conditions affect observed root exudation?**

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Abstract

Sampling unaltered root exudates in natural soil environments is challenging due to exudates sorption by the soil matrix and imminent microbial decomposition. Growing plants and sampling root exudates in hydroponics under sterile conditions allows us to obtain root exudates unaltered by sorption and microbial decomposition; however, the ecological significance of these results with respect to processes occurring in the natural soil environment remains questionable. Considering the crucial impact of growth conditions on plant metabolism and consequently root exudation, a soil growth-hydroponic exudation sampling hybrid approach combined with the application of a sterilizing agent in the sampling solution may serve as suitable alternative to hydroponics-only set-ups. In this study we investigated the effect of sampling volume (300-1200 mL) on maize (*Zea mays*) root exudation and assessed the suitability of Micropur as a sterilizing agent during hydroponic exudation sampling. Bioorthogonal Noncanonical Amino Acid Tagging (BONCAT) was used to observe *in situ* microbial activity in roots and to evaluate the efficacy of MP under different concentrations of the inhibitor (0, 1 and 10 mg MP L⁻¹). Exudates were analysed for total carbon (C), nitrogen (N), carbohydrates, amino acids, and total phenols. Furthermore, we tested potential plant stress responses induced by Micropur by determining reactive oxygen species (ROS) content and stress related enzymes in plant root and shoot tissue. Our results will allow us to further optimize existing exudation sampling strategies and help to delivering more ecologically meaningful exudation results in the future.

Poster presentation

A SOC Hedgerow Model: Assessing effects of hedgerows on C-fraction dynamics and sequestration potentials in cropland soils of Lower Austria

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Abstract

The objective of this thesis is to investigate the temporal contributions of perennial hedge-systems to SOC sequestration and its partitioning into protected and unprotected C-fractions in Lower Austrian agricultural soils. A SOC hedgerow model was designed based on a series of hedgerow sites and adjacent agricultural fields in Lower Austria with known planting ages from 1950-2019. By choosing sites of homogenous soil type and climate, the aim is to create a model that successfully simulates changes in protected and unprotected SOC-fractions over a 69-year period after the introduction of a high C-input system without soil disturbances.

Central research questions include: (1) Does SOC-sequestration increase with increasing hedgerow age compared to adjacent cultivated soils? (2) Which proportion of OC is protected by mineral particles <20µm in hedgerows compared to cropland soils and how is the depth distribution in the 0-20 and 20-40 cm? (3) Can this hedgerow model determine carbon saturation potentials and how they are attained over time?

C stored in soil organic matter (SOM) varies in persistence and it is recognized that SOM fractions sorbed to or occluded in clay- and fine-silt-sized mineral particles and microaggregates (<20µm) are more persistent than fractions of larger particulate organic matter. To separate functionally diverse fractions size fractionation by use of ultrasonication as well as pressure filtration is being performed to separate SOM into three fractions: Particulate organic matter (2000-20 µm), mineral-associated organic matter (20-0.45 µm) and dissolved organic matter (<0.45 µm).

Preliminary results from 6 sites in the 0-20 cm representing 1966-1990 show higher TOC concentrations in hedges compared to cropland soils. This increase is mostly pronounced in the larger POM fractions while OC in the protected <20 µm fraction does not indicate differences. Furthermore, the effect of hedge age on OC in fractions cannot yet be confirmed in the preliminary data.

Oral presentation

Quantifying the involvement of microbial processes in the phosphate turnover in the soil system using a $^{18}\text{O}\text{-PO}_4$ labelling approach

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Abstract

Phosphorous (P) has a crucial role in plants' life cycle. Its availability directly affects the biomass production and overall plant growth and is substantially affected by sorption and precipitation. Even though microbial processes influence the P availability and uptake, they are not well explored. As P is limiting in natural conditions, the use of the rock phosphate fertiliser is boosting, leading to eutrophication. This study aims to assess microbial turnover of P using an isotope labelling approach whilst identifying changes in the isotopic PO_4 source signature. It involves the determination of phosphate contents and oxygen isotope ratio in soil and plants after 0, 5 and 17 days. Rye seeds are planted after treating them with ethanol and sodium hypochlorite. The purpose of this step is to sterilize the seeds hence increasing their germination percentage and seedling growth. Plants are harvested and their biomass is measured after 5 and 17 days. HCl and hexanol extractions + anion exchange membranes are used to study total, available, and microbial pool in the soil, respectively. The purification of extracts is carried out by precipitation and dissolution of both ammonium phospho-molybdate (APM) and magnesium ammonium phosphate (MAP). Cations are removed from the extracts and precipitates of purified Ag_3PO_4 are filtered for further analysis using CF-IRMS. The hypothesis is that the turnover of phosphate is more in available pool than in total pool. Further methodology and preliminary results will be presented.

Oral presentation

Influence of ammonium fertilization and clay amendments on caesium dynamics in the soil

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Abstract

Radioactive Cs (¹³⁷Cs) is considered as a technogenic radionuclide (TRN) and can be released by nuclear accidents as e.g. in Fukushima and Chernobyl. A major concern is the subsequent pollution of soils and the ¹³⁷Cs uptake of crops, which displays a threat to human health. Therefore, the aim of this thesis is to elucidate the dynamics of ¹³³Cs (used as a proxy for ¹³⁷Cs) in soils in dependence of clay mineral amendments and NH₄⁺-application. These variables are of interest as clay mineral amendments were already used as countermeasures after nuclear accidents and NH₄⁺ fertilization is conducted on many arable soils to increase yields.

For this thesis, a Gleysol, an Andosol and a Cambisol from Japan, as well as an Anthrosol from Belarus and a Chernozem from Austria are investigated. Every soil is treated with either 300kg NH₄⁺ -N or not treated with NH₄⁺. The impact of the competition between NH₄⁺ and Cs⁺ for exchange sites in soils will be clarified by analyzing exchangeable NH₄⁺ as well as NH₄⁺ and Cs⁺ in soil solution. As NH₄⁺ can be converted to NO₃⁻ through nitrification processes, NO₃⁻ in soil solution will also be determined. By using ¹⁵N labeled fertilizer, these processes can be understood more clearly. Additionally, the allophanics soil will be treated with zeolite, vermiculite and smectite, to particularly understand the ion dynamics in presence of these clay minerals. The results of this thesis will contribute to more precise measure recommendations against Cs-pollution of arable soils.

*Poster presentation***The role of rhizosphere traits in phosphorus efficiency of upland rice**Henning Schwalm^{1*}, Christiana Staudinger¹, Markus Puschenreiter¹, Eva Oburger¹

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Abstract

Phosphorus (P), an essential plant nutrient, is mainly obtained from non-renewable resources which has led to a perturbation of P cycle with subsequent environmental risks like eutrophication. In the future, P scarcity could limit plant production and aggravate food security challenges. High P efficiency (PE) of rice (*Oryza sativa* L.), which is a staple food for more than half of the world's population, could be crucial to reduce P fertilizer demand while maintaining sufficient crop yields, especially in low-input upland rice systems. Previous studies have shown that upland rice genotypes differ in PE independent of specific morphological parameters such as characteristics of root hairs and root system size. Furthermore, it has been suggested that cell wall related-properties and mobilization from inorganic sources by pectins are involved in rice P remobilization efficiency.

This work aims to investigate root and rhizosphere traits potentially responsible for a high PE in rice. We hypothesize that high PE under low P availability is driven by (i) different quality and quantity of root exudates and/or by (ii) differences in root cell wall properties. Therefore, we will grow four rice genotypes with contrasting PE and root hair properties (DJ123 - high PE, high root hair length and density (RLD); Nerica4 - low PE, low RLD; Santhi Sufaid - high PE, low RLD; Sadri Tor Misri - low PE, high RLD) in semi-hydroponic systems under low P and high P conditions. Root exudates and root cell wall material will be collected at two time-points in order to test whether spatio-temporal dynamics of rhizosphere traits can be related to different P efficiencies among rice cultivars. Our findings will contribute to a better understanding of the underlying mechanisms of high PE in rice and help improve crop selection in sustainable agriculture.

Oral presentation

Phytosiderophore release of contrasting barley (*Hordeum vulgare*) cultivars grown in Zn and Cu deficient soils

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Abstract

Crop micronutrient (MN) deficiency often occurs in arid and semi-arid areas dominated by high pH soils. Successful micronutrient acquisition strategies of crops are crucial for maintaining high yield on nutrient-poor soils and producing micronutrient-dense crops. In the case of iron (Fe), graminaceous plants are known to increase Fe phytoavailability by the release of root exudates called phytosiderophores (PS) which form strong complexes with Fe but also with other micronutrients such as zinc (Zn) or copper (Cu) in the soil solution that plants can readily take up. Many studies focus on the importance of PS in Fe plant nutrition, while only scarce information is available on the role of PS in Zn and Cu acquisition. Moreover, PS related studies have mainly been carried out under artificial hydroponic growth conditions.

In this study, we aimed to investigate the effect of Zn and Cu deficiency on PS release rates and reveal the mechanisms controlling PS exudation from barley (*Hordeum vulgare*) grown under natural soil conditions. The selected soils have been identified as severely deficient in DTPA (diethylenetriaminepentaacetate) extractable Zn (Sultanonu, Turkey) and Cu, respectively (Mt Ney, Australia). Four barley genotypes differing in MN uptake efficiency were grown under Zn/Cu deficient and fertilized conditions. We collected samples at three different plant developmental stages to reveal plant age dependency of PS exudation and gene expression. PS analysis was achieved with a novel LC-MS/MS method for the accurate simultaneous quantitative determination of the entire spectra of naturally occurring PS. The underlying mechanisms controlling PS release are investigated through plant molecular analysis on a root subsample. Our results will allow for a better understanding of the mechanisms controlling PS mediated micronutrient acquisition of barley grown in natural soil environments.

Oral presentation

The potential of pioneer management systems to improve soil organic carbon

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Abstract

The recent IPCC report depicts the urgent need to cope with climate change. With uncertainties regarding our livelihoods driven by the consequences of climate change, the natural carbon cycle gains unprecedented importance. The soil and more precisely the contained organic matter are the second-largest active carbon stock, which makes it the largest terrestrial system for storing carbon. To elucidate the potential carbon sinks of terrestrial ecosystems is therefore of crucial importance for mitigating anthropogenic driven climate change via greenhouse gas sequestration potentials. In particular, there is a need for a better understanding of how agricultural practices could increase soil organic carbon (SOC) content. An international initiative worth being mentioned at this point, is the so called „4 per 1000“, addressing climate change and food security simultaneously under the aspect of sustainable development through appropriate management of soils. The present thesis aims to compare soil organic carbon quantity among three different systems (conventional agricultural land, pioneer management land, and grassland as a reference soil) to a total depth of 35cm in three intervals and twenty sites. Sixteen of which are spread across the region of Lower Austria and four sites are located in Burgenland. Different soil parameters are analyzed, such as the pH value and the electrical conductivity, carbonate content, as well as the dissolved organic carbon and the carbon to nitrogen ratio is being determined. Once the organic carbon concentration of the different soils is known, the total organic carbon is calculated with the help of the bulk density values. Ultimately, the SOC and its qualities of the three different systems will be compared and related to the various soil types and properties. For identifying varying carbon qualities, the Fourier transformed infrared (FTIR) analysis is used in this thesis.

Oral presentation

Effects of soil temperature, soil moisture and topography on CO₂, CH₄ and N₂O fluxes from a temperate upland forest soil

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Abstract

Understanding the effect of environmental variables on the greenhouse gases (GHG) carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) are a prerequisite to estimate the impacts of global warming. In temperate upland forest soils, soil temperature and soil moisture do not always influence GHG fluxes as expected, and there is an interplay between topography and environmental conditions, which ultimately influences the dynamics of the soil GHG fluxes. In this study, soil-atmosphere fluxes of CO₂, CH₄ and N₂O were measured from a temperate deciduous forest in the Rosalian mountains. State-of-the-art automated static chambers were used to produce reliable GHG fluxes estimates with high temporal resolution, with 16 sampling locations across flat and mid-slope positions at different distances (0.5m, 5m, 10m, 15m) from a forest stream. Three hypotheses were tested: 1) the temperate upland forest soil emits higher amounts of CO₂ in flat locations; 2) the soil CH₄ sink capacity is higher on mid-slope positions, due to higher soil temperature and low soil moisture and; 3) N₂O emissions are higher in flat positions due to higher soil moisture, despite the lower temperature. Experimental set-up will be presented, and preliminary results will be discussed.

*Oral presentation***Development of physical-biological filter for groundwater remediation. Removal of groundwater organic contaminants (PCE and naphthalene) by adsorption and biodegradation technology**

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Abstract

Hydrophobic organic solvents such as tetrachloroethylene (PCE) and naphthalene are volatile organic compounds that account for a large number of soil and groundwater contamination sites in Europe. These pollutants are amongst the 43% of the suspected contaminants enlisted in the contaminated land registry and contaminated sites of the Federal Environment Agency. Their emission into the environment has been associated with severe health and environmental adverse impacts, which has led to the development of different technologies for their effective removal from the environment. This study will contribute to the search for an appropriate and sustainable removal technology. Hence, the overall goal of this study is the development of physical-biological filter for the removal of tetrachloroethylene and naphthalene from contaminated groundwater. In this study, batch and column experiments will be conducted to evaluate the performance of a laboratory-scale physical-biological filter, for removal of tetrachloroethylene and naphthalene in groundwater and to explore the removal of adsorption and biodegradation individually and combined. Compound specific stable isotope analysis will be used to differentiate both processes and contaminant degradation. The filter materials for the adsorption experiment will be carbon neutral, inexpensive, re-usable and local resource-efficient filter material such as biochar as well as the industrial reference material (activated carbon). Microbial community forming biofilms in the filter material will be employed for improving the biodegradation of naphthalene and tetrachloroethylene in aerobic and anaerobic conditions respectively. The adsorption mechanism will be investigated in batches as well as in columns and quantified using different isotherm model like, Langmuir, Freundlich, Dubinin-Radushkevich and Temkin isotherms. The outcome of this study will contribute to the growing innovation in groundwater remediation thereby providing an appropriate and sustainable tetrachloroethylene and naphthalene removal technology for the treatment of contaminated groundwater with the use of cost effective and environmentally friendly sustainable materials.

Oral presentation

Estimation of greenhouse gas emissions of a cropland in the pre-alpine region: A modelling approach

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Abstract

The role of soils and soil organisms in the cycling of greenhouse gases (GHG) through their function as source and sink has been the topic of many global and national strategies to reduce the amount of GHG in the atmosphere. One example is the potential of agricultural cropland in the pre-alpine region to emit GHG, and the mitigation potential through appropriate management. To answer the question of how much these croplands impact the atmospheric GHG concentrations, a specific site in the Rhine valley in Austria was modelled, using LandscapeDNDC. The site is on a Fluvisol used to grow vegetables and grass and managed by an organic farmer. After calculating the fluxes of the relevant GHG (CO₂ & N₂O) and other emissions, two sub models were made to show the positive and negative effects of high and low C input through fertilizers on the GHG fluxes and soil C stocks. Furthermore, the effects of specific management practices on GHG fluxes, e.g. use of cover crops and tillage, are shown. The results show that higher application rates of organic manure can lead to an increase in soil C stocks but will also increase CO₂ & N₂O emissions. A comparison of cover crops and bare fallow shows the importance of the former, as GHG and other emissions are higher in the bare fallow model. The results are then discussed to give an overview on how to reduce soil GHG emissions and increase the soil carbon stock while maintaining other emissions and crop yields in acceptable quantities.

*Poster presentation***Methanotrophic soil microbial communities under extreme weather events and enhanced N inputs**Gabriela Villalba¹, Sophie Zechmeister-Boltenstern¹, Ellen Kandeler², Eugenio Diaz-Pines¹

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Abstract

The alteration of weather patterns due to climate change has resulted in heavy rainfalls and droughts periods expected to increase over time. Furthermore, anthropogenic land management has induced an enrichment of the nitrogen levels in terrestrial ecosystems. The combination of both factors may cause shifts in soil biogeochemical processes, nutrient cycling, and microbial communities; that eventually might affect the capability of soils to act as sinks of Greenhouse Gases (GHG) and thus, result into an accelerating feedback for climate change. However, there is still limited information about the effect of these interactions in soil GHG fluxes, especially with regard to methane (CH₄) uptake, a process carried out by methanotrophic bacteria in virtually all upland soils. This project seeks to analyse soil CH₄ uptake as affected by extreme weather events (drying-rewetting cycles) and high N atmospheric deposition rates in two experimental forests of Austria (Rosalia and Klausenleopoldsdorf). Results obtained from previous studies in the area allow us to formulate the following hypotheses: 1) Soil CH₄ uptake will increase after drying-wetting cycles, and reduce over time due to a subsequent acclimation/adaptation of microbial communities to the new environmental conditions. 2) Additional N availability will reduce CH₄ uptake rates due to alterations of the methanotrophic activity. In addition to an environmental control, three treatments will be considered: enhanced N availability, severe drying-wetting stress, and the combination of both.

The first soil sampling campaign started in the winter period (February 2021), where 28 samples from the topsoil (0-10 cm) were collected and processed in the laboratory for analysis of nutrients, microbial biomass and methanotrophic communities. After molecular analysis via *pmoA* (particulate methane monooxygenase) gene encoding, the methanotrophic communities were under our limit of detection. Potential reasons for absence or inactivity of the bacteria will be studied by literature review (availability of CH₄, season, nutrients, water content, pH). The second soil campaign corresponding to the beginning of the growing season was done by mid April 2021, which included a second soil depth (10-20 cm). The molecular analysis of soil methanotrophic bacteria is still being processed. When results of microbial biomass, nutrients and soil methanotrophic bacteria are available, the data will be correlated with information of soil GHG fluxes monitored in the field with automated chambers.

Institute of Forest Engineering

Oral presentation

A comparative view on cable-yarding productivity

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Abstract

Cable yarding is a widespread method for wood-extraction in mountainous regions in most parts of the world. Especially in Austria extraction by cable is relevant at 57% of the forest covered land since it has terrain slopes of more than 30%. Since it is an elaborate and expensive extraction-method, the productivity of cable yarding-systems is of great interest for decision makers. Work- and time-studies are a comprehensive domain in the scientific field of forest engineering to create productivity models for cost estimation, simulation and other decision support systems or simply to compare different harvesting systems.

The present work investigates work studies on cable operations published in the scientific literature, in regards of assessment-methods and to establish a knowledge base on cable yarding productivity models. A comprehensive literature-research is performed to identify relevant studies in a first step. Information about the investigated extraction-campaigns in matters of site-specifics, stock-specifics, the employed equipment alongside the work-study-methods as well as the statistical approaches for model creation are collected. In a next step, the gained data and models will be processed or systematically analysed in order to compare different harvesting systems in regards of productivity and their influencing factors, respectively.

*Oral presentation***Einsatz eines personengetragenen Laserscanners zur automatischen Detektion und Vermessung von Forststraßenquerprofilen**Jana Pirolt^{1*}, Markus Pirker^{1*}, Christoph Gollob², Arne Nothdurft², Karl Stampfer¹

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*Correspondence: jana.pirolt@students.boku.ac.at, markus.pirker@students.boku.ac.at**Abstract**

Der Anspruch an Daten und Datenanalysen in der Forstwirtschaft ist in den letzten Jahrzehnten stetig gestiegen und erreicht mit zunehmender Digitalisierung ein Niveau, das nicht mehr allein mit konventionellen Zustandserhebungen erreicht werden kann. Der Einsatz von Laserscanning-Systemen hat das Potential diese Informationslücke in Zukunft zu schließen.

Für Waldinventur- und Waldmonitoring-Anwendungen werden diverse Lasertechnologien, wie Airborne Laserscanning (ALS), terrestrisches Laserscanning (TLS) oder personengetragenes Laserscanning (PLS), schon erfolgreich erforscht und erprobt. Darüber hinaus eröffnet PLS neue Potenziale in der Digitalisierung von forstlichen Erschließungs- und Produktionssystemen. Ziel der Bachelorarbeit war es, einen automatischen Algorithmus für die Identifikation, Vermessung und Visualisierung von Forststraßenquerprofilen zu entwickeln.

Untersuchungsobjekt für die Arbeit stellte eine sach- und fachgerecht errichtete Forststraße dar, welche mit einem personengetragenen Laserscanner gescannt wurde. Aus den gewonnenen 3D-Punktwolken wurde manuell im Programm vgh „CloudCompare“ die Forststraße detektiert und die Querprofilelemente (Fahrbahn, bergseitiger Graben, bergseitige/talseitige Böschung und Gelände) segmentiert. Diese händisch segmentierte Forststraße diente einem Klassifizierungsalgorithmus als Trainings- und Evaluierungsdatensatz.

Über eine Vielzahl an Inputvariablen (bspw. Nachbarschaftsbeziehungen der 3D Punkte, Höhenunterschiede, Distanzen zur Straßenachse) wurde ein SVM-Klassifikator (Support Vector Machine) an den Trainingsdatensatz angepasst. Die Evaluierung der Klassifizierung anhand der Referenzdaten ergab, dass die 3D-Punkte zu 93% richtig und automatisch den Klassen talseitige Böschung, Fahrbahn, bergseitiger Graben, bergseitige Böschung und Gelände zugeordnet werden konnten. Eine optimale Größe des Trainingsdatensatzes wurde über Kreuzvalidierungen ermittelt.

Darauf aufbauend wurden im Anschluss Vergleiche zwischen den Referenzquerprofilen und den automatisch klassifizierten Querprofilen der Forststraße getätigt. Die Breiten von talseitiger Böschung, Fahrbahn, sowie bergseitigen Graben und bergseitiger Böschung konnten mit einem RMSE von 0,44 m, 0,32 m, 0,68 m und 1,41 m bestimmt werden. Der dazugehörige bias betrug -0,30 m, 0,08 m, 0,04 m und -0,14 m. Der bergseitige und talseitige Böschungswinkel konnte mit einer Genauigkeit (RMSE) von 0,64° und 2,12° automatisch ermittelt werden. Der dazugehörige bias betrug -0,05° und -0,06°.

Die vorliegende Arbeit hat gezeigt, dass mit personengetragenen Laserscannern und entsprechenden Algorithmen eine automatische Detektion von Forststraßenquerprofilen machbar ist. Gleichzeitig bietet sich die Möglichkeit, diese Technologie für interessante zukünftige Fragestellungen beim Aus- und Neubau, sowie der Erhaltung, von Forststraßen einzusetzen.

Assessment catalogue for the comparison of relevant cable yarder parameters

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Abstract

In lack of standardization and unification in the European cable yarding industry this thesis aims to make a first step for a real comparability of different cable yarder fabricates. The relevancy of this thesis is also supported by the latest developments around the European Standard "Mobile yarders for timber logging" by the European Committee for Standardization.

In a first step, the thesis summarizes the state of the art of the most important components of every cable yarding fabricate and delivers later on a technical and physical analysis of it. As a result, it gives a recommendation regarding the comparability of the component.

The statements and concepts in this thesis are collected from expert talks with producers and users of cable yarders in Austria, as well as existing literature and comparison catalogues.

The outcome of this thesis is a catalogue of parameters which allows a more fundamental comparison of different cable yarder fabricates for users and producers.

*Poster Presentation***Fossil-free forestry: Utopia or a way out into the future?**Lukas Weikl, Martin Kühmaier¹

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Abstract

Even for the last critics, it is difficult to deny that climate change has arrived in the forestry sector. Fossil fuels are limited and not good for the climate, so renewable energies should be prioritized. It is in our hands that climate change can be mitigated or even slowed down.

The aim of this work is to show if fossil-free forest management will be possible or if it is a utopia. Conclusions should be drawn from this to what extent fossil-free forest management is possible, in order to be able to continue stable forest management in the future in the case that fossil fuels are exhausted.

The research questions are: Is it even possible to operate fossil-free forestry with the current technology? Can sub-processes or even entire processes be replaced without fossil fuels? How long will it take to replace fossil fuels and what effort and technology is necessary for that? What is the potential for saving greenhouse gas emissions if fossil fuels are dispensed with?

The methodology includes a literature research as well as the survey of the most important fossil and renewable energy sources. Furthermore, a process analysis and a data analysis will be executed. The next step is an identification of the most important processes in forestry and their consumption of fossil fuels. What amounts and types of fossil fuels are used in forestry? Furthermore, an identification of the processes that can be operated fossil-free will be done as well an assessment of the acceptance, feasibility, costs and savings potential of the new technologies.

The results should show data about the fossil energy consumption of the timber harvesting processes including delivery to the plant. Available and future technology that can replace fossil fuels in timber harvesting will be described and analyzed according to assessment of the acceptance, feasibility, costs and savings potential system. An outlook in the future should give an estimation at which time the fossil-free forestry will become reality.

Institute of Silviculture

Oral presentation

Entwicklung einer Douglasienaufforstung auf Kalk

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Abstract

Diese Arbeit beschäftigt sich mit der Pflanzung von Douglasien auf Kalkstandorten. Einen solchen Versuch legte das Waldbauinstitut der Universität für Bodenkultur Wien in einem Gebiet der Niederösterreichischen Kalkalpen an. Auf vier Teilflächen mit jeweils ca. 400 Exemplaren wurden zwei unterschiedliche Provenienzen getestet, Ashford (USA) und Douglasie Nordwestdeutschland. Es wurden die Jahreshöhenzuwächse gemessen, die Mortalität und die Vitalität festgestellt und beurteilt. Weiters wurden von einem repräsentativen Baumkollektiv Nadelproben gewonnen, und im Labor die Nährstoffgehalte an N, P, K, Ca und Mg ermittelt. In den statistischen Auswertungen wurde versucht, den Einfluss der unterschiedlichen Standortsfaktoren, Herkünfte und Nährstoffgehalte auf die Zielgrößen Höhenzuwachs, Mortalität und Vitalität zu erfassen. Bisher stehen die Messergebnisse von zwei Wuchsperioden zur Verfügung. Es zeigt sich, dass unterschiedliche Standortbedingungen, insbesondere die Exposition, einen nachweisbaren Einfluss auf den Wachstumsfortschritt haben, die Entwicklung der beiden Herkünfte jedoch weitgehend konform verläuft. Als überraschend zu werten ist das Ergebnis, dass bei allen überprüften Nährstoffen die vitalen Pflanzen über signifikant geringere Nährstoffmengen verfügen als die nicht vitalen Exemplare. Forschungsfragen: Gibt es einen Einfluss der Waldstandorte bzw. der Herkünfte auf den Höhenzuwachs? Gibt es einen Einfluss der Waldstandorte bzw. der Herkünfte auf die Mortalität? Gibt es einen Einfluss der Nährstoffe auf die Vitalität?

*Poster presentation***Waldbauliche Analyse von Fichten-Lärchenwäldern aus Hochlagenaufforstungen beim Murursprung (Lungau /Salzburg)**Martin Eder¹, Hubert Goldberger¹, Raphael Klumpp¹

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Abstract

Großflächige Entwaldung in den Hochlagen der Alpen, bedingt durch Almweide und Bergbau, sind bis in die Bronzezeit zurück nachweisbar und dauerten bis in das 18. Jahrhundert an. Erst die Umweltkatastrophen wie Bodenerosion, Lawinen und Muren des 19. Jahrhunderts führten zum Umdenken und mündeten in massive Hochlagenaufforstungen in Österreich in der 2. Hälfte des 20. Jahrhunderts.

Die vorliegende Arbeit befasst sich mit Hochlagenaufforstungen im Ursprungsgebiet der Mur („oberste Mur“), die zwischen 1954 und 1968 erfolgten. Das Untersuchungsgebiet mit einer Größe von 18,2 Hektar, befindet sich in der Gemeinde Muhr, Bezirk Tamsweg (Lungau), im Südhang des sogenannten Weißeck und Nebelkareck.

Auf einer Seehöhe zwischen ca. 1800m und 1900m wurden Aufforstungen mit Fichte und Lärche aus den Jahren 1954 bis 58 analysiert. Hierzu wurden insgesamt 10 Aufnahmeflächen angelegt mit einer Größe von 20x20m, in welcher Stabilitätsträger definiert und mittels metrischer (BHD, h) und qualitativer Merkmale charakterisiert wurden. Ferner wurden innerhalb der Aufnahmefläche eine Vollerhebung in einem Quadranten (10x10m) durchgeführt und alle Bestandesglieder mittels metrischer (BHD, h) und qualitativer Merkmale charakterisiert.

Die Auswertungen ergaben einen durchschnittlichen Bhd von 13,3 cm sowie einen durchschnittlichen H/D-Wert von 80,4. Die Säbelwuchsausbildung in den Aufgenommenen Flächen liegt bei durchschnittlich 59%, die Stammzahl je Hektar liegt bei 4950 Bäumen.

Oral presentation

Genetische Untersuchung der Artidentität und Autochthonie ausgewählter Stieleichenbestände im Kamptal in Niederösterreich

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Abstract

Die Baumart Eiche gilt als potenzieller „Gewinner des Klimawandels“, da sie sich an prognostizierte Klimaszenarien mit steigenden Dürre- und Hitzeperioden anpassen kann.

Die vorliegende Arbeit ist Teil des grenzüberschreitenden BiodivERsA Projektes „ACORN“, dessen langfristiges Ziel es ist, Saatgutquellen für zukünftige klimafitte Eichenwälder zu selektieren und Konzepte für den Transfer dieses Vermehrungsguts auf andere Standorte zu entwickeln, um die Anpassungsfähigkeit für Wälder in der Zukunft zu erhöhen.

Für diese Arbeit wurden vier Stieleichenbestände (*Quercus robur*) an zwei trockenen und zwei frischen Standorten im Kamptal in Niederösterreich ausgewählt und hinsichtlich 1) der taxonomischen Identität der dort stehenden Eichen, 2) ihrer intraspezifischen Diversität und Differenzierung und 3) refugialen Herkunft untersucht. Mittels einer bayesischen Clusteranalyse basierend auf 15 Kern-DNA-Mikrosatellitengenorten wurden 118 Bäume der Stieleiche und zwei der Traubeneiche zugeordnet. Weitere zwei wiesen einen intermediären Genotyp zwischen Stiel- und Traubeneiche auf. Ferner zeigte sich, dass sich die Stieleichen aus dem Kamptal sowie eine *Q. robur* Referenzpopulation aus Mitteleuropa (Oberrhein, Deutschland) auf der einen Seite genetisch deutlich von den zwei phylogenetisch zueinander näheren, mitteleuropäischen Referenzpopulationen der Trauben- (*Q. petraea*) und Flaumeiche (*Q. pubescens*) (ebenfalls aus dem Oberrhein, DE), abgrenzen ($F_{st} = 0,111$).

Im innerartlichen Vergleich mit den Stieleichenproben aus dem Oberrhein, DE, differenzieren sich die Kamptaler Stieleichen geringer ($F_{st} = 0,037$), aber ebenfalls signifikant. Die populationsgenetische Untersuchung innerhalb der vier Stieleichenbestände ergab, dass es sich im Kamptal um recht homogene Populationen handelt, wobei sich einer der trockenen Standorte mit höheren F_{st} - Werten tendenziell von den anderen drei Populationen unterscheidet.

Eine weitere Analyse von 10 Mikrosatelliten der Chloroplasten-DNA bewies, dass sich im Kamptal zwei eiszeitliche Rückwanderungswege größtenteils aus dem Apennin und zu einem kleineren Anteil aus dem Balkan trafen und es sich um autochthone Populationen handelt.

*Poster presentation***Vergleich der heimischen Weißtanne mit Provenienzen aus Südosteuropa anhand eines regionalen Provenienzversuches in Vorarlberg**Mathias Klien¹, Michael Klien¹, Raphael Th. Klumpp¹

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Abstract

Climate change effects are present already in Central European Forests and according to different models, it can be assumed that there will be even more significant changes in future. Thus, extreme weather events, such as prolonged droughts, storms and heavy rainfalls, are expected to occur more frequently. These climate changes will have significant impact on the growth dynamics of silver fir (*Abies alba*).

A silver fir provenance test was established in 2016 in order to find out, which provenances of European silver fir may fit best to the region of Vorarlberg under future climate conditions. The trial was established at two different elevations in Hittisau (1200 m a.s.l.) and Satteins (500 m a.s.l.) using a block design with one replicate per site and 64 plants per cell. One local provenance, one provenance from Romania, one from Bulgaria as well as one provenance each from *Abies borisii-regis* und *Abies bornmuelleriana* are included.

This bachelor thesis analyses the regional silver fir provenance trial of Vorarlberg at an age of 5 years after completing. Metric data such as total height, annual height increment (2017-2020), diameter d_{0,1}, as well as different traits such as vigor, mortality, and stem shape will be measured.

We expect first results showing the interaction between provenances and environment at the two different trial sites of Vorarlberg. Provenance reaction to extreme drought conditions of the years 2018 and 2019 are of particular interest, as *Abies alba* is currently discussed to be a potential substitute for Norway spruce in European forestry.

Development and application of IT-supported collaborative planning methods considering uncertainty for advising sustainable development

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Abstract

The arising global environmental change is going to lead to undesired and irreversible consequences for large parts of the world. Collaborative planning to solve sustainability problems has to cope with a tremendous complexity arising from human-environment interaction. In the process of making such decisions, elements of uncertainty may be ignored, which bring along unintended consequences. Hence, the overall goal of this thesis is to further develop and to apply IT-supported collaborative planning methods to support decision-making regarding sustainability problems considering uncertainty.

Two sustainability problems are in depth analyzed: 1) On the micro-level, a heating system purchase decision for a family house is studied by a broad scale simulation experiment using R. It uses the Analytic Hierarchy Process and is based on random data to analyze if the consideration of uncertainty (e.g., model conceptualization uncertainty) changes the ranking of the alternatives compared to the ranking computed neglecting uncertainty. 2) On the macro-level, a SDG target prioritisation is studied by the application of multiple models to assess if the SDG target ranking of the country case of Sweden is sensitive to the approach. The model input data embraces scorings provided by experts. Furthermore, the Analytic Network Process is firstly applied to assess SDG target interactions.

The results show that neglected uncertainty is a game changer as the consideration of uncertainty leads to rank reversals for the heating system purchase decision. With respect to SDG target prioritisation, the Analytic Network Process validates the two SDG target rankings calculated by the Weitz et al. (2018) approach, which indicates that the rankings of the Weitz et al. (2018) approach provided are robust. However, the communication regarding the involved uncertainty and its validation attempts are crucial for the acceptance of the recommended advice computed by the IT-supported collaborative planning method.

*Oral presentation***Waldbauliche Analyse einer Zirbenaufforstung in Winklern/Kärnten**Stella Antonia Waszilovics, Mirijam Zimmermann, Raphael Th. Klumpp¹

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Abstract

Die Zirbe bedeckt in Österreich in etwa 0.5% der Waldfläche. Sie ist eine der wichtigsten Baumarten bei Hochlagenaufforstungen im Schutzwald. Trotz der hohen Bedeutung der Zirbe für den Schutzwald sind die frühen Hochlagenaufforstungen aus der zweiten Hälfte des 20. Jahrhunderts in Österreich kaum untersucht. Lediglich in der Schweiz gibt es intensiv dokumentierte und analysierte Hochlagenaufforstungen wie etwa das Beispiel „Stillberg“ in Davos.

Die folgende Arbeit beschäftigt sich mit einer Hochlagenaufforstung mit Zirbe in Kärnten. Der untersuchte Waldbestand befindet sich im oberen Mölltal bei Winklern, am Fuße des Großglockners. Die aufgenommene Fläche trägt den Namen „Zirbenfläche Agrargemeinschaft Penzelland“ und befindet sich auf dem Penzelberg. Das 1982 mit Zirbe aufgeforstete Gebiet umfasst etwa 3 Hektar und liegt mit einer Höhe von 1800m im mittleren Abschnitt des Subalpinum. Die Fläche ist Teil des Wuchsgebietes 1.2 Subkontinentale Innenalpen-Westteil und hat einen Jahresmittelniederschlag von 758mm. Die Jahresmitteltemperatur beträgt 10,6°C (ZAMG, 2021).

Jeder Zukunftsbaum und die dazugehörigen Bedränger wurden aufgenommen. Zusätzlich wurde bei jedem vierten Zukunftsbaum ein fixer Probekreis, insgesamt 25 Stück, aufgenommen um einen Überblick über den Gesamtbestand zu bekommen. Es wurden 285 Bäume der Baumarten Zirbe, Fichte und Lärche aufgenommen. Diese Individuen beinhalten 85 Zukunfts bäume (Z-Bäume) und 132 Bedränger. Die aufgenommenen Daten umfassten die GPS Position der Bäume, Baumart, Soziologie, BHD, Höhe, Höhe des Kronenansatzes, Höhe des ersten Totastes und Schäden. Sofern es sich um einen Zukunftsbaum handelte wurden zusätzlich die Z-Baum Nummer, Kronenradius nach Nord, Süd, Ost und West und jeweils der stärkste Ast beziehungsweise die Art des Astes in verschiedenen Bereichen des Baumes erfasst. Die Z-Bäume wurden in die Bereiche B, C und D, welche jeweils 40cm Höhe umfassten, eingeteilt, um einen besseren Überblick über die Astigkeit der Bäume zu gewährleisten. Bei den Bedrängern wurde zusätzlich die Bedrängernummer, Distanz zum Zukunftsbaum und der Kronendurchmesser aufgenommen.

Es wird untersucht, wie sich die Konkurrenz auf die Astigkeit und somit auf die Stabilität des Baumes und die Qualität des Holzes auswirkt. Mit Hilfe des Konkurrenzindex nach Hegyi wird die Konkurrenz von Bedrängern und Zukunfts bäumen des Bestandes dargestellt. Des Weiteren wird der Einfluss von qualitätsmindernden Merkmalen wie Wipfelbrüchen und Zwieselbildung auf die Holzqualität beurteilt.

Außerdem wird die Frage des Einflusses von ausgewählten Zukunfts bäumen als Stabilitätsträger für den zukünftigen auf der Fläche stockenden Wald behandelt.

Institute of Forest Growth

Poster presentation

Heizwertzuwachs und Trockensubstanzverlust durch Lufttrocknung von gelagertem Rundholz

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Abstract

Based on an annual assessment of the Linz AG storage, the stacked wood is measured as total cubic volume, which is subsequently converted into the energy content. The aim of the present work is to determine the energy content of the stacked biomass at the time of the assessment of the inventory holding. Another objective was to determine how the storage of logs affects the moisture content, dry weight (biomass), and calorific value.

To determine this, logs were sampled at the time of storage for the three factors listed above. After a storage period of 1 to 2 years, the logs were sampled again before they were utilized for energy and the changes were determined.

This study indicates that the loss of dry weight was more significant than the reduction in moisture content. The energy content at the time of storage was higher than at the time of removal from storage. The storage period used by Linz Ag for the logs was too long to have a positive effect on the calorific value.

Oral presentation

Evaluation of reforestation in high altitudes

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Abstract

Many campaigns for reforestation in high altitudes in Austrian mountains were started from the 1950s to the 1970s to mitigate the effects of former deforestation. Potential avalanche depletion areas at the tree line were reforested to reduce avalanche hazard and to protect people in the valley. To address efficient strategies for the future reforestation, these plantations need to be evaluated.

In this study 30 reforestations established from 1964 to 2013 in the Paznauntal and Stanzertal were evaluated. For all reforestations shapefiles were available from previous bachelor thesis. Tree species planted according to reforestation chronicles were mainly Norway Spruce, European larch and Cembran pine.

First orthophotos were classified in forest and non-forest areas (meadow, rock, shadows) using the random forest learning machine algorithm. To this end shapefiles from the reforestations from the Paznauntal and Stanzertal were georeferenced and training data sets for different land cover classes were created with QGIS. These training data sets were then exported to RStudio. The random forest was trained and the orthophotos classified and classification results were visually verified in QGIS.

In a second step, tree species were classified using the same algorithm. In a final step classification of tree species will be verified in the field.

The Random Forest detected the presence of trees with an accuracy of 80-90%. Also, for the classes “rock”, “meadow” and “shadow” the classification worked well. It was not possible to assign the class shadow to the respective landcover class. The proportion of trees in the different reforestation areas ranged between 11-74%. The classification of different tree species showed good classification results between Norway spruce, European larch and Cembran pine, but was more problematic for tree species of the same genus.

Digitale Waldinventur mit dem iPad-Laserscanner

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Abstract

In der modernen Waldinventur gewinnen terrestrisches Laserscanning (TLS) und mobiles personengetragenes Laserscanning (PLS) immer mehr an Bedeutung. Stand zunächst die Entwicklung automatischer Auswertelgorithmen von 3D-Punktwolken zur Baumentdeckung, Durchmesser- und Höhenmessung im Vordergrund wissenschaftlicher Forschung, so sollten nun die neuen Technologien und Routinen im praktischen Waldinventureinsatz umfassend getestet und angewandt werden. Hohe Anschaffungskosten von TLS und PLS Systemen verhindern häufig eine breitere Anwendung in der forstlichen Praxis. Im Jahr 2020 implementierte Apple einen LiDAR (Light Detection and Ranging) Sensor in das Apple iPad Pro (4. Gen) und iPhone Pro 12. Dadurch können nun erstmalig LiDAR-generierte 3D-Punktwolken mit Consumer-Geräten erfasst werden. Im Rahmen dieser Bachelorarbeit wurde der Einsatz eines iPad Pro zur automatischen Entdeckung von Baumpositionen und zur Messung von Durchmessern auf Waldinventurstichprobenpunkten untersucht.

Im Rahmen dieser Arbeit wurden Messungen auf 21 Probeflächen der Betriebsinventur im BOKU-Lehrforst unternommen. Diese Probeflächen repräsentierten eine breite Vielfalt der möglichen Außenbedingungen hinsichtlich der Waldstruktur, der Geländeneigung und der Baumarten. Die Messungen wurden separat mit drei verschiedenen Apps durchgeführt, mit der „3D Scanner App (Version 1.8.2)“, mit „Polycam (Pro-Version 1.3.1)“, und mit „Sitescape (Version 1.0.4)“. Bei jedem Scan wurde eine zuvor festgelegte Route begangen. Zu Vergleichszwecken wurde auch mit dem bewährten personengetragenen Laserscanner GeoSlam ZEB-Horizon gescannt. Als Referenzdaten für die Beurteilung der Güte der Baumfindung und Durchmesserermessung dienten manuell kontrollierte Stammverteilungspläne aus früheren Studien und kluppierte Bruthöhendurchmesser (BHD). Die Datenauswertung hinsichtlich Baumposition und BHD wurde mit am Institut für Waldwachstum (WAFO) entwickelten automatischen Algorithmen durchgeführt.

Die Entdeckungsraten der Bäume mit BHD ≥ 10 cm betragen mit der 3D Scanner App 97,33%, mit Polycam 90,65% und mit Sitescape 95,06%. Die PLS Scans hatten eine Entdeckungsrate von 99,52%. Der RMSE der automatischen BHD Messung betrug bei der 3D Scanner App 3,65 cm (bias -0,50 cm), bei Polycam 4,51 cm (bias 1,03 cm) und bei Sitescape 3,46 cm (bias -0,41 cm). Im Vergleich dazu hatte der PLS Scan einen RMSE von 1,59 cm (bias -0,54 cm).

Die Ergebnisse waren überraschend gut, auch wenn nicht die gleiche Genauigkeit des PLS erreicht wurde. So ist die Entdeckungsrate bereits sehr gut, die Genauigkeit der BHD-Messungen ist noch ausbaufähig. Zusammenfassend erscheint der Einsatz des iPads zur digitalen Waldinventur jetzt schon möglich. Der breite Einsatz in der Waldinventurpraxis ist aber momentan noch durch die geringe Reichweite des LiDAR Sensors und die Verfügbarkeit geeigneter Softwarelösungen limitiert. Im Vergleich zu TLS und PLS sind die Anschaffungskosten beim iPad wesentlich geringer. Außerdem sind Weiterentwicklungen des LiDAR Sensors bei Apple und bessere Softwarelösungen in Zukunft sehr wahrscheinlich.

Oral presentation

Vermessung liegenden Holzes mithilfe terrestrischer Laserscans

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Abstract

Die Ermittlung des Bestandesvorrats wie auch des Einzelbaumvolumens stellt eine der zentralen Aufgaben der Waldinventur dar. In den letzten Jahren konnten zur automatisierten Entdeckung und Vermessung von stehenden Bäumen Algorithmen für die Auswertung von terrestrischen Laserscandaten erfolgreich entwickelt und angewendet werden. Zunehmende Schadereignisse sowie Weiterentwicklungen in der Ernte- und Rücketechnologie benötigen darüber hinaus jedoch automatisierte und präzise Informationen von liegenden Bäumen.

Ziel dieser Arbeit war es, aus einer mit einem terrestrischen Laserscanner (TLS) erstellten Punktwolke, liegende Baumstämme automatisiert zu erkennen und zu vermessen, um die Anzahl liegender Stämme, deren Durchmesser und Volumina bestimmen zu können. Dazu wurden 43 Fichten und Tannen gefällt, entastet und mit einem TLS (Faro Focus^{3D} X330) gescannt. Als Referenzdaten dienten händische Messungen der Stammlängen sowie sektionsweise Kluppierungen.

Nach einer Klassifizierung der Punktwolke in Bodenpunkte und Nicht-Bodenpunkte wurden letztere mit einer dichte-basierten Clusteranalyse in Cluster eingeteilt. Diese Cluster konnten dann nach ihrer Länge sowie nach dem Varianzanteil der ersten Hauptkomponente gefiltert werden, um die liegenden Baumstämme von Störelementen wie beispielsweise Ästen oder sonstiger Vegetation zu trennen. Anschließend wurde jeder Stamm (Cluster) um jene Punkte erweitert, die eingangs fälschlicherweise als Bodenpunkt kategorisiert oder einem falschen Cluster zugewiesen wurden. Mehrere Cluster, die denselben Stamm darstellten, wurden anschließend automatisch miteinander verbunden.

Die liegenden Stämme konnten mit einer Entdeckungsrate von 91 % automatisch gefunden werden, die Falschpositivrate betrug 0 %. RMSE und Bias der vom Algorithmus ermittelten Stammlängen betragen 3,9 m (21,1 %) und -2,7 m (-14,5 %). Die Durchmesser entlang der Stämme wurden mit 1,8 cm (10,1 %) RMSE und -0,4 cm (-2,2 %) Bias automatisch ermittelt. Das Einzelstammvolumen des automatisch entdeckten liegenden Holzes konnte mit einem RMSE von 0,13 fm (24,1 %) und Bias von -0,01 fm (-2,8 %) automatisiert bestimmt werden. Im Vergleich zu bereits publizierten Verfahren ist die Genauigkeit des neuen Verfahrens außergewöhnlich hoch.

Poster presentation

Development and evaluation of automatic algorithms for the dynamic measurement of wood chip stockpiles using different terrestrial laser scanning systems

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Abstract

Supply chain management is key for an efficient organization of the wood supply from forest raw materials. A precise inventory of the resources along the complete supply chain is mandatory for an efficient and profitable procurement of the raw materials. However, nowadays and according to traditional practice methods, changes in the woodchip stock are only coarsely monitored. In recent years, laser-scanning technology was developed that provides highly precise measurements in 3D. Thus far, the application of laser scanning for the monitoring of woodchip stocks was simply hindered by lacking software routines for automatic processing of the 3D data (point clouds) as well as by the high investment costs of the laser scanners. The aim of this study is to test whether automatic detection, volume estimation, and change detection of the stockpiles is possible with laser scanners. Further, it is tested in more detail whether an automatic size categorization of the wood chips is also feasible. For this purpose, new algorithms are developed for the analysis of the 3D point cloud data from laser scanning of woodchip stockpiles. The laser scanning of the woodchip piles was performed with three different scanners: (i) a stationary terrestrial laser scanner (TLS, Faro Focus3D X330), (ii) a personal laser scanner (PLS, GeoSlam Zeb Horizon), and (iii) a tablet computer (Apple iPad Pro 4th Gen.). Using each device, a time series of scans was produced when the size of the stockpile was successively increased by loadings from wheel loader. The standardized bucket volume, specified by the manufacturer, served as reference data. Wood chip probes were sampled from the piles, and manual measurements of the chips served as reference for the automatic chip-size estimation with the laser scanner. In total, 546 m³ (reference volume) of wood chips were scanned.

Poster presentation

Intra-annual radial tree growth of Norway spruce (*Picea abies*) and Swiss stone pine (*Pinus cembra*) at high elevation sites in Tyrol

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Abstract

Alpine ecosystems are facing a trend of rising atmospheric temperatures and changes in seasonal precipitation allocations. Therefore, intra-annual growth research is significant to understand how different climate conditions affect growth dynamics. Object of this thesis is to capture, to model and to interpret the intra-annual radial tree growth as a function of varying climatic conditions, considering the different growth periods and tree species.

From 2013 to 2019 radial stem growth of Norway spruce and Swiss stone pine was observed via hourly measurements using automatic band dendrometers. The monitored trees were arranged along altitudinal gradients, within a vertical range from 1300m to 2050m a.s.l., at high elevation sites in Tyrol (Gerlos, Hinteres Zillertal). As diameter increment, soil and air temperature were monitored in situ on an hourly temporal resolution as well. Precipitation data was provided from nearby precipitation measuring stations inside the relevant catchment areas.

A general additive model (GAM) was fitted to the data by using the *mgcv* package in R. With the help of smooth functions, GAM's are capable to model the nonlinear, sigmoid shaped intra-annual growth curves. Consecutive smooth functions of variables, random effects and interactions of covariates via tensor products are tested and applied in the model.

Evaluierung des Einsatzes videogrammetrischer Punktwolken zur Positionsbestimmung und Durchmessermessung von Bäumen im Vergleich zu PLS-Daten

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Abstract

Personengetragene Laserscanner (PLS) werden zunehmend für den praktischen Einsatz in der Waldinventur erforscht und erprobt. Dabei werden 3D-Punktwolken mithilfe von Light Detection and Ranging (LiDAR) Sensoren und Simultaneous Localization and Mapping (SLAM) Algorithmen erstellt. Anschließend werden klassische Waldinventurparameter (Baumposition, BHD, Höhe, etc.) mit automatischen Auswerteroutinen aus den Punktwolken extrahiert. PLS weisen zurzeit noch sehr hohe Anschaffungskosten auf, wohingegen die Photogrammetrie (PGM) eine kostengünstige Alternative darstellen könnte.

Bei der PGM wird eine 3D-Punktwolke aus einer Vielzahl an herkömmlichen 2D-Bildern generiert. Anwendungen der terrestrischen PGM im Rahmen von Waldinventuren beschränken sich bisher auf wenige Studien, in denen viele Fotos von Waldinventurpunkten zur 3D-Punktwolkenerstellung verwendet wurden. Da dieses Verfahren sehr zeitaufwendig ist, wurde im Rahmen dieser Arbeit die Möglichkeit 3D-Punktwolken aus Videos zu generieren untersucht (Videogrammetrie, VGM) und die Qualität und Performance hinsichtlich der Baumfindung und Durchmessermessung mit erprobten PLS-Verfahren verglichen.

Datengrundlage bilden 10 Inventurpunkte im Lehrforst der BOKU, deren Einzelbaumdaten (BHD, Baumposition) bereits bekannt waren. Die PLS-Daten wurden mit einem GeoSlam ZEB-Horizon Scanner und die Videos mit einer handelsüblichen Videokamera (Panasonic HC-X929) aufgenommen. Zur Erstellung der Punktwolken und deren Auswertung wurden die Programme FFMPEG, Agisoft Metashape, CloudCompare, sowie R-Studio verwendet. Des Weiteren wurde zur automatischen Auswertung der Punktwolken hinsichtlich Baumposition und Durchmesser ein Algorithmus des Instituts für Waldwachstum verwendet.

Es zeigte sich, dass VGM keine brauchbare Alternative zu PLS darstellt. VGM-Punktwolken konnten lediglich für 5 der 10 Inventurpunkte erstellt werden und für diese Inventurpunkte war die Qualität der VGM-Daten wesentlich schlechter als die der PLS-Daten: Die Baumentdeckungsrate betrug 46,56% mit VGM und 81,46% mit PLS, die Falschpositiv-Rate bei der Baumentdeckung betrug mit VGM 14,28% und mit PLS 2,52%. Der Bias der BHD-Messung betrug bei VGM 2,69% gegenüber -0,85% bei PLS und der Bias der Positionsbestimmung betrug bei VGM 0,80% gegenüber 0,04% bei PLS.

Institute of Forest Entomology, Forest Pathology and Forest Protection

Oral presentation

Wolbachia* dynamics in the invasive North American Cherry Fruit Fly, *Rhagoletis cingulata

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Abstract

The bacterial endosymbiont *Wolbachia* is a maternally inherited bacterium that can manipulate the reproduction of its hosts like many arthropod species and nematodes. Cytoplasmic incompatibility (CI) is the most dominant form of manipulation, it promotes vertical transmission and results in selection pressure on uninfected males. *Wolbachia* have potential to be used for biological control agent against harmful pests, particularly in combination with the Sterile Insect Technique SIT. One less understood phenomenon of *Wolbachia* is its potential for horizontal transfers between distant species which has been shown in phylogenetic studies but experimentally only a few studies exist.

Wolbachia infection dynamics has been studied in the American cherry fruit fly, *Rhagoletis cingulata*, an invasive species in Europe making it as a model organism for understanding horizontal *Wolbachia* transmission. Indeed, the *Wolbachia* strain *wCer1* in the native host *Rhagoletis cerasi* is found to be identical to *wCin1* in the invasive *R. cingulata* which indicates recent horizontal transmission. Screening *wCin1* in the European *R. cingulata* populations is scientifically of high interest to determine the location and frequency of *wCer1* transfer to *R. cingulata*.

In this thesis 350 individuals from about ten populations from three European countries (France, Belgium, and Italy) collected in 2020 were screened for the *wCin1* presence. The strain *wCin2* is omnipresent in *R. cingulata* and thus was used as positive control. DNA was extracted from individuals followed by PCR amplification and gel electrophoresis. Some individuals will be sequenced with the *wsp* primers to identify *wCin1*. Furthermore, individuals showing negative results for *wCin2* will be sequenced via DNA-barcode to identify if these individuals belong to *R. cingulata* or are different species. The prospective results provide a better understanding of *Wolbachia* infection dynamics across Europe and raise our knowledge of horizontal transfer between two phylogenetically distant species.

Untersuchungen zu etwaigen non-target Effekten an landwirtschaftlichen Nutzpflanzen durch das *Verticillium nonalfalfae* - Isolat Vert56

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Abstract

Der Götterbaum (*Ailanthus altissima*) ist eine aus Asien stammende, invasive Baumart (Neophyt), die im 18. Jh. als Zierbaum nach Europa gebracht wurde und sich in den letzten Jahren aufgrund seiner hohen Konkurrenzfähigkeit zu einer Problembaumart entwickelt hat. In bisherigen Studien hat sich das *Verticillium nonalfalfae*-Isolat-Vert56 als geeignet zur biologischen Bekämpfung des Götterbaums erwiesen, wobei an anderen Gehölzarten bisher keine oder nur sehr geringe Effekte auftraten.

In diesem Folge-Versuch wird nun die Auswirkung dieses Welkepilz-Isolats auf weitere zehn landwirtschaftliche Kulturpflanzen untersucht. Bei den zu testenden Arten handelt es sich um Bohne, Rote Rübe, Rettich, Tomate, Paprika, Kartoffel, Knollensellerie, Weißkraut, Melanzani und Erdbeere. Letztere werden bereits als Pflanzen von einem Gartenmarkt bezogen, alle anderen Arten werden im BOKU Forschungsglashaus aus Samen selbst angezogen. Zur Kontrolle der Pathogenität des verwendeten Welkepilz-Isolats werden zudem getopfte Götterbäume in die Untersuchung einbezogen, die wenige Wochen nach der Behandlung eine deutliche Welke zeigen sollten.

Außer für Kartoffel erfolgt die Inokulation der Pflanzen durch Eintauchen des freigelegten Wurzelsystems in eine Sporensuspension nach der Methode von Flajšman et al. (2017), die Inokulation der Kartoffelpflanzen erfolgt nach Tai et al. (2013) durch Eingießen der Sporensuspension in zuvor hergestellten Löcher in der Topferde, wodurch auch kleine Verletzungen des Wurzelsystems induziert werden sollen. Der Zeitpunkt der Behandlung hängt von der Größe der Pflanzen, d.h. von der Entwicklung ihrer Wurzelsystems ab und wird in der Regel erfolgen, wenn die Pflanzen zwischen 4 - 6 (8) Wochen alt sind.

Alle behandelten Pflanzen werden für weitere 8 Wochen im Glashaus aufgestellt und wöchentlich eine Bonitur etwaiger Symptome einer *Verticillium*-Welke mittel einer 5-teiligen Bewertungsskala durchgeführt. Danach werden die Pflanzen geerntet, Re-isolierungen zum Nachweis des Erregers in infizierten Pflanzen durchgeführt und die Biomasse der Welkepilz-behandelten sowie der Kontrollpflanzen bestimmt.

*Oral Presentation***Spatial spread of the *Wolbachia* strain wCin1 in *Rhagoletis cingulata***Lukas Vonmetz^{1*}, Thomas Wolfe¹, Hannes Schuler², Christian Stauffer¹

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Abstract

The intracellular, maternally inherited bacterial endosymbiont *Wolbachia* is widespread in arthropods and filaria nematodes. *Wolbachia* manipulates the reproduction process of its host. One of the major manipulations of *Wolbachia* is cytoplasmic incompatibility (CI), which occurs when an infected male mates with an uninfected female, and arrests embryonic development. This mechanism gives infected females an advantage over uninfected females and allows *Wolbachia* to spread effectively through a host population. In the last decades, *Wolbachia* been used to control species that are plant pests or vectors of human pathogens.

The American cherry fruit fly, *Rhagoletis cingulata*, is an invasive pest species on sweet and sour cherries which was introduced in Europe in the second half of the 20th century. In its native range North America, *R. cingulata* populations are only infected with wCin2, whereas European *R. cingulata* populations harbour two *Wolbachia* strains wCin1 and wCin2. Horizontal transmission events are rarely observed in nature, but studies have suggested that in the case of *R. cingulata* a recent transfer of wCer1 from the native European cherry fruit fly, *R. cerasi*, occurred. Natural population studies of *Wolbachia* infection rates enable us to better evaluate the spread of the endosymbiont into new hosts and new territories. Factors leading to a successful and fast spread include *Wolbachia*'s ability to efficiently transmit from mother to offspring and its influences on host fitness and the strength of CI.

In this thesis a total of 360 individuals from 15 locations in five different European countries (Germany, Hungary, France, Belgium, Netherlands) collected in 2019 were screened for wCin1 infections. All populations were infected with wCin1 and infection rates varied between 50% and 100%. The Hungarian populations had infection rates between 25% and 61,9 %. In comparison to previous results, this shows an increase of wCin1 infections in natural *R. cingulata* populations in Germany and Hungary since the last time assessed between 2006 and 2012.

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Poster Presentation

Wachstum von Bäumen auf einer Wiederbewaldungsfläche einer Finca der Tropenstation La Gamba, in der Region Puntarenas, Costa Rica

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Abstract

Die weltweite Fläche an Tropenwald nimmt seit mehreren Jahrzehnten durch menschliche Tätigkeit ab, weshalb Wiederbewaldungsprojekte international relevant sind und ein spannendes Forschungsgebiet darstellen. Im Rahmen der Arbeit wurde das Wachstum von zehn verschiedenen Baumarten auf einer 16ha großen Wiederbewaldungsfläche mit schwierigen Wachstumsbedingungen im südwestlichen Costa Rica quantifiziert. Auf der aufgenommenen Fläche wurden dabei rund 700 Bäume im Alter von 2,5-3,5 Jahren in Form von BHD, bei kleineren Bäumen die Höhe, gemessen, sowie Fraßschäden und der Einfluss von Lianen über die gesamte Fläche repräsentativ verteilt erfasst. Im Alter von ca. drei Jahren betrug der BHD zwischen 0 und 27 cm. Der Einfluss von Fraßschädlingen, hier sind vor allem Blattschneiderameisen zu erwähnen, stellt am Standort ein größeres Problem dar als der Einfluss von Lianen. Dabei wurde jedoch nur bei wenigen Baumarten ein vermindertes Wachstum bei stärkerem Befall festgestellt. Das Wachstum der Bäume auf der untersuchten Fläche ist geringer als auf einer anderen Wiederbewaldungsfläche in der Gegend, was auf die schlechtere Nährstoffversorgung und den besonders sauren Boden zurückzuführen sein dürfte. Die Ergebnisse der Arbeit informieren über die Eignung verschiedener Baumarten am Standort sowie über Faktoren, die das Wachstum limitieren. Daraus lassen sich mögliche Pflegeinterventionen am Standort und allgemein Empfehlungen für das Management von Wiederbewaldungsflächen in der Region ableiten.

Index of contributors

Abalos, D.....	36
Aleksza, D.	26, 29, 34
Ammerer, U.	9, 44
Außerwöger, A.	11, 50
Barbosa, A.C. de A.....	9, 19
Behringer, M.....	11, 13
Bertrand, I.....	25
Bilyera, N.....	25
Bitar, A.....	11, 20
Böhm, S.....	9, 40
Brunetti, G.	37
Carlsen, H.	48
Causon, T.....	34
Daudin, G.	25
de Jong, P.	11, 21
Dercon, G.	32
Diaz-Pines, E.....	36, 38, 39
Dippold, M.	21, 29
Dobetsberger, G.....	11, 60
Dovas, A.....	9, 14
Eder, M.....	11, 45
Eguchi, T.	32
Eichinger, C.....	28
Eisner, A.....	9, 44
Elshal, A.	9, 57
Englisch, M.....	17
Esparza Robles, U.R.....	11, 22
Fernández Balado, C.	11, 23
Finke, P.	36
Fitzky, A.C.	9, 15
Fohrafellner, J.	9, 24
Foldal, C.....	38
Friesl-Hanl, W.....	28
Gerzabek, M.H.	19, 32
Gillespie, L.....	36
Godbold, D.L.	16, 18
Goldberger, H.....	11, 45
Gollob, C.	41, 52, 53, 54, 56
Grätz, T.A.....	9, 51
Graus, M.....	15
Gruber, S.....	9, 46
Hann, S.	34
Hasenauer, H.	44
Hauser, M.T.....	26
Hembach, S.....	57

Index

Herold, L.....	11, 27
Hietz, P.....	60
Hochbichler, E.....	46
Hommel, S.....	9, 44
Hood-Nowotny, R.....	28
Hummel, C.....	9, 25
Jandl, R.....	38
Kandeler, E.....	39
Kanzian, C.....	40
Karl, T.....	15
Kaser, L.....	15
Katzensteiner, K.....	13, 17
Keiblinger, K.....	23, 24, 35, 37
Kjøller, R.....	16
Klien, Ma.....	11, 47
Klien, Mi.....	11, 47
Kloimböck, T.....	11, 26
Klumpp, R.....	45, 47, 49
Kotsia, R.M.....	9, 16
Kühmaier, M.....	40, 43
Leitner, S.....	23, 37
Lippold, E.....	25
Mahmoud, M.....	15
Murugan, R.....	22, 24
Nelson, W.....	22
Neophytou, C.....	46
Noller, C.....	9, 28
Nothdurft, A.....	41, 52, 53, 54, 56
Oburger, E.....	25, 26, 29, 33, 34
Oostenbrink, C.....	19
Otxandorena Ieregi, U.....	11, 29
Peron, A.....	15
Pesendorfer, M.....	15
Petrovic, D.....	12, 58
Philipsen, F.....	12, 30
Pirker, M.....	9, 41
Pirolt, J.....	9, 41
Pülzl, H.....	48
Puschenreiter, M.....	20, 26, 29, 33
Rahman, U.....	12, 31
Razavi, B.S.....	25
Rewald, B.....	2, 15
Ritter, T.....	52, 53, 54, 56
Rohling, M.....	9, 32
Rötter, R.P.....	22
Sanden, H.....	14, 15
Santangeli, M.....	25, 29
Santner, J.....	25
Scheidl, C.....	51

Schlüter, S.....	25
Schmidt, H.....	29
Schrötter, A.	12, 17
Schuler, H.....	57, 59
Schwalm, H.	12, 33
Schweitzer, S.	10, 52
Seywald, J.	10, 53
Soja, G.	37
Spiegel, H.....	21, 24
Spielvogel, S.	25
Spiridon, A.	10, 26, 34
Stampfer, K.	41, 42, 54
Staudinger, C.	33
Stauffer, C.	57, 59
Steiner, P.....	10, 35
Steinparzer, M.	10, 18
Stelzer, M.	11, 50
Strobel, B.....	30
Stumpp, C.	37
Tholen, D.....	15
Tlustoš, P.	14
Tonner, M.....	12, 54
Toth, W.....	10, 48
Triches, N.....	10, 36
Tunega, D.....	19
Ugochukwu, T.U.....	10, 23, 37
Vacik, H.	48
Valkama, E:.....	24
Vetter, R.	10, 38
Vetterlein, D.....	25
Villalba, G.	12, 39
Vilsmeier, A.	10, 42
Vonmetz, L.	10, 59
Vospernik, S.....	50, 51, 55
Waszilovics, S.A.....	10, 49
Watzinger, A.....	23, 28, 31, 37
Weigl, L.....	12, 43
Welser, F.	10, 55
Wenzel, W.	21, 25, 30
Wessely, M.....	10, 56
Wimmer, R.	50
Winder, M.	10, 52
Wissuwa, J.	28
Wolfe, T.	10, 57, 59
Zechmeister-Boltenstern, S.....	22, 24, 39
Zhang, X.....	25
Zimmermann, M.	10, 49

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