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SUSALPS Conference 2018 – Book of Abstracts: Montane and alpine grasslands under climate change – ways in a sustainable future

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Title SUSALPS Conference 2018 – Book of Abstracts: Montane and alpine grasslands under climate change – ways in a sustainable future

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Date November, 6th 2018

Abstract From 18 to 20 September 2018, the SUSALPS Conference "Montane and alpine grasslands under climate change – ways in a sustainable future" was held in Garmisch-Partenkirchen, Germany. More than 60 participants from nine nations attended the conference. The event covered a broad scope and offered the opportunity to discuss both fundamental research and practical approaches in grassland management. At the conference's closing day, excursions took place to the SUSALPS experimental areas in Fendt and on the Brunnenkopfalm. This publication provides the abstracts of all oral and poster presentations.

Keywords montane and alpine grasslands, soil organic matter, microbiome, plant diversity and productivity, biogeochemical cycles, remote sensing, ecosystem services, alpine farming

Book of Abstracts

MONTANE AND ALPINE GRASSLANDS UNDER CLIMATE CHANGE – WAYS IN A SUSTAINABLE FUTURE

18-20 September 2018 | Garmisch-Partenkirchen, Germany

SUSALPS CONFERENCE 2018

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BONARES

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Abstracts

Session 1: Soil organic matter dynamics in mountainous grassland soils

Grassland soil organic matter dynamics along management intensity and temperature gradients

CHRISTIAN PÖPLAU[1]

[1]*Thünen Institute of Climate-Smart Agriculture*

Abstract:
Globally, grasslands are a major land-cover type and store large amounts of soil organic matter (SOM). Small relative changes in soil organic carbon (SOC) stocks can thus have a significant influence on the global carbon cycle driving climate change. The majority of grasslands are managed, so understanding the effect of agricultural management practices on processes affecting SOM in grasslands is crucial. At the same time, another human-induced impact on grassland SOM dynamics needs to be quantified and understood: climate change as such. Especially warming leads to increased mineralization of SOC, whereby detailed process understanding is lacking. Grasslands are thus under double anthropogenic pressure, which will be addressed in mainly three case studies, covering grasslands in a wide range of pedoclimatic environments: 1. SOM dynamics in seven different temperate long-term mineral fertilization experiments, 2. Cutting frequency effects on SOM dynamics in Swedish urban lawns, and 3. Geothermal soil warming effects on bulk SOM and SOM fractions in an Icelandic semi-natural mountain grassland. Processes inducing SOM build-up and losses are identified and discussed. It is concluded that not only biomass production and its appropriation shall be considered in climate-smart and sustainable grassland management, but that also soil microbial and structural as well as plant physiological responses to management and warming are important drivers for SOM dynamics in grasslands.

Keywords: soil organic matter, climate change, grassland management

Soil structure and carbon storage in grassland soils along an elevation gradient in the Northern limestone Alps of Germany

NOELIA GARCIA-FRANCO[1], MARTIN WIESMEIER[1,2], MARCUS ZISTL-SCHLINGMANN[3], RALF KIESE[3], MICHAEL DANNENMANN[3], INGRID KÖGEL-KNABNER[1,4]

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[2]*Bavarian State Research Center for Agriculture, Freising, Germany*
[3]*Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research*
[4]*Institute for Advanced Study, Technical University Munich, Garching, Germany*

Abstract:
Mountainous grassland soils may become a source of greenhouse gas emissions under global warming due to large amounts of labile carbon. Alpine and pre-alpine grassland soils in Bavaria represent a good example for mountainous grassland soils faced with climate change and the identification of a successful indicator of soil structural improvement and C sequestration in these soils is necessary. In this regard, aggregate-occluded and mineral associated C may play a key role in the stabilization of soil organic matter in mountainous grassland soils. Nevertheless, few studies have focused on different soil aggregates sizes classes related with the physical protection of soil organic carbon (SOC). We sampled grassland soils of the northern limestone Alps in Bavaria along an elevation gradient from 550 to 1300 m above sea level. We determined the distribution of SOC in different aggregate size classes: large macroaggregates (2000 µm, LM), small macroaggregates (250-2000 µm, SM), microaggregates (63-250 µm, m) and silt and clay (<63 µm, s+c). We found higher OC contents with higher proportions of large water-stable macroaggregates at high elevations (Esterberg, 1300 m a.s.l. > Graswang 900 m a.s.l. > Fendt, 500 m a.s.l.). In addition, Esterberg showed higher iPOM (intra-aggregate particulate organic matter) occluded into large- and small macroaggregates, a potential source of formation of new and OC- rich microaggregates occluded into macroaggregates. The final aim of this study is to identify a diagnostic fraction that can be used as an indicator for future C changes in mountainous grassland soils.

Keywords: Mountainous grasslands, occluded soil microaggregates, intra-aggregate particulate organic matter, stabilization mechanisms

How do plants, microorganisms and soil organic carbon in a long-term abandoned alpine pasture respond to re-grazing at short- and long-term?

ALIX VIDAL[1], NOELIA GARCIA-FRANCO[1], ANDREAS VON HEßBERG[2], MARTIN WIESMEIER[1,3], CARSTEN W. MUELLER[1], MICHAEL DANNENMANN[4]

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Abstract:
Traditionally grazed alpine pastures have shaped the landscapes of the Alps for centuries. However, these lands tend to be abandoned since the 1950s, significantly changing plant and organism diversity, as well as soil functions. We aim at evaluating the potential for a sustainable revitalization of abandoned alpine pastures via extensive grazing. This project relies on a strong collaboration between scientists, farmers, Bavarian State Agricultural Advisors, and nature conservation authorities. More specifically, this study aims at investigating the impact of re-grazing on plants, microorganisms, nutrient cycles, as well as soil physical and chemical characteristics. In May 2018, we set up a pilot grazing experiment at Brunnenkopfalm (1500-1700 m.a.s.l.) in the northern limestone Alps (Ammergauer Alpen), which was an abandoned pasture since 1955. Around five hectares were fenced and re-grazing was induced between May and August by a herd of rustic, local and endangered cows, i.e. Murnau-Werdenfelser breed (ca 1/ha). The site contains five fenced grazing exclosure (control) plots and five grazed plots for intense scientific monitoring (plot size 100 m^2 each). Each plot was split into 1 m² subplots used as replicates along the six years of experiment. Three replicates will be re-sampled in 2-3 year-intervals in order to investigate the long-term impact of grazing on plants (coarse/fine root and shoot biomass, C, N) and soil characteristics (C, N, aggregate stability, organic matter composition), at three depths (0-5, 5-15 and 15+ cm). After two months of grazing (June 2018), we investigated the short-term grazing effect along a gradient from non-grazed to heavily-grazed areas. We quantified microbial biomass and classified major microorganism groups using the fumigation-extraction method to obtain microbial biomass, as well as the analysis of phospholipid-derived fatty acids (PLFA). We depicted faster cycling carbon pool by analysing the dissolved organic carbon (DOC) for total organic carbon. To analyse the chemical composition of the DOC in more detail and thus account for possible chemical alterations due to grazing, we used ^{13}C nuclear magnetic resonance spectroscopy (^{13}C-CPMAS-NMR). We will present preliminary results of the ongoing project. From the first data of the short grazing period, it becomes already clear that an increase in dissolved OC and microbial biomass is associated with more intense grazing. Our results will help to depict the impact of abandonment and re-grazing on key soil functions and ecosystem services, and thus, to provide urgently needed knowledge to develop management strategies that preserves alpine pastures from degradation.

Keywords: root and shoot biomass, aggregate stability, fumigation-extraction, microbial biomass, dissolved organic carbon

Effects of land-use change on the resilience of grassland carbon dynamics to extreme drought

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Abstract:
Climate extremes and land-use changes can have major impacts on the terrestrial carbon cycle. However, their combined effects on ecosystem functioning and carbon cycling have been rarely tested. Therefore, we investigate how the abandonment of mountain grassland alters the resilience of carbon dynamics to extreme summer drought. In an *in situ* common garden experiment, we simulated and extreme summer drought on soil-vegetation monoliths from a traditionally managed mountain meadow and an abandoned grassland. We determined the resistance and recovery of the two grasslands with repeated measurements of CO_2 fluxes and biomass. To understand the mechanisms that underpin grassland resistance and recovery, carbon allocation within the plant-soil-atmosphere system was studied with two $^{13}CO_2$ pulse-labeling campaigns. The assimilated ^{13}C was traced in plant carbohydrates, microbial PLFA and in soil respiration using isotope laser spectroscopy. Abandonment has increased the resistance of carbon dynamics to drought, but the capacity for post-drought recovery. This inverse relationship is associated with the plant and microbial functional composition of the two grasslands. The abandoned grassland was more resistant, because it is mainly composed of slow-growing plant species and because it maintained a higher level of plant-fungal interactions. In contrast, the managed meadow is dominated by fast-growing plants, which recovered rapidly after drought. The fast recovery of the meadow was supported by a significantly increased uptake of nitrogen from soil and a rapid restoration of plant-bacterial coupling. In conclusion, this study demonstrates that different sets of mechanisms and attributes underpin the drought resistance and recovery of ecosystem functions. They are closely associated with the plant and microbial community composition and can be modified by land-use change. Therefore, land-use changes have the potential to profoundly alter the impacts of climate extremes on grassland C dynamics.

Keywords: mountain grassland, carbon allocation, abandonment, resistance, recovery

Session 2: Microbiomes as driver for nutrient cycles in soil

The role of arbuscular mycorrhizal fungi in managed grasslands

TESSA CAMENZIND[1], MATTHIAS C. RILLIG[1], STEFAN HEMPEL[1]

[1]*FU Berlin*

Abstract:
Arbuscular mycorrhizal fungi (AMF) represent a ubiquitous group of obligatory symbionts which are associated with most land plants worldwide. Especially in grassland sites their high abundance and diversity is well documented. The AM association improves plant growth by enhanced nutrient and water uptake, but also influences carbon sequestration and soil structure and thus is often discussed as an alternative sustainable method to maintain yields in managed systems. However, conventional management affects AMF abundance and diversity, though outcomes are site- and context-dependent. Especially nutrient input via fertilization shifts the balanced mycorrhizal association, since plant investment (carbon provisioning) to its fungal partners depends on nutrient availability. Here, we present results from different experiments testing the effects of nitrogen (N) and phosphorus (P) additions on AM abundance and diversity, as well as its relation to responses in plant productivity, soil structure and carbon storage. (1) A two-factorial fertilization experiment in a co-limited tropical montane pasture revealed higher root length and mycorrhization following P additions. (2) Across seven long-term (up to 60 years) fertilized grassland sites in Germany, except from moderate site-specific effects no overall shifts in mycorrhizal abundance were observed. (3) By contrast, within the large-scale experiment of the German Biodiversity Exploratories a positive effect of N addition on intraradical AMF abundance via increased root growth was found in some years and some areas, whereas extraradical abundance was decreased, and AMF community composition showed a clear shift. Together with findings from the literature, these results show that responses of AMF to increased nutrient availability depend on respective site conditions, but are generally more resilient than expected from theoretical models, though functional implications of observed community shifts are still understudied.

Keywords: arbuscular mycorrhizal fungi, N and P fertilization, mycorrhizal abundance

Effects of extensive and intensive management on soil microbial abundance and function along an altitudinal gradient of (sub)alpine grassland sites

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Abstract:
Microbial communities and their functional traits associated with biogeochemical cycles have been studied in montane grasslands soils in several experimental settings in recent years. Nevertheless, the impact of climate change together with management strategies remains still unknown. We investigated the effect of extensive and intensive grassland management (15N manure application and mowing) on the abundance of microbes and their activity which trigger key transformation processes of the N turnover. Intact plant-soil mesocosms previously translocated from Esterberg (Eb, 1400 m a. s. l.) to Graswang (Gw, 900 m a. s. l.) and Fendt (Fe, 550 m a. s. l.) were treated using typically management practices from the region. Soil samples from two different depths (0-5 cm and 5- 15 cm) were taken and microbial C:N ratios as well as the abundance and activity of diazotrophes, nitrifiers and denitrifiers was measured taking temporal long term- and short-term temporal constraints into account. Further selected enzymatic activities were analyzed. Manure application resulted in increased N uptake into the microbial biomass and reduced C:N ratios in the microbiome. For the abundance of denitrifers and diazotrophs transplantation as well as soil depth were identified as major drivers. Only for ammonia oxidizers an additional fertilization effect was measured, which varied with altitude. Whereas for the highest altitude, fertilization induced an increase of ammonia oxidizers mainly in spring both on the level of abundance and activity, in the transplanted soils mainly ammonia oxidizing bacteria responded to the application of manure. Interestingly this observation was only true for spring and not for later sampling time points. Pearson correlation analysis revealed that N-aceyl-β-D-glucosaminidases and leucine aminopeptidases were positively correlated with ammonia oxidizers, which indicates the importance of ammonia formation from organic material despite fertilization. Overall our data clearly indicates that climate change (as simulated by transplantation in our studies) strongly influences nitrification mainly in fertilized soils, which shows the importance of the development of new sustainable fertilization strategies in the light of global change in alpine grassland ecosystems.

Keywords: microbial communities, gen abundance, microbial activity, grassland management, N turnover, ammonia oxidizers.

Interactive effects of warming, elevated CO_2 and weather extremes on N_2O and CH_4 emissions in a managed grassland

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Abstract:
Climate projections for the next decades predict a significant increase in air temperature, atmospheric CO_2 concentrations and frequency and intensity of extreme weather events. While the impact of individual environmental factors on greenhouse gas (GHG) emissions are relatively well studied, there are only few studies that have investigated the combined effects of the several changes to be expected, namely warming, elevated CO_2 and enhanced drought events. Especially fertilized and managed grasslands, which are widely spread in Central Europe, are recognized to play a significant role in the GHG exchange with the atmosphere usually as a source of nitrous oxide (N_2O) and a sink for methane (CH_4). The aim of the present study is to evaluate the contribution of managed grassland soils to the production and consumption rates of N_2O and CH_4 in the frame of a multi-level, factorial climate manipulation experiment involving alteration of air temperature, atmospheric CO_2 concentration and artificial soil drying-rewetting cycles. A combination of static chamber measurements and measurements of GHG concentrations in the soil profile will be presented. During the observation period, warmed plots showed lower N_2O emissions, while plots with higher CO_2 concentrations tended to have higher N_2O emission rates. Simulated drought reduced soil N_2O emissions and enhanced the soil CH_4 uptake strength. GHG concentrations in the soil profile indicated that the drought likely reduced N_2O production along the whole soil profile, since overall lower N_2O concentrations were observed. CH_4 concentrations at depth were very low (< 500 ppb) with some single observation < 100 ppb, suggesting that high-affinity methanotrophic communities may take up CH_4 at such low concentrations. Rewetting largely increased N_2O and decreased CH_4 concentrations in the soil profile, respectively, although this was only marginally reflected in the soil-atmosphere GHG exchange, suggesting an interactive role of production/consumption and gas diffusion processes in the net release/uptake of GHG in the soil surface.

Keywords: grassland soils, global change, nitrous oxide, methane, static chamber measurements

Dinitrogen emissions as an overlooked component of the N balance of montane grasslands

MARCUS ZISTL-SCHLINGMANN[1], JINCHAO FENG [1,2] RALF KIESE[1], RUTH STEPHAN[1], XING WU [1,3], ZHE CHEN [1], JIN FU [1], BÄRBEL FÖSEL[4], STEFANIE SCHULZ[4], MICHAEL SCHLOTER [4], KLAUS BUTTERBACH-BAHL [1], MICHAEL DANNENMANN[1]

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Abstract:
Numerous ecosystem studies have been conducted on the dynamics and annual budget of gaseous N losses in form of NO_x, NH_3 and N_2O emissions from soil. However, very little information is available on soil emission dynamics and annual loss of inert dinitrogen (N_2). This is mainly due to the huge methodological problems involved in the quantification of soil N_2 emissions against atmospheric N_2 concentrations. Here we used the Helium soil core incubation technique to directly quantify soil N_2 and other gaseous N losses in montane grassland soil as affected by climate change and management. Background N_2 losses were quantified over an entire year for intact plant-soil mesocosms either exposed to simulated climate change conditions (warming, reduced summer precipitation, induced by space-for-time translocation along an elevation gradient in the Bavarian Alps) or to ambient climate (within site translocation). Furthermore, we investigated the effect of manure fertilization and freeze-thaw events on N_2 and other gaseous N losses in targeted high temporal resolution laboratory incubation experiments. Background N_2 emissions were ca 8 and 16 kg N ha^{-1} yr^{-1} for control and climate change treatments, thus exceeding N_2O emissions by several orders of magnitude. Fertilization with 50 kg manure-N ha^{-1} resulted in immediate gaseous N losses of >20 kg N ha^{-1}, strongly dominated by N_2 emissions, which even exceeded NH_3 emissions. In contrast to N_2 and NH_3, N_2O and NO only marginally contributed to N losses after manure application.
Pronounced peak emissions of both N_2O and N_2 were observed during thawing of frozen soil, with N_2 pulses exceeding those of N_2O by almost an order of magnitude. Analysis of the dynamics of expression of nitrification and denitrification functional genes indicated that freeze thaw induced peaks of N_2O and N_2 loss were caused by biological activity rather than physical release of entrapped gas. Highest N_2 emissions and total N losses occurred when freeze-thaw cycles were occurring in recently fertilized soil. This showed that manure application in late autumn results in reduced N use efficiency.
In sum, we show that N_2 is a so far overlooked key component of the N mass balance of montane grassland soils. The findings have direct implications for agricultural practice as they provide pointers how to reduce environmental N losses and improve N use efficiency.

Keywords: dinitrogen, nitrous oxide, fertilization, N mass balance, grassland, ammonia

Session 3: Plant diversity and productivity of montane and alpine grasslands in a warmer future

Short term impacts and legacy effects of heat waves and drought in alpine grassland

HANS DE BOECK[1]

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Abstract:
Climate change is rapidly increasing both the frequency and intensity of weather extremes such as drought spells and heat waves. Moreover, drought and heat are usually coupled, and the compound effects can often not readily be derived from observations of the single-factor impacts. I here present results from an experiment carried out in the Alps, looking into both immediate and after-effects of climate extremes. Alpine grassland communities were subjected to heat waves with varying intensity by translocating monoliths to four different elevations (2440–660 m above sea level) for 17 days. Half of these were regularly irrigated while the other half were deprived of irrigation to additionally induce a drought at each site. Responses in the short term (i.e. during the extreme) showed that heat waves only caused significant physiological stress leading to senescence and productivity declines if soil water was in short supply. In the next two years, with the monoliths back at their original location, green cover continued to be suppressed in communities that had been exposed to the most intense hot drought, while aboveground biomass production had returned to control levels two years after the extreme. The initial lower resistance of the forb fraction in the communities was not compensated by faster recovery later on. This resulted in alpine communities that became (and remained) relatively enriched with graminoids, which resisted the original extreme better. The alpine grassland in this study responded similarly than lowland grassland to heat extremes with or without drought in the short term, but exhibited longer legacy effects, with delayed recovery of aboveground production and persistent changes in community composition. This suggests that once initial resistance thresholds are exceeded, impacts may be longer-lasting in alpine grassland, where recovery is constrained by both the short growing season and difficult seedling establishment. I conclude the talk with some thoughts on advantages and drawbacks of translocation as a warming technique, compared to other methods.

Keywords: alpine grassland communities, heat waves, drought

Disturbance and indirect effects of climate warming support the establishment of non-native plants at high elevations

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Abstract:
The number of plant invasions into mountains is still relatively low compared to other ecosystems. However, biotic resistance of alpine plant communities might be reduced under climate warming and increasing land use. Our study is the first to investigate in mountains the effect of these two components of global change together with intra-specific variability of the invading species. Thus, we jointly analyzed community invasibility and invasiveness of the non-native plant. In a transplant experiment in the European Alps (Wetterstein Mountains, Garmisch-Partenkirchen), we tested if warmer temperatures, disturbance and climatic pre-adaptation of a non-native species in the invasion range favour its establishment. We transplanted grassland turfs between high and low elevations and within both common garden sites, and planted therein seedlings of *Senecio inaequidens* from 16 non-native populations distributed across Europe. Half of the turfs at each common garden site were disturbed by removing the vegetation cover. Disturbance had a strong positive effect on plant growth and survival, while we did not find increased invasibility for turfs transplanted to low elevations and thus warmer temperatures. Survival was highest for populations with least differences between the local climate of population origin and climate in the common gardens. This indicates that during the spread of *Senecio inaequidens* in Europe, local adaptation to climate has taken place. Thus, climate warming might indirectly promote plant invasions at high elevations by reducing climatic differences to source populations. In combination with increased disturbance through land use intensification, mountain ecosystems might be increasingly threatened by plant invasions in the future.

Keywords: biological invasions, disturbance, climate matching, local adaptation, global change, transplant experiment

Subalpine grassland growth during five years of warming

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Abstract:
In a five year field experiment we quantified the response of subalpine pasture productivity to climate change factors temperature and precipitation in interaction with the atmospheric N-deposition.
On six southerly exposed alps across the Canton Graubünden (all at c. 2150 masl, but six different plant communities) 0.25 × 0.40m area turf monoliths were excavated. Some monoliths remained at the original sites to serve as controls, 216 monoliths were transported to the experimental Climate Change-scenario sites (CS) in Engiadina Bassa. Monoliths were reinstalled in the ground at six altitudinal levels (from 2360 to 1680 masl) on the south slope of Piz Cotschen. Compared to the mean temperature at the original sites the altitudinal gradient of the CS represented a temperature contrast (April – October) of -1.4 to +3.0°C. Supplemental irrigation aimed at adding up to 50% of natural precipitation to compensate for increased evapotranspiration under higher temperatures. The N-deposition treatment was equivalent to +3 and +15 kg N ha^{-1} yr^{-1}, on top of a background deposition of c. 4 kg N ha^{-1} yr^{-1}. Grassland yield was assessed annually as aboveground plant dry matter (>2cm) at canopy maturity.
Yield responses to experimental treatments and annually changing weather conditions showed the limits of beneficial temperature effects at different soil moisture availabilities in this warmth limited ecosystem. The 'comfort zone' for this ecosystem can now be clearly defined.
We found surprisingly high tolerance towards increasing water scarcity, making temperature related yield gains possible even at the +1.8°C site. Both warmth and water availability individually modulated the yield by about 30% of the maximum. Preliminary analysis has not yet revealed an N-deposition effect on plant productivity, even in the +15 kg N ha^{-1} yr^{-1} treatment.

(The experiment was supported by the Federal Office for the Environment BAFU in the context of UNECE Convention on Long Range Transport of Air Pollutants CLRTAP)

Keywords: subalpine grassland, plant productivity, warming, precipitation, N-deposition

Consistent decreases in biodiversity but conditional increases in aboveground biomass of montane and alpine grasslands observed under experimental climate warming

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Abstract:
Climate change, especially warming, is likely to be most severe at higher latitude and elevation. This leads to uncertainty for future ecosystem services such as biodiversity and productivity of montane and alpine grasslands. Increasing temperature may increase growing season length and metabolic rates, but can conversely restrict growth by causing direct heat stress or indirect drought stress. Both mechanisms can alter aboveground biomass antagonistically to one or another and are likely to change interspecific competition of species within communities, thereby posing challenges to maintain ecosystem services. This study investigates the effect of climate warming on aboveground biomass and plant community composition of montane and alpine grassland ecosystems. We hypothesize that increasing temperature leads to i) increased aboveground biomass, ii) decreased species richness and iii) shifts in plant community composition towards dominance of strong competitors. We addressed these hypotheses by translocating 126 plant-soil monoliths of five different montane and alpine grasslands to lower sites representing an elevation gradient of 2090 m in the European Alps, in order to simulate possible future climate scenarios and to test for ecological limits of community stability. Our findings after one entire year of translocated plant communities being exposed to novel climates suggest that aboveground biomass increases with increasing temperature as long as precipitation regime is not severely altered. Changes ranged from 52% increase to -23% decrease. Species richness declined consistently with warming, ranging from 13% –to 46% species loss. Functional group composition shifted towards more graminoid dominated communities. However, translocated communities became neither more nor less similar to each other than control communities, indicating no deterministic directional change at the species level. Our results further suggest that plant communities of montane and alpine grassland are sensitive to water limitation, which may co-occur with increasing temperature. Finally, we briefly highlight how the use of standardized phytometers offer insight into the role that site specific soil properties play in driving our results. Generally, we show that a loss of species in montane and alpine environments is associated with future climate change, while changes in aboveground biomass were conditional on concurrent precipitation changes.

Keywords: biodiversity; community ecology; elevation gradient; grasslands; vegetation dynamics

Session 4: Biogeochemical cycles of grasslands

Effects of climate change on grassland biodiversity and productivity: The need for a diversity of models

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Abstract:
There is increasing evidence that the impact of climate change on the productivity of grasslands will at least partly depend on their biodiversity. A high level of biodiversity may confer stability to grassland ecosystems against environmental change, but there are also direct effects of biodiversity on the quantity and quality of grassland productivity. To explain the manifold interactions, and to predict future climatic responses, models may be used. However, models designed for studying the interaction between biodiversity and productivity tend to be structurally different from models for studying the effects of climatic impacts. Here we review the literature on the impacts of climate change on biodiversity and productivity of grasslands. We first discuss the availability of data for model development. Then we analyse strengths and weaknesses of three types of model: ecological, process-based and integrated. We discuss the merits of this model diversity and the scope for merging different model types.

Keywords: data needs; empirical models; integrated models; process-based models; review

Effects of elevated temperature and CO_2-concentration on the soil water balance

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Abstract:
The predicted climate change involving increasing CO2-concentrations and increasing temperatures will directly affect precipitation and evapotranspiration rates and thus soil water fluxes. In addition, climate change is expected to alter the vegetation and potentially also the soil properties, which will indirectly affect soil water fluxes.
The aim of this work is to gain a better understanding of potential direct and indirect effects due to the changes of elevated temperatures and CO2-concentrations on the soil water balance components in an alpine area of a managed permanent grassland.
For this purpose, data of six high precision weighable grassland lysimeters are available, which are part of the Lysi-T-FACE concept (Herndl et al. 2011), where the free-air on two lysimeters will be enriched with CO2 (+300 ppm) and two are heated by infrared heaters (+3° C). One lysimeter is a reference plot which is neither heated nor fumigated, another is a combination of both, fumigated and heated. The Lysi-T-FACE concept was developed on the "Clim Grass Site" at AREC Raumberg-Gumpenstein (Pötsch and Herndl, 2014). The quantification of the water balance components is based on both an automatic and a user-defined control (Slawitsch et al., 2016). The water balance components are compared over three years, where in the first year the lysimeters were neither heated nor fumigated.
The precipitation differ only slightly on the six plots, whereas the measured seepage, soil water storage as well the calculated evapotranspiration were different between the individual lysimeters, except for the first year (without treatment) where the differences were small between individual lysimeters. In the following two years, the seepage water as well the upper boundary flux showed the lowest rates on the heated plots, the highest rates on the fumigated ones, reaching a difference of more than 200 mm. The evapotranspiration exhibits an opposing trend in the two years with treatment. A distinct difference with the highest rates of the heated plot (815mm/720 mm) and the lowest rates of the fumigated one (647 mm/620mm) was observed.

First results over two years shows that, an increase of the CO2 concentration cause a lower yearly evapotranspiration as well a higher seepage water, whereas an increase of the air temperature caused a higher yearly evapotranspiration as well a lower seepage. Further work will also examine the interactive effects of elevated CO2 and temperature and attempt to identify changes of soil hydrological processes and properties using inverse modelling.

Keywords: grassland lysimeter, climate change experiment, CO_2 enrichment, temperature increase

Drought and rewetting dynamics of grassland soil CO2 – production and -emissions in a current and a future climate

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Abstract:
As climate change proceeds, extreme climatic events (ECEs) such as drought are expected to increase in intensity and in frequency, with consequences for the carbon cycle. Soil respiration (Rs) is the biggest flux of CO_2 from terrestrial ecosystems to the atmosphere. While effects of drought on Rs have been repeatedly studied, less is known how a future warmer climate under elevated CO_2 will modify drought responses. While climate warming is expected to enhance drought induced reduction in soil respiration, elevated CO_2 has been suggested to enhance soil respiration and slow down the drying of soils. As contribution to the ClimGrass-project we assessed Rs-dynamics during and after a drought event under ambient conditions (C0T0) and under a +3°C warming scenario with a CO_2 increase of 300ppm (C2T2). For each of the four treatments three replicate plots were equipped with an automated soil respiration system to assess high resolution Rs fluxes before, during and after drought. Additionally we investigated soil CO2 concentrations with a multiplexed membrane tube system installed across the soil profile. Our results show that Rs fluxes were generally higher under future (C2T2) compared to ambient (C0T0) climate conditions and were generally reduced during drought-treatments. All drought and post-drought effects on Rs were more pronounced in a future compared to a current climate. This included Rs reduction during drought and CO_2 pulses after rewetting, which led to a transient overshooting the magnitude of corresponding control-fluxes after the drought. An in-depth analysis of soil CO_2 gradients and fluxes across the soil profile showed unexpected modifications of soil-CO_2 production and transport processes, concerning both drought and post-drought effects.

Keywords: soil CO_2, drought, climate change, soil respiration, recovery, warming

Simulation of C and N cycling and associated losses of montane grassland soils under contrasting climate and management conditions

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Abstract:
Alpine and pre-alpine grasslands provide important economic value via fodder used for milk and meat production. Grassland soils also support environmental key functions such as carbon and nitrogen storage, water retention, erosion control and biodiversity. At present, these soil functions are jeopardized by climate change and moreover rapid land use and management changes, which both are likely to be accelerated in coming decades.
Understanding impacts of these changes on the montane grassland soils and developing environmentally and economically sound adaption strategies are key scientific and socio-economic challenges.
The process-based biogeochemical model LandscapeDNDC (Kraus et al., 2014; Haas et al., 2013; Kiese et al., 2011) integrates all relevant processes on carbon, nitrogen and water cycling with a strong focus on soil-plant carbon and nitrogen cycling. LandscapeDNDC is used under current management and climate conditions and within scenario studies to evaluate best management options for sustainable use of grassland ecosystems under changing environmental conditions.
The model was applied and validated with climate, soil, vegetation and management data available from various SUSALPS and associated research sites at different elevations and thus different climatic and management conditions (intensive/extensive). Furthermore, the elevational gradient is used as a space-for-time approach to imitate climate change conditions on plants and soils by transferring soil mesocosm and lysimeters from higher to lower elevation.
The results show that LandscapeDNDC is capable of simulating C, N and water fluxes and losses (e.g. nutrient leaching, GHG emissions) of montane grassland sites under different climate and management regimes. Overall, due to efficient N uptake by plants, N2O emissions (below IPCC emission factors) and NO3 leaching losses (<5.0 kg N ha-1 yr-1) were rather low leaving main ecosystem N losses to NH3 and N2. Long term scenario simulations (30years) revealed that soil C and N stocks likely decrease with climate change highlighting a risk on soil fertility and thus productivity of montane grassland soils. The magnitude of decrease was also strongly depending on the slurry regime (extensive>>intensive) and thus the magnitude of C and N reapplication with manure, which can even exceed the climate change effect. Even under current climatic conditions and intensive management a significant decrease of soil C and N stocks is predicted. Here, scenario simulations demonstrate that a moderate increase of manure application, which contradicts current national fertilizer regulations (Düngemittelverordnung), could compensate for C/N losses without significant increase of environmental harmful N fluxes (N_2O, NO_3) for these montane loamy grassland soils.

Keywords: LandscapeDNDC, biogeochemical modelling, C and N fluxes, SUSALPS, (sub-) alpine grassland

Session 5: Remote sensing of temperate grasslands

Monitoring of Alpine grasslands with multitemporal optical and radar remote sensing

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Abstract:
The European Alps are providing important ecosystem resources such as water, food, or timber. Satellite remote sensing can act as an important data source for the observation of many parameters related to these resources, offering spatially continuous, high-resolution measurements for large areas.
This talk will concentrate on the possibilities for the monitoring of Alpine grasslands with optical and radar remote sensing, which is related to several projects at the Institute of Earth Observation at Eurac Research. The aims are twofold: 1) to get a better understanding of the multitemporal remote sensing signals in relation to grassland and soil conditions in mountain areas; 2) to explore the capability to distinguish different types of grassland using multitemporal radar images, in combination with optical images and in-situ data.
The Copernicus satellites Sentinel-1 and Sentinel-2 act as the main source of information. Sentinel-1 carries a so-called Synthetic Aperture Radar sensor, which is an active sensor operating in the microwave region of the electromagnetic spectrum (C-Band). It consists of a constellation of two satellites, which produce an image of the same area every six days. In its main operational mode, Sentinel-1 generates images with an original resolution of 5 by 20 m. Due to the characteristics of an active sensor and the used wavelength, images can be acquired independent of the sun and the atmospheric conditions (i.e. clouds). The Multispectral Instrument (MSI) aboard Sentinel-2 is measuring the Earth's reflected radiance in 13 spectral bands from the visible light to short-wave-infrared, with spatial resolutions between 10 and 60 m. The constellation of two satellites provide an image over the same area every 5 days.
Studying the Sentinel-1 data, we can show that the multi-temporal SAR signal shows good potential for the monitoring of different types of crop and grasslands and the soil conditions (especially soil moisture). Optical data are required to clearly distinguish between grassland and other types of crop. Despite the limitations of SAR in mountainous areas, due to the independence of the weather conditions it is possible to clearly detect the phenological dynamics, as well as the time of harvest of grasslands. Overall, the combination of optical and radar imagery allows to overcome some of the limitations of the two individual sensing methods to produce more reliable observations.

Keywords: Sentinel-1 and -2, remote sensing of grasslands

Monitoring alpine grassland dynamics with optical sensors on multiple spatial scales

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Abstract:
Grasslands areas are the second largest land cover type in the Alps ranging from intensively managed meadows to semi-natural pastures for livestock covering all altitudes and exposures. Although grasslands are well studied from an ecological point of view, changing climatic conditions as well as the high biodiversity and intensive management of grasslands require a continuous monitoring of their conditions and health. Recently, advances in the availability and detection frequency of observations from optical sensors have been accomplished through new sensors (e.g. Copernicus Sentinels), alternative platforms (e.g. UAV) or further adapted technology (e.g. repeated digital imagery or station networks) which can be used to link optical responses to real biophysical processes.
We are examining the growth dynamics of four different grasslands in South Tyrol, Italy during the period of 2017. On these managed meadow sites we produced the NDVI index from four different sensors: Sentinel-2 MSI, Netcams (Phenocams), Spectral Reflectance Sensors (SRS) and a spectroradiometer. We analysed how measurements on different S2-pixels are correlated by sensor on the respective scale and what the strengths and weaknesses of each sensor are.
First results show clear differences between the NDVIs acquired from the diverse scales. Although applying intense filtering, the linear correlation among the sensors spans relatively wide (R^2 0.46-0.92). The NDVI saturation level of the diverse sensors is reached at different periods as well as at different maxima. These factors have potential impacts on the calibration of each sensors and the combined use of the same optical index from different sensors on analysing vegetation dynamics (e.g. stress, drought), anthropogenic interaction (e.g. irrigation, harvesting) and for the prediction of biophysical parameters (e.g. LAI).

Keywords: vegetation dynamics, Alpine grassland, Sentinel-2 MSI, phenocam, station sensor networks, spectrometer, multiscale, multisensor

Spatial monitoring of grassland use for biodiversity assessment in Switzerland

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Abstract:
The Swiss grassland system is highly dynamic due to frequent land use change between grass- and cropland, as well as due to variable management in terms of mowing and grazing practices. Thus, spatial monitoring of the grassland system is challenging but required for ecosystem assessment and sustainable grassland management. We developed a spatial monitoring system for grassland to detect dominant management practices and use intensities. Moreover, we investigated the impact of grassland management on biodiversity in comparison to related environmental variables. First, using spectral imagery from the Landsat archive, we obtained spectral time series covering the vegetation period in 14 time steps and the grassland area of 2015 in a spatial resolution of 30 x 30m. Based on the time series data, we estimated the number of management events and biomass productivity. Both variables were used to map the dominant management practice (mowing vs. grazing) and the respective use intensity by a stepwise clustering approach. The resulting grassland management classes were evaluated with land use data from the canton Berne. Second, we investigated links of the grassland management classes, terrain and soil variables, as well as Ellenberg indicators to species richness of vascular plants, derived from 120 plots distributed across Switzerland. We applied Pearson`s correlation coefficient, as well as the variable importance measure and out-of-bag accuracy of a Random Forest modelling approach. The clustering results in 3 classes of dominant mowing and grazing respectively, while all classes vary in terms of use intensity. For the mowing-dominated classes the number of management events ranges between 1-7 with a mean biomass productivity between 0.33-0.62. The grazing dominated classes show a number of management events between 1-9 with a mean biomass productivity between 0.13-0.34. The grassland management classes correspond to the Bernese land use data with respect to management practice and use intensity. The mean species richness decreased by 19% with increasing use intensity in areas of dominant grazing and by 30% in areas of dominant mowing. The Ellenberg indicator for nutrient availability, biomass productivity, and the grassland management classes showed the strongest and statistically significant ($p < 0.0001$, 95% confidence interval) links to species richness (nutrient availability: $r = -0.68$; biomass productivity: $r = -0.49$; grassland management classes: $r = -0.45$). The Random Forest modelling showed an accuracy of $R2 = 0.49$ and identified nutrient availability as most important predictor for species richness, followed by biomass productivity and the grassland management classes.

Keywords: grassland management, spatial monitoring, use intensity, species richness, NDVI time series

Vegetation indices analysis for grasslands assessment over Romanian Carpathian regions

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Abstract:
Global climate changes manifested by increasing temperature, regime change and precipitation amounts, determined in the last decades an increase in drought-affected areas worldwide. In the last two decades several regions from Europe have been affected by drought. In southern and south Eastern Europe the precipitation deficit will keep enhancing, in step with the global warming.
Drought is a specific climate characteristic of Romania due to its excessive temperate climate with a large deviation from the normal values of climatic and hydrologic parameters. Agricultural surfaces, including grasslands are the most affected by drought in Romania.
Remote sensing techniques can enhance and improve the drought analysis, especially considering the scarce availability of measured ground truth data. The advantage of multi-annual imagery availability allows the overlay and crosschecking of doughty, normal or rainy years. In this framework a sixteen years (2002 – 2018) analysis of NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index) obtained from MODIS data was made related to grasslands assessment, over Carpathian regions, including transitional woodland shrubs. The initial results revealed strong relationship between the two indices and drought conditions. Analysing the evolution of NDVI and NDDI during the study period, it was observed that for grassland areas the difference between the average NDVI and NDW were lower under drought conditions (NDVI< 0.5 and NDWI < 0.3) than under non-drought conditions (NDVI > 0.6 and NDWI < 0.4). Comparing NDVI to NDWI for grasslands the second one shows a strong and quicker response than the first, under drought conditions. For a better analysis, a combination between NDVI and NDWI using NDDI (Normalized Difference Drought Index) was performed. The results of this analysis revealed that NDDI had a stronger response to summer drought conditions than a simple difference between NDVI and NDWI, therefore being a sensitive indicator of drought in grasslands than NDVI or NDWI alone. The satellite database imagery analysed consists in 8 day MODIS Reflectance products (MOD09 A1). The analysis was made using climatological data (precipitation and temperature) recorded in the national meteorological stations network also.

Keywords: NDVI, NDWI, NDDI, grasslands assessment, drought, MODIS

Session 6: Socio-economy of grassland ecosystem services

Changes in ecosystem services of mountain grassland – trends, impacts, and drivers

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The provision of ecosystem services of mountain grassland is strongly linked to management intensity and environmental conditions. Future provision depends on the resilience of ecosystem services to scope with land-use changes and accelerating climate change. To quantify past and future changes in six ecosystem services as well as their resilience, plant trait-based models were applied in the Stubai Valley (Austria), located in the Central Alps. Over the last 150 years, abandonment and the reduction of the management intensity at high altitudes generally resulted in lower levels of provisioning services but improved regulating services. The intensification of grassland in the valley bottom instead concentrated on an increased forage production. Whereas land-use changes seem currently to decelerate and will be less important under future socio-economic scenarios, changes in land cover can still be expected in the future due to natural reforestation processes on abandoned grassland, causing a shift to forest-related services. Climate change will become more important on the long-term affecting in particular provisioning services. Although the high resilience potential of most ecosystem services will be maintained in the future, climate change seems to have rather negative impacts. Consequently, decision makers and farmers will be faced with the higher vulnerability of ecosystem services of mountain grassland. Future policies therefore need to account for both socio-economic and environmental dynamics to support a sustainable management of mountain grassland and to maintain the provision of related ecosystem services.

Keywords: ecosystem services, shift of provisioning services, vulnerability

Ecosystem services as both influence to and outcome of farmers' grassland management decisions under climate change

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Abstract:
Grasslands are the predominant land-use type in agricultural areas of the alpine and pre-alpine regions. They are the basis for a multitude of ecosystem services ranging from provisioning (e.g. fodder production), to regulating (e.g. carbon sequestration) and cultural services (e.g. tourism). Given their significant influence on matters of food production, soil fertility, climate change and biodiversity, grasslands are of central importance to stakeholders from political, business as well as private sectors.
Based on socio-economic parameters from interviews with both farmers and members of the public, we examined the importance of grassland ecosystem services and their impact on decisions about grassland management. Furthermore, spatially-explicit data was used to calculate marginal returns from alpine grassland areas based on soil quality, as well as to illustrate people's preference about grassland localization.
Results show that soil fertility, water quality and erosion control rank among the most important ecosystem services for farmers. When it comes to choosing their preferred fertilizer regime, they are most concerned about ground water pollution, but also feel restricted by cross compliance and other legal requirements. For the general public, recreation, ground water quality, climate regulation, and pollination are the most important ecosystem services from grassland. Furthermore, spatial results show that grassland areas with higher monetary returns do not necessarily coincide with those preferred by the general public.
Our results show that grassland areas are appreciated for mostly the same ecosystem services by both private and business stakeholders, albeit for differing reasons. We conclude that conducted interviews deliver an important basis for political decision-makers in creating win-win situations for managing grassland in order to balance the supply of ecosystem services.

Keywords: alpine grassland, agricultural management, ecosystem services, socio-economy

Opportunities for farming in alpine countries – pathways to truly grassland-based beef and milk production in Austria and Switzerland

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Abstract:
Farming in the alpine countries of Austria and Switzerland fulfils important economic, socio-cultural and ecological functions for society. At the same time, it is responsible for important environmental impacts, whereas nitrogen balance surpluses and related impacts play a central role. It is crucial to reduce nitrogen inputs and site-adapted production and closing material cycles are core elements of ecologically sustainable land use.
The study analysed the effects of adapted beef and dairy systems on the environmental impact and the food production with the help of the SOL mass-flow model. This includes higher reliance on grassland-based feed by abandoning the use of concentrate feed and forage maize, locally adapted reduction of livestock numbers, increased use of nitrogen-fixing legumes, reduction in mineral nitrogen fertilization, site-specific plant production and increase in nitrogen efficiency in both animal husbandry and crop production.
The implementation of such a grassland-based beef and milk production results in lower ammonia emissions, reduction of nitrogen balance surpluses and lower total greenhouse gas emissions from agriculture. These environmental improvements exceed the effects of the agricultural policy since the 1990s, even though the latter has increasingly focussed on environmental impacts. Moreover, the reduction in concentrate feed and forage maize releases arable land for alternative use. This allows for increased plant-based food production and therefore minimizes the competition between food and feed production. Other options for the use of the released land are less intensive farm operations, ecological compensation areas and/or nature conservation. Finally, the reduction in animal-based food production could be offset by changed dietary patterns and the increase of plant-based food production.
The suggested transformation from a production focussed to an ecologically-oriented land use and food system requires a political framework and market conditions which cannot be implemented quickly but need awareness raising and fundamental societal change.

Keywords: agricultural policy, environmental impact, ruminant, concentrate feed, nitrogen, modelling

Farmers' decision-making and (sub-) alpine grassland ecosystem services: an agent-based modelling approach

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Abstract:
The agricultural use of grasslands in Bavaria is strongly linked to fodder production and cattle farming, but is also responsible for providing other valuable ecosystem services such as carbon sequestration and nutrient regulation. Economically driven decisions conducted by farmers can lead to negative impacts on such services and underlying ecological processes. In order to design more sustainable measures of grassland management, a better understanding of the factors governing farmers' decision-making is needed. An agent-based model is being developed to more adequately model the decision-making processes of farmers in the subalpine Bavarian watershed Ammer. This NetLogo model is conceptualized in a way that it can be coupled with a bio-geochemical Landscape DNDC model to identify potential impacts of the grassland management, specifically fertilization. As these outputs again alter the decisions of farmers, the respective results shall then be placed as inputs into the NetLogo model. Factors of interest concerning the decision-making are attitudes towards ecosystem services, subjective norms, and behavioral constraints. Data originate from several sources including farmers' surveys, specific land use data (InVeKoS), and farm-level characteristics ("Agrarsturkturerhebung"). Consequences of policy and market scenarios on grassland management and the provisioning of ecosystem services can thereby be analyzed. In the future, the model shall be validated in workshops with local stakeholders and identify hotspots and coldspots of valuable ecosystem services in the landscape affected by farmers' grassland management. Other management decisions, such as mowing, grazing, and grassland renewal shall additionally be included in the model.

Keywords: decision-making**,** agent-based model, agricultural policy

Session 7: Zukunft der Almwirtschaft

Almen standortangepasst bewirtschaften

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Abstract:
Die standortangepasste Almbewirtschaftung fördert einerseits eine ausgewogene Futterbasis für alle gealpten Tiere während des Almsommers und andererseits eine hohe Biodiversität mit einer Vielzahl an unterschiedlichen Tier- und Pflanzenarten.
Wenn Almen nicht ihrem naturschutzfachlichen und landwirtschaftlichen Potenzial entsprechend bewirtschaftet werden, sinkt die Futterqualität. Verbuschung und Verwaldung setzen ein. In anderen Fällen kann es durch punktuelle Überbestoßung oder Intensivierung der hüttennahen Bereiche zu einer Nutzungsauflassung der Grenzertragslagen kommen. Diese Entwicklungen führen zu einem Rückgang der Biodiversität auf allen Almflächen.
Um eine Alm standortangepasst zu bewirtschaften sind Kenntnisse über die Wuchsbedingungen und den ökologischen Wert der Alm erforderlich. Die Almbewirtschaftung wird dabei der Höhenlage der Alm, dem Ausgangsgestein und dem Boden angepasst. Je nachdem, welche Tierarten und Kategorien gealpt werden, sind andere Erfordernisse notwendig.
Die wesentlichen Leitlinien hierfür sind:

- Standortangepasste Beweidung: Die Nutzung soll dem Potenzial der Weidefläche angepasst werden. Dementsprechend sollen Fettweiden mehrmals jährlich gründlich abgeweidet werden, ertragsschwache Magerrasen sollen hingegen nur extensiv abgeweidet werden.
- Angemessene Ernährung der Weidetiere: Das beste Futter auf der Alm soll den Milchkühen und hochträchtigen Kühen zur Verfügung stehen. Die schlechteren Flächen sind für Jungrinder und extensive Rinderrassen ausreichend. Pferde haben als Raufutterverzehrer geringe Ansprüche, sie sollten erst nach den Rindern mit den Weideresten ihr Auslangen finden (vor allem auf Borstgrasrasen und Rasenschmielebeständen).
- Geordneter Weideumtrieb: Die Unterteilung der Almweiden in mehrere Koppeln bzw. Staffeln ist von großer Bedeutung um die Auswirkungen der selektiven Beweidung zu verringern. So sollen tiefer gelegene Weideflächen zuerst beweidet werden, degradierte Borstgrasrasen möglichst früh. Kalkmagerrasen und Niedermoore haben hingegen eine hohe Nutzungselastizität, sie bieten auch nach der Blüte eine ausreichend gute Futterqualität. Die späte Beweidung dieser Standorte ist auch aus naturschutzfachlicher Sicht von großer Bedeutung.
- Berücksichtigung der Standortbedingungen bei der Düngung: Welcher Dünger wo ausgebracht wird, ist für die Qualität der Alm von großer Bedeutung. Prinzipiell soll der Dünger den flach geneigten Fettweiden vorbehalten sein. Zur Reduktion der Verheidung nach Schwendmaßnahmen und zur Erhöhung der Artenvielfalt in degradierten Borstgrasrasen kann eine Düngung zielführend sein. Prinzipiell sollen artenreiche Magerweiden und Steilflächen nicht gedüngt werden.

- Regelmäßiger Wechsel in der Beweidungsintensität auf Teilflächen: vor allem auf artenreichen Flächen soll die Blütenbildung und das Aussamen wertvoller Arten ermöglicht werden.
- Weidepflege früh und kontinuierlich durchführen: Jährlich sollen aufkommende unerwünschte Pflanzenarten entfernt werden. Dadurch können großflächige Revitalisierungen vermieden werden.
- Revitalisierungen sollen kleinflächig und gründlich durchgeführt werden. Die Größe der wiederhergestellten Fläche soll dem Bedarf an Futter entsprechen. Ansonsten wird die Fläche rasch wieder verbrachen.

Almbewirtschaftung unter Berücksichtigung dieser Leitlinien ist wesentlich für den wirtschaftlichen Erfolg der Alm und für die langfristige Bereitstellung von Ökosystem-Dienstleistungen.

Keywords: Weidemanagement, Standortseignung, Wirkungsfaktoren, Beweidungsintensität, Revitalisierung, Maßnahmenumsetzung

Anpassung der Beweidung von Almen und Alpen an den Klimawandel

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Abstract:
Während der letzten Jahrzehnte musste auf vielen Almen, zumindest auf Teilflächen, ein Verlust an „wertvollen Weideflächen“ verzeichnet werden. Zunächst zeigt sich eine zunehmende Verungrasung; d.h. Teilbereiche der Alm werden über den Sommer hinweg nicht mehr ausreichend abgegrast und überständig. Als Folge werden wertvolle Untergräser, Kräuter und Blütenpflanzen aus der Fläche verdrängt. Auf solchen Flächen breiten sich schnell verholzende Obergräser und vor allem der gefürchtete Bürstling (Borstgras) aus.
Eine standortangepasste Beweidung der Almen und Alpen sichert nachhaltig ein von Menschenhand geschaffene Kulturlandschaft im Bergebiet. Die Offenhaltung dieser Landschaft ist aus verschiedenen Gründen ein gesellschaftliches Ziel und wird staatlicherseits durch entsprechende Fördermaßnahmen unterstützt. Mussten in früheren Jahrhunderten die Weideflächen mittels Weideregeln/-rechte vor einer Übernutzung geschützt werden so ist seit einigen Jahrzehnten auf vielen Almen eine sich ausdehnende Unterbeweidung zu beobachten. Teils sind nur die Randbereiche einer Alm nicht mehr ausreichend beweidet, teils sind aber ganze Almen von einer Unterbeweidung stark betroffen. Die Weiden Verunkrauten immer mehr und Baumanflug breitet sich aus. Da diese Entwicklungen langsam über Jahrzehnte ablaufen, werden sie meist nicht zeitnah wahrgenommen. Die in den letzten drei Jahren durchgeführten Vorortkontrollen haben allerdings vielen Almbauern die Realität vor Augen geführt.
Zunächst nur diskutiert, ist mittlerweile der allgemeine Klimawandel allzeit zu beobachten. Seit Mitte des vergangenen Jahrhunderts, insbesondere seit den 80ziger Jahren lässt sich ein rasanter Anstieg der mittleren Jahrestemperatur beobachten. Im Stauraum der Alpen werden zudem die Sommerniederschläge mehr und die Winter trockener. Diese Kombination führt dazu, dass Futtererträge in den Höhenlagen zunehmen. Dies bedeutet für die Almbewirtschaftung, dass im Vergleich zu den 60ziger Jahren des letzten Jahrhunderts mehr gewachsenes Futter zur Verfügung steht.

Keywords: Almbewirtschaftung, Klimawandel

Almen aktivieren, aber richtig! Schlüsselmerkmale und Handlungsempfehlungen zum verbesserten Schutz charakteristischer Tierarten des alpinen Grünlands

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Abstract:
Wie bei den meisten europäischen Graslandschaften handelt es sich auch bei den Almen um naturnahe Lebensräume, deren Entstehung, Bewirtschaftung und Artenvielfalt mit menschlichen Eingriffen verbunden ist, insbesondere mit der extensiven landwirtschaftlichen Nutzung als Weideland oder Wiese. Ihre Erhaltung ist eng mit bestimmten landwirtschaftlichen Praktiken verbunden, die oft jahrhundertealte Traditionen repräsentieren. Folglich sind Veränderungen in der Nutzung eine der Hauptursachen für die Degradierung und das Verschwinden von naturnahem Grünland. Selbst kleine Veränderungen in der Bewirtschaftung, wie z. B. geringfügige Veränderungen in Beweidungsart und -intensität, Einführung zusätzlicher Rinderfütterung, Aufsprühen von Gülle oder Entfernung von Steinen, Felsen, Sträuchern oder Ökotonen können zu großen Verlusten bei den charakteristische Pflanzen- und Tierarten (insbesondere Wirbellosen) führen. Dieser negative Trend kann durch eine nachhaltige Grünlandbewirtschaftung rückgängig gemacht werden.
Auf Grundlage unserer Erfahrungen im InterReg IV A-Projekts „Almen aktivieren - Neue Wege für die Vielfalt“ sowie den Schlussfolgerungen eines Expertenworkshops zur Verbesserung des bestehenden Grünlandmanagements in der alpinen biogeografischen Region im Kontext des biogeografischen Natura-2000-Prozesses sind einige Empfehlungen entstanden. Diese sollen, mit einem Focus auf charakteristische Invertebraten der Almen, vorgestellt werden.
Am Beispiel von mehreren brachliegenden Almen wurden im oben genannten Projekt Almaktivierungen mit naturschutzfachlichem Schwerpunkt durchgeführt. Hauptaugenmerk lag auf einer Beweidung mit gefährdeten, standortangepassten Nutztierrassen. Über ein umfangreiches vegetationsökologisches, zoologisches und almwirtschaftliches Monitoring wurde gezeigt, wie sich die Arten- und Lebensraumvielfalt mit der Bewirtschaftung verändert. Hauptziele der zoologischen Alm-Forschung in den Projektgebieten in Salzburg und Bayern waren die tierökologische Beschreibung und die naturschutzfachliche Bewertung der Almweideflächen vor und nach der Wiederbeweidung. Untersucht wurden bestimmte Zeigertiergruppen auf charakteristischen Weidebiotopen und deren Verbrachungsstadien auf lange nicht bestoßenen Almen: Spinnen, Weberknechte, Zikaden, Wanzen, Heuschrecken, Laufkäfer und Tagfalter. Sie zeigen auf kleinmaßstäblicher Ebene und auf einzelne Biotoptypen bezogen Veränderungen der Tierwelt und der Artendiversität sehr präzise an und fungieren damit als sogenannte Bioindikatoren. Generell sind Almen tierartenreiche Standorte. Diese Vielfalt ist aber sensibel und ab einem bestimmten Intensitätsgrad nimmt sie rasch ab. Es kommt zu einer Vereinheitlichung und „Trivialisierung“ der Kleintierfauna. Gerade die hochgefährdeten Arten der Roten Listen sind oftmals störungssensibel. Bei der Umgestaltung von Weideland in bestehenden Weiden oder bei der Reaktivierung verbrachter Standorte ist es daher wichtig, viele Faktoren sorgfältig zu berücksichtigen. Insbesondere Standortbedingungen und Mikroklima, Sonderstandorte wie Moore, Teiche, Waldökotone, nährstoffarme und steinige Gebiete sind entscheidend für die Lebensraumvielfalt und viele bedrohte Arten. Beweidungsmanagement und -praktiken müssen in diesen Fällen besonders sensibel angepasst werden, um die Vielfalt zu erhalten.

Keywords: Almaktivierung, Beweidung, Intensivierung, Verbrachung, Artendiversität, Invertebraten

Session 8: Von der Forschung in die Anwendung

Angewandte Forschung im Dienst der Berglandwirtschaft am Beispiel von webGRAS

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Abstract:
Um die Ergebnisse angewandter Forschung erfolgreich umzusetzen und in der Praxis zu implementieren, sind mehrere Elemente zu berücksichtigen: Neben einem rigorosen wissenschaftlichen Ansatz sind die Vernetzung mit den jeweils relevanten Stakeholdern und Wissenschaftlern, ein partizipativer Ansatz in der Definition der Forschungsziele, längerfristig angelegte und konsequent verfolgte Projektziele sowie eine sorgfältig geplante und gezielte Übermittlung der Ergebnisse notwendig. Das Versuchszentrum Laimburg ist seit 1975 in Südtirol Ansprechpartner der lokalen Landwirtschaft im Bereich der angewandten Forschung. Seine Tätigkeiten decken nahezu alle Kulturen und Nutzungsformen ab, welche in der landwirtschaftlichen Praxis in Südtirol vorzufinden sind. Der vorliegende Beitrag erläutert die am Versuchszentrum Laimburg entwickelte Web-Applikation webGRAS zur Schätzung der potenziellen Futterqualität vom ersten Aufwuchs der Südtiroler Dauerwiesen. Auf der Grundlage einer mehr als zehnjährigen Datenbasis wurden statistische prädiktive Modelle für insgesamt 19 Parameter der Futterqualität ausgearbeitet, welche die Entwicklung der Futterqualität über sieben Wochen ab Beginn Schossen an 202 Umwelten beschreibt. Für die Prognose werden topographische und meteorologische Einflussgrößen (vom System automatisch generiert) sowie vom Nutzer gelieferte Auskünfte herangezogen. Die lokalen Experten und Stakeholder in den Bereichen Futterbau und der Fütterung wurden bei der Planung und bei aller Phasen der Entwicklung und Gestaltung der Applikation involviert. Insgesamt haben 8 Treffen mit 35 lokalen Experten von insgesamt 12 Institutionen stattgefunden. Bei diesen Treffen wurden die Teilnehmer in regelmäßigem Zeitabstand über die Entwicklung des Projektes informiert und ihre Meinung dazu in strukturierter Form eingeholt. Entsprechende Entscheidungen wurden aufgrund der Aussagen dieser Arbeitsgruppe getroffen. Dazu gehören zum Beispiel die Definition der Priorität der zu erstellenden statistischen Modelle, die Einschätzung der den meisten Landwirten bekannten Größen und die Überprüfung der Praxistauglichkeit des Workflows der Applikation sowie der Eingabemasken und der Hilfetexte. Die Applikation ist seit 2016 online (www.webgras.laimburg.it) und hat seit seiner Einführung über 400 Anfragen aus den meisten Haupt- und Seitentälern Südtirols erfolgreich bearbeitet. Ihre Anwendung ist mittlerweile Bestandteil der landwirtschaftlichen Beratung und des Unterrichts. Das größte Hindernis für eine breitere Anwendung besteht für die Landwirte darin, im Laufe der Vegetationsperiode die notwendigen Informationen für die Nutzung der Anwendung zu sammeln. Mögliche Verbesserungen der Applikation sind zurzeit in Ausarbeitung.

Keywords: angewandte Forschung, Dauerwiesen, Futterqualität, Web-Applikation

Poster session

Disentangling the contributions of climate and soil to biomass production across climatic gradients

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Abstract:
The production of biomass by plant communities is co-limited by climatic and edaphic processes. Separating these processes is notoriously difficult due to covariation, non-independence, and non-linearities. This may be particularly problematic for coordinated distributed experiments or studies operating along gradients that attempt to isolate one or a few drivers. Here we show the results of our common metric approach to this problem using phytometers, or standardized plant communities, grown in both a standard substrate and the local soil at 18 sites spanning an aridity gradient across Europe. We show that the coupled use of standardized plant communities grown in local site soils and standardized substrates clarifies previously masked soil effects on biomass production. Specifically, aridity emerged as the strongest determinate of biomass production in local soils, explaining 72.5% of total biomass production ($p < 0.001$). Our standard substrate phytometers showed a similar response of biomass production to aridity ($R^2 = 0.64$; $p < 0.001$). Relativizing the local soil response to the standard substrate phytometer responses revealed complex underlying soil processes previously masked in the local soil phytometers. Most notable was an important role of phosphorous availability, which explained 45% of the relativized difference between local and standard biomass production at each site. We then partitioned the phytometer biomass production of the three constituent species. Generally, each species reacted similarly to the aridity gradient, albeit with weaker relationships. Beyond that, each species was best described by a unique set of additional abiotic variables. The weaker species relationships and variation in underlying drivers are suggestive of resource use

complementarity. Overall, our study suggests a surprising role of phosphorus availability in driving community biomass that was only weakly evident in the local soil phytometers. Nitrogen availability and the C:N ratio of soil showed only weakly negative effects on biomass production in comparison. The community phytometer approach allowed for sensitivity to both climatic and soil drivers that may otherwise have been non-apparent in a single species study. We present our phytometer approach as a common metric for community ecology to more clearly elucidate underlying drivers of productivity. We envision a wide role for phytometers in both coordinated experiments as well as studies that cover large climatic or edaphic gradients.

Keywords: climatic gradient, primary production, plant-soil relationship, common metric, alpine gradient

Flowering phenology of sub-alpine grasslands and potential shifts under warmer conditions

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Phenology refers to the timing of periodic biological events, we here focus on the flowering phenology (e.g. onset and duration) of sub-alpine and pre-alpine plant species. Flowering phenology of mountain plant species is highly influenced by environmental events that determine the growing season such as snow cover, date of snowmelt, temperature and precipitation regimes as well as drought or frost events. Reactions to altered climatic conditions are species-specific and depend on which trait has been monitored (e.g. onset, peak and end of flowering might react independently). We here test differences in onset and duration of flowering phenology of alpine, sub-alpine and colline species within a translocation experiment. Intact plant-soil monoliths have been translocated downslope along an elevational gradient of six different study sites in the European Alps in 2016. We weekly recorded the percentage of green cover and flowering phenology of the monoliths at our lowest study site Bayreuth and expected a higher plasticity regarding flowering phenology of high-mountain species resulting in a premature onset of flowering. Against our hypothesis we did not find significant differences in the average onset or duration of flowering of species from different sites. Species from the two lowest sites showed slight trends to a longer flowering duration. This indicates inertia in flowering phenology despite experimental climate change.

Keywords: vegetation dynamics, elevational gradients, experimental climate change, translocation experiment

A low cost method to assess the role of topography on vegetation dynamics in highly productive grasslands under climate change.

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Abstract:
Topography is a key factor affecting mountain grassland ecosystems indirectly through soil parameters, such as soil water content (SWC) and soil Temperature (ST). In this work the effects of elevation (1500 vs 2000 m a.s.l.) and inclination (south exposed vs flat) on SWC and ST were investigated within 3 representative grassland regions of South Tyrol, central Alps (ITA). A light extinction model was employed to model main grassland vegetation dynamics aspects such as start of growth and daily increment (DPI) of Plant area index (PAI) of a twice cut meadow with manure fertilization. Growing curves from an exceptionally warm and dry year were compared with the year 2016, which was close to the long-term average in temperature and precipitation. Nor exposition and elevation, neither the different climatic years lead to a significant change in the maximum PAI. But, topography had significant impact on the timing of the above ground phytomass growth. South exposed meadows started earlier and faster on both investigated elevations, reaching finally the same PAI max. By employing a multiple linear model the respective role of SWC and ST on the Daily PAI Increment (DPI) was analyzed. ST had a higher impact in describing the DPI than SWC, However, none of the comparisons (elevation, inclination, warmer year) lead to a significant shift in the relative importance of SWC and ST. In contrast to our expectations, the growth of south exposed meadows at lower elevations did not show a clear dependency on soil water content and had no limiting effect on the vegetation growth. Surprisingly, also under warmer conditions (year 2015), no limiting effect could be determined. The results suggest, that a slightly warmer future (+2°) does not lead to an immediate reduction of aboveground phytomass growth of mountain grassland above 1500m a.s.l., independently whether they are flat or south exposed.

Keywords: vegetation dynamics, climate change, topography

N_2O losses from Austrian grassland under climate change - A modelling approach

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Abstract:
The increasing use of nitrogen (N) as fertilizer in agriculture combined with climate change is of major interest in research. Temperature increase and precipitation change will impact crop yields and N losses. Within the "NITROAUSTRIA" project nitrous oxide (N_2O) emissions from Austrian grassland soils were simulated using the LandscapeDNDC model and proved to be higher than emissions from croplands. We focused on six soil types covering more than 70% of intensively managed grassland area in five different regions representative for Austrian intensive managed grassland. The objectives of this study were to predict N_2O fluxes from intensively managed grasslands considering the impact of climate change. A baseline scenario (2005 to 2014), 2 temperature and 3 precipitation change scenarios (2031 to 2040) were chosen. The results indicate that lower precipitation decreases NO_3^- leaching and increases N availability in soil. Peak N_2O emissions are mainly responsible for high annual fluxes and these peaks may increase in future under lower precipitation due to drought-rewetting events triggering gaseous N-losses.

Keywords: N_2O, grassland, LandscapeDNDC

Pastoral fires *vs.* prescribed fires under global change, sustainable tools to preserve open landscapes?

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Abstract:
Fire and herbivorism have created and preserved open landscapes and highly diverse grasslands across mountain areas. Ancient humans understood these natural disturbances and used them (pastoral fires -PAF- and extensive grazing) for their own benefit. In the 20th century, socio-economic changes led to traditional land-uses abandonment accelerating shrub encroachment. In NW Spain, gorse (*Ulex gallii* Planch.) is expanding, developing dense shrublands that accumulate high fuel-loads, ignite easily and persist during long periods as alternate stable states. Under this scenario, traditional *bush-to-bush* PAFs (farmers burn shrubs but maintain herbaceous vegetation intact) are being replaced by prescribed fires (PRF, planned use of fire by specialised teams).
This study compares the effects on soil function and nitrogen (N)-cycle of PAF and PRF performed under similar conditions (winter time, moist soils) in a protected area of SW Pyrenees (SCI Roncesvalles-Selva de Irati), but differing in biomass (light- *vs.* high-encroached montane grasslands) and the continuity of the surface burnt. Soils were sampled at 0-10 cm depth in burned plots and adjacent control (unburned) plots during two years after the fires. We analysed soil mineral N contents (ammonium and nitrate), dissolved organic N (DON), microbial biomass carbon (C) and N, and enzymes activities (urease, phosphatase and β-glucosidase).
Fires caused transitory and long-term changes in N-cycle and soil function. Mineral N forms and DON increased after the burnings, but pulses were more persistent and intense in PRF compared to PAF, C and N in the microbial biomass was depressed 18 and 7 months in PAF and PRF, and a long-term depression of urease activity in burned soils was also recorded. The results suggest that N losses from the ecosystem may happen when soluble N pulses parallel periods of low biological retention by plants and soil microorganisms. Therefore, an appropriate planning of controlled fires (recurrence and timing) is needed to consolidate desired changes in gorse-encroached lands, which have a rapid resprout after fire. Facing this challenge a new SUDOE project, Open2preserve, is starting up in SW Europe, which aims to develop a sustainable management model combining controlled fires and guided grazing techniques in encroached mountain ecosystems in order to preserve high-valuable open landscapes endangered by the global change.

Keywords: land use changes, encroached grasslands, *ulex gallii*, controlled burnings, soil N

Impacts of climate change on carbon fluxes in pre-alpine grasslands

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Abstract:
Given the huge carbon stocks in vegetation and soils of grassland ecosystems, their high vulnerability to climate change have a profound effect on ecosystem carbon exchange with the atmosphere and in turn feedback with future climate warming. To in-situ investigate impacts of climate change on montane grassland carbon exchange processes grassland in the Bavarian Alps/ pre-Alps TERENO Observatory, lysimeters (diameter approx. 1 m, depth 1.4 m) were translocated from higher elevation to sites at lower elevation. Depending on different management regimes (cutting and manuring events) half of the lysimeters were intensively and the other half extensively management. Within a two-year period, we recorded carbon fluxes of gross primary production (GPP), ecosystem respiration (Reco) and net ecosystem exchange (NEE) with manual transparent and dark chamber measurements, as well as grass height and biomass. Results revealed, climate change slightly increased GPP resulting in increased plant productivity (NPP) in extensive and intensive treatments. As Reco increased even more than GPP, NEE was slightly lower under climate change conditions, particularly under hot and dry soil conditions. From measured flux data and environmental conditions, we developed empirical models using e.g. soil temperature, air temperature, soil moisture, and photosynthetically active radiation, for prediction of daily and annual carbon fluxes of the respective treatments.

Keywords: carbon fluxes, grassland, climate change, R10, Q10

Impact of climate and land management on the water balance and nitrogen leaching of montane grassland soils

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Abstract:
Long term observations are indispensable to improve our knowledge of the complex interactions of the biosphere-hydrosphere-atmosphere and to detect and analyse impacts of climate change. In south Bavaria, grassland is mainly managed as intensive dairy farming with potentially high risks of nitrogen export to water bodies. This region is characterized by steep elevation and thus climatic gradients. Impacts of climate change on grassland nitrogen cycling and associated losses is less understood.
In the Ammer catchment in southern Bavaria, a lysimeter network, consisting of 36 soil monoliths at three locations differing in altitude was established in the frame of the TERENO (terrestrial environmental observatories) network. Soil monoliths are a) kept as control at their origin and b) translocated along the existing natural gradient in temperature and precipitation. The approach is used to analyse the effects of climate change on plant productivity and composition, biogeochemical cycles such as C- / N-cycles and storage, nutrient export (NO_3, NH_4, DON, DOC) by seepage water, and the water balance and its components (e.g. the partitioning of water fluxes as subject to climate and agricultural management).
The poster gives an overview over the experimental setup and some results of the precipitation, evapotranspiration, seepage water and coupled nutrient export observed at the different lysimeters.

Keywords: TERENO, water balance, nitrate export, climate change, land management

Application of drone-technologies within the SUSALPS project

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Abstract:
In the last few years, the application of drones for a lot of different purposes became increasingly popular, especially for the generation of high resolution aerial images and surface models. The development of high resolution sensors alongside with a reduction in size and weight, the development of small, lightweight and powerful batteries and the optimization of image processing software packages based on increasing processing power of computers are the main factors of this development.

Within the SUSALPS-project ("Sustainable use of alpine grassland soils in a changing climate") drone-technologies are used for several purposes like:

- generation of high-resolution orthomosaics and digital surface models to use as base maps for all SUSALPS sites
- exact georeferencing of the SUSALPS-mesocosms and implementation in the SUSALPS databasse
- creation of background datasets for display purposes in the SUSALPS website and the SUSALPS database user-interface
- mapping vegetation at the Brunnenkopfalm as reference for the SUSALPS re-grazing experiment
- 3D-visualization of the Brunnenkopfalm for presentation purposes / participation
- Monitoring of grazing-induced changes in vegetation structure of the Brunnenkopfalm
- test of multispectral sensors

The poster describes the drone systems used in the project and presents some of the above mentioned examples. Furthermore, an outlook will be given on the planned drone applications in the second phase of SUSALPS, where multispectral sensors will be used e.g. to map plant N content and plant biomass.

Keywords: UAV, UAS, drone technology

Comparison of different methods for the detection of cutting frequency of grassland with radar satellite data

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Abstract:
Grassland occupies a large proportion of utilised agricultural area, especially in mountainous regions. Despite its importance current and resilient data on grassland yields and cutting frequencies with a sufficient spatial coverage are lacking. Both are essential for optimizing the use of grassland, nature conservation and policy consultation. Model approaches for the assessment of grassland yields take cutting dates and frequency into account despite environmental and cultivation factors.
The European Earth Observation Programme 'Copernicus' provides large quantities of spatial and temporal high resolution data collected by a set of Sentinel satellites. The freely and openly accessible Sentinel-1 radar data form a valid basis for automated satellite and ground data processing methods to detect cutting events. These cutting frequencies are an essential factor for the further process – the computation of grassland yields with different model approaches.
At the SUSALPS conference 2018 we like to present a comparison between two different automated data processing methods to detect cutting frequencies from radar satellite data in three different regions in Bavaria. The more common ratio detection represents a robust and reliable way by analysing time series of Sentinel-1 radar images of the same acquisition geometry with time intervals of 6 days. In contrast, machine learning techniques offer the opportunity to increase the accuracy and limit cutting dates to more precise time intervals.

Keywords: radar, change detection, Copernicus, Sentinel-1, grassland, cutting frequency

Land use change, erosion dynamics and vegetation succession at a subalpine grassland site

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Abstract:
In many parts of the Alps grassland in the montane to alpine elevation zone is affected by shallow erosion as a result of shallow landslides or snow movements frequently displacing patches of turf together with soil and unconsolidated material. This results in bare earth areas and a loss of soil for pastures and meadows, often with negative impacts on mountain agriculture. On the one hand, several previous studies reported an increasing occurrence of shallow erosion over several years to decades and partly attributed this to agricultural abandonment or extensification. On the other hand, periods of increased and decreased erosion, respectively, have been observed to alternate irregularly and, for some areas and time periods, the recovery of eroded areas by vegetation succession seems to counterbalance the development of new eroded areas. Nevertheless, there seems to be no unique picture on erosion and succession for single sites, slopes and regions due to manifold triggers steering erosion activity. To improve the understanding of opposing erosion and succession processes and their dynamics, we propose a systematic monitoring of eroded areas and present a case study from the Tuxer Alps (Austria). The monitoring site covers about 50 ha in the subalpine zone and is characterized by a high susceptibility for shallow erosion and extensified agricultural use. Recent advances in close-range and remote sensing as well as in automated image analysis improve the possibilities for monitoring. Considering the small size and large number of the eroded areas, the main improvements concern the spatial and temporal resolution, as well as the efficiency, repeatability, and transferability of the monitoring methodology. The presented monitoring approach is based on multi-temporal eroded area mapping using (i) archives of orthophotos acquired from manned airplanes and (ii) imagery acquired with a UAV (unmanned aerial vehicle) for those years not covered by aerial orthophotos. The resulting eroded area maps are integrated into a multi-temporal inventory. The quality of the automated mapping results, considering spatial and spectral characteristics of input data from different platforms and sensors, is assessed for evaluating the consistency of the eroded area inventory. This approach enables a systematic, orthophoto-based analysis of spatio-temporal eroded area development on a grassland site under changing land use conditions, thus contributing to a better understanding of erosion processes as well as the vegetation succession at eroded areas. This is essential in order to evaluate past and current developments and give recommendations for sustainable land use management.

Keywords: subalpine grassland, erosion monitoring, orthophotos, UAV, OBIA, Alps

Mapping vegetation parameters in pre-Alpine and Alpine grasslands with multispectral sensors

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Abstract:
Pastures and natural grasslands are an important part of the pre-Alpine and Alpine landscape ranging from intensive grasslands in the lower regions to highly diverse seasonal mountain pastures and specialized natural ecosystems. Despite the economic value and the significant role of plants in grassland carbon (C) and nitrogen (N) cycling, spatially explicit information on grassland management and yields (biomass and quality) are rarely available. Within the SUSALPS project, we aim to use new Copernicus satellite data to derive spatially explicit information (maps) on grassland management and biomass production, including cutting frequencies and plant N contents. Satellite remote sensing will be complemented by unmanned aerial vehicle (UAV)-based data acquisition to better bridge the scale gap from field measurements to regional assessment, and to validate satellite-derived products on larger scales. In April 2018, we conducted a field campaign to investigate the potential to map biomass, leaf N content, and other vegetation parameters with two different UAV-based multispectral sensors (Parrot SEQUOIA; RedEdge-M by MicaSense). Data over ten different grassland sites in southern Bavaria was collected via UAV and field sampling (destructive and proximal sensing) and will be analyses for correlations between different multispectral bands/indices and vegetation parameters. This contribution will present the sampling design and first results of the field experiment.

Keywords: UAV, drone, Sentinel 2, biomass, foliar N

SUSALPS-Wiederbeweidungsexperiment Brunnenkopfalm

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Abstract:
Almen sind ein besonders arten- und strukturreicher Lebensraum und zudem ein gesellschaftlich hoch geschätzter Teil der alpinen Kulturlandschaft in Bayern. Sie wurden vor Jahrhunderten angelegt, über Generationen genutzt und vom Waldaufwuchs offen gehalten. Seit den 1950er Jahren wurden jedoch viele Almen aufgelassen. Dies führte zur Bildung einer Grasdominanz mit teils negativen Folgen für Biodiversität, Bodenwasserhaltekapazität, Hochwasserschutz und Hangstabilität. Zudem fördert der Klimawandel mit einer im Alpenraum im Vergleich zum globalen Durchschnitt doppelt so starken Erwärmung die Verbuschung und Ausbreitung von Waldbäumen auf den Almflächen. Im Rahmen des SUSALPS-Projektes wird untersucht, wie die Grünlandbewirtschaftung im Alpenraum unter den Bedingungen des Klimawandels angepasst werden muss, um sowohl wirtschaftliche wie auch ökologische Ökosystem-Funktionen zu erhalten. Somit soll auch untersucht werden, wie über Jahrzehnte aufgelassene Almen durch eine erneute Beweidung erhalten werden können und welche Folgen dies für zentrale Bodenfunktionen und Ökosystemdienstleistungen hat. Zu diesem Zweck wurde auf der seit 1956 nicht mehr beweideten Brunnenkopfalm im Ammergebirge ca. 1600-1700 m) ein Wiederbeweidungsexperiment eingerichtet und erstmals im Mai 2018 wieder Rinder der traditionellen Rasse Murnau-Werdenfelser aufgetrieben. Die wissenschaftlichen Untersuchungen umfassen die Auswirkungen der Wiederbeweidung auf Biodiversität (Pflanzen, Mikroorganismen, Insekten, Vögel), Futterwert, Nährstoffkreisläufe, Kohlenstoffspeicherung, Niederschlagsinfiltration und Wasserqualität. Erste Ergebnisse zeigen keine negativen Auswirkungen der Beweidung auf Nitratbelastung im Wasser, sowie eine außerordentlich hohe pflanzliche Biodiversität auf der untersuchten Alm.

Keywords: Alm, Wiederbeweidung, Klimawandel, Nährstoffkreisläufe, Biodiversität, Nitratbelastung

Das SUSALPS Decision Support System – ein nutzerfreundliches Werkzeug zur Optimierung der Grünlandbewirtschaftung

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Abstract:
Das Ziel des vom BMBF geförderten Projekts SUSALPS (Sustainable use of alpine and pre-alpine grassland soils in a changing climate) ist die Verbesserung des Kenntnisstandes der Auswirkung derzeitiger und zukünftiger Klima- und Bewirtschaftungsbedingungen auf wichtige Ökosystemfunktionen von Grünlandböden. Dabei werden regionsspezifische sozio-ökonomische Rahmenbedingungen berücksichtigt. Auf Basis dieser Erkenntnisse sollen nachhaltige Bewirtschaftungsformen für Grünland in den Alpen und im Alpenvorland entwickelt werden, die die Klimaschutzfunktion dieser Böden unterstützen.
Das SUSALPS Decision Support System basiert auf dem biogeochemischen Modell LandscapeDNDC, welches in ein nutzerfreundliches und anwendungsorientiertes Expertensystem eingebettet wird. Hauptziel ist es, den Endnutzern (und hier v.a. Landwirten und Landwirtschaftsberatern) ein einfaches Werkzeug zur Optimierung der Grünlandbewirtschaftung zur Verfügung zu stellen. Besonders betrachtet werden hierbei Dünge- und Mahdzeitpunkte, sowie die Minimierung von Umweltbelastungen, wie Treibhausgasemissionen und Nitratauswaschung.
LandscapeDNDC ist ein am KIT IMK-IFU entwickeltes prozessbasiertes biogeochemisches Modell, das die Simulation von Kohlenstoff-, Stickstoff und Wasserkreisläufen und -bilanzen und der zugehörigen Treibhausgasemissionen (CO_2, N_2O, CH_4), sowie die Nährstoffausträge unter aktuellen und zukünftigen Klimabedingungen für Grünland, Agrar- und Waldökosysteme ermöglicht.
Die Grundlage für das webbasierte Decision Support System bildet das im Rahmen des SUSALPS-Projekts weiterentwickelte LandscapeDNDC-Modell und seine Verknüpfung mit sozioökonomischen Parametern. Die Eingangsdaten setzen sich aus bestehenden GIS-Datensätzen (z.B. Bodenparameter), Klima-Szenarien und kurzfristigen Wettervorhersagen sowie nutzerspezifischen Bewirtschaftungsdaten zusammen.
Um das System in Echtzeit zu betreiben und externen Nutzern einen schnellen Zugang zu der Modellierung zu ermöglichen, wurde das Modell optimiert und auf einem separaten Projektserver installiert. Alle relevanten Datensätze werden in einer PostgreSQL/PostGIS-Datenbank gehalten. Das Frontend wird mit der neuen PWA-Technologie (Progressive Web App Technologie) entwickelt. Die Technik erlaubt die Erstellung von plattformübergreifenden, schnellen, zuverlässigen und responsiven Web-Anwendungen, die auf Nutzerseite keine zusätzliche Installation erfordern.

Keywords: Decision Support System, LandscapeDNDC, Grünlandbewirschaftung

Trockentoleranzzüchtung bei Futtergräsern

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Abstract:
Der Klimawandel wird auch im Alpenraum zu einer Veränderung der jahreszeitlichen Niederschlagsverteilung führen, sowie zu einer Zunahme von Wetterextremen (etwa Starkregenereignisse, aber auch temporäre Trockenphasen). Pflanzen haben unterschiedlichste Anpassungsstrategien entwickelt. Zur Verbesserung der Trockentoleranz von Futtergräsern werden an der Bayerischen Landesanstalt für Landwirtschaft mehrere Forschungsansätze parallel verfolgt, die unterschiedliche Trockentoleranzmechanismen adressieren:
Das mit Abstand bedeutendste Futtergras, das deutsche Weidelgras, besitzt allgemein keine ausgeprägte Trockentoleranz. Ein Hauptgrund hierfür ist in der wenig tiefgründigen Bewurzelung zu suchen, ein Großteil der Bewurzelung findet in den obersten 20 cm des Bodens statt. Jedoch konnte in Rain-out Shelter Experimenten mit europäischem Sorten- und Genbankmaterial genetische Diversität für das Wiederaustriebsvermögen nach einer zeitlich begrenzten Trockenperiode beobachtet werden. Des Weiteren wurde an selektierten Einzelpflanzen nachgewiesen, dass für die über die ^{13}C-Kohlenstoffisotopendiskriminierung erfasste intrinsische Wassernutzungseffizienz ebenfalls genetische Diversität vorhanden ist. Für beide Merkmale wurden spaltende Nachkommenpopulationen erstellt, die derzeit eingehend in einem 2-ortigen Rain-out Shelterexperiment phänotypisiert werden. In Verbindung mit Daten des Pflanzengenoms (Genotypisierung mit 3k SNP Chip) und -metaboloms (NMR-basierte Detektion von Pflanzenmetaboliten) werden im Rahmen des Projektes DRYeGRASS Vorhersagemodelle entwickelt, mit dem langfristigen Ziel der effizienteren Züchtung trockentoleranterer Sorten. Mit isogenem Pflanzenmaterial wird derzeit der Einfluss der Ploidiestufe auf die Trockentoleranz untersucht. Erste Hinweise deuten darauf hin, dass die durch Colchizinierung erstellten tetraploiden Vertreter eine höhere Trockentoleranz besitzen als ihre diploiden Ausgangsformen, die Gründe könnten u.a. in einem ausgedehnterem Wurzelsystem oder einem unterschiedlichem Blattaufbau liegen.
Grünlandbestände sind stets Artengemenge. Daher wird neben dem Untergras Deutsches Weidelgras auch das Obergras Wiesenschwingel züchterisch bearbeitet. Neben einer ausgeprägten Kältetoleranz, die den Wiesenschwingel auch in auswinterungsgefährdeten Lagen anbauwürdig macht, besitzt er aufgrund einer tiefreichenden Bewurzelung bis ca. 60 cm Tiefe bereits eine gute Trockentoleranz. Früher war der Wiesenschwingel in Bayern eine der häufigsten bestandesbildenden Arten im Grünland, wurde aber durch die geringere Konkurrenzfähigkeit in Grasnarben bei intensiverer Nutzung (> 3 Schnitte/Jahr) aus den Beständen durch das schnittverträglichere deutsche Weidelgras (z.B. wie bei Sportrasen erkennbar mit Schnitten alle 3-4 Wochen) weitgehend verdrängt. Ziel ist daher bei dieser Art, die Schnittverträglichkeit und damit die Konkurrenzfähigkeit des Wiesenschwingels züchterisch zu erhöhen. Da für dieses Merkmal nur sehr geringe Variation in der Art selbst zur Verfügung steht, sollen die gewünschten Eigenschaften über weite Kreuzungen mit Deutschem Weidelgras und dem „Transferorganismus“ *Festulolium* in den Wiesenschwingel übertragen werden. Erste erfolgversprechende Ergebnisse aus frühen Kreuzungsgenerationen liegen hierzu vor.

Keywords: Deutsches Weidelgras, Wiesenschwingel, Wiederaustriebsvermögen, Wassernutzungseffizienz, Ploidie, *Festulolium*

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