[O19.01]

Coupling crop and vegetation modelling to quantify impact of cattle and crop management on ecosystem services in southern African landscapes

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Smallholder farming in many parts of southern Africa is characterized by the integration of livestock and cropping. Throughout summer, cattle graze rangelands, and crop areas are fenced off. Cattle are allowed to graze on crop residues in the winter. These practices can positively affect income, manure availability and farmers' prestige. However, competition for crop residues and the possible threat of overstocking reducing quality habitat remains. The interconnectedness of different land use systems demands an approach that evaluates the effects of current and possible intervention strategies on landscape level ecosystem services. Such analysis is experimentally challenging, given the fact that the success of any interventions depends on specific environments, such as soil-climate combinations. We coupled process-based models APSIM for arable land and aDGVM2 for rangeland to investigate effects of current management practice and an intensification scenario over a period of ten years on soil organic carbon change under rangeland and arable land, potential erosion, productive water use, biomass production, monthly feed gaps, and rangeland habitat quality.

We selected three villages in the Limpopo province (South Africa) along a climate gradient from humid to semi-arid. Surveys were conducted in each village to describe soil conditions, farming practices and livelihood conditions. Current cropping practices are characterized by no fertilizer, heavy weed infestations, maize monocultures and grazing in the cropping area over winter. Sustainable intensification simulations were set up as follows: maize-soybean rotation, 50 kg N-fertiliser/ha, continuous weeding, manure applied at sowing, and with 50% of crops residues maintained and 50% used for cattle feed. Preliminary analysis showed that sustainable intensification closed the feed gap, but further reduced soil organic carbon. Overall, coupling vegetation and crop models appears promising to provide meaningful insights into the highly complex interconnectedness of the different ecosystem services at a landscape level.

Keywords: crop modelling, vegetation modelling, sustainable intensification, integrated land use modelling

[O19.02]

Modelling land use as a driver of phenology shifts in the Lowveld Region of South Africa

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Although climate change may already play a significant role in shifting vegetation phenological patterns (timing and duration of vegetation greening characteristics), the rate at which human activities and natural disturbances, such as fire, transform the landscape may pose even greater consequences for the functionality of vegetation phenology. In the Lowveld region of South Africa, the landscape supports formal protected areas together with large-scale rural settlements, agriculture, forestry plantations and mining activities. Spatio-temporal shifts in phenology may therefore have very different trends in protected areas, such as the Kruger National Park (KNP), than in matrix area outside the protected areas with its intensive and varied human footprint. The overall aim of this ongoing study is therefore to understand and compare the relative roles of climate, natural disturbances (e.g. fire) and anthropogenic disturbance (e.g. land use) for areas inside and outside the KNP. We use satellite-observed vegetation index data to explore the spatio-temporal relationships between changes in vegetation phenology and precipitation between 2000 and 2018 for each of the land use categories. For the KNP, preliminary results show that precipitation along with disturbances such as fire and herbivory dictate vegetation phenology trends, while land use intensity (e.g. increased removal of ecosystem resources such as fire wood) and land use changes may have been a dominant driver of phenology shifts outside protected areas during the study period. We further interrogate these findings through the specific relationship between the seasonality of climatic variables and vegetation phenology, comparing the magnitude of the 'land use effect' between the areas in the landscape that has undergone changes in land use with areas where land use remained the same. An understanding of land use as an additional driver of vegetation phenology is imperative for land use management decisions in current and future climate change scenarios.

Keywords: phenology, land use, precipitation, change detection

[O19.03]

Climate change and land use impacts on vegetation – using dynamic vegetation models to understand multi-functionality in savanna rangelands

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Climate change and land use have severe impacts on vegetation in savanna rangelands, such as biodiversity loss, shrub encroachment or changes in fire regimes. These impacts on the biosphere feed back to influence the climate system via changes in albedo and biogeochemical cycles, and human societies via changes in ecosystem services and ecosystem functions such as fuelwood provision, livestock and crop production or non-timber products. Understanding these interactions in multi-functional landscapes requires advanced modelling techniques. Dynamic global vegetation models (DGVMs) are based on an explicit representation of ecophysiological processes and they are widely applied to simulate climate change impacts on vegetation. In addition, DGVM are used to assess how management can mitigate climate change impacts and ensure provision of important ecosystem services. We developed aDGVM, a vegetation model specifically for tropical grass-tree systems. We show that in the absence of land use, large savanna areas are susceptible to woody encroachment and transitions to forest due to CO_2 fertilization effects. Yet, land use can accelerate or mitigate undesired vegetation changes due to climate change and avoid ecosystem tipping. We then coupled aDGVM with an economic model that represents cattle owners and fuelwood harvesting, two of the main land use forms in savanna rangelands. Using an optimization framework, we identify sustainable land use strategies and show that current land use intensities exceed optimized intensities. We conclude that dynamic vegetation models are powerful tools to integrate our knowledge of multi-functional landscapes and to derive sustainable land use strategies under future climate conditions. This knowledge is essential to inform policy, management and conservation and to feed into decision support.

Keywords: savanna, dynamic vegetation model, climate change, land use

[O19.04]

Developing spatio-temporally realistic representations of agricultural landscapes for assessing the impacts of landscape management on population dynamics

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The currently observed changes in agricultural landscapes, such as the expansion or up-scaling of field sizes resulting in general landscape simplification, are considered one of the main causes of the biodiversity loss, along with the widespread use of pesticides. These drivers may interact in non-linear ways and are inherently spatio-temporal in nature. Therefore, classic two-dimensional categorical representation describing landscape as a mosaic of patches fails to capture the dynamic complexity of agro-ecosystems. Here we present a species-independent framework for modelling the spatio-temporal heterogeneity in agricultural landscapes. The framework has been implemented in the ALMaSS system, integrating agent-based models of selected species with detailed description of an environment from which modelled individuals obtain information necessary to simulate their behaviour. We conducted the global sensitivity analysis using meta modelling approach to illustrate how changes in such a complex landscape system may affect population dynamics of non-target organisms. We used the carabid beetle *Bembidion lampros* as our model species being a typical non-target arthropod of agricultural landscapes. We used ten landscapes, each 10×10 km, with varying landscape and farmland heterogeneity (composition and configuration of elements) in which the influence of changes in landscape management on the beetle population parameters (abundance and occupancy) was analysed. Changes in landscape management concerned the percentage of farmers following conventional vs non-tillage system, and applying insecticides at different levels of toxicity. Generalized linear models showed that changes in both landscape management and landscape and farmland heterogeneity (described using landscape metrics) strongly influenced beetle population parameters. The results highlight the necessity of including landscape perspective into ecological risk assessment, while the method used in our study provides a highly efficient and flexible tool for landscape-scale population-level risk assessments.

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Keywords: ALMaSS, landscape system, landscape-scale risk assessment, meta modelling

[O19.05]

Agent-based modelling for integrated land use systems analysis in Southern Africa

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Agent-based modelling for integrated land use systems analysis in Southern Africa

Agriculture in Southern Africa is expected to become increasingly exposed to climate-induced risks. These risks can be expected to considerably affect land use systems, both at farm level, for instance shifts towards more drought resistant and/or multi-annual crops. And at sectoral level through structural change, for instance market exit of farms with relatively low efficiency levels and takeover of the respective land by farms with higher efficiency levels and potentially different production types. Hence, the objective of this study is to develop an agent-based market model, which is capable of analyzing land use decisions of heterogenous farmers and the respective implications for the long-term evolvement of structural change and land use systems at sectoral level. The model will be applied to the Limpopo region in South Africa by using available farm level data of surveys amongst different farm types conducted prior to the modelling exercise. The basic model is capable of analyzing market entry and exit as well as land-use decisions of heterogeneous farms in a competitive environment (Feil and Musshoff, 2017). This modelling approach will be enhanced by the following aspects: First, it will consider not just one, but various types of agri-relevant risks relevant to the region in the long term. Second, the farms in the model will additionally interact by competing for agricultural land. Through this, land use changes caused by the prevalence of certain farm types against others can be explicitly considered and depicted. Third, the model will be expanded by a quadratic programming approach, which allows every farm in the model to make adjustments or extensions of their particular production program. Hereby, not just land-use changes on a regional level, but also at the very farm level can be modeled over time.