The `Rhythm´ of Rangeland Management – Rest-Rotation Strategies in Simulated Savannah Vegetation Dynamics

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Plant Ecology and Nature Conservation

Dirk Lohmann[a], Elise Münch[a], Florian Jeltsch[a]

[a] University of Potsdam, Plant Ecology and Nature Conservation, Am Mühlenberg 3, 14476 Potsdam, Germany

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Background

- Savannah rangelands are prone to degradation associated with significant losses of important ecosystem services (van Auken 2009; Rhode & Hoffman 2012; Reynolds et al. 2007).
- highly debated management methods consider spatial and temporal patterns of intense use alternating with times of rest (Briske et al. 2008, Teague et al. 2009).
- underlying assumptions: More equal grazing of plants, mimicking of natural grazing → migrating herds of ungulate herbivores (Teague et al. 2009).
- Although of high relevance to actual land users, there is little but controversary evidence for or against the benefits of rotational grazing in semi-arid rangelands (Teague et al. 2009).
- most rangeland models do not allow for an assessment of such impacts and often lack the necessary resolution of processes like growth and grazing

Objectives

- development of a savanna rangeland model capable of addressing the issue of herd rotation.
- Can rotational grazing significantly impact long-term vegetation dynamics of semi-arid southern African savanna rangelands
- Do different rotation schemes differ in their effects?

Results

- strong effect of the "**adaptive**" rotational herd management strategies (S3 & S4)
- **Grass biomass** is largely **increased** (Figs. 3,4)
- average **woody plant cover is strongly limited** (Figs. 3,4,6)
- The system is capable of **supporting higher livestock densities** in the long run

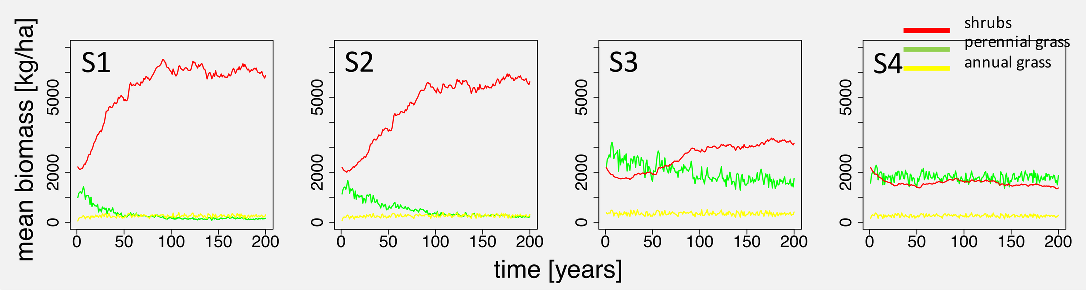

Fig. 3: Mean of 10 independent time series simulations (200yrs) of **plant biomass** at a high stocking rate (10 ha/LSU) on a 5 camp farm (values are the mean over all camps). Columns represent scenarios 1-4 (see scenario description on the right).

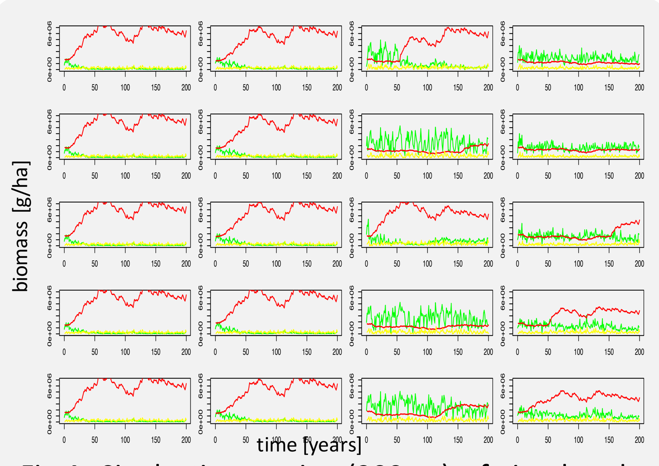

Fig.4: Single time series (200yrs) of simulated **plant biomass** at a high stocking rate (10 ha/LSU) for 5 single camps (rows). Columns represent scenarios 1-4. Note the differences between single camps

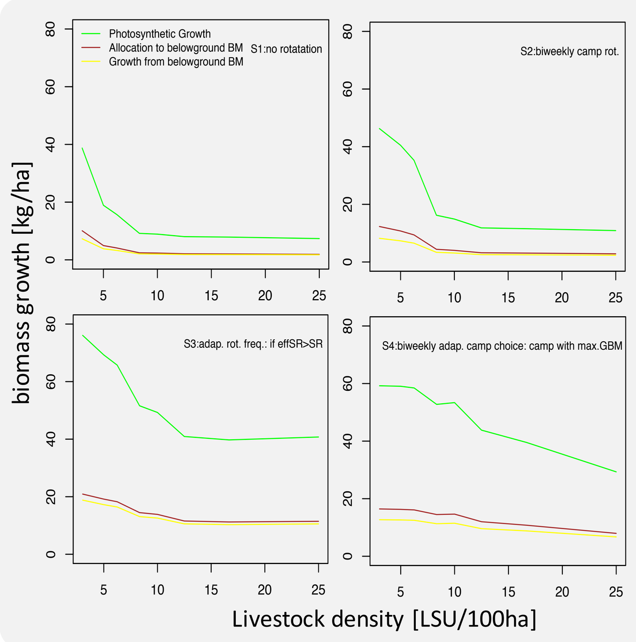

Fig. 5: Mean **growth of perennial grasses**: photo-synthetic growth (green), growth of reserve biomass (brown) and growth from reserve biomass (yellow) for different stocking rates for the 4 scenarios (panels). Mean values of 10 repeated simulations of 200 years. Grazing is detri-mental to growth, how-ever this is much less the case for scenarios 3 and 4, where root reserves are regenerated more quickly

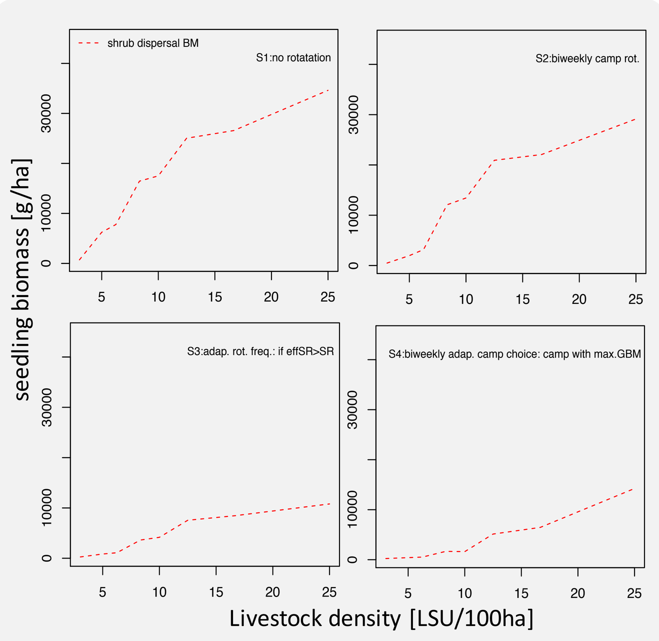

Fig.6: Mean **seedling biomass** for different stocking rates (on x axis) for the 4 scenarios (in the 4 panels). Mean values of 10 repeated simulations of 200 years.

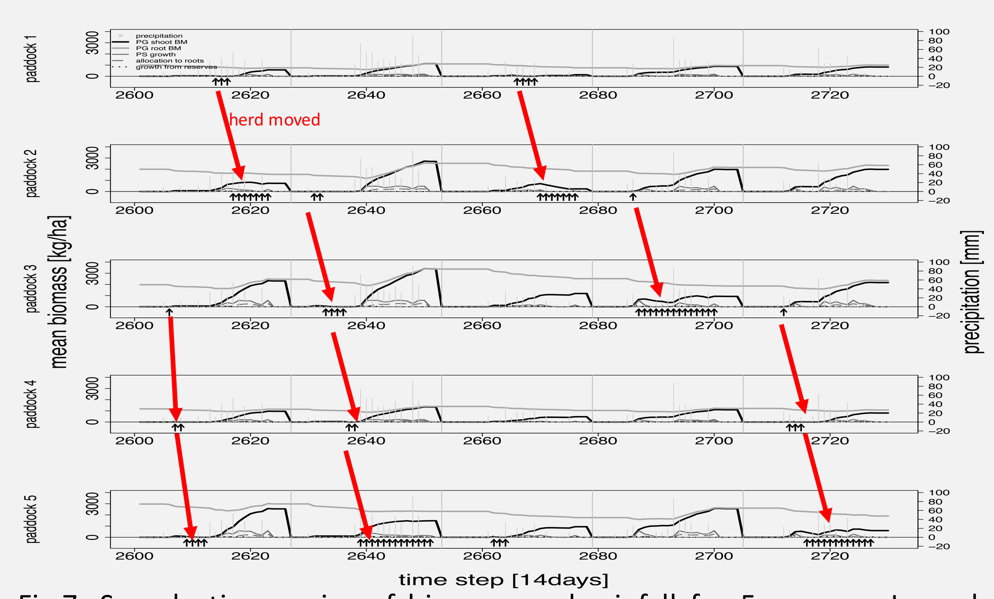

Fig.7: Sample time series of biomass and rainfall for 5 seasons. In early season droughts, herd is rotated fast → equally distributed grazing pressure under drought conditions; During peak rainy season or in good seasons / on helathy camps, the herd often remains on a camp for several months → long rest for other camps under good conditions.

Model development

- We have amended the existing ecohydrological model EcoHyD (Tietjen et al. 2010, Lohmann et al. 2012).
- Revision of "perennial grass" type
- to include above and belowground biomass
- re-growth of green tillers from root re-serves (during times of rest)
- biweekly resolution of grazing impact simulation → spatio-temporal grazing simulation.
- parameterized and validated with data from a semi-arid Namibian camelthorn sa-vanna (MAP 400mm and loamy-sand soil)

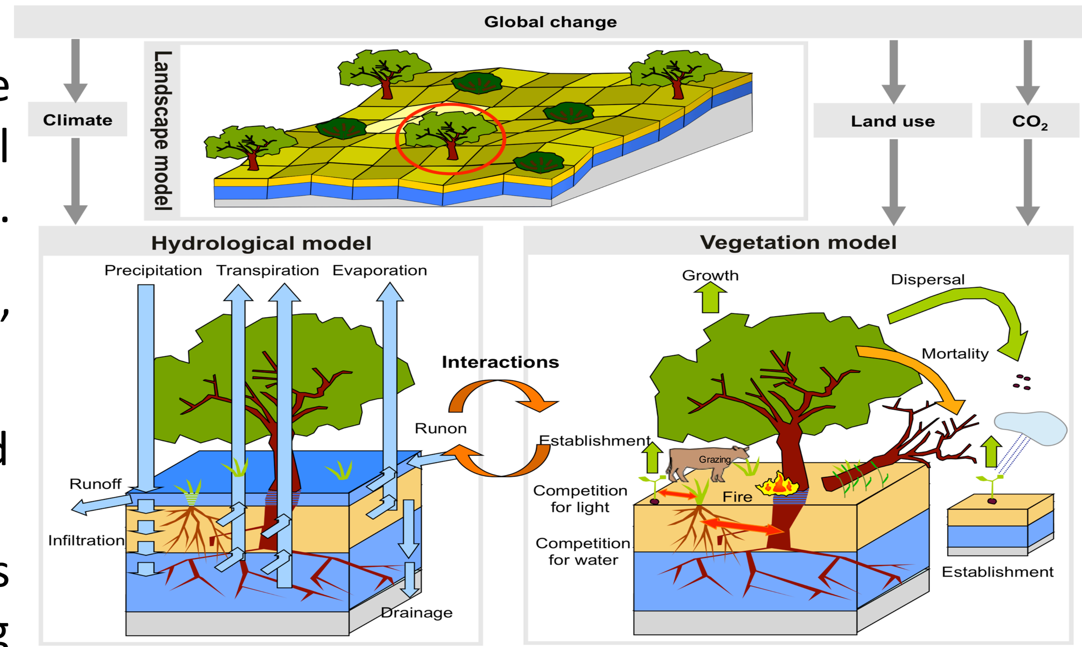

Fig. 1: Graphical repre-sentation of EcoHyD, consisting of two submodels: A hydro-logical and an eco-logical model. Sub-models are dynami-cally linked (from Tietjen et al. 2010)

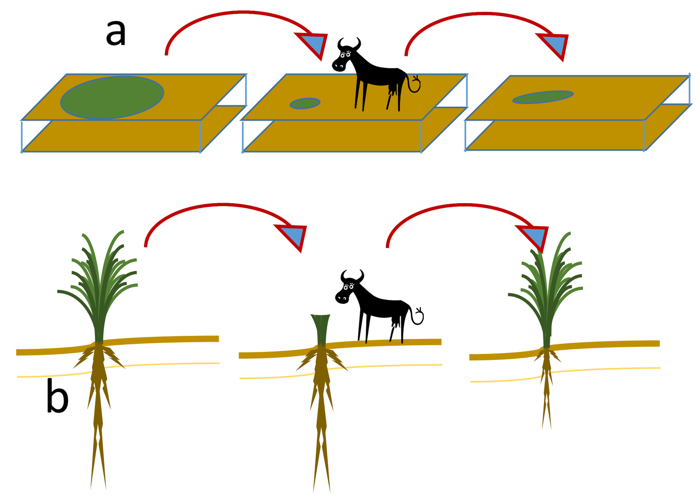

Fig. 2: a) Original version of EcoHyD (Lohmann et al 2012) → annual grazing based on aboveground cover of grasses
b) New version of EcoHyD → biweekly grazing and inter-dependent growth of above and belowground biomass

Scenarios of herd rotation

We have simulated 4 different scenarios of rotational grazing

- **Scenario 1 – continuous grazing**: control scenario. Herd ranges free on the farm and consequently feeds on grasses with an equal intensity throughout time and space

Rotational grazing scenarios (S2-S4): For the following scenarios we assume the herd to graze on all camps equally during the dry season. During the growing season of grasses, we assume three different types of herd rotation. All simulations consider a 5 camp system with one herd.

- **Scenario 2 – biweekly rotation**: In this scenario, we rotate herds every 2 weeks to the next camp. A camp consequently faces 5 times the intensity of grazing for two weeks, followed by a 6 week rest period.
- **Scenario 3 – adaptive rotation**: The rule for rotation depends on available grass biomass in the given camp. The herd is moved to the next camp once edible biomass is depleted. The consequence is a variable duration of grazing and resting. Healthy camps are grazed longer, stressed camps get longer rests (Fig. 7).
- **Scenario 4 – best camp first:** Here, rotation happens every 14 days, just like in scenario 2 but the herd is always moved to the camp with the highest available biomass. Duration of grazing is always 2 weeks, but duration of rest depends a lot on the camps vegetation state.

Conclusions

Our results are relevant with regard to both main objectives of our study. First, we could successfully **implement a model, capable of simulating herd rotation in dryland systems**. The model was further parameterized to a Namibian savanna and validation of plant biomass matched well with literature data. Second, we could show that based on our mechanistic understanding of ecosystem functioning, **the spatio-temporal rhythm of resting and grazing intervals has important implications for the effects of livestock production on vegetation composition.**

The positive effect of **adaptive** rotational strategies on perennial grass biomass was related to 1) an increase in soil moisture under certain conditions, likely due to infiltration and shading being improved by grass cover and 2) to an increase in net growth of perennial grasses (Fig 5) as a result of recovery from healthy root reserves. Further, the maintenance of a healthy grass sward strongly decreased recruitment of woody plant species (Fig. 6) and thus avoided shrub encroachment, hence reducing tree-grass-competition.

Next steps: 1) exactly determine what aspects of our adaptive rotation scenarios are the main reason for their success. 2) Quantify our findings and make reliable recommendations to land users Therefore **we emphasize the need for more empirical research** on the effects of short term, heavy grazing and resting on plant growth. Also the relation between above and below ground biomass of grasses in drylands prone to grazing and fire is largely unknown.

Contact

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Author & Project Contact:

Dr. Dirk Lohmann
Plant Ecology and Nature Conservation
University of Potsdam
Am Mühlenberg 3,
14476 Potsdam, Germany

Email: dirk.lohmann@uni-potsdam.de
Fon.: +49 331 977 4811
Web: www.optimass.org

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