The role of key resources in ensuring livelihood security and ecological sustainability – a range management modeling study

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Introduction

Semi-arid grazing systems are prone to ecological degradation due to rising climatic variability, leading to an increased frequency of droughts.

- It is a need to learn what limits the amount of livestock in the long-term.
- Challenge: Identify **key resource (KR)** areas to support sustainable land use.
- **KR** are defined to sustain livestock populations during scarce times. [1; 2]
- We developed a grazing model to assess the proportionate importance of **KR** to sustain livestock herds within a heterogeneous and variable environment.
- **KR** are evaluated for different access regimes, by excluding pastures, to analyze the role of these resources for **livelihood security** and to reveal **tipping points** of herdsize dynamics in the ecological system.

The grazing model BUFFER – which pasture contributes most to support livestock?

In a case study from the High Atlas Mountains in South Morocco we found spatio-temporally heterogenous conditions for the rangelands. There, pastoral nomadic people move with their livestock during the seasons along an altitudinal gradient.

We built a **spatially implicit** grazing model (see Fig. 1, 2) with

- **seasonal timesteps** for animal movements between pastures and
- **annual timesteps** for the adaptation of the herd size.

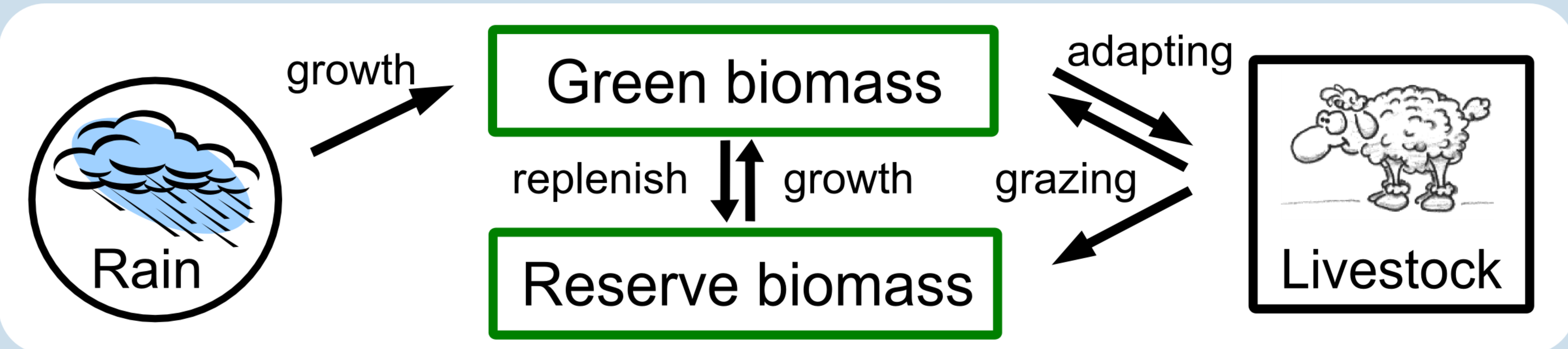

Figure 1: The concept of the ecological model with the main processes.

1. Green biomass growth is driven by stochastic rainfall. Woody biomass serves as a reserve which buffers rainfall variability, and it is partly palatable for animals.
2. The adaptation of the herd size is driven by the availability of green biomass at the scarcest time of the year. At this time, we evaluate whether a certain pasture is a bottleneck and serves as a **KR**.

Biomass growth is calculated for each pasture along the altitudinal gradient while the herd is seasonally moved to the pasture with the highest amount of available biomass.

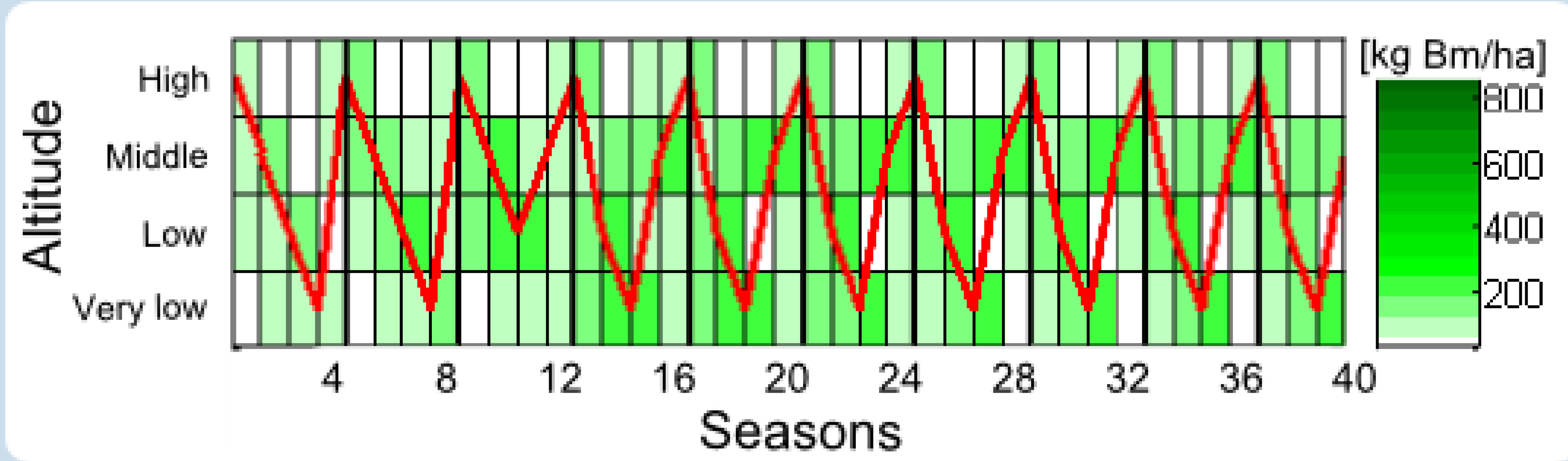

Figure 2: Example of one simulation with the pasture set from very low to high altitudes. The intensity of green denotes the amount of biomass and the red line the seasonal movement of animals.

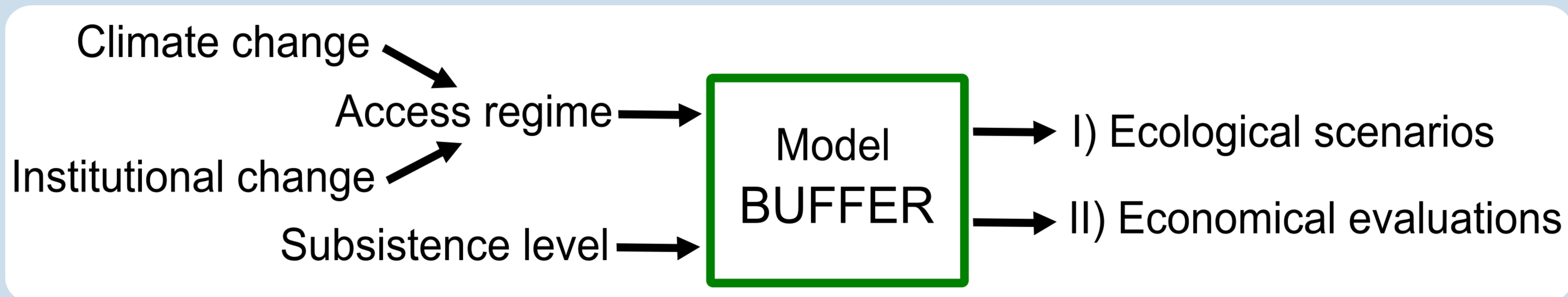

Figure 3: Possible applications for the model BUFFER.

Results from ecological scenarios: Varying pasture size reveals tipping point of animal dynamics

For the **KR** evaluation, we compare herdsize dynamics with different sets of pastures. It is assumed that pastures differ in annual rainfall along a gradient from 200 mm at low to 320 mm at high pastures.

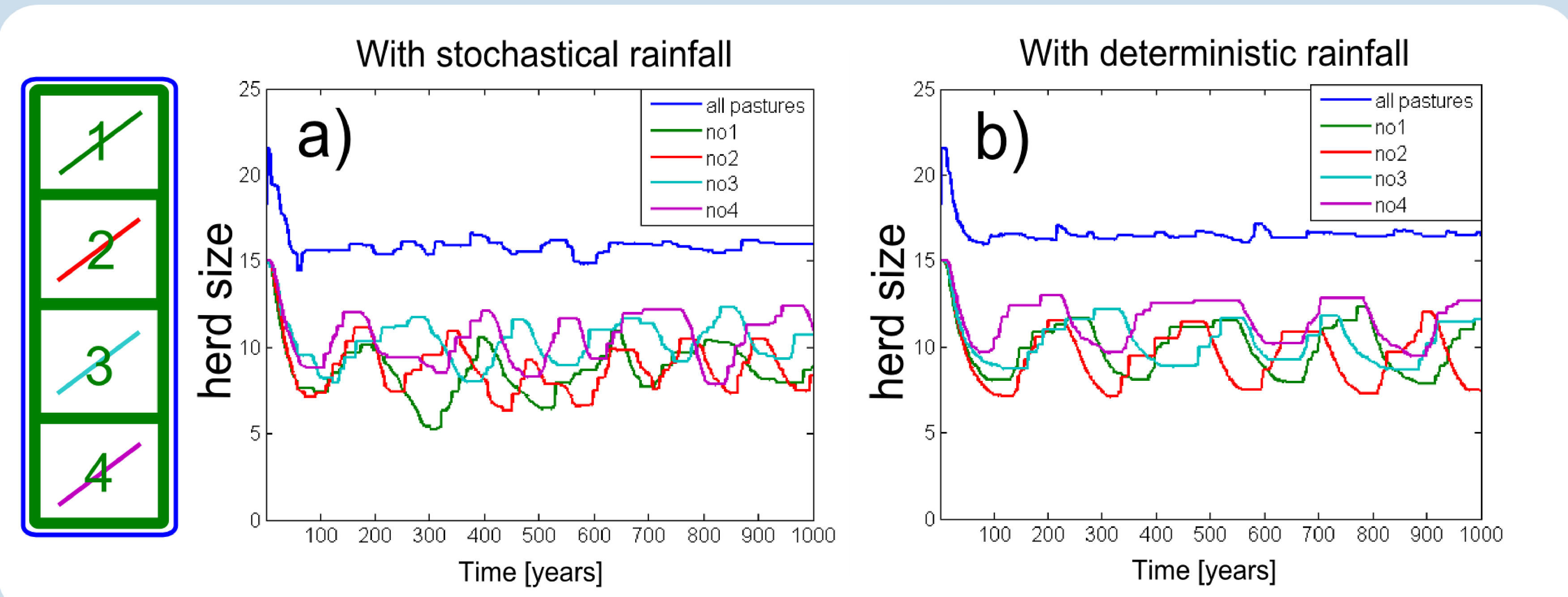

Figure 4: Animal numbers over time for different pasture sets. For each run except the first, one pasture was excluded. a) shows the simulations driven by a stochastical rainfall scenario, b) shows the same simulations for deterministic rainfall.

The simulation of restricted access to pastures reveals a decrease in herd size and a qualitative shift in herd size dynamics. The comparison of stochastical and deterministic rainfall proves that the herd size dynamics are driven by feedback mechanisms rather than by environmental stochasticity.

To identify the critical pasture size where herd size dynamics change, we evaluate animal timeseries for different pasture sizes.

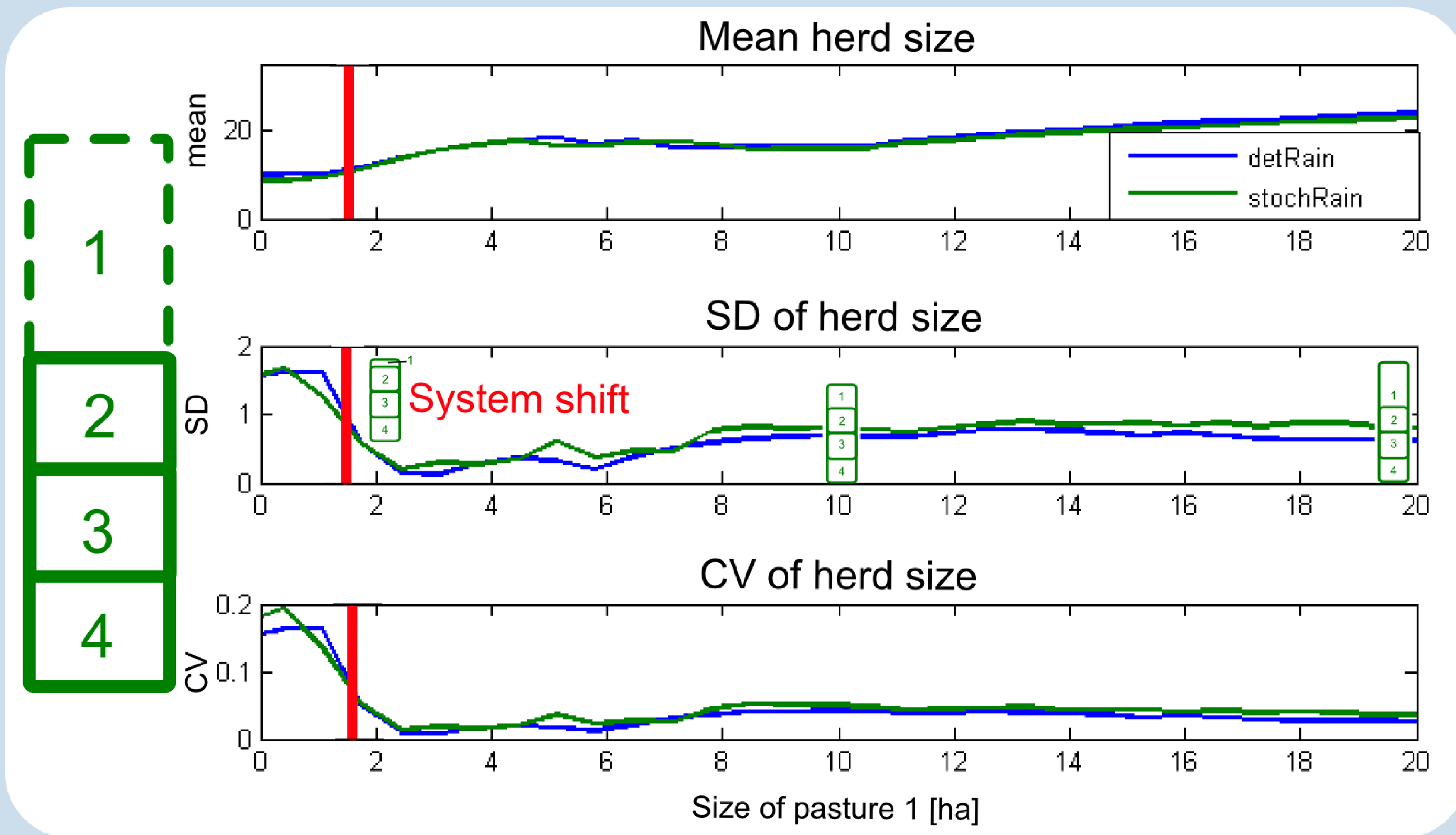

Figure 5: Development of the mean herd size, the standard deviation (SD) and the coefficient of variation (CV) over simulations with an increasing pasture size. Red lines denote system changes: e.g. increasing the pasture size with one ha drops the CV from 20% to almost zero.

Conclusions and Outlook

- The exclusion of pastures changed the herd size dynamics in our simulations qualitatively to an oscillation that reveals a **tipping point** in the ecological system.
- We will investigate factors that impact resource use and herd size dynamics, like management strategies of nomadic households, that directly relate to **livelihood security**.

References

[1] A. W. Illius and T. G. O'Connor. Resource heterogeneity and ungulate population dynamics. *Oikos*, 89(31):283–294, 2000.

[2] A. Linstädter and A. Bolten. Space matters - sustainable range management in a highly variable environment. In O. Bubenzer, A. Bolten, and F. Darius, editors, *Africa Praehistorica*, pages 104–107. Institut für Ur- und Frühgeschichte der Universität zu Köln, 2007.

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