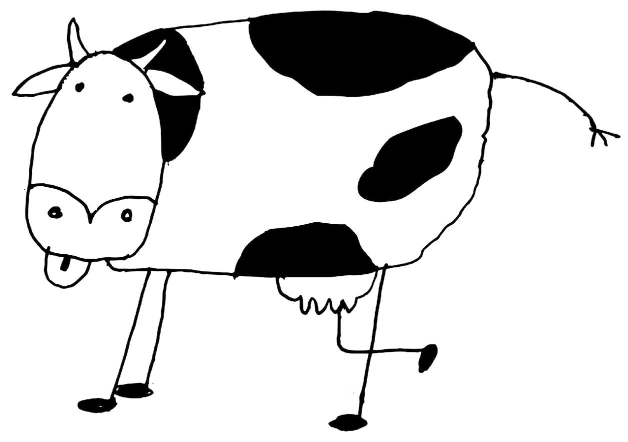

Semi-arid Savanna rangeland degradation and management: A landscape scale model

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Motivation

Land degradation and desertification are serious threads in extensively farmed arid and semi-arid savanna range-lands. Land degradation processes such as bush encroachment, loss in vegetation cover or soil erosion are differing strongly in the applied management regime (stocking rates, camp rotation system, animal species). An appropriate assessment of the impact of different management strategies on the various land degradation processes is inherently difficult, mainly due to: (i) mismatch between time scales of management (i.e. observation and production) and land degradation processes; (ii) different spatial scales of various degradation and management processes; (iii) unpredictability of precipitation; (iv) complex and non-equilibrium vegetation dynamics.

Aim

The intend of this research is to develop a simulation model that helps to improve our understanding of farm and reserve management in semi-arid savanna rangelands. In particular interest is how different management measures lead to an overall recovery or degradation on a large spatial scale. As focused on rangelands, we also do look for effects of different management measures on stocked animal herds.

Conclusion

The simulation model can be used to explore different management measures and make predictions of their impact on possible vegetation changes. The model also takes animal condition and a possible change in environment into consideration. This model can help to develop sustainable management strategies to combat land-loss and desertification in semi-arid savanna regions in long-term.

Study Area

In order to compare the resulting data we have chosen differently managed areas in the North-West Province in South Africa as a study area. The study sites, including the Molopo Nature Reserve on the Botswana border and its surrounding communal and commercial managed rangelands have all equally deep sandy soil and are situated in a uniform rainfall zone.

Vegetation types

Together with local botanists, five different vegetation types for the study areas have been identified as a representative species: annual grass (*Schmidtia kalahariensis*); palatable perennial grass (*Schmidtia pappophoroides*); unpalatable perennial grass (*Aristida stipitata*); small woody (*Acacia mellifera*), that are susceptible to fire and fire-resistant large woody (*A. mellifera*).

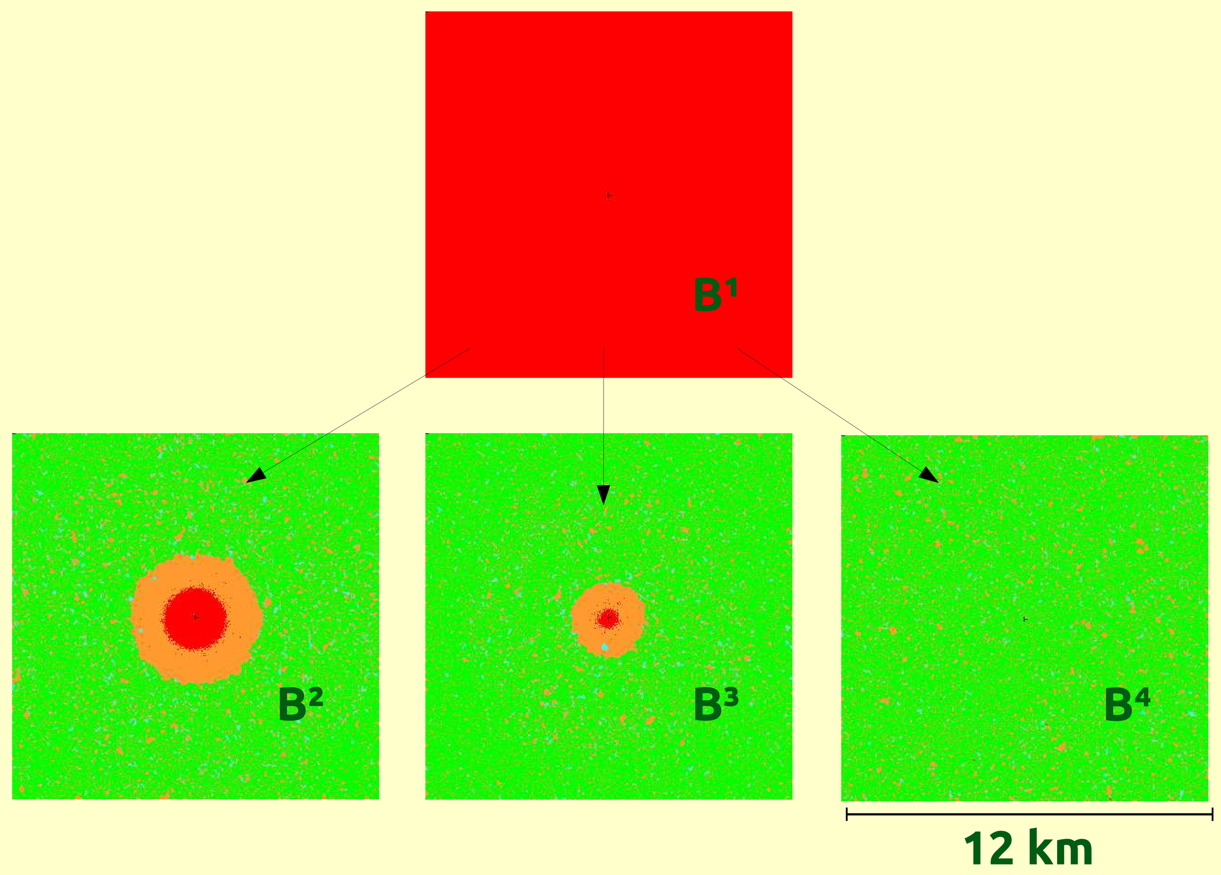
Data acquisition

Qualitative data from the literature as well as expert's knowledge about important processes and variables was gained during two workshops together with local scientists held in Jena, Germany and Potchefstroom, South Africa and a field trip in autumn 2009 when farmers and reserve managers were interviewed.

Data verification

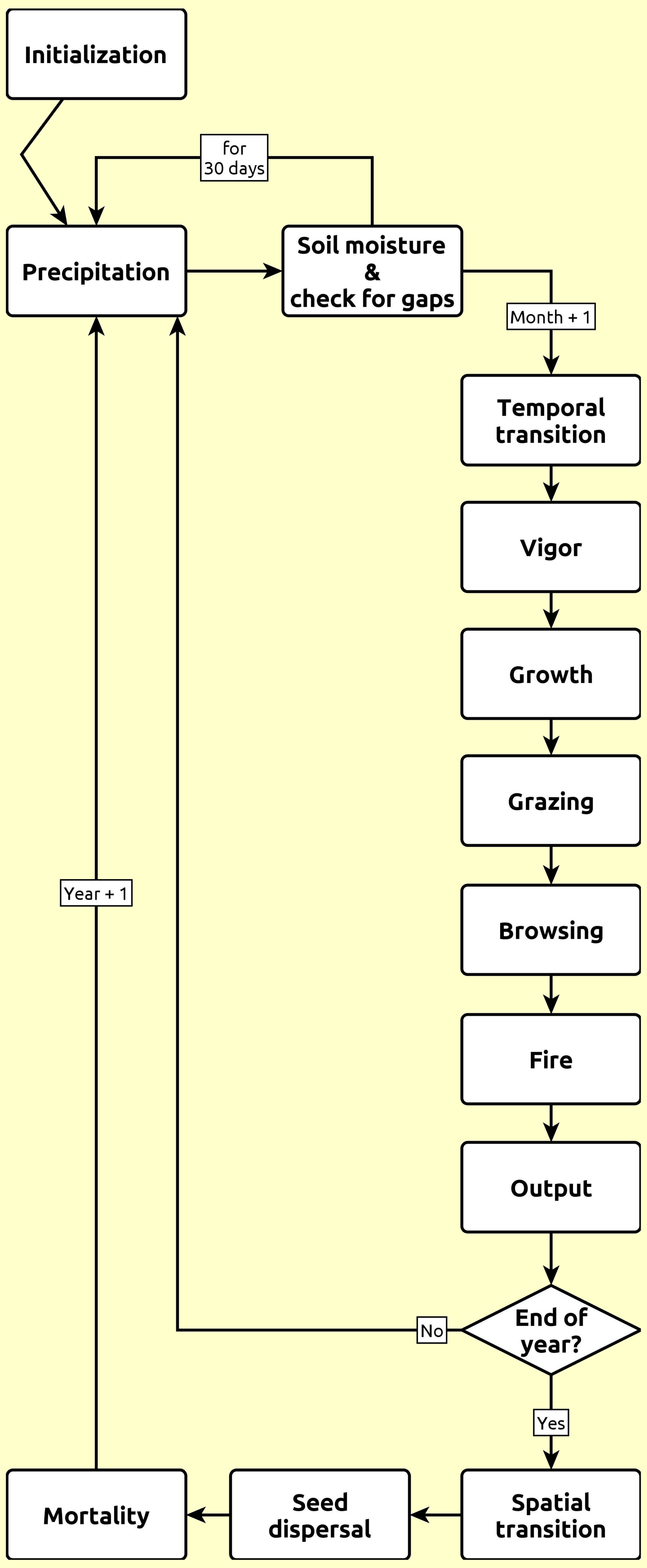
Model parametrization and output comparison will be carried out by real data provided by exploration plots measuring in particular biomass production and vegetation shift in small scale as well as by satellite data (LANDSAT 4 and 5 from 1984 on). The satellite data is classified by ground-truthing and supplemental satellite images.

B



Piosphere genesis (**Fig. B**) after 50 years of moderate grazing with camp rotation (**B³**) and without (**B²**). The simulation started on an artificial landscape (bare ground, **B¹**). For comparison, **B⁴** was not utilized at all. Different colors represent different vegetation (red: bare/annuals; yellow: annuals; green: palatable perennials; blue: unpalatable perennials; (light-) brown: (young) woody vegetation).

A



Precipitation is modeled stochastically for each day and is distributed using artificial clouds.

Soil moisture is calculated and monitored daily to check if it is sufficient for germination.

The **Vigor** of a vegetation type 'memorizes' past precipitation events and affects the rain use efficiency.

Growth is proportional to the amount of monthly rainfall. It is driven by vegetation density, temperature and vigor.

Grazing and browsing depends on the management and water distribution.

A cell is ignited and may catch **fire** by chance. After a cell caught fire, it ignites its eight neighboring cells which may catch fire again.

Temporal transition is the change of the vegetation type with monthly time-steps. It consists of germination and establishment. Important are time, space, seed and soil moisture.

Spatial transition changes vegetation due to its own vegetation condition (integrated as basal cover) and the condition of its neighbors.

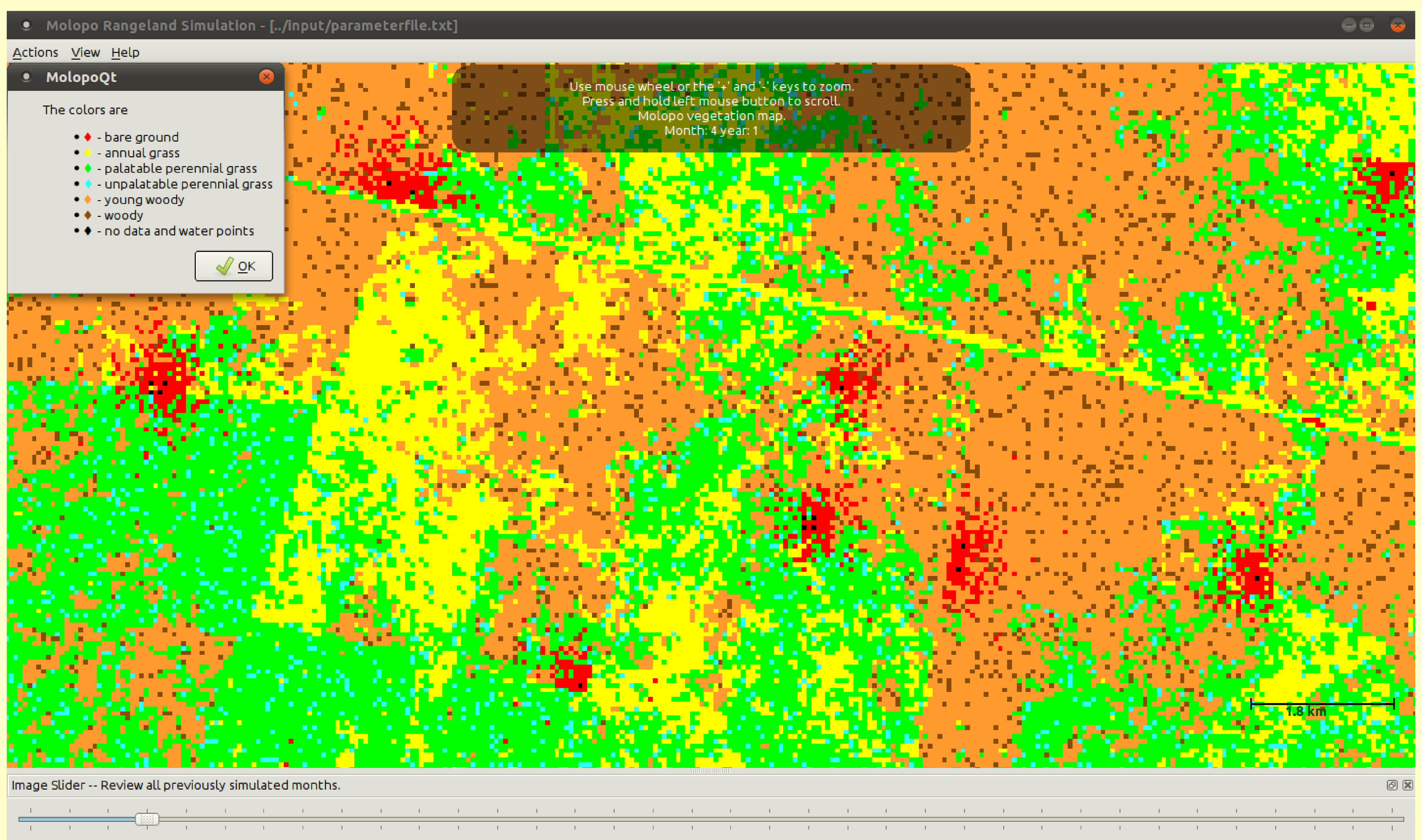
Mortality is implemented either by random - in the case of woody plants - or as regular proportion in the case of the grasses.

Seeds are either ubiquitous (annuals) or are produced and dispersed according to the vegetation condition.

Model Description

The model's landscape is represented by a rectangular grid of cells with a cell size of 30 m x 30 m. The cell size corresponds to the pixel-size of LANDSAT satellite images, which can be used as input data for simulations. The smallest useful spatial extent is one camp within a farm, the largest extent can be up to landscape size with several differently managed areas. The model proceeds with daily, monthly and annual time steps and includes various sub-models (Fig. A). Each cell is fully described by three groups of state-variables: vegetation, environment and management.

C



Screen-shot (Fig. C) of a simulation run on real satellite data. Each pixel represents a dominating vegetation type. Fence-line effects are visible due to different paddocks. Clusters of bare ground (red) appearing around watering points are a combined result of grazing and trampling. The large diagonal line is an artifact from a road crossing the area.

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