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# An ecohydrological approach to predicting hillslope-scale vegetation patterns and dynamics in dryland ecosystems

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Drylands are an important ecosystem, as they cover over 40% of the Earth's land surface and are know to exhibit threshold behavior in response to climatic change and anthropogenic disturbance. Where dryland vegetation supports pastoralist livestock production, catastrophic ecological shifts present a grave concern because of the direct coupling between the livestock forage available and human livelihoods. In this research we investigate the spatiotemporal organization of grazing resources on hillslopes by developing a relatively simple spatially explicit daily stochastic ecohydrological 1-layer bucket model with dynamic vegetation and grazing components. The model, MVUA MINGI (Mosaic Vegetation Using Agent-based Modeling Incorporating Non-linear Grazing Impacts), was constructed using a 2-year observational study in central Kenya combining in-situ sensors with near surface hydrogeophysical surveys. The data were used to derive an empirical patch water balance of three representative patch types, bare soil, grass, and tree. Visual and hydrogeophysical observations indicated the system is dominated by Hortonian runoff, overland flow, and vertical infiltration of water into vegetation patches. The patch-based water balances were next incorporated into a Cellular Automata model allowing us to simulate a range of surface flowpath convergence states across the hillslope during a rain event. The model also allows the root to canopy radius of the tree patches to vary affecting the length scale of water competition. By changing the length scales of facilitation and competition, we find the model demonstrates a range of most efficient static vegetation patterns from random to highly organized. In order simulate the vegetation dynamics we incorporated continuous transition probabilities for each patch type based on the frequency and duration of drought and grazing intensity. The modeled vegetation dynamics indicate various stable states and the timescales between the state transitions. The findings of this work support the mechanism of symmetry-breaking instabilities for pattern formation in drylands.