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Feedbacks along ephemeral rivers – an integrated ecohydrological approach

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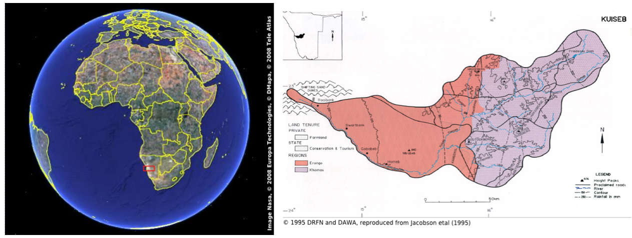
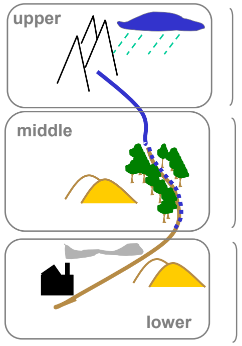
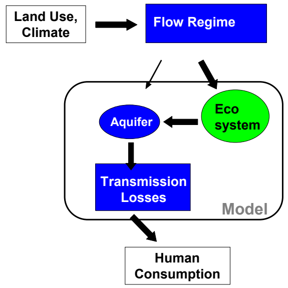






Background

We investigate the relationship between flooding events and ecosystem dynamics in an ephemeral river in Nambia: the Kuiseb.

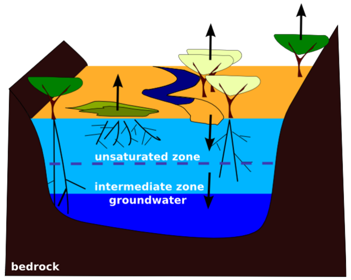
In this area, about 90% of the flood water is lost to the aquifer, most of which is probably used by the ecosystems for transpiration.

Questions

Which factors shape the dynamics of the ecosystem?

How do ecosystem dynamics respond to management, like

- changes of the flood regime from damns and
- changes of the aquifer water level from pumping?

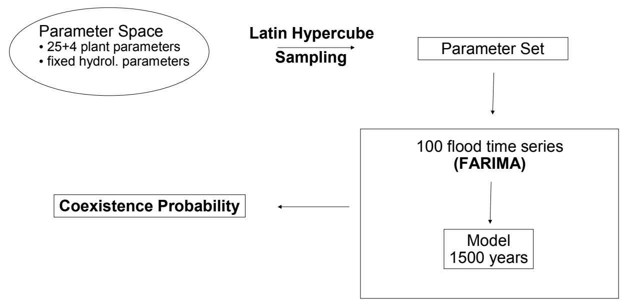


Problem

Little information is available on both species properties as well as the hydrological input.

Approach

In the face of great uncertainty about input and parameters, we built a conceptual model, which captures the known processes. We declare the parameters as unknown and search the entire parameter space for coexistence. For parameter sampling we use Latin Hypercube approach and for the generation of flood time series we apply the autoregressive approach FARIMA (Fractionally AutoRegressive Integrated Moving Average). Depending on the outcome the model will be updated to include additional processes.



Hydrological Model

Single cell storage model

- Stochastic flood regime (flood occurence, flood height, flooding length)
- Infiltration by predefined infiltration rates into saturated and unsaturated zone (Dahan et al., 2008)
- Removal of water by plants based on stress term
- Lateral water flow within the aquifer

Ecosystem Model

Population model for three different species populations (Acacia sp., Faidherbia sp., Tamarix sp.)

Model A

- Seasonal phenology
- Different access to water stores through root morphology
- Growth and mortality dependent on available water ressource
- Competition for water

Model B

as above plus

- Vulnerability to flooding

Table 1: Difference between the species coexisting along the Kuiseb River

Species	Transpiration $[g(H_2O)/g(G)*hr]$ (Bate and Walker, 1991)	Leaf Shedding	Root Morphology	Vulnerabiltity by Flood
Acacia sp.	1.03	dry season	Phreatophyte	Medium
Faidherbia sp.	1.50	rainy season	Phreatophyte	Low
Tamarix sp.	1.07	evergreen	Mesophyte	High

Results

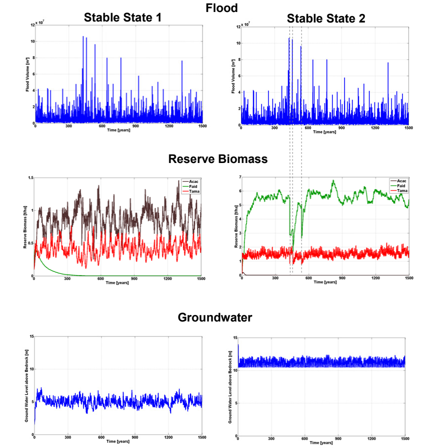


Figure 1: Two stable states, but not at the same time. Left side: Coexistence of Acacia sp. and Tamarix sp. with low groundwater level. Right side: Coexistence of Faidherbia sp. and Tamarix sp. with high groundwater level.

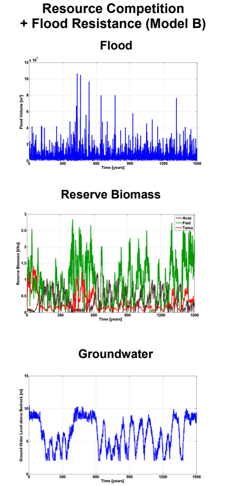


Figure 2: Coexistence of all three species when plant specific flood resistance is included.

Coexistence Probability

0 %

20 Mio. Parametersets (Model A)

Coexistence Probability

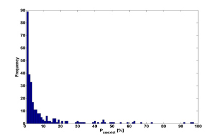


Figure 3: Histogram of Coexistence Probabilities for 40,000 Parameter Sets (Model B)

Conclusions

- Realistic ecological parameters modeled (root depth, growth rate of reserve biomass)
- Two stable states identified: (1) Acacia sp. and Tamarix sp. with low groundwater level, and (2) Faidherbia sp. and Tamarix sp. with high groundwater level
- With Model A two stable states can be reached (not at the same time) → no coexistence modeled
- With Model B coexistence is modeled as alternate states between (1) and (2)
- Including flood resistance led to successful modeling of coexistence, no tragedy of the commons

References

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