Integrated modelling of ecohydrological processes along ephemeral rivers
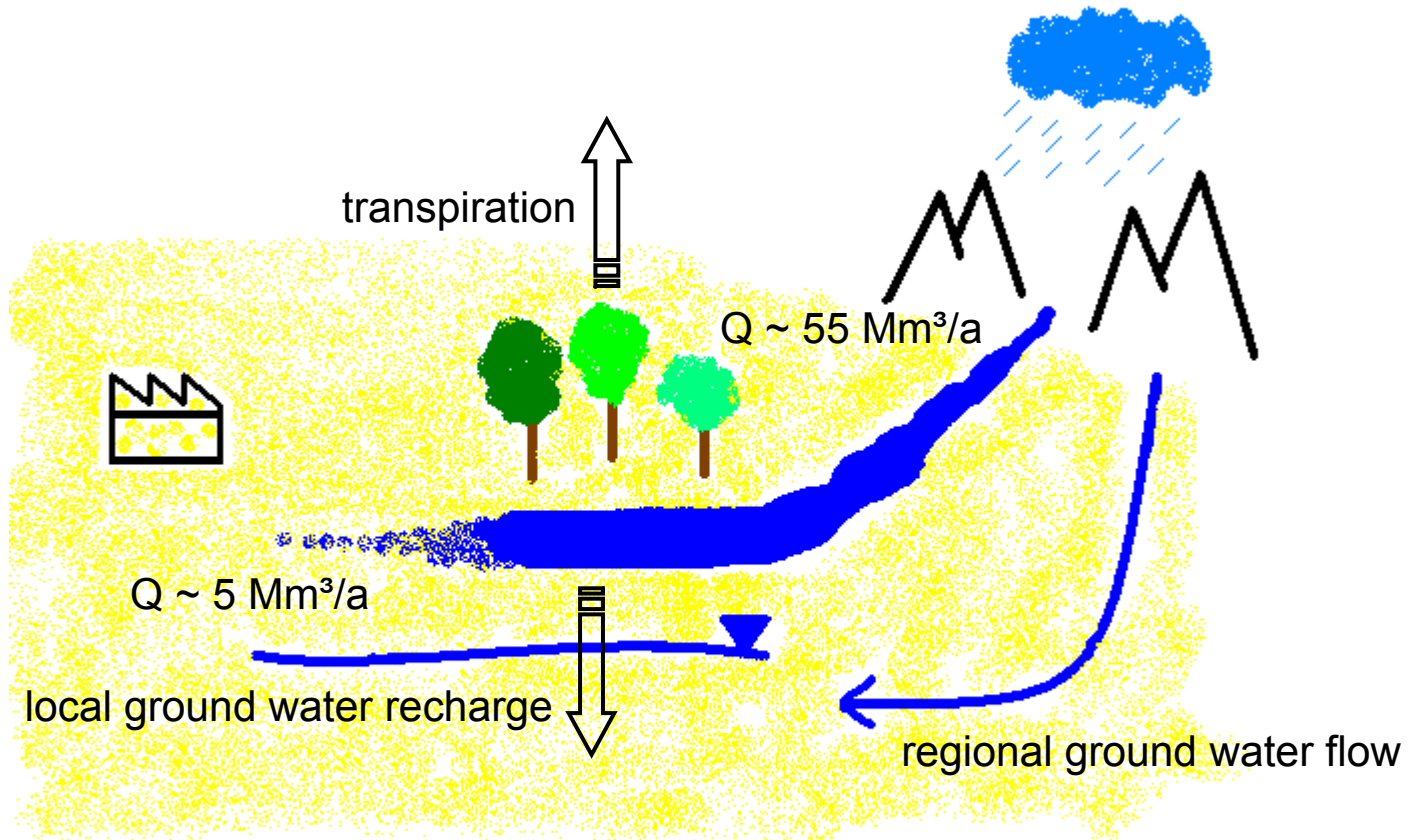
Sven Arnold, Sabine Attinger, Karin Frank, and Anke Hildebrandt

Leipzig, 17.09.2009
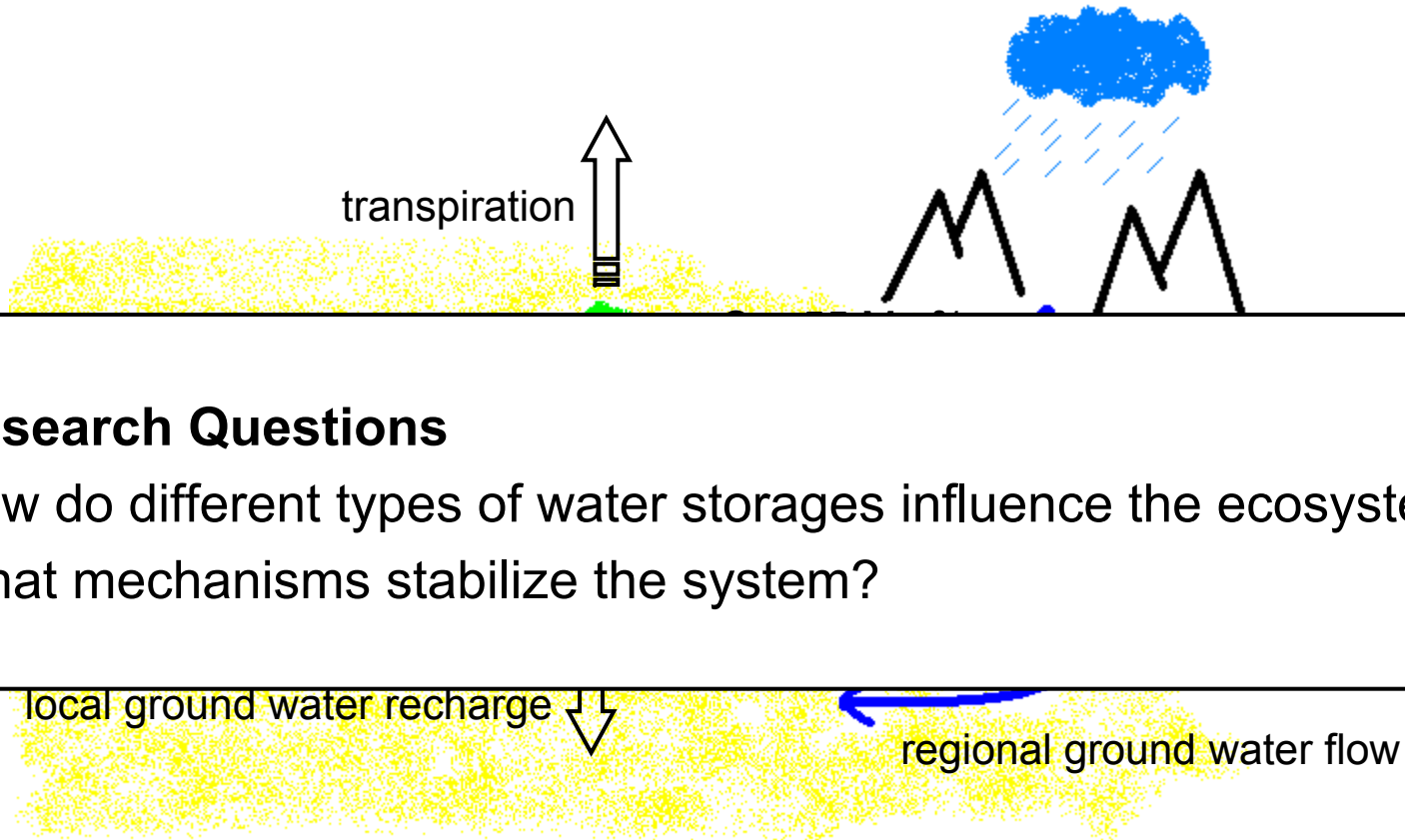
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Problem Definition ... Kuiseb River

transpiration

Q ~ 55 Mm³/a

Q ~ 5 Mm³/a

local ground water recharge

regional ground water flow

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Problem Definition ... Kuiseb River

transpiration

Research Questions

How do different types of water storages influence the ecosystem?

What mechanisms stabilize the system?

local ground water recharge

regional ground water flow

Motivation

State of the art

Ecology: qualitative/probabilistic models with no memory in hydrology
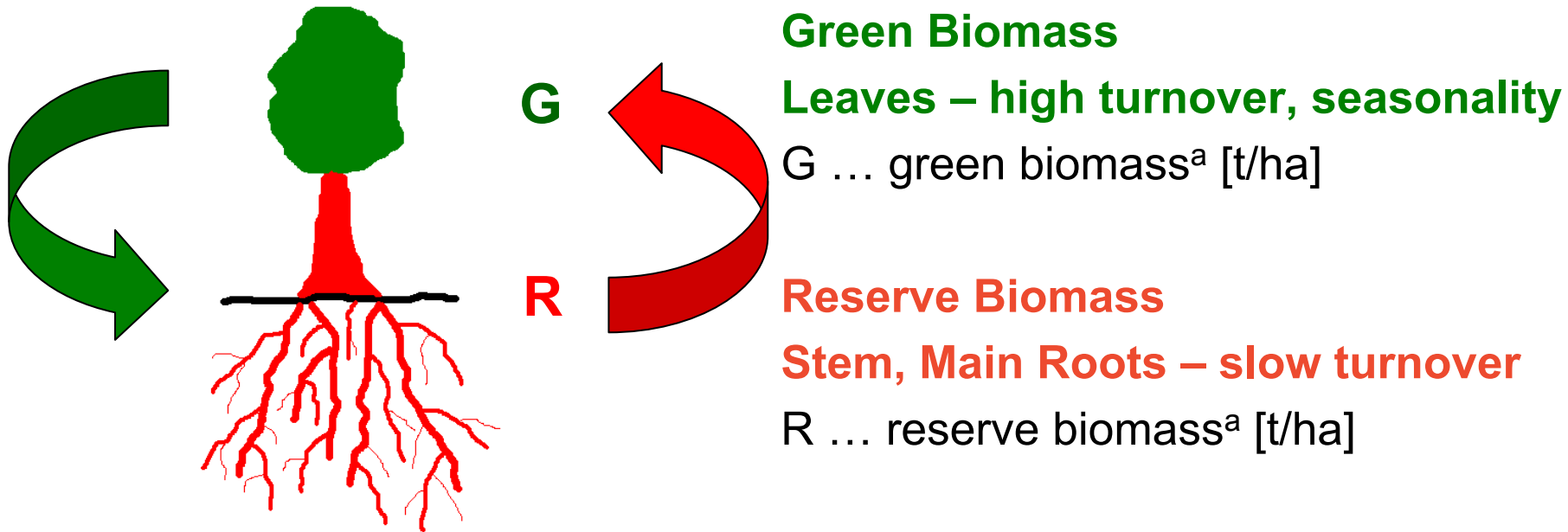
Hydrology: Sink or source term „transpiration" does not depend on ecological dynamics

Our approach

**Ecology:**   Flood has short- and long-term memory (Hurst-Effect)

Hydrology: Quantitative water flux **with dynamic feedbacks** to ecosystem dynamics

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Model

G

R

Green Biomass

Leaves – high turnover, seasonality

G … green biomass[a] [t/ha]

Reserve Biomass

Stem, Main Roots – slow turnover
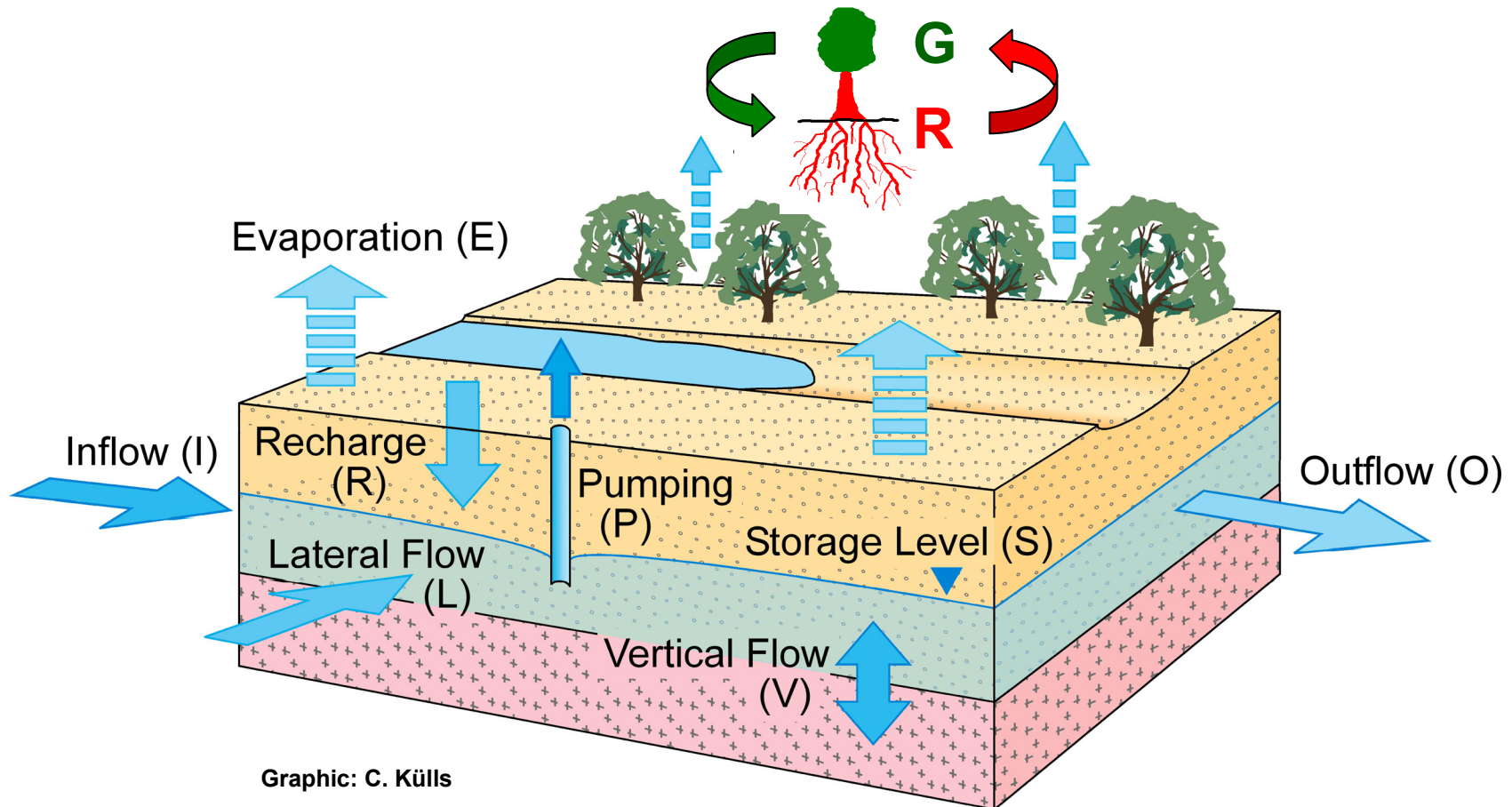
R … reserve biomass[a] [t/ha]

[a] Noy-Meir, I., 1982. Stability of plant–herbivore models and possible applications to Savanna.
In: Huntley, B., Walker, B.H. (Eds.), Ecology and Tropical Savannas. Springer, Berlin, pp. 591–609.
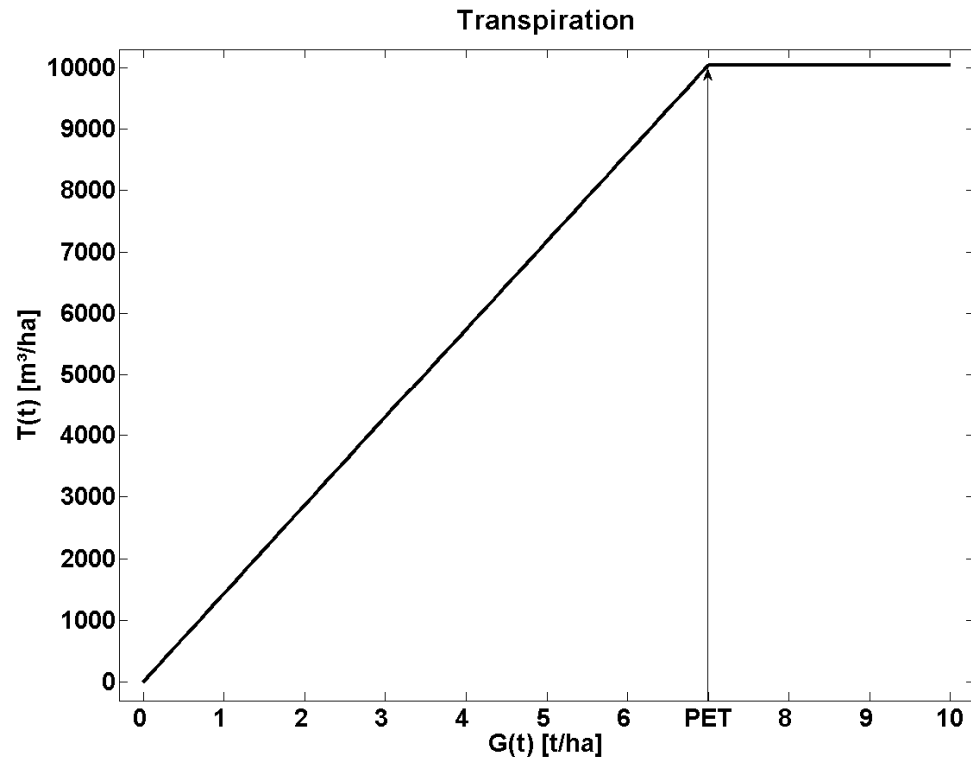
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Ecohydrological Interface
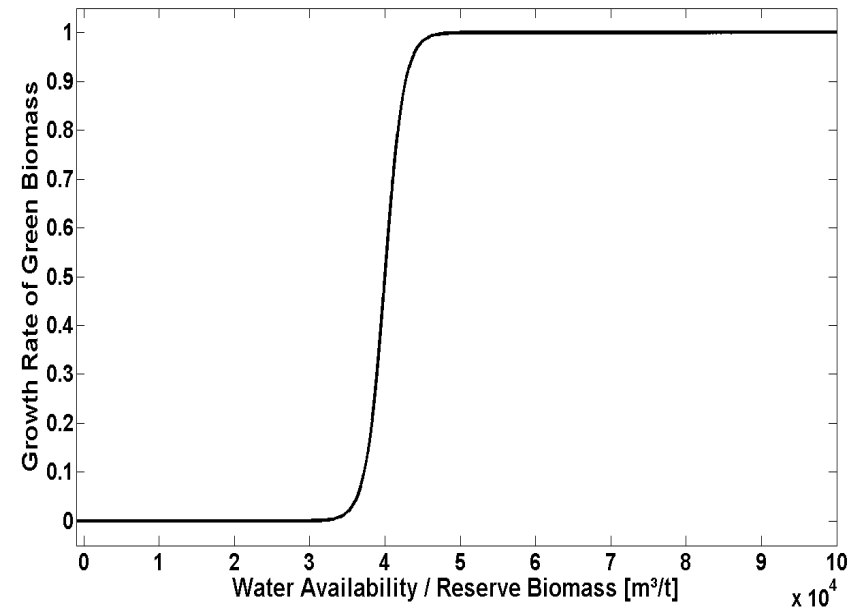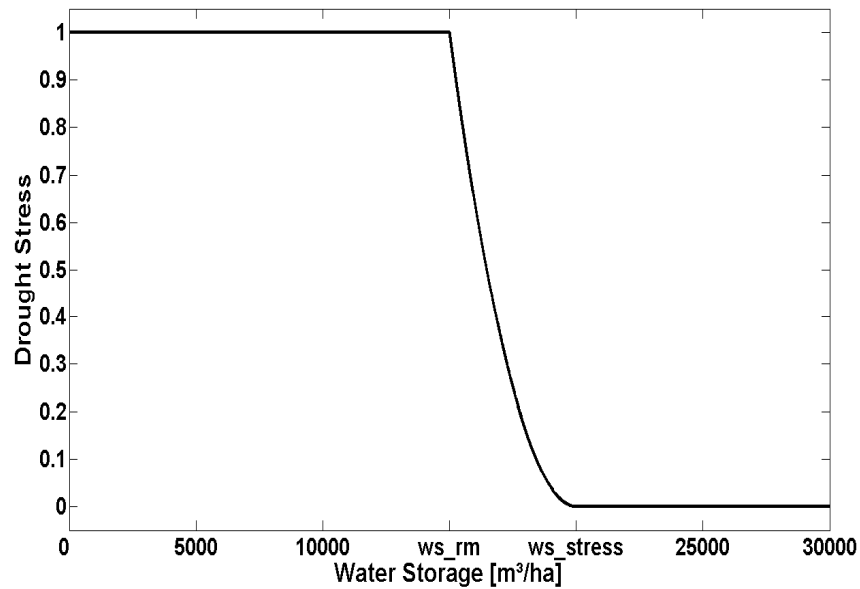
Species	Transpiration [g(H_2O)/g(G)*hr]	Leaf Shedding
Acacia sp.	1.03[a]	dry season
Faidherbia sp.	1.50[a]	rainy season
Tamarix sp.	1.07[a]	evergreen

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[a] Bate and Walker 1993. Water relations of the vegetation along the Kuiseb River, Namibia. Madoqua, 18(2), 85-91.

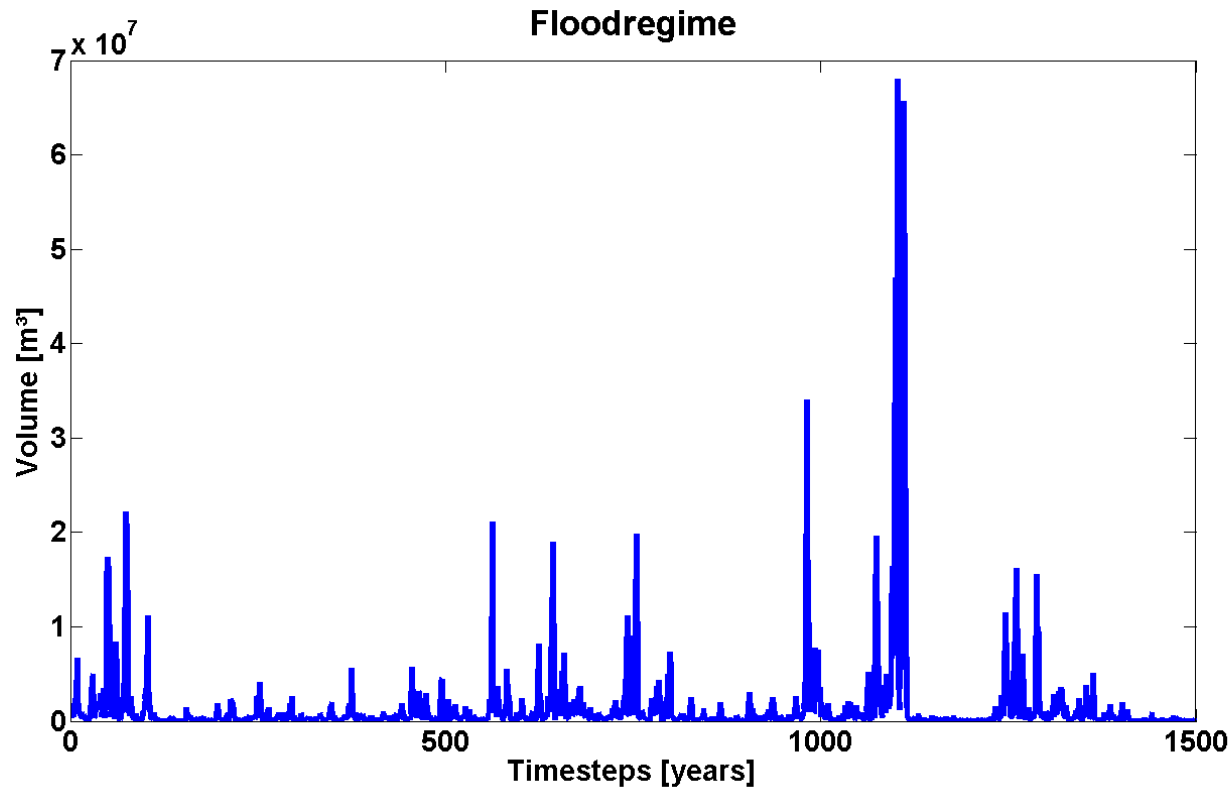# Conceptual Water Balance Model

Graphic: C. Külls

Input

Floodregime simulated by autoregressive approach (FARIMA)
(**F**ractionally **D**ifferenced **A**utoregressive **I**ntegrated **M**oving **A**verage)

„In contrast to using traditional ARIMA models, this approach allows the modeling of both **short- and long-term persistence** that are present in many hydrologic long-memory processes."[a]
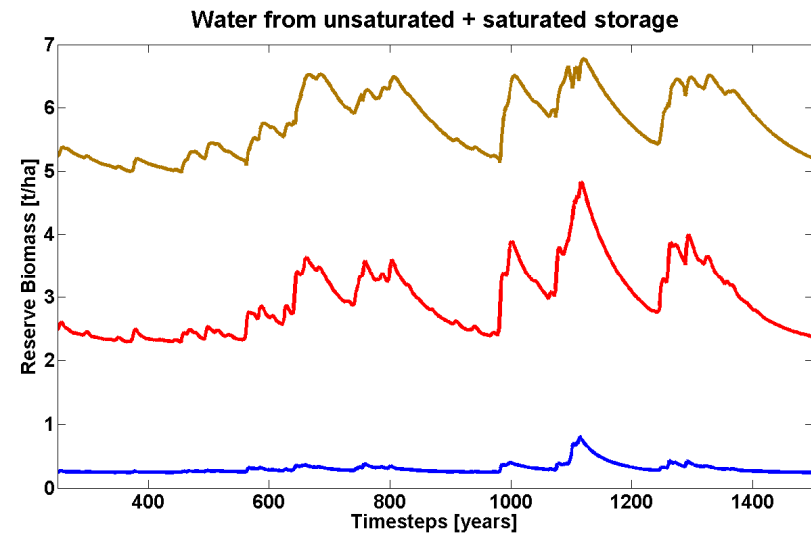
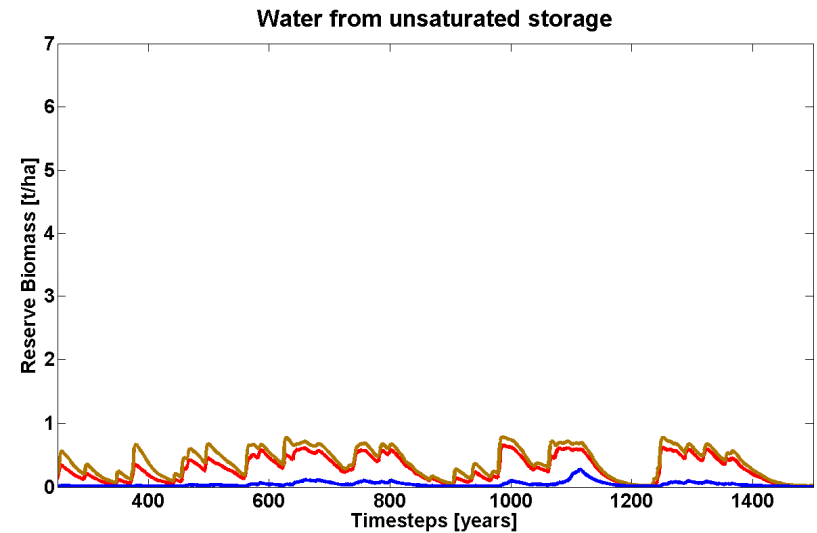[a] Montanari et al. 1997. Fractionally differenced ARIMA models applied to hydrologic time series: Identification, estimation, and simulation. Water Resources Research, 33, 1035-1044.

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Floodregime

Wet and drought periods   → **Joseph Effect**[a]

Extraordinarily high and low floods   → **Noah Effect**[a]

[a] Mandelbrot and Wallis, 1968 and 1969

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First Results ... **without** interspecies competition
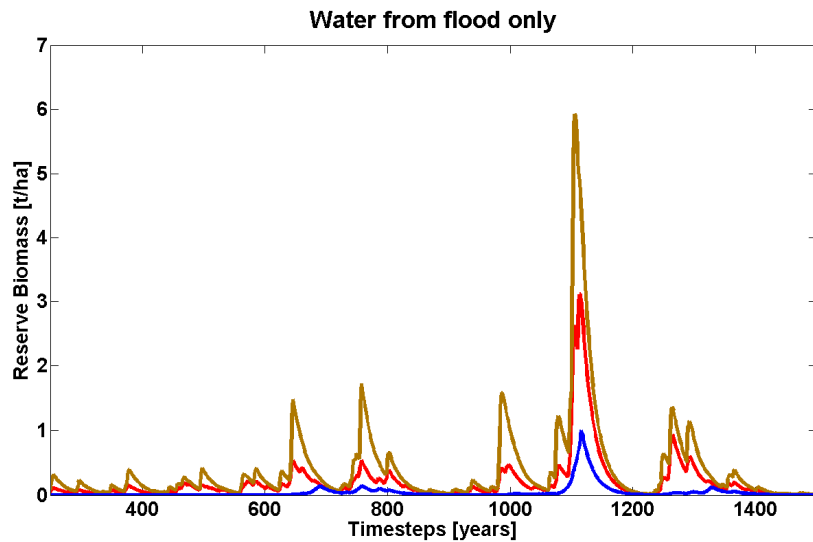
Water from flood only

Water from unsaturated storage

Water from unsaturated + saturated storage

Species	Transpiration [g(H_2O)/g(G)*hr]	Leaf Shedding
Acacia sp.	1.03[a]	dry season
Faidherbia sp.	1.50[a]	rainy season
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First Results ... **with** interspecies competition
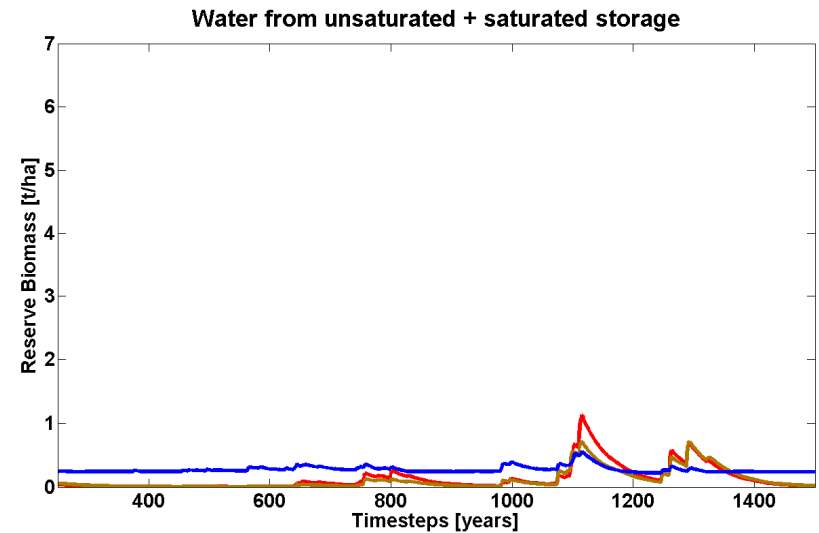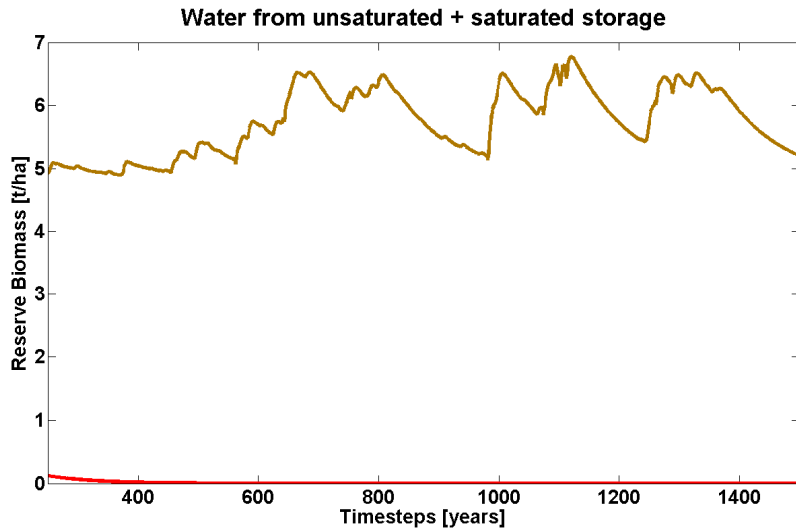
Water from unsaturated + saturated storage

Water from unsaturated + saturated storage

Species	Transpiration $[g(H_2O)/g(G)*hr]$	Leaf Shedding
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Summary

How do different types of water storage influence the ecosystem?

Increasing storage capacity leads to:

(1) Increase of mean reserve biomass

(2) Decrease of variability of reserve biomass

Which factors influence system stability?

Water storage (buffering mechanism)

Species composition (presence of Tamarix sp. leads to co-existence and decreased biomass variability)

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Thank you!

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