Probabilistic spatial and temporal resilience landscapes for the Congo basin

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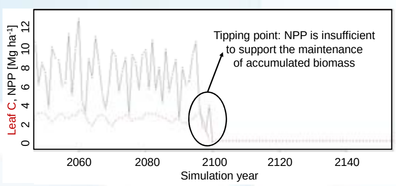
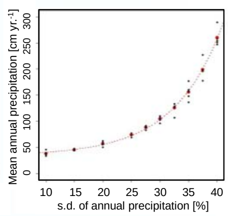
Introduction

Recent research by Hirota et al. (2011) introduced the concept of resilience landscapes for tropical forests and savannahs by statistically relating the probability of current forest/savannah occurrence with the concept of tipping points. This work uses biogeochemical modelling to create probabilistic resilience landscapes.

Tipping points

Sudden forest dieback results from a combination of favourable and unfavourable climate years. A favourable climate year boosts leaf area for the next year. When the next year is unfavourable, NPP may be insufficient to support the larger leaf area. Leaf area declines in the following year, causing reduced NPP. A tipping point has been surpassed and the forest stand breaks down. The occurrence of tipping points is related to inter-annual variation in mean annual precipitation.





Resilience landscape

The number of occurences of forest dieback events within a 100.000 year simulation gives the dieback probability.

Conclusion

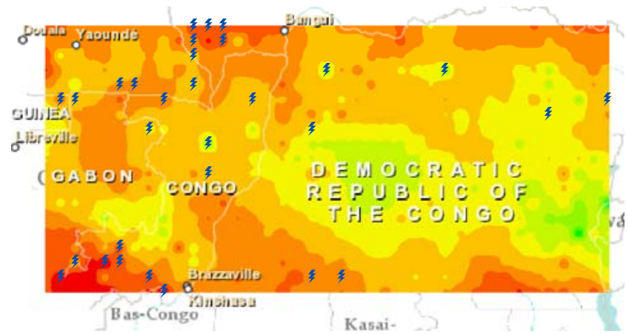
Besides spatial resilience landscapes the temporal evolution of resilience provide information on the resilience status of the rainforest biome. For the forests of the Congo basin, resilience is highest during the breakdown and regeneration phases, when only a few large, old trees are surrounded by massive regeneration. Management operations should spare the largest individuals per species in favour of middle class diameters. Forestry Codes of the Congo basin may consider to reduce the current diameter thresholds for exploitation (> 60-80cm).

Methods & Data

We use Biome-BGC 4.1.2 (Thornton et al, 2002) including dynamic mortality (Pietsch and Hasenauer, 2006) with a parameterization for the Congo Basin (Gautam, 2012) at a half degree resolution. Soil data for the Congo basin were taken from the harmonized World Soil Database (HWSD; FAO/IIASA/ISRIC/ISSCAS/JRC, 2012). Daily climate data for running the model were generated using MarkSim (Jones and Thornton, 1999) with corrections for the Congo basin (Bednar, 2011).

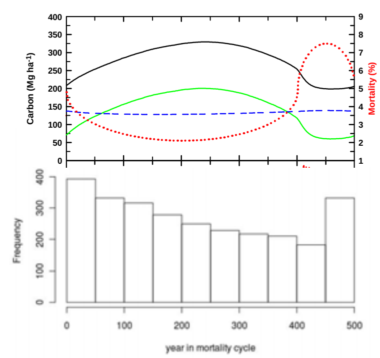
Spatial occurence

Under current climate conditions, patch level forest dieback events may occur along the meteorological equator, where cosecutive years may exhibit either no dry season or two dry seasons, and in the rainshadows of mountain ranges.



Temporal resilience

Along the patch level forest growth dynamics dieback probability differs with growth stage.



The probability of forest dieback differs during the five stages of the forest stand development cycle (see Pietsch and Hasenauer, 2009). It is highest during the adolescence and optimum growth stage, declines during the old growth phase and reaches a minumum during the breakdown and regeneration phases.

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