Leonie Naujoks
M.Sc. Landscape Ecology & Nature Conservation
s-lenauj@uni-greifswald.de

Imke Pelloth
M.Sc. Biodiversity & Ecology
s-impell@uni-greifswald.de

Amazon Rainforest

Climate change and Deforestation drive Dieback to Savannah

UNIVERSITÄT GREIFSWALD
Wissen lockt. Seit 1456

Introduction

Importance of the Amazon Rainforest

- one of the most **biodiverse** terrestrial ecosystems
- large **carbon sink**: stores about 150 - 200 GtC [1]
- creates up to **50 %** of its **own rainfall** [2] via process of **moisture recycling** [3]
  → stability of downwind forest enhanced by cascading moisture transport [4]

Amazon Rainforest is a tipping element

- two **alternative stable states** depending on precipitation amount: **rainforest** and **savannah** [5]
  → below **2,000 mm** mean annual precipitation forest might **shift** to savannah (Fig. 1)

Climate change and deforestation could push Amazon to a tipping point

- **self-amplified forest loss** due to breakdown of moisture recycling & cascading moisture transport [6]

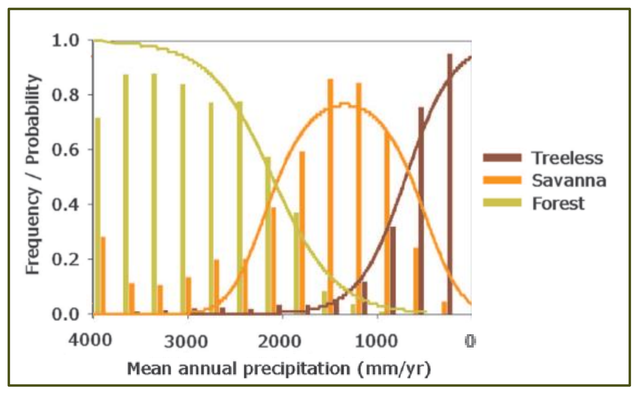

Fig. 1: Probability of three vegetation types depending on mean annual precipitation (adapted from [5]).

Moisture Recycling and the Drivers of its Breakdown

1 Forest

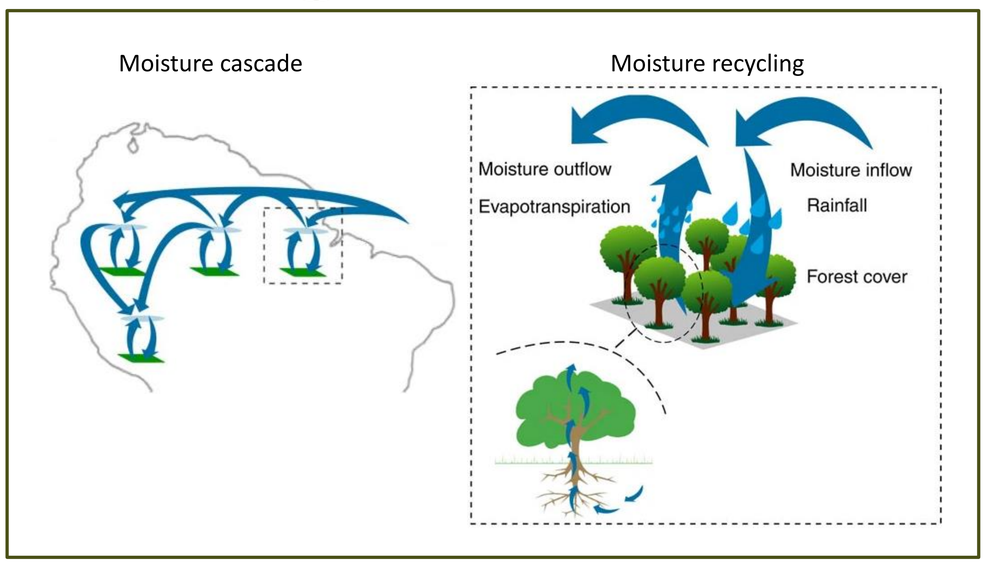

Fig. 2: Mechanism of moisture recycling and cascading moisture transport (adapted from [6])

2 Savannah

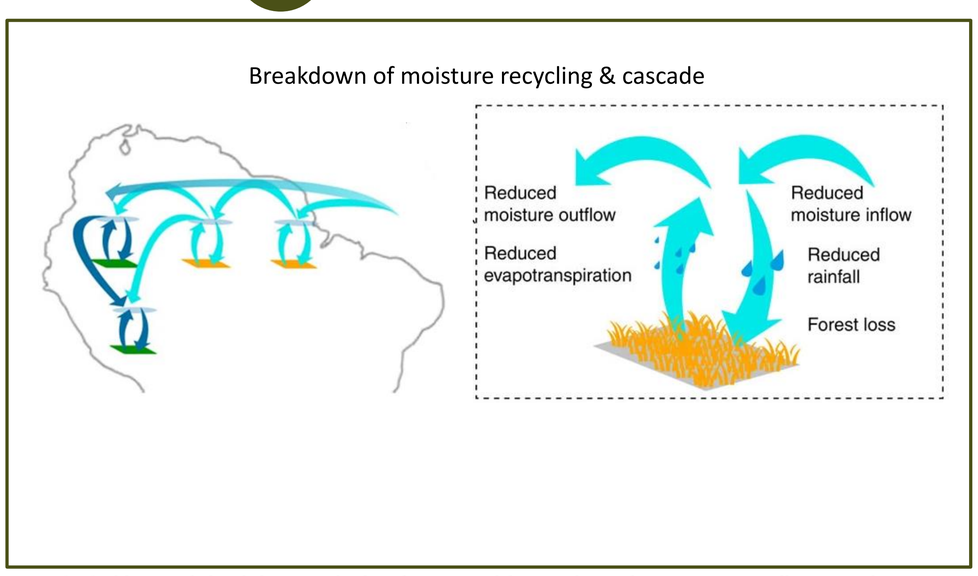

Fig. 3: Self-amplified forest dieback caused by reduced moisture inflow and recycling (adapted from [6])

Reduced Precipitation

3 - 4 °C [9,14]

40 % [12]

20 - 25 % deforestation [15]

Climate Change

Global warming leads to:

- **less precipitation** over tropical South America [7]
- **more droughts** when sea surface temperatures in tropical Atlantic and Pacific are high (reduced moisture inflow) [8,9]
- longer and drier dry seasons [10,11]
- more frequent and intense **extreme weather events** [7]

Deforestation

Land-use change leads to:

- **reduced evapotranspiration** from pastures and croplands, higher air temperature [12]
- breakdown of moisture recycling, regional and large-scale **precipitation reduction** [13]

Synergistic Effects [16]

Consequences

Accelerating climate change

- total dieback could lead to release of 53 - 70 GtC [17] → amplifying global temperature rise, further forest loss

Loss of biodiversity

Agriculture and human well-being at risk

- dry seasons might become longer because of reduced evapotranspiration [18]
- less rainfall, changes in seasonal rainfall patterns, and more climatic extremes impair agriculture [19]

References

[1] Malhi, Y., Wood, D., Baker, T. R., Wright, J., Phillips, O. L., Cochrane, T., ... & Vinceti, B. (2006). The regional variation of aboveground live biomass in old-growth Amazonian forests. Global Change Biology, 12(7), 1107-1138.
[2] Van der Ent, R. J., Savenije, H. H., Schaefli, B., & Steele-Dunne, S. C. (2010). Origin and fate of atmospheric moisture over continents. Water Resources Research, 46(9).
[3] Eltahir, E. A., & Bras, R. L. (1994). Precipitation recycling in the Amazon basin. Quarterly Journal of the Royal Meteorological Society, 120(518), 861-880.
[4] Staal, A., Tuinenburg, O. A., Bosmans, J. H., Holmgren, M., van Nes, E. H., Scheffer, M., ... & Dekker, S. C. (2018). Forest-rainfall cascades buffer against drought across the Amazon. Nature Climate Change, 8(6), 539-543.
[5] Hirota, M., Holmgren, M., Van Nes, E. H., & Scheffer, M. (2011). Global resilience of tropical forest and savanna to critical transitions. Science, 334(6053), 232-235.
[6] Zemp, D. C., Schleussner, C. F., Barbosa, H. M., Hirota, M., Montade, V., Sampaio, G., ... & Rammig, A. (2017). Self-amplified Amazon forest loss due to vegetation-atmosphere feedbacks. Nature communications, 8(1), 1-10.
[7] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, …, B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32
[8] Yoon, J. H., & Zeng, N. (2010). An Atlantic influence on Amazon rainfall. Climate dynamics, 34(2), 249-264.
[9] Cox, P. M., Betts, R. A., Collins, M., Harris, P. P., Huntingford, C., & Jones, C. D. (2004). Amazonian forest dieback under climate-carbon cycle projections for the 21st century. Theoretical and applied climatology, 78(1), 137-156.
[10] Fu, R., Yin, L., Li, W., Arias, P. A., Dickinson, R. E., Huang, L., ... & Myneni, R. B. (2013). Increased dry-season length over southern Amazonia in recent decades and its implication for future climate projection. Proceedings of the National Academy of Sciences, 110(45), 18110-18115.
[11] Gloor, M. R. J. W., Brienen, R. J., Galbraith, D., Feldpausch, T. R., Schöngart, J., Guyot, J. L., ... & Phillips, O. L. (2013). Intensification of the Amazon hydrological cycle over the last two decades. Geophysical Research Letters, 40(9), 1729-1733.
[12] Sampaio, G., Nobre, C., Costa, M. H., Satyamurty, P., Soares-Filho, B. S., & Cardoso, M. (2007). Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. Geophysical Research Letters, 34(17).
[13] Zemp, D. C., Schleussner, C. F., Barbosa, H., & Rammig, A. (2017). Deforestation effects on Amazon forest resilience. Geophysical Research Letters, 44(12), 6182-6190.
[14] Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S., & Schellnhuber, H. J. (2008). Tipping elements in the Earth's climate system. Proceedings of the national Academy of Sciences, 105(6), 1786-1793.
[15] Lovejoy, T. E., & Nobre, C. (2018). Amazon tipping point. Science Advances, 4(2), eaat2340.
[16] Staal, A., Dekker, S. C., Hirota, M., & van Nes, E. H. (2015). Synergistic effects of drought and deforestation on the resilience of the south-eastern Amazon rainforest. Ecological Complexity, 22, 65-75.
[17] Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., ... & Schellnhuber, H. J. (2018). Trajectories of the Earth System in the Anthropocene. Proceedings of the National Academy of Sciences, 115(33), 8252-8259.
[18] Nobre, C. A., Sellers, P. J., & Shukla, J. (1991). Amazonian deforestation and regional climate change. Journal of climate, 4(10), 957-988.
[19] Lawrence, D., & Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. Nature climate change, 5(1), 27-36.