Bolin Centre for Climate Research
Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship
Stockholm University
TU Delft
PIK

Programme **HS2.1.5:**
**Advances in forest hydrology**

# Water stress and their implications on the ecohydrology of rainforests



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Sharing is encouraged

# Background

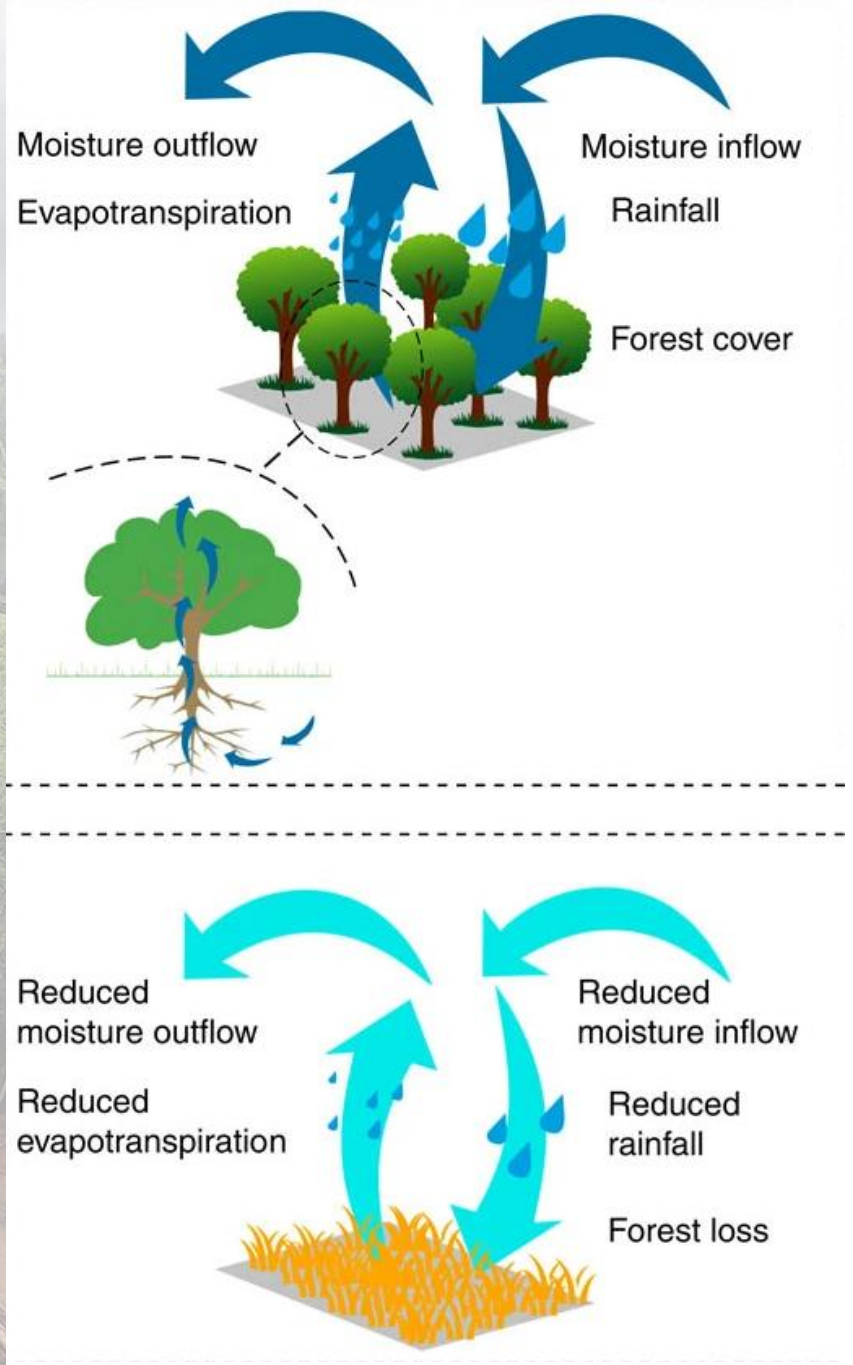
**Why rainforest?**

Because they:

- Hosts vast biodiversity
- Stabilize Earth's climate
- Maintain and influence global water cycle

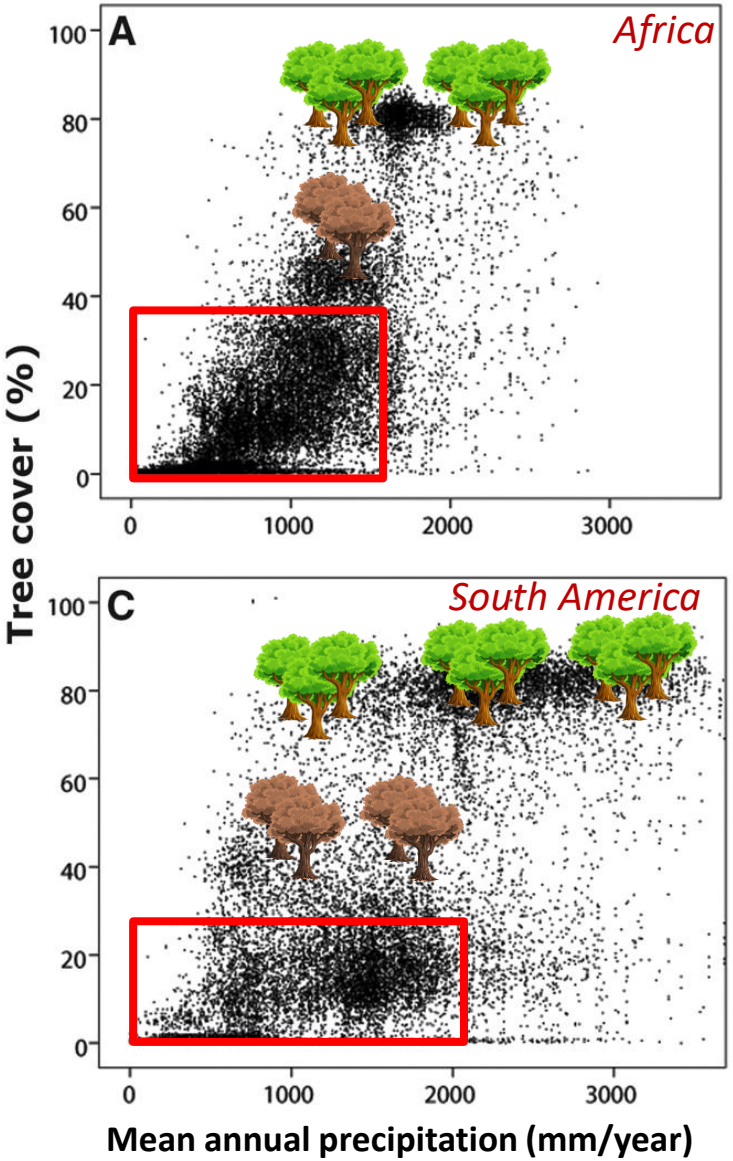
**What is happening to the rainforest?**

- Influenced by climate change
- Along with deforestation and fire
- Increasing risk of self-amplified forest loss



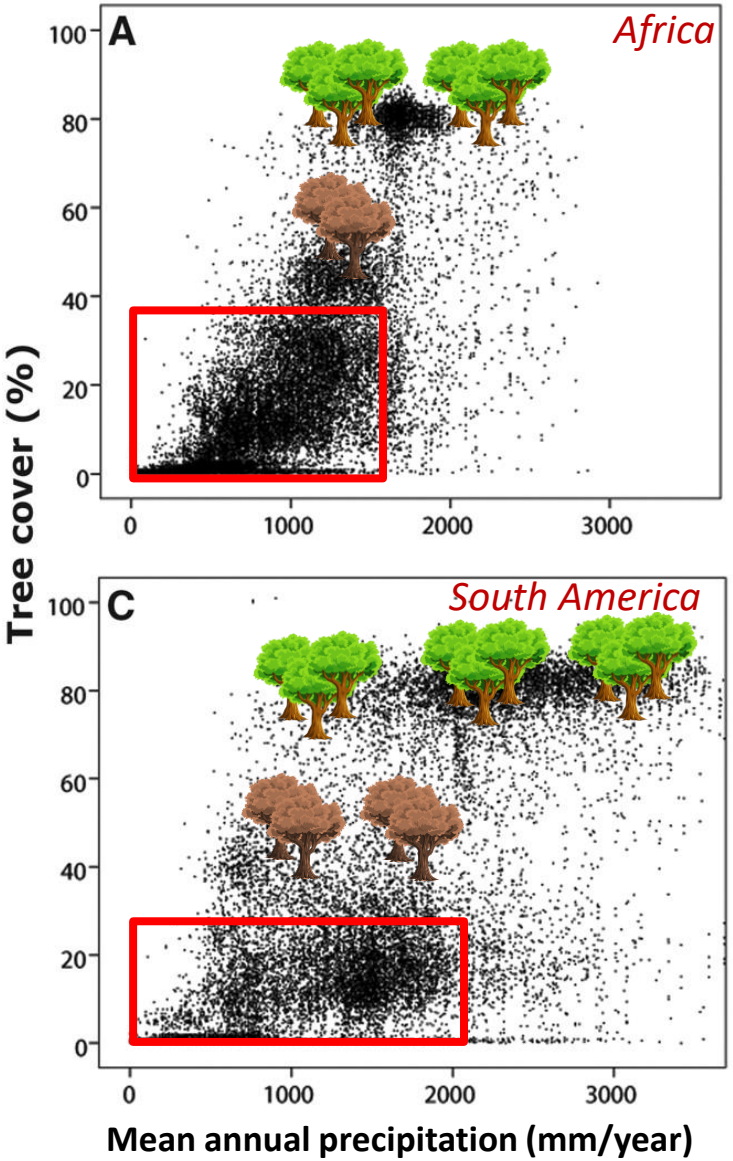

Source: Zemp et al. (2017), *Nat. Comm.*

# Previous researches




Source: Hirota et al. (2011), *Science*

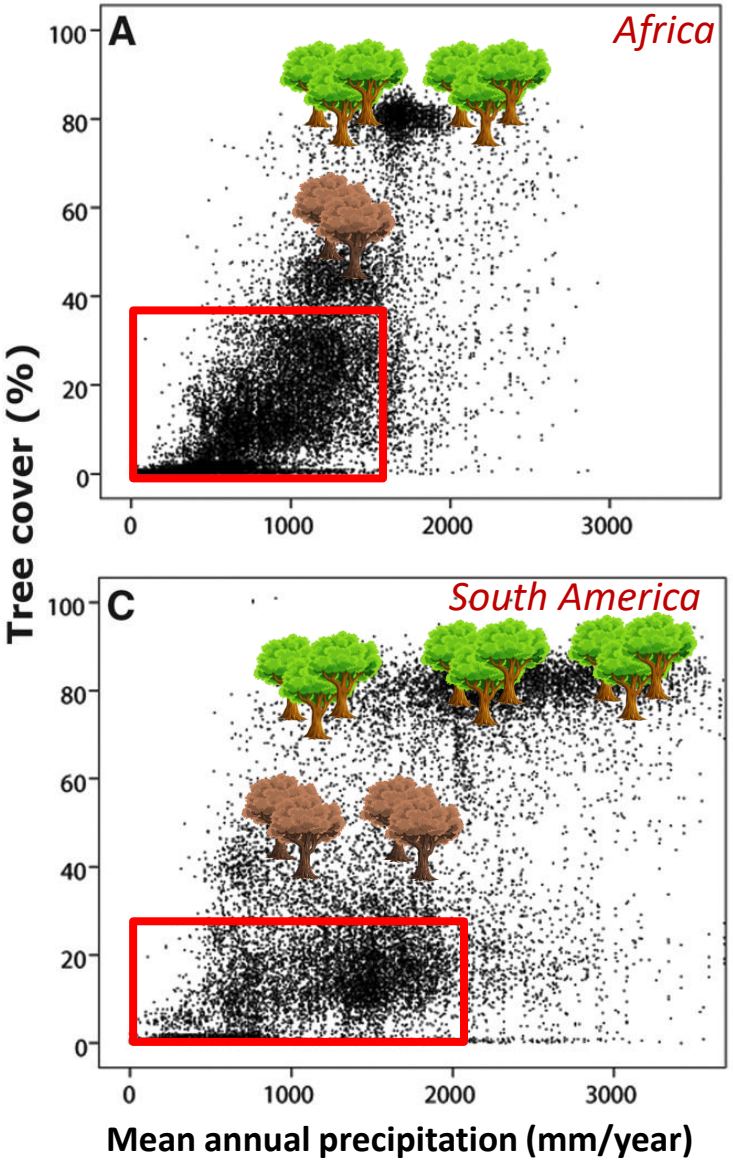
# Previous researches




- Dependence on climate (Mean annual precipitation)
- However, lacks dynamics related to ecosystem processes

Source: Hirota et al. (2011), *Science*

# Our question?




Q. Why can forest survive at different rainfall levels?, and
Q. Why are some ecosystems more vulnerable than others?

*Hypothesis*: Maybe, the subsurface dynamics is playing an important role here?

Source: Hirota et al. (2011), *Science*

# Aim

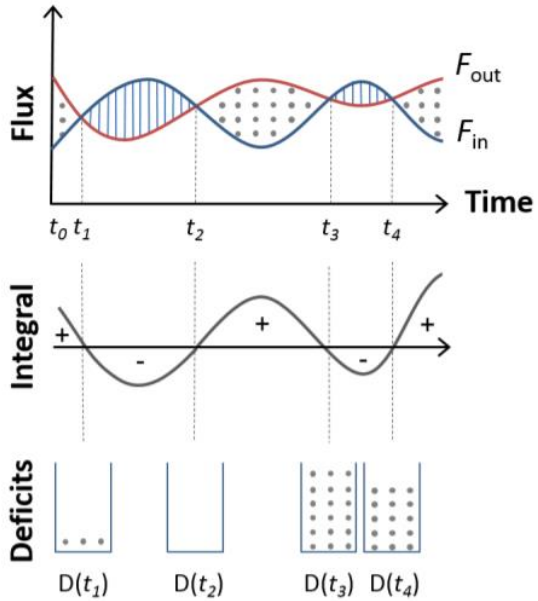
- To quantify water-stress and drought coping strategies of the rainforest-savanna ecosystems in South America and Africa

# Methods

- Metric that would represent the ‘subsurface moisture availability of the ecosystem (large scale)’.

Rootzone storage capacity ($S_r$), which is the maximum amount of moisture that can be stored and accessed by vegetation for transpiration during dry periods

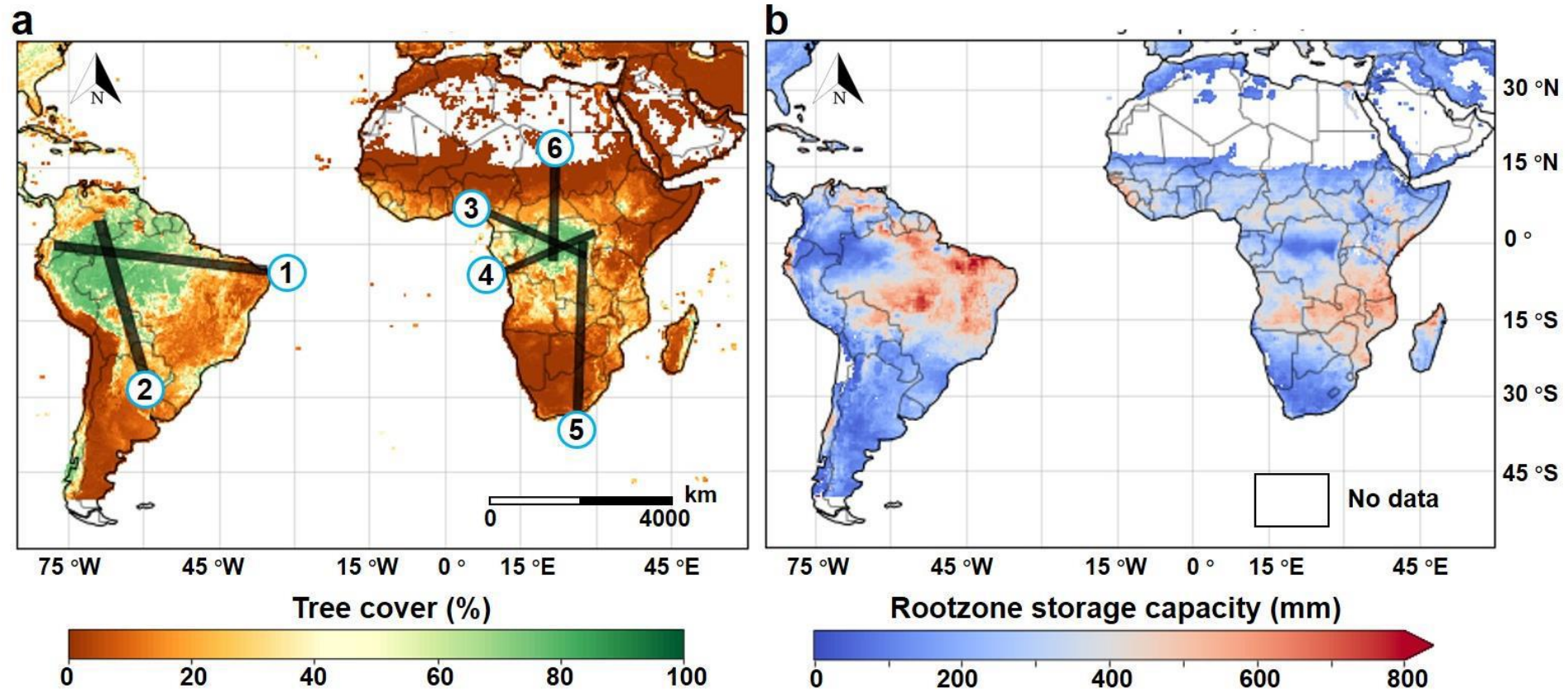
Only uses precipitation ($F_{in}$) and evaporation ($F_{out}$) estimates.




Assumption: ecosystems **do not invest** in expanding their storage capacity **more than necessary** to bridge the water-deficit **experienced (past)** by the vegetation in dry periods

Source: Wang-Erlandsson et al. 2016, *HESS*

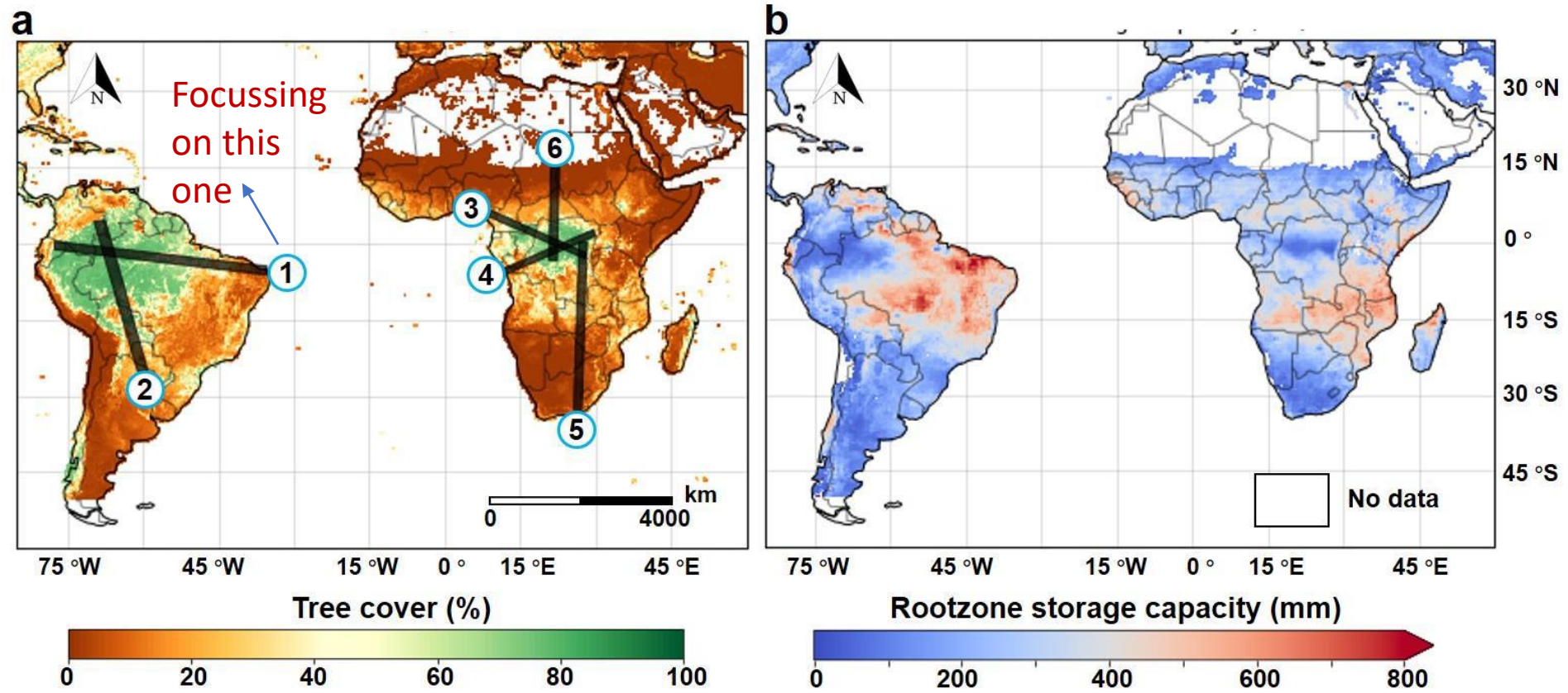
# Methods




Rootzone storage capacity ($S_r$): vegetations capacity to store and utilize subsoil storage

Singh et al. (2020), *ERL*

# Methods

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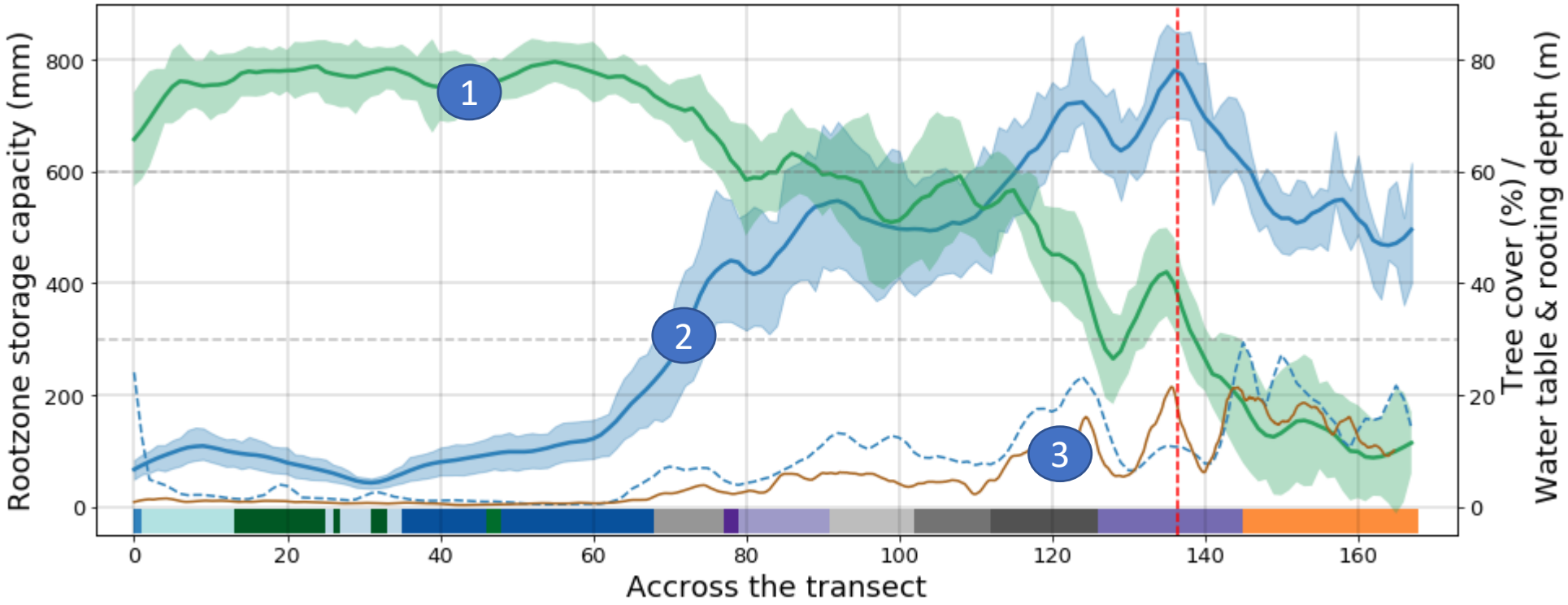
# Results




Singh et al. (2020),
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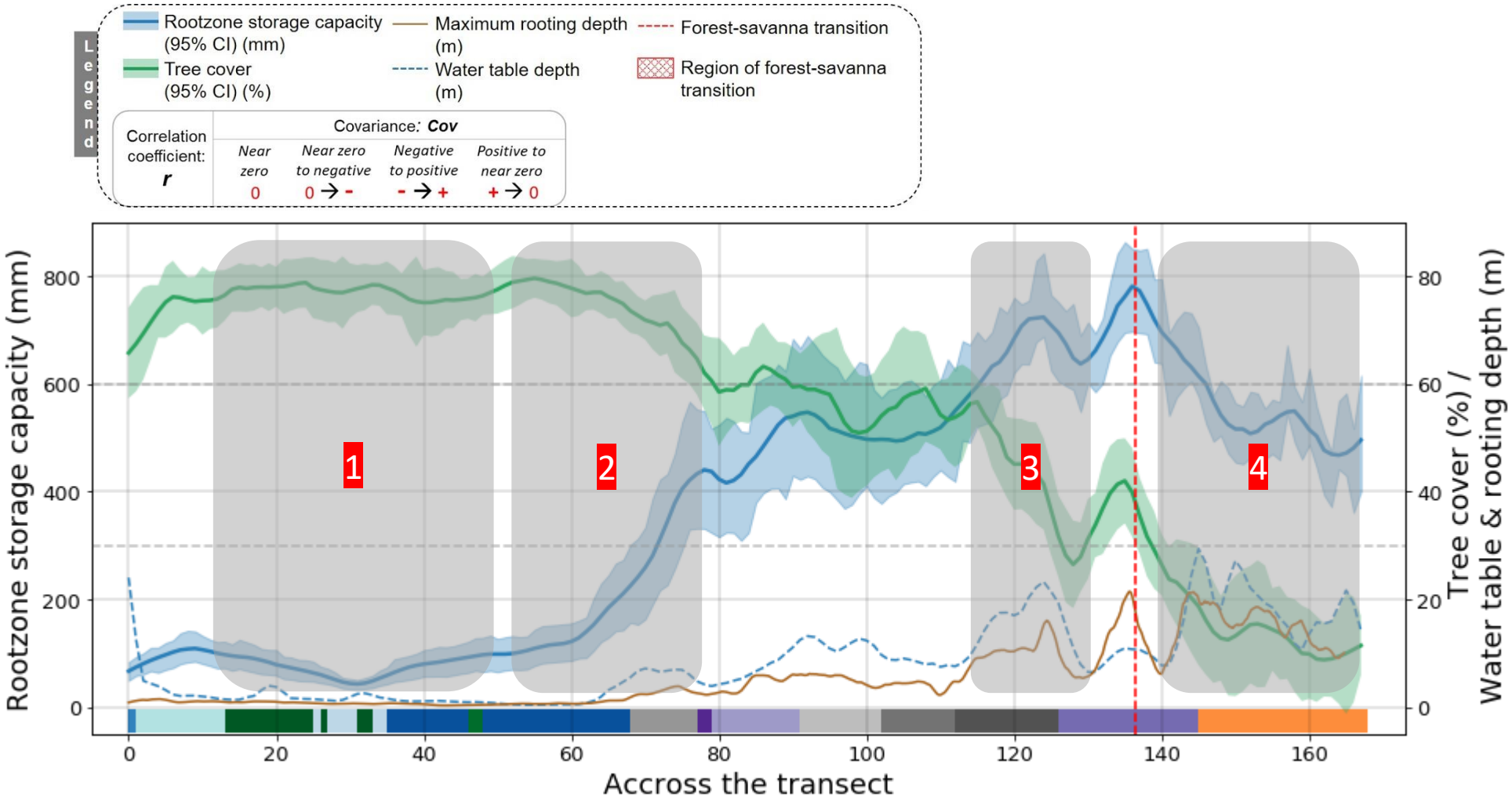
# Results

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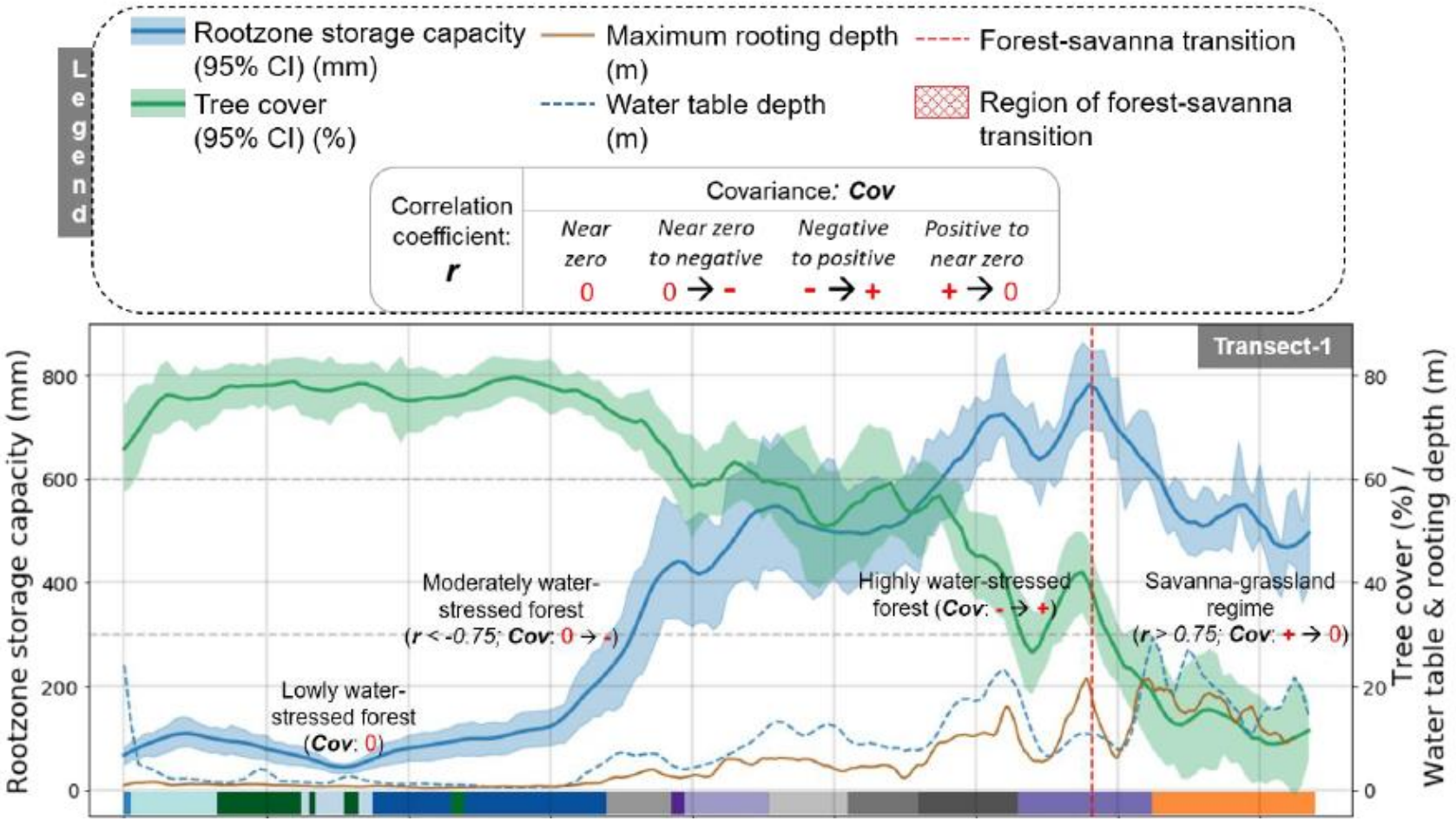
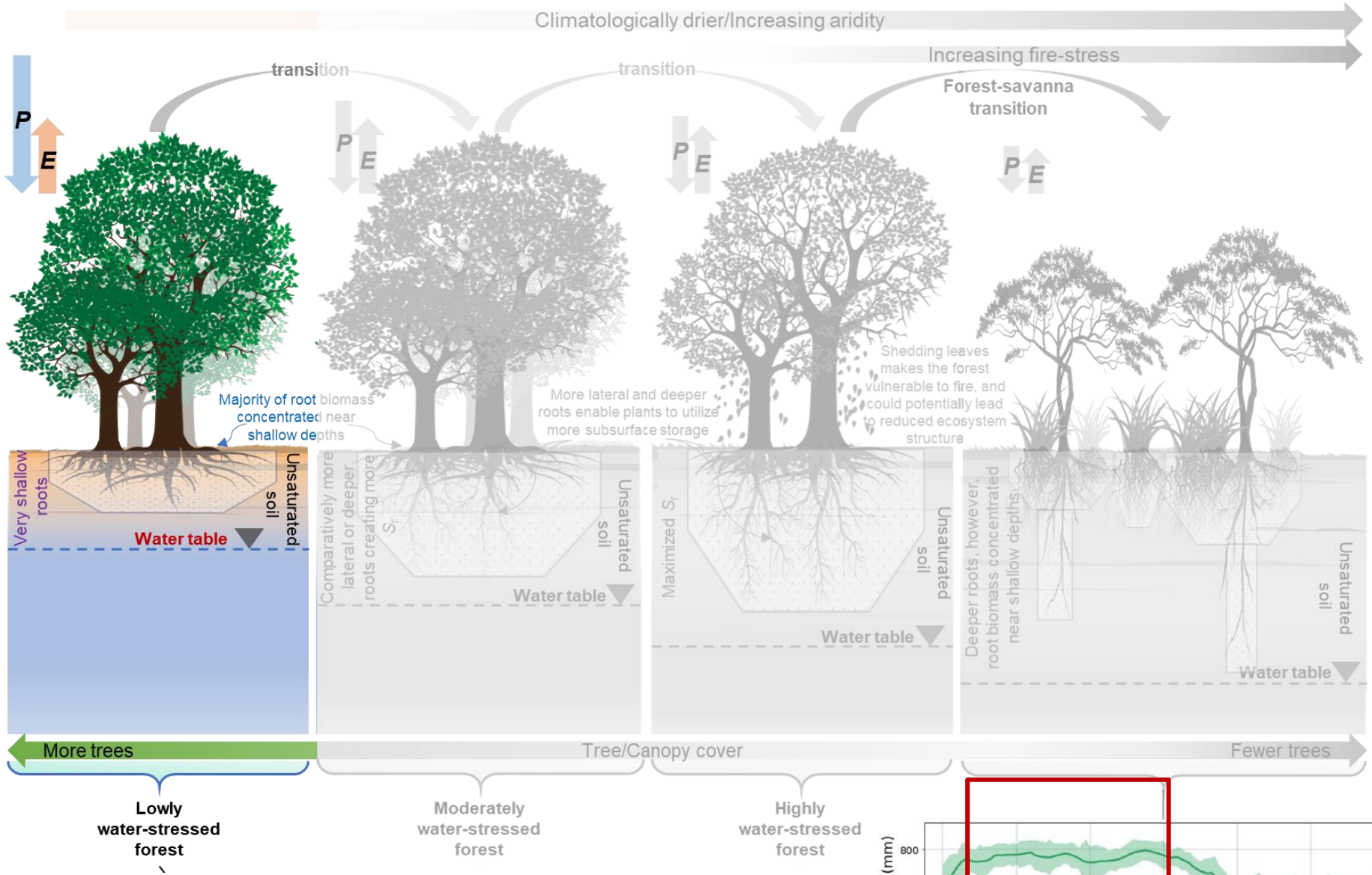



Change in rootzone storage capacity and tree cover in South America across transect #1.

The quantification of term 'water-stressed' in the class name represents both **quantified magnitude and duration of water-deficit experienced by vegetation** which can inhibit plant growth, as well as the **probability of them transitioning** to a savanna-grassland regime

Singh et al. (2020), *ERL*

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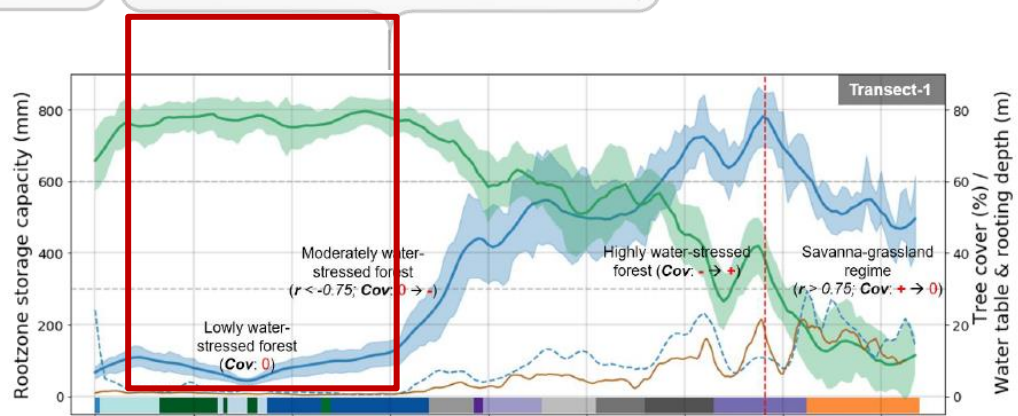

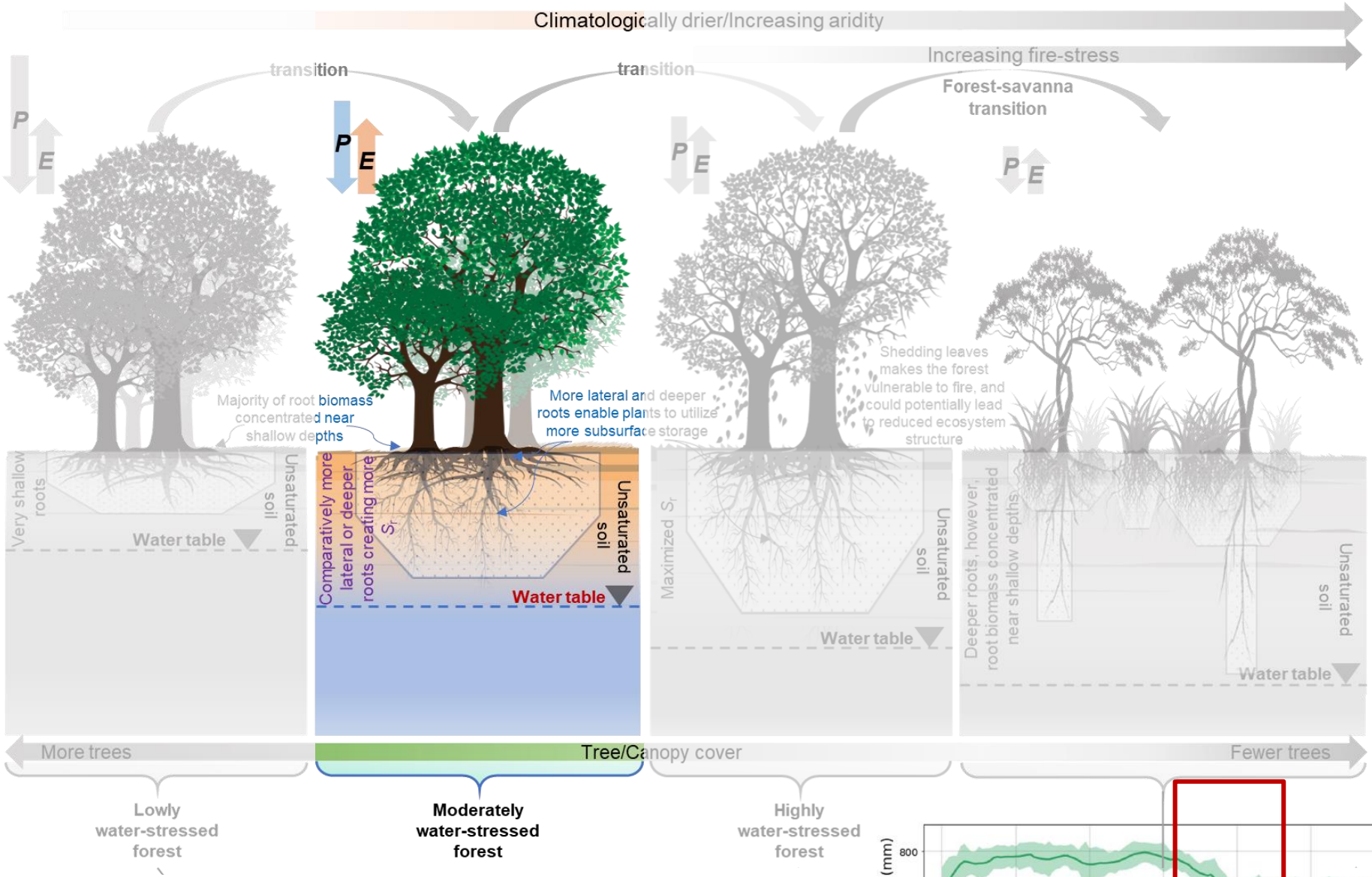


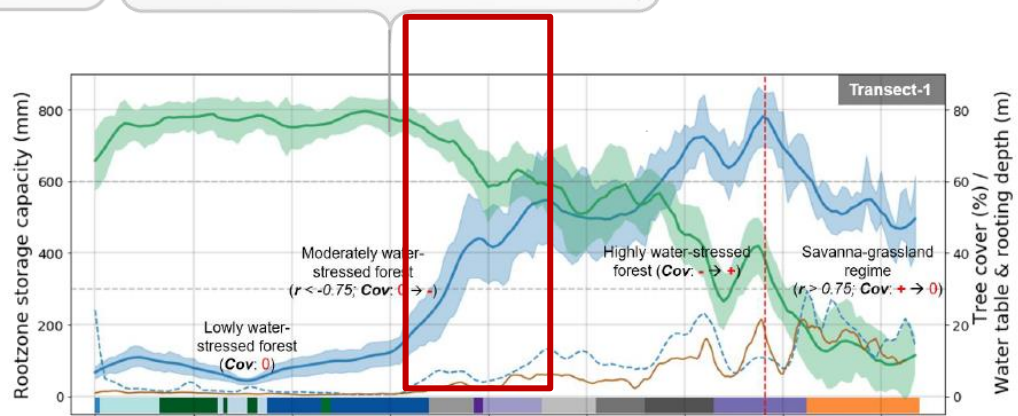


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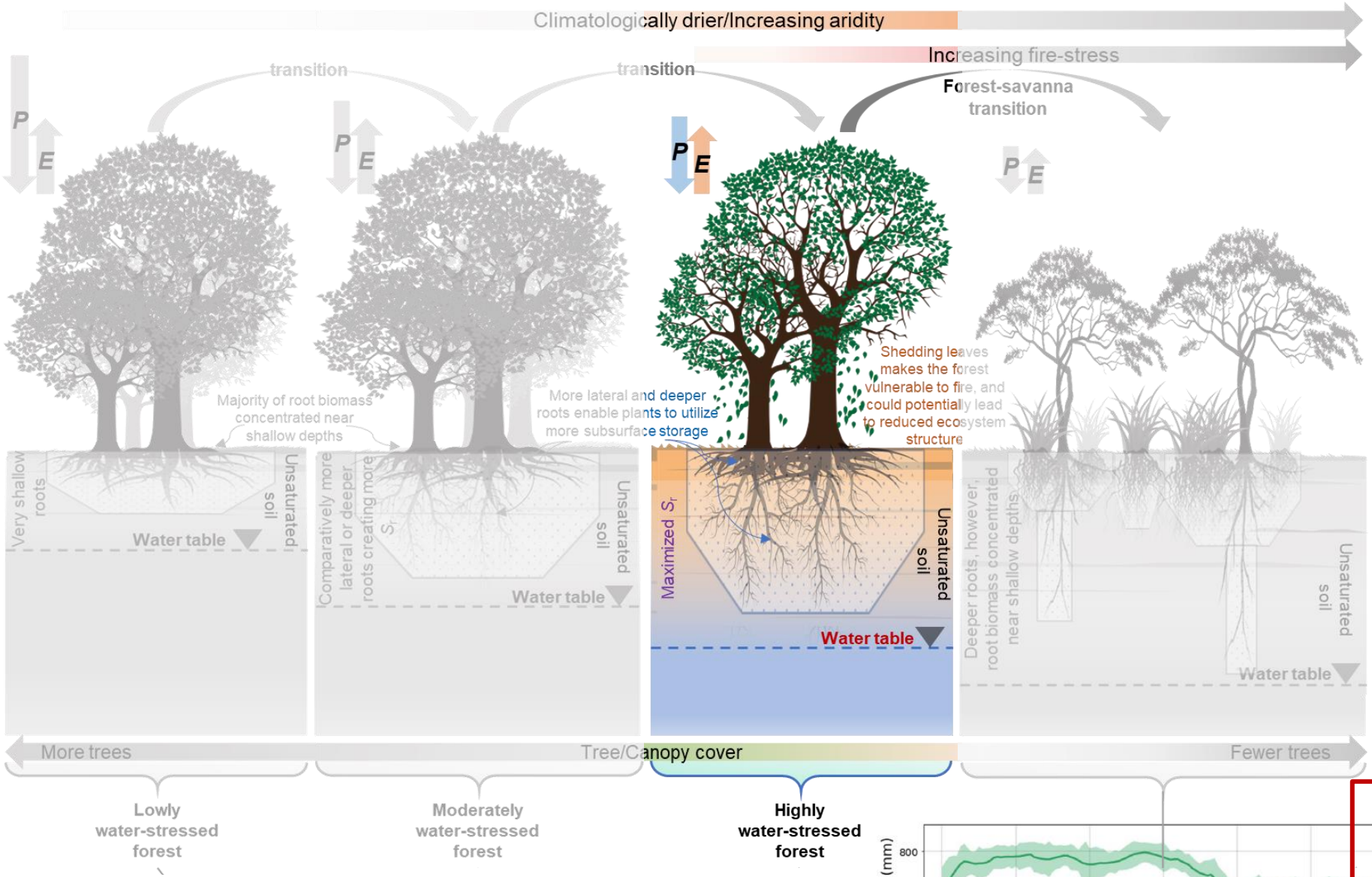


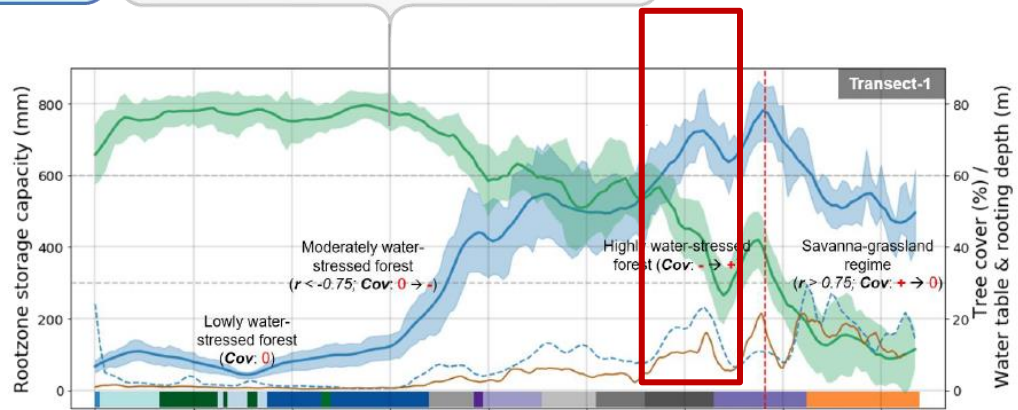


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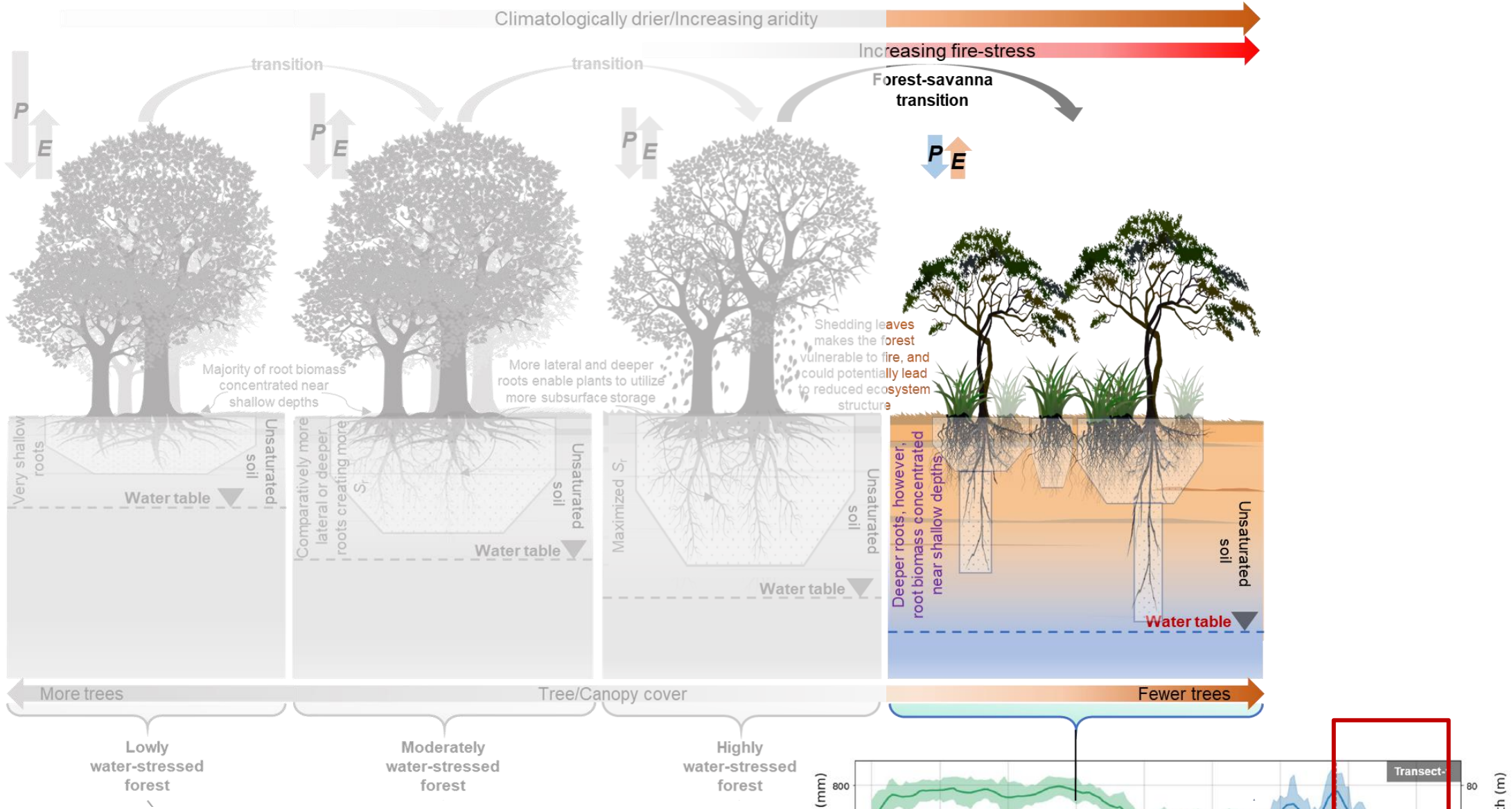


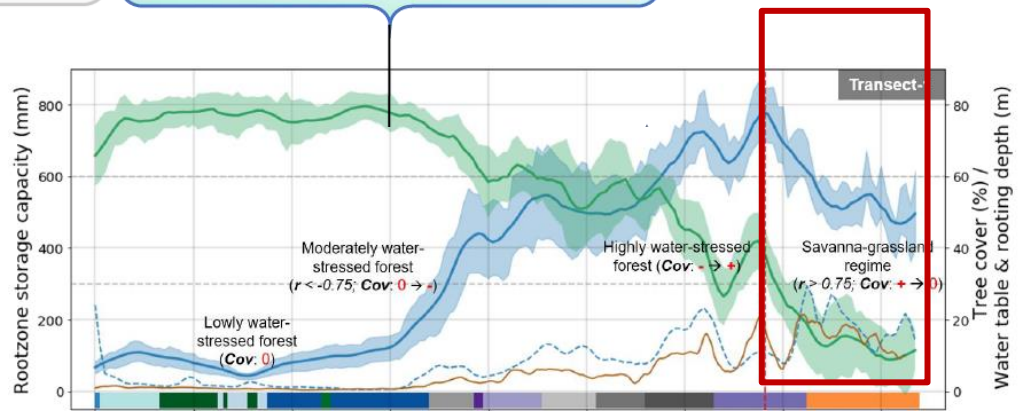


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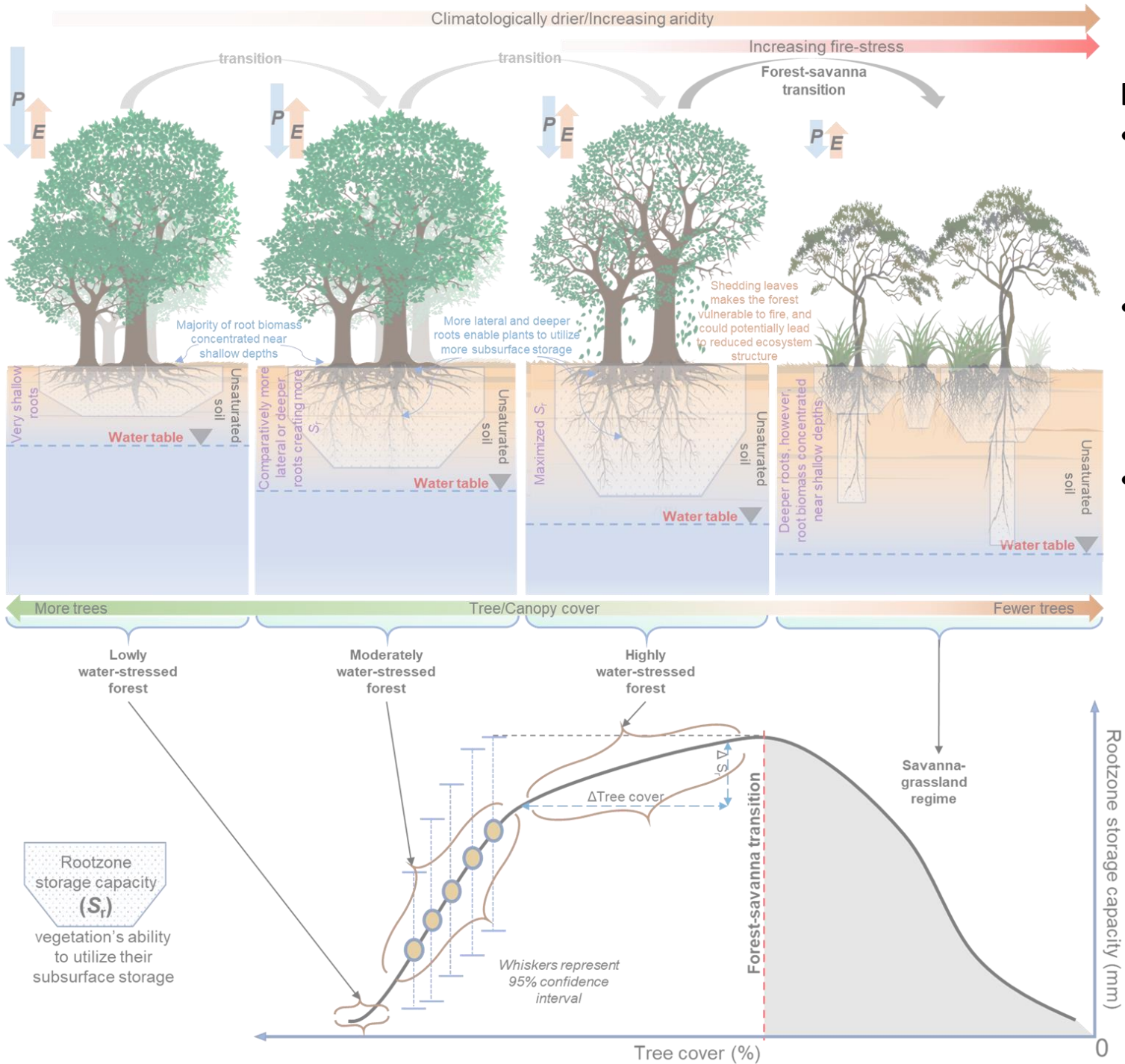


**Key messages:**

- Forests subsequently invest in their rooting strategy and modify their above-ground forest cover in response to the water-stress experienced by it.
- These responses are focused towards allocating carbon in the most efficient way possible to maximize their hydrologic benefit.
- Sr thresholds of forest-savanna transition to be around 550-750 mm (for South America) and 400-600 mm (for Africa) at a TC of about 30-40%. Low moisture carryover capacity and high water-use efficiency (due to the abundance of C4 grasses) in Africa might be the reason for a lower Sr threshold.

Singh et al. (2020), *ERL*



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# Thank you