Two decades of forest monitoring shows instability in the rainforests

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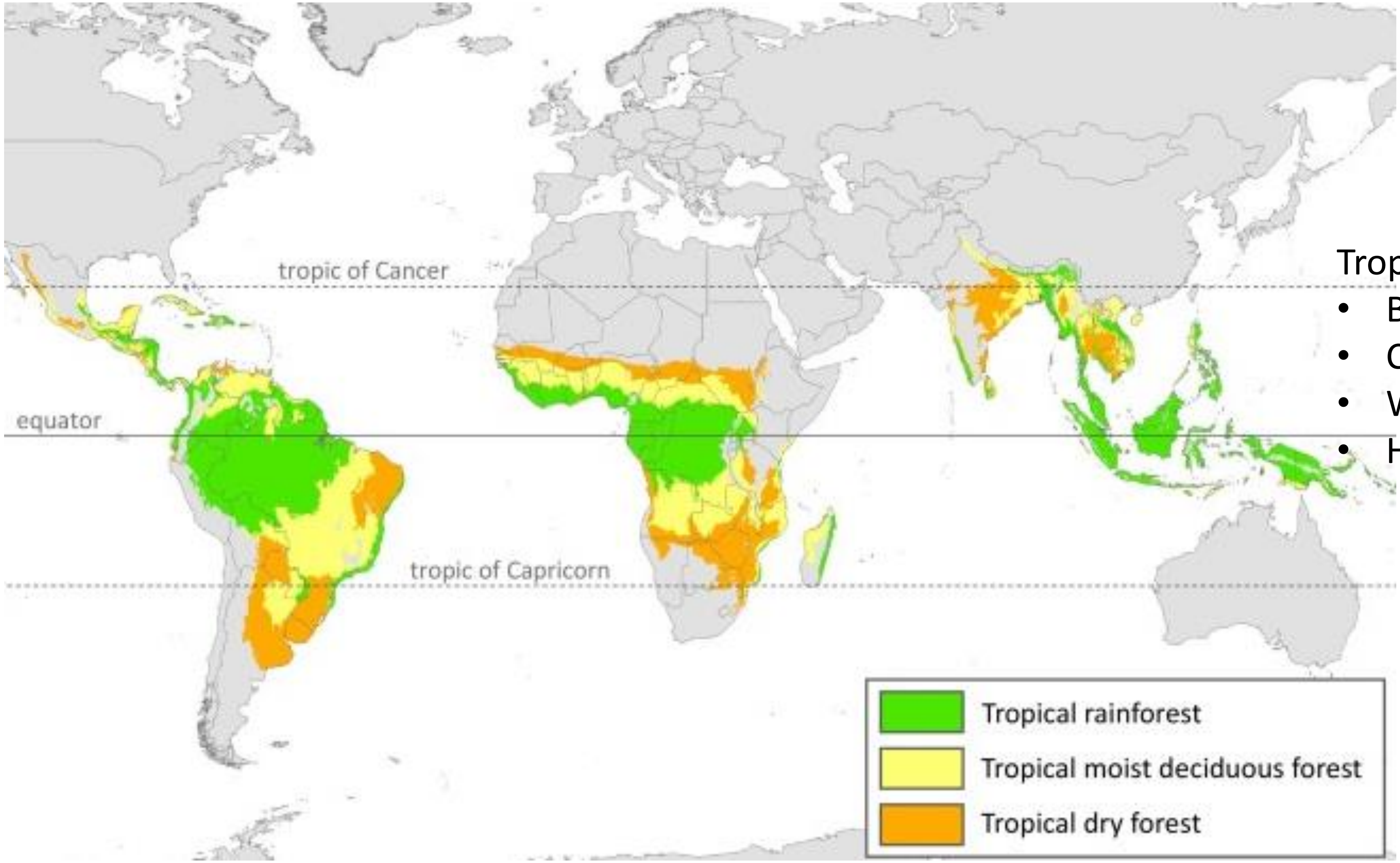
Background



Koyama et al., 2019 (RSE)

Tropical rainforests contribute to:

- Biodiversity
- Carbon sequestration
- Water cycle
- Human-influenced land systems

Background

Tropical rainforest under threat:

- Climate change
- Deforestation due to agricultural and pasture conversion
- Human-induced fires
- Logging and other resource extraction

Image source: Varl Disouza/ Getty images

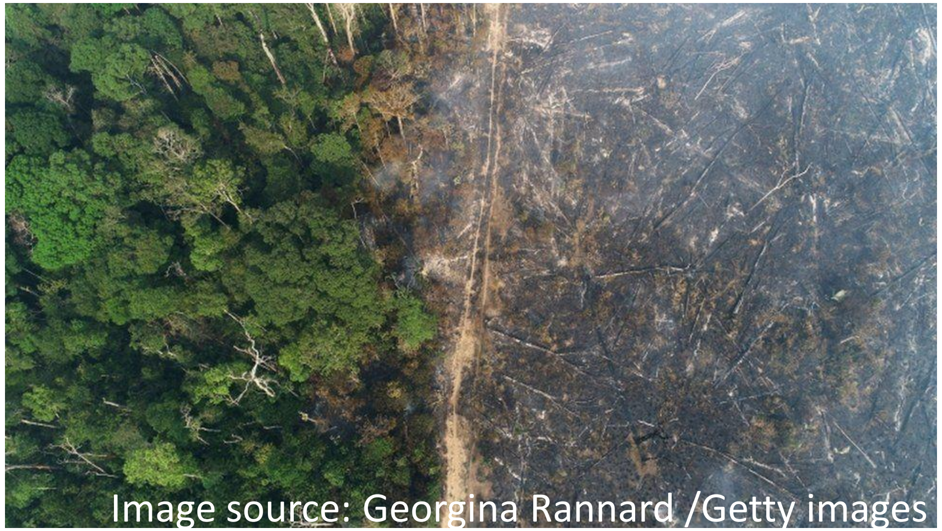


Image source: Georgina Rannard /Getty images

which reduces **forest resilience** towards future water-induced perturbations, and increases risk of a **forest-savanna transition**

- Difficult to predict forest-savanna transition due to non-linearity in ecosystem response against perturbations

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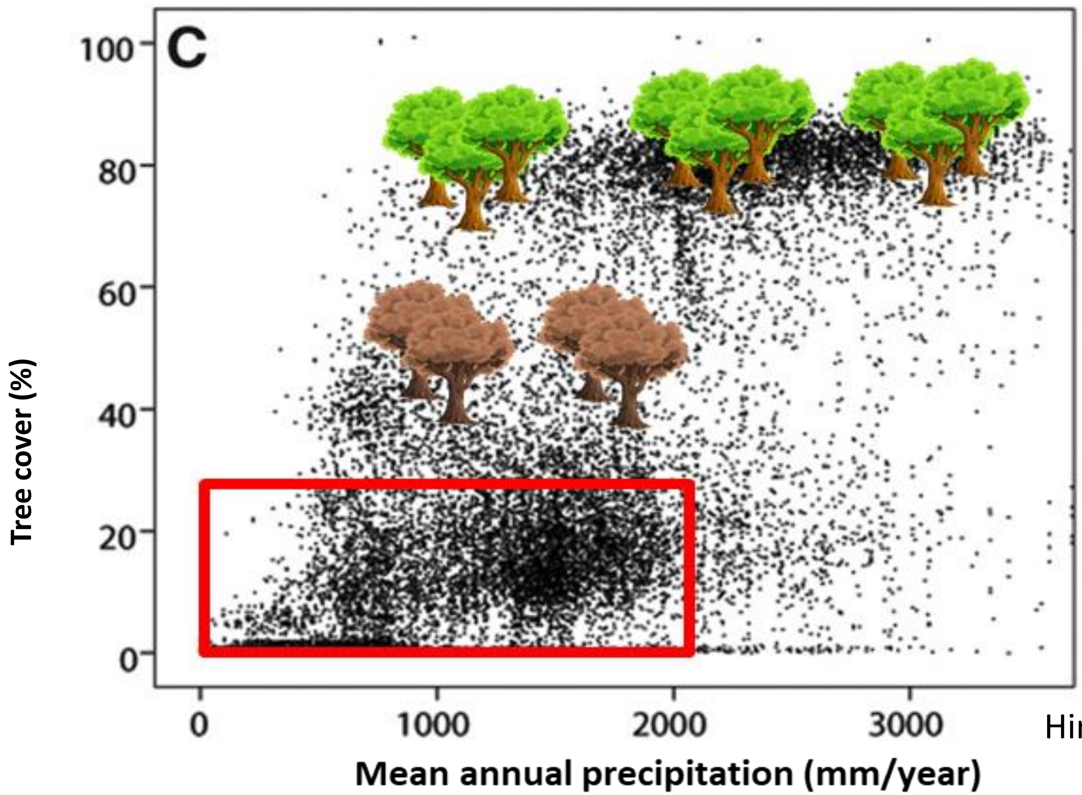
- Precipitation provides limited understanding of ecosystem dynamics; subsoil dynamics is lacking



Hirota et al. (2011)

Research question

How does tropical terrestrial ecosystems respond and adapt to changes in precipitation?

Methodology

Observation-driven (remotely sensed) datasets (2000-2019):

- Precipitation (CHIRPS) and Evaporation (FLUXCOM, BESS, PML)
- Satellite-derived products (Continuous vegetation cover; Land cover)

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- Plant available moisture – **Root zone storage capacity (S_r)**

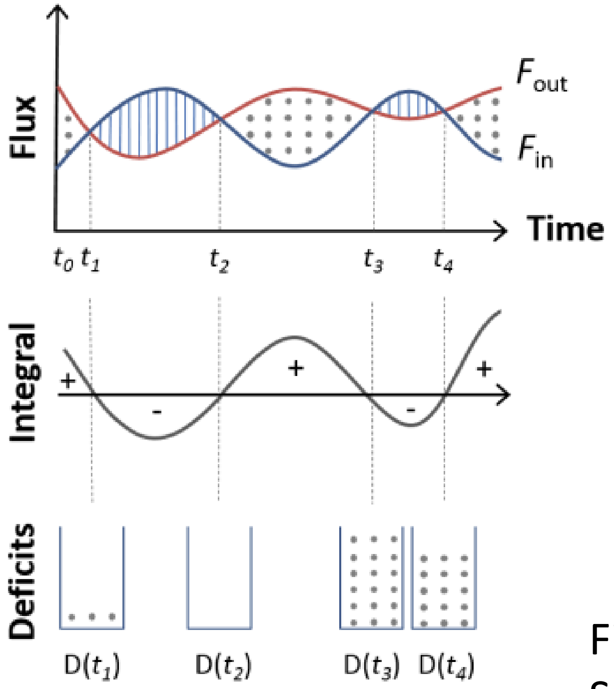

Fig. Calculation of root zone storage capacity; Source: Wang-Erlandsson et al. 2016

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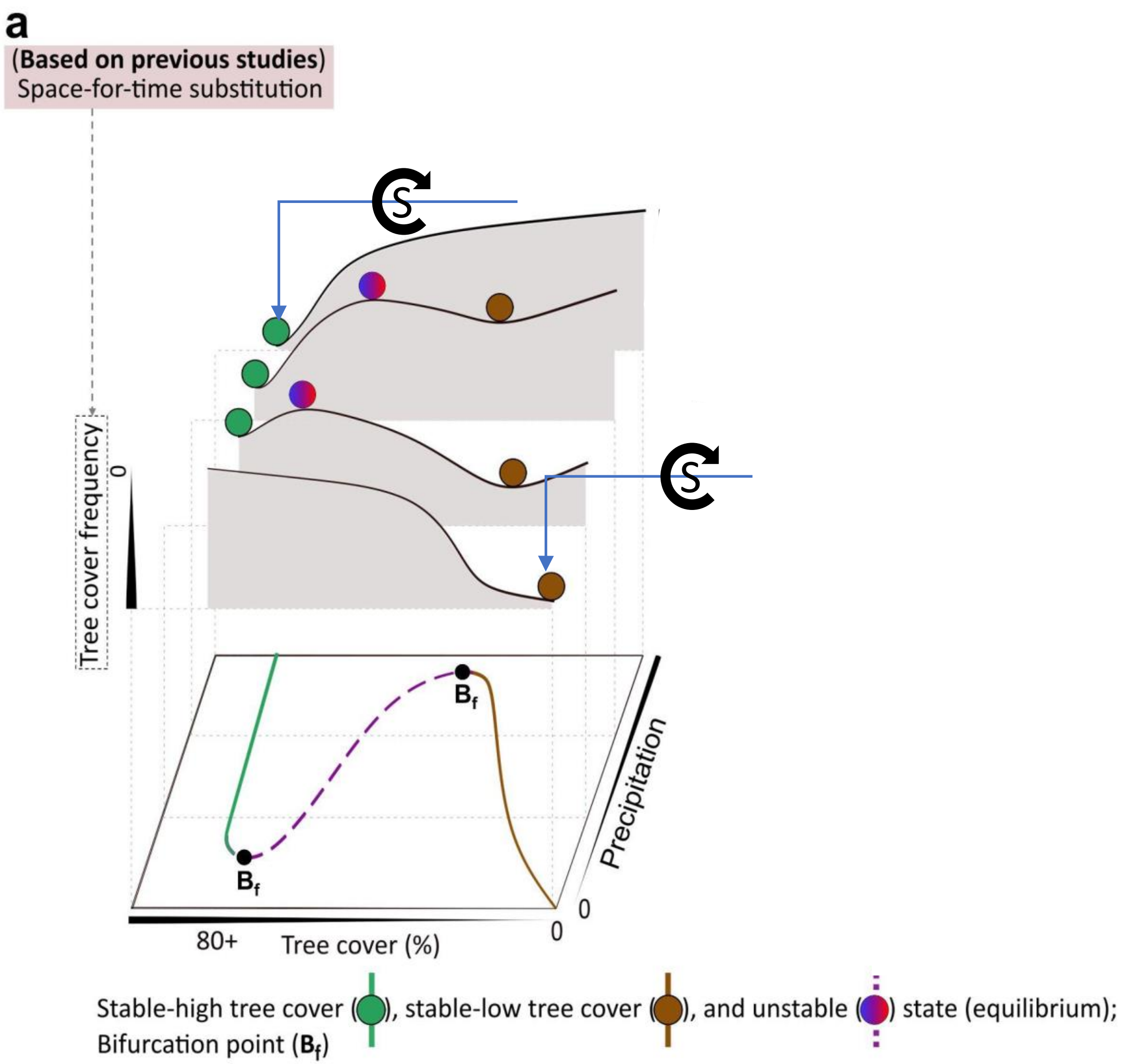
- Plant available moisture – **Root zone storage capacity (S_r)**
- Study area: South America and Africa



Singh et al. 2022

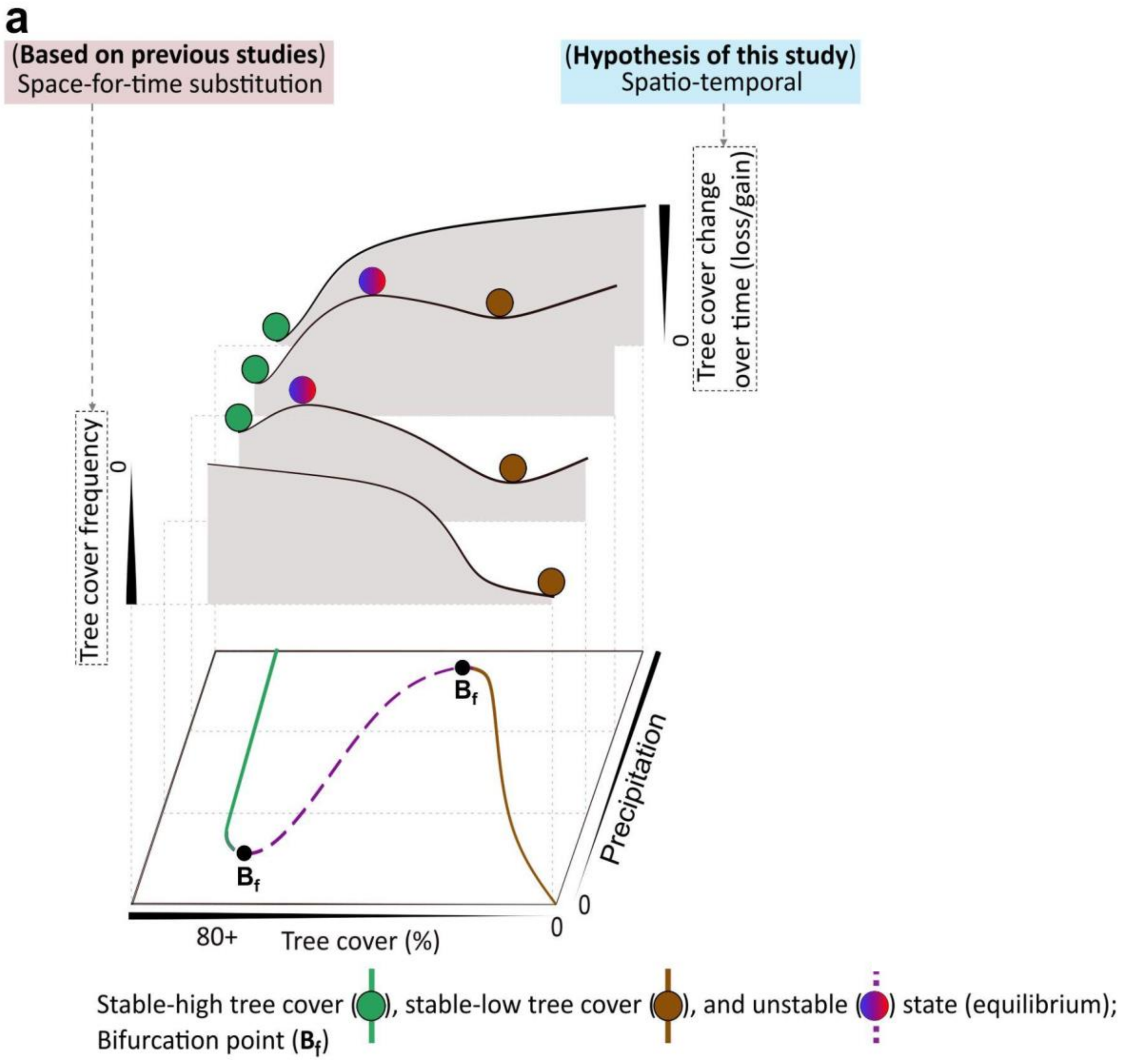
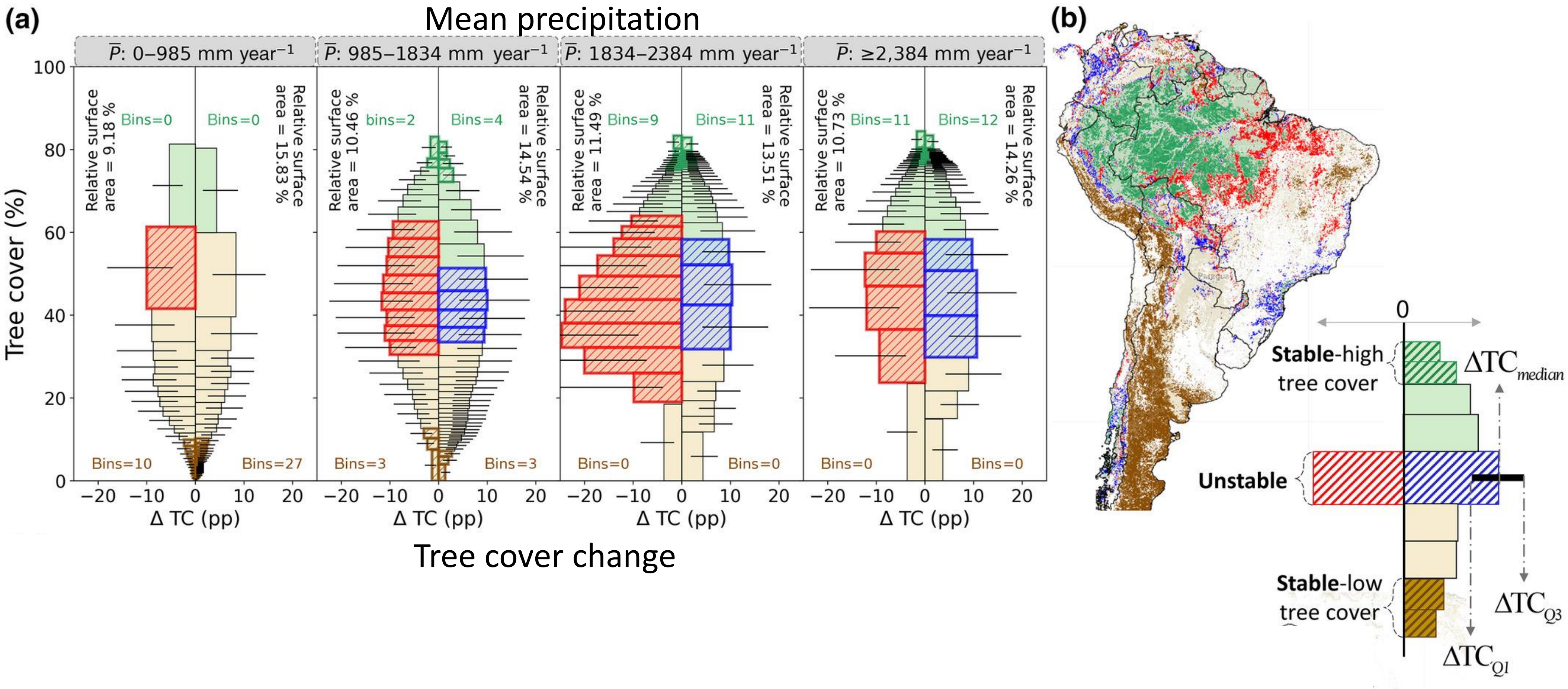
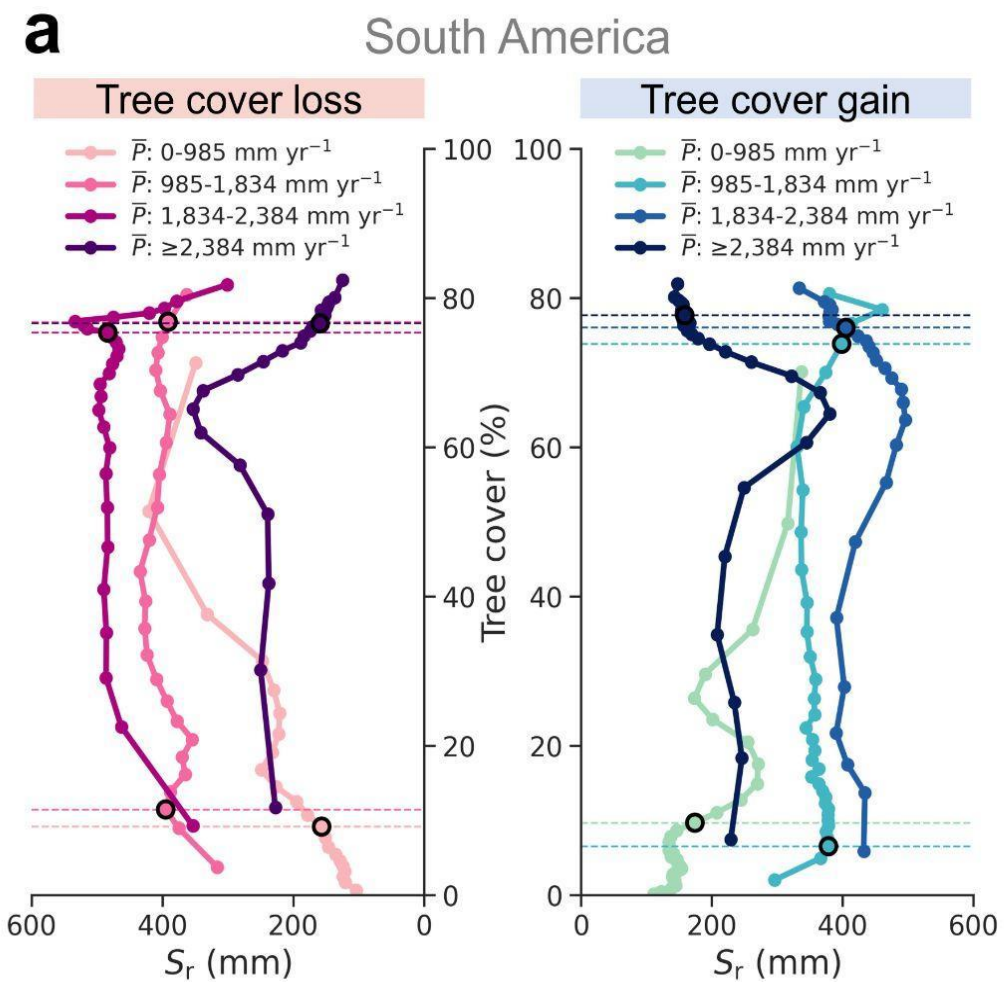


Fig. Stability landscape

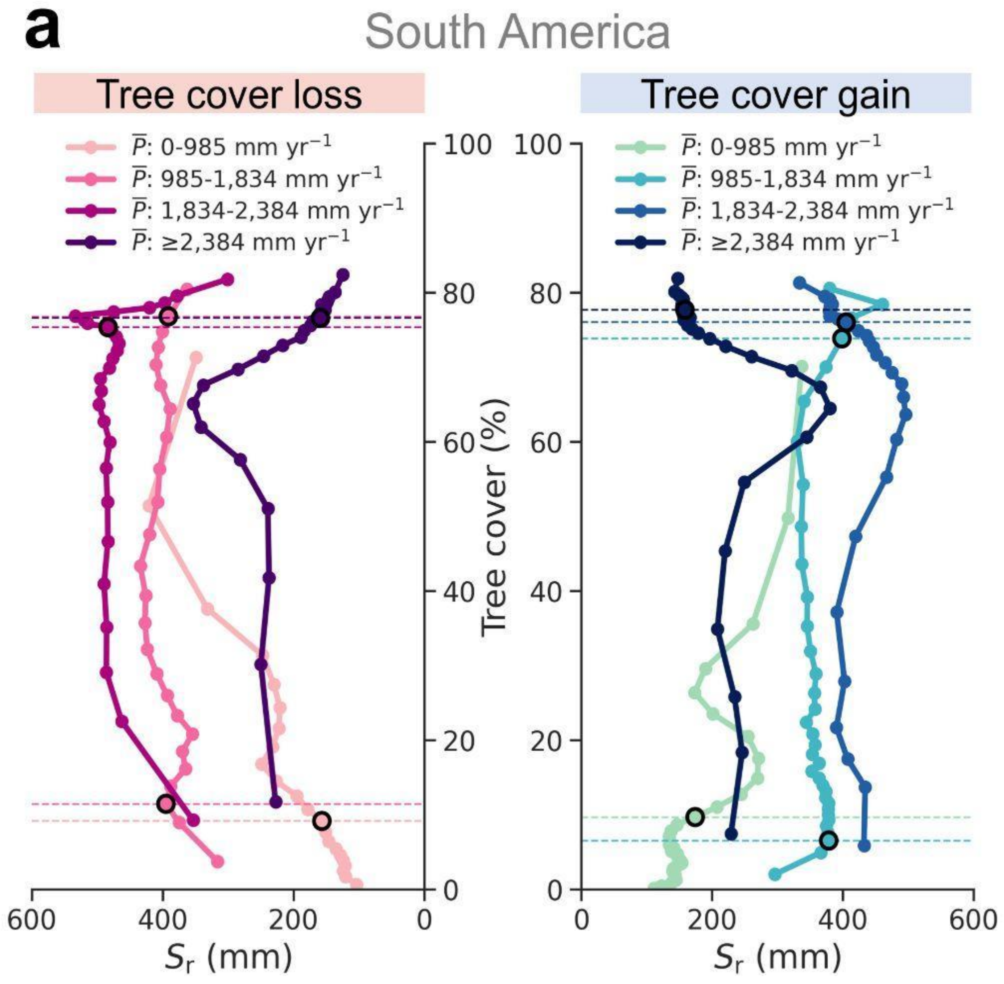


(a)
Mean precipitation
$\overline{P}$: 0–985 mm year^{-1}
$\overline{P}$: 985–1834 mm year^{-1}
$\overline{P}$: 1834–2384 mm year^{-1}
$\overline{P}$: ≥2,384 mm year^{-1}
Tree cover (%)
Relative surface area = 9.18 %
Relative surface area = 15.83 %
Relative surface area = 10.46 %
Relative surface area = 14.54 %
Relative surface area = 11.49 %
Relative surface area = 13.51 %
Relative surface area = 10.73 %
Relative surface area = 14.26 %
Bins=0
Bins=0
bins=2
Bins=4
Bins=9
Bins=11
Bins=11
Bins=12
Bins=10
Bins=27
Bins=3
Bins=3
Bins=0
Bins=0
Bins=0
Bins=0
Δ TC (pp)
Tree cover change
(b)
0
Stable-high tree cover
ΔTC$_{median}$
Unstable
Stable-low tree cover
ΔTC$_{Q3}$
ΔTC$_{Q1}$

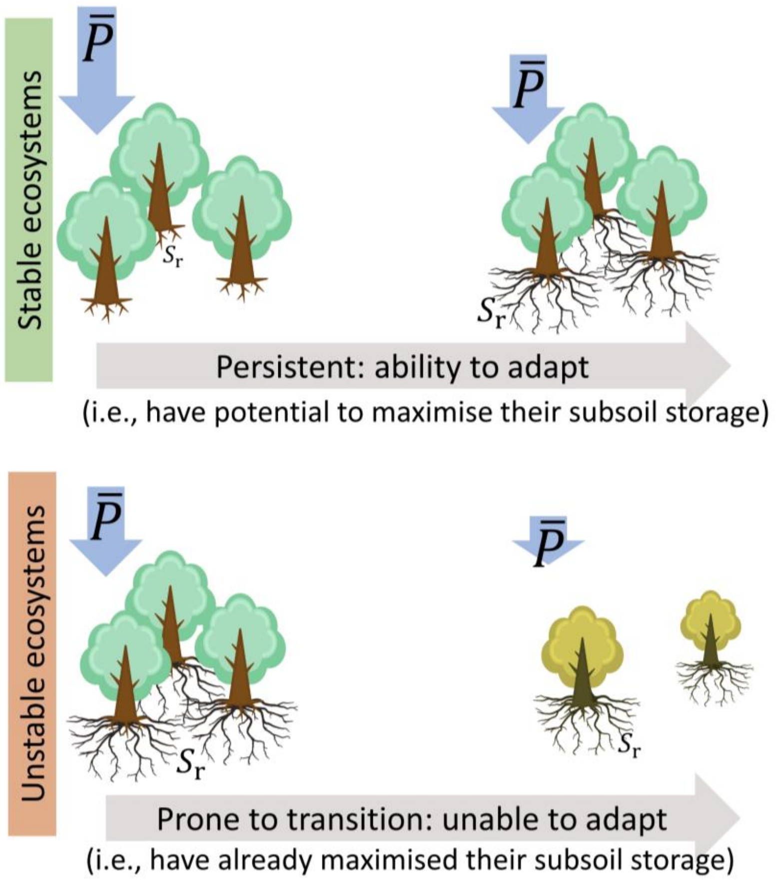


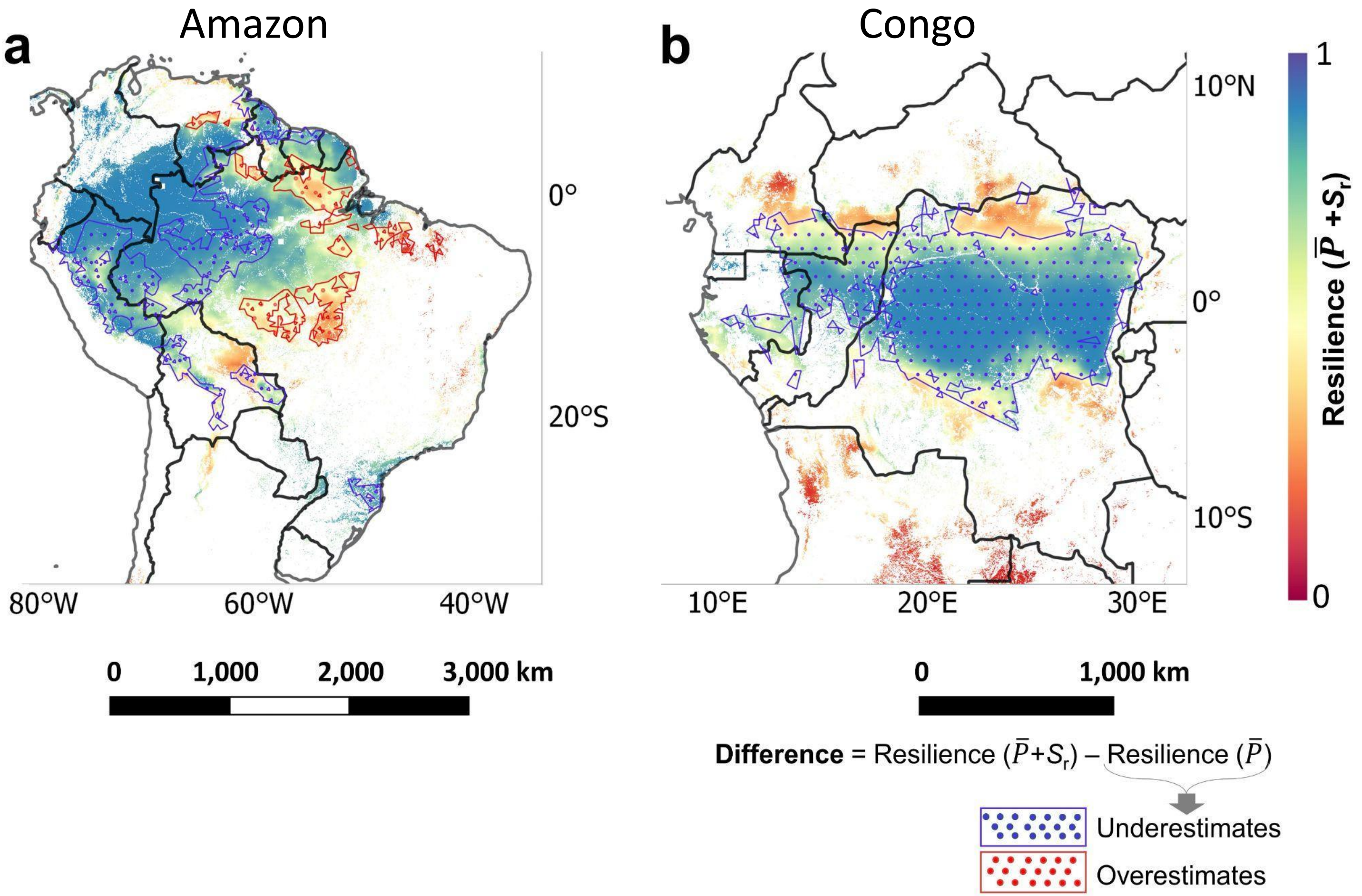
Root zone storage capacity

Fig. Stability equilibria vs Root zone storage capacity

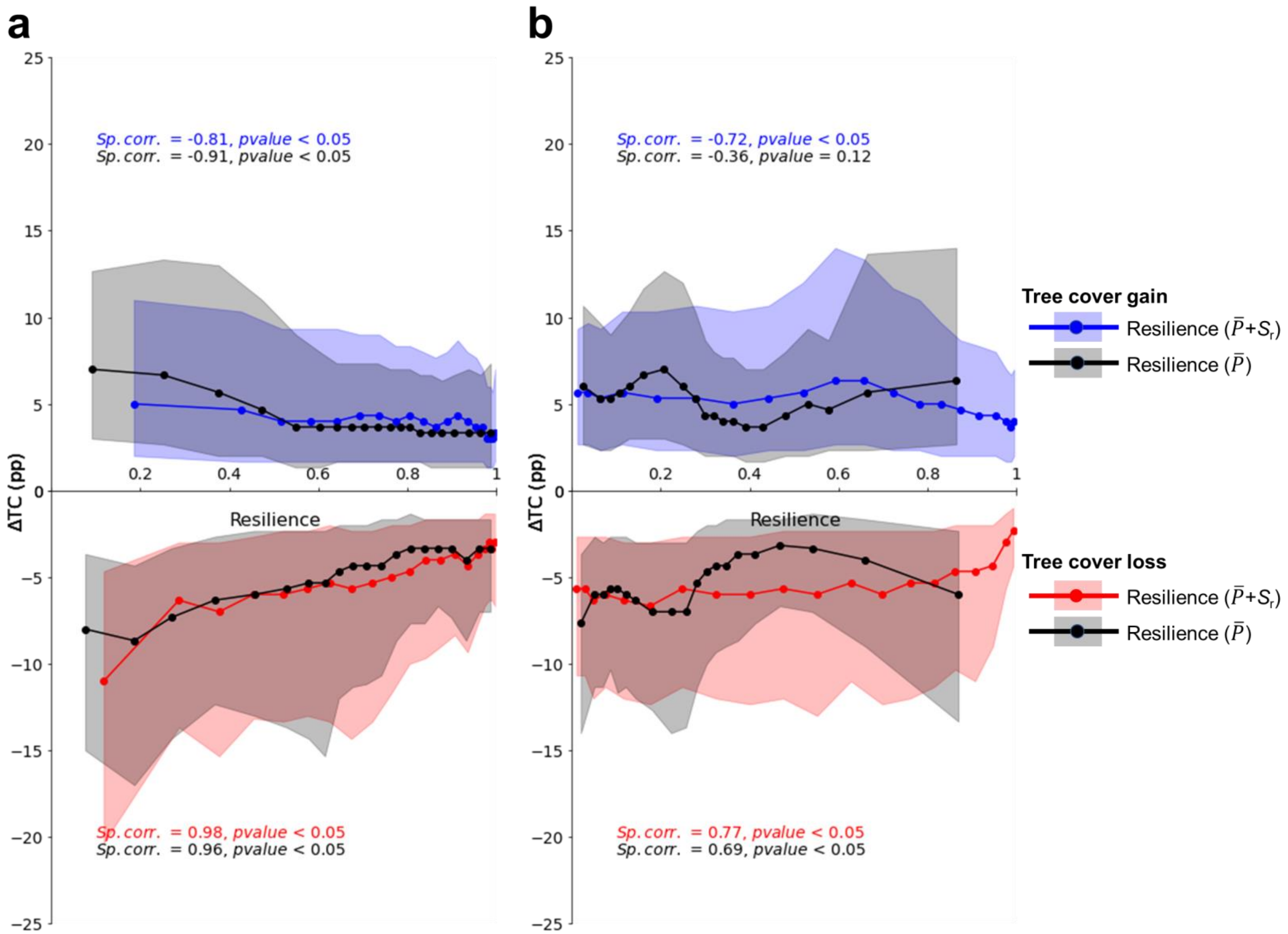


Root zone storage capacity





a
Amazon
0°
20°S
80°W
60°W
40°W
0
1,000
2,000
3,000 km
b
Congo
10°N
0°
10°S
10°E
20°E
30°E
0
1,000 km
1
0
Resilience ($\bar{P}$ +S_r)
Difference = Resilience ($\bar{P}$+S_r) – Resilience ($\bar{P}$)
Underestimates
Overestimates



Including root zone storage capacity:
-Better model performance
-Better correlation with tree cover change

Key messages

Inferring terrestrial ecosystem dynamics from remote sensing trends

- Early warning signal for determining forest-savanna transition risk.
- Highlights adaptation dynamics under changing climate
- Empirical (time-derived) evidence to alternative stable states
- Spatially explicit mapping – strengthening conservation and management efforts
- Broadens its applicability across the globe

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Acknowledgements

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Thank you

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