



Amazonian tipping points past and future

Miles Silman

**Andrew Sabin Chair in Conservation Biology
Director, Center For Energy, Environment and Sustainability
Wake Forest University**

Photo: JasonHouston.com

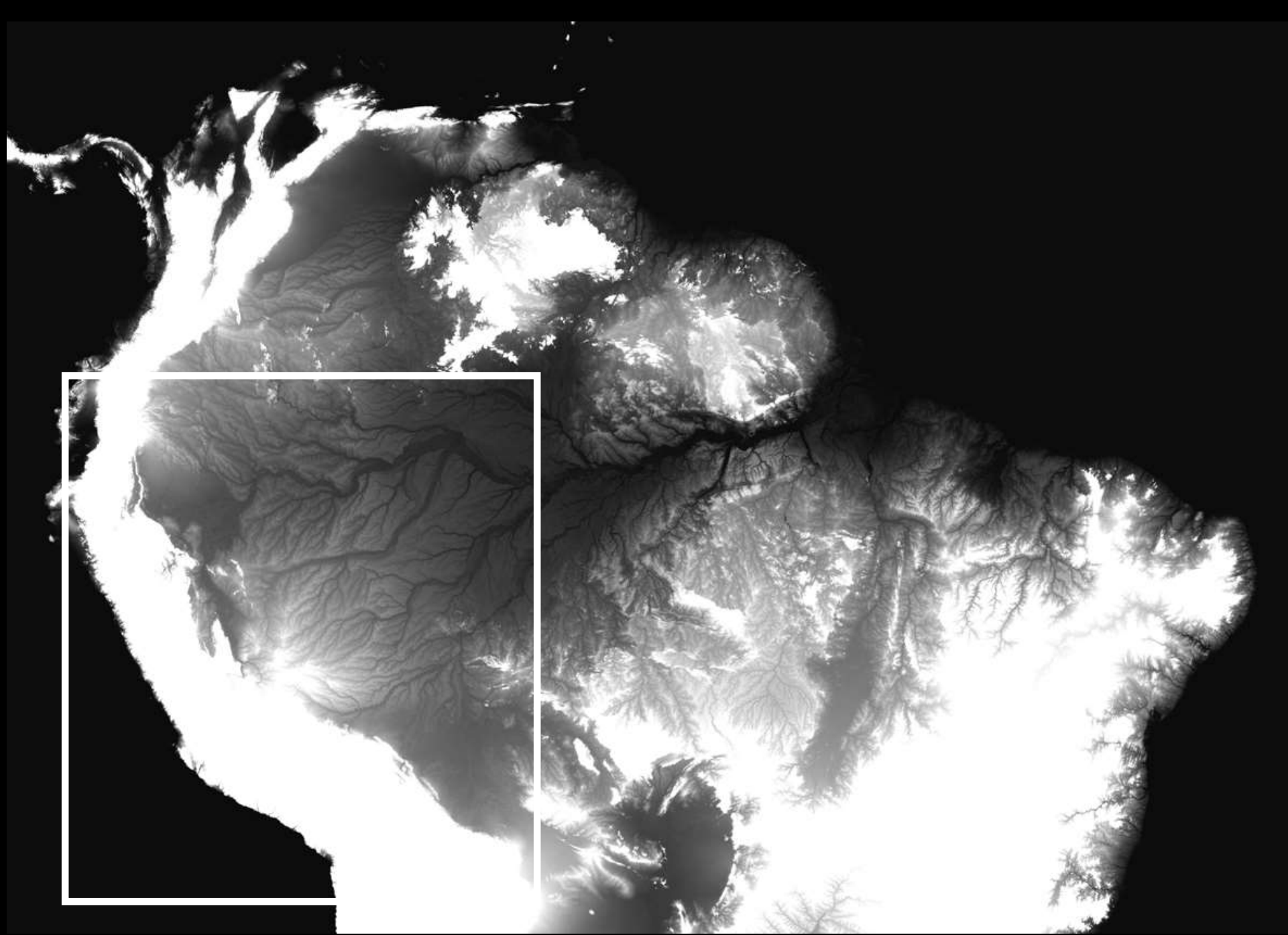
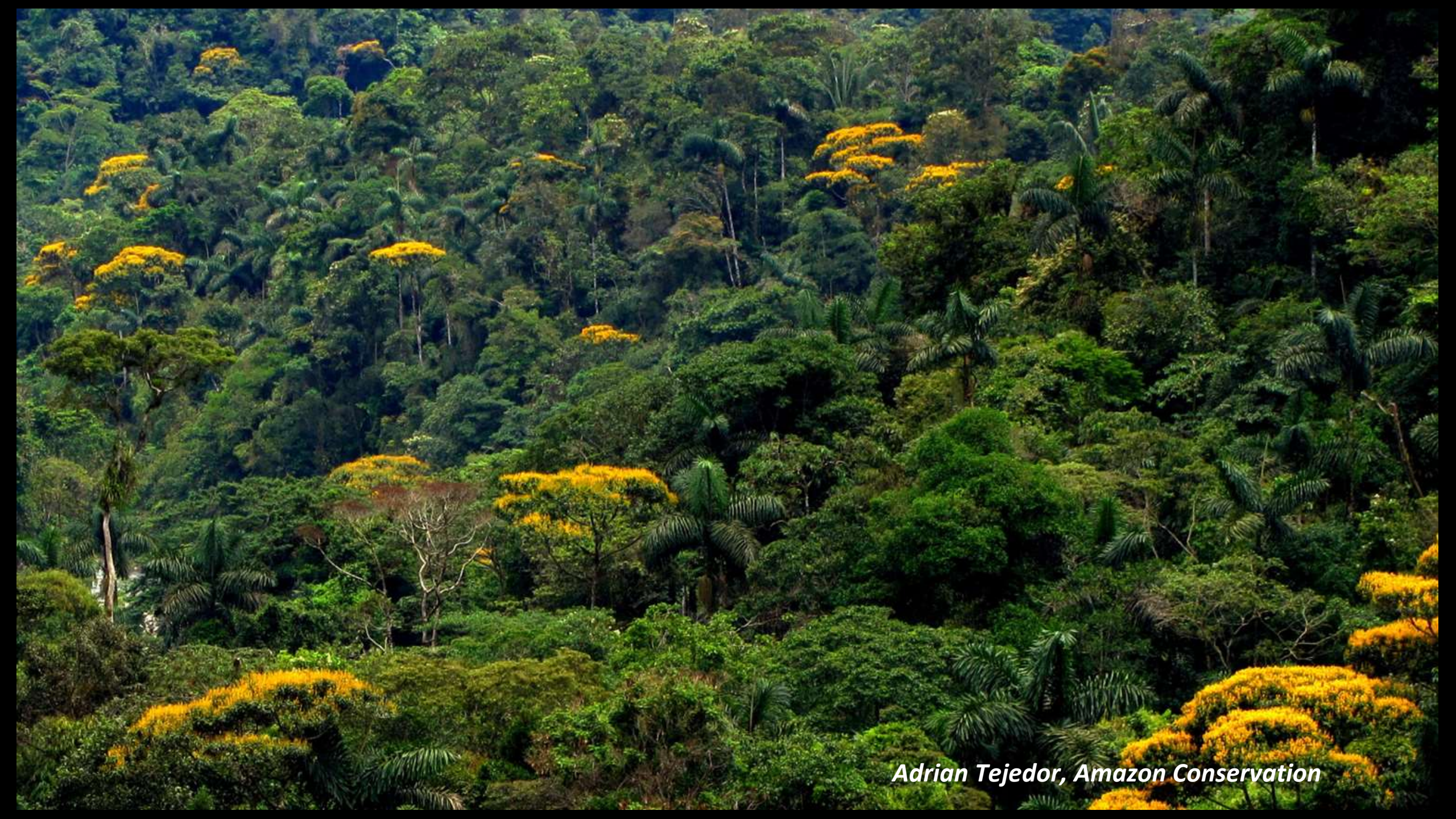




Photo: JasonHouston.com



Adrian Tejedor, Amazon Conservation



Adrian Tejedor, Amazon Conservation



Adrian Tejedor, Amazon Conservation



NASA



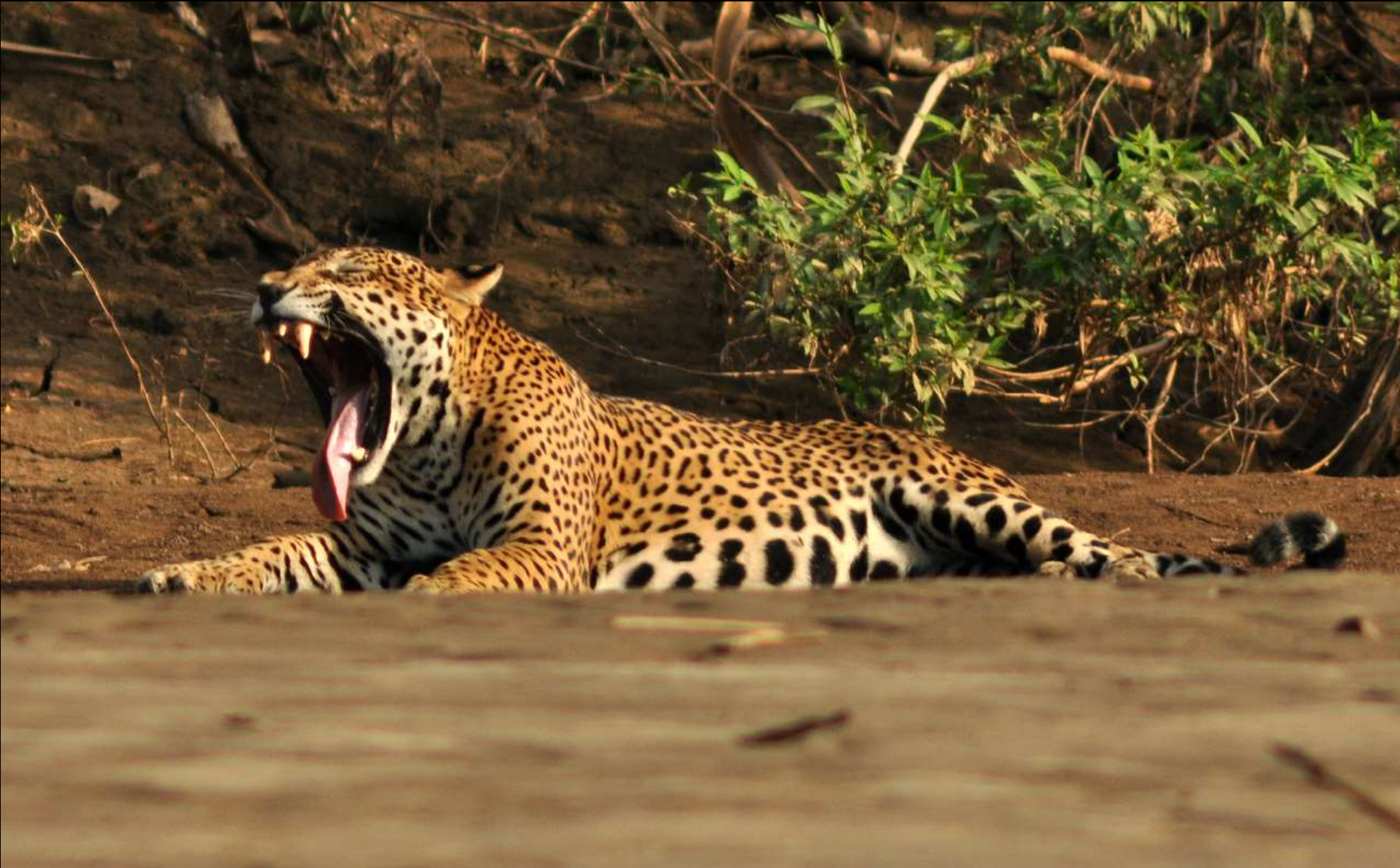














Photo: Jason Houston



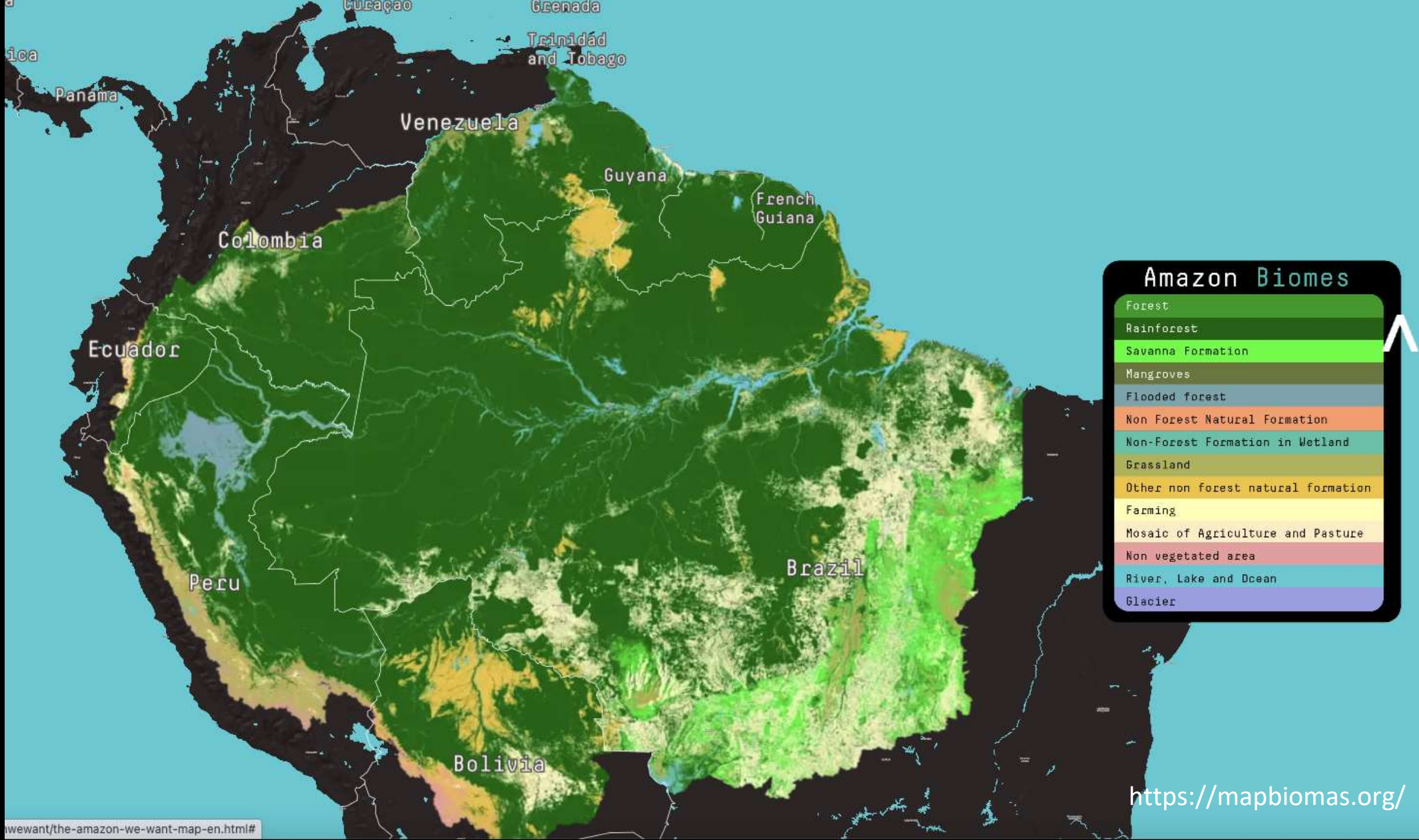




Brando et al. 2014 PNAS

Change in Amazonia

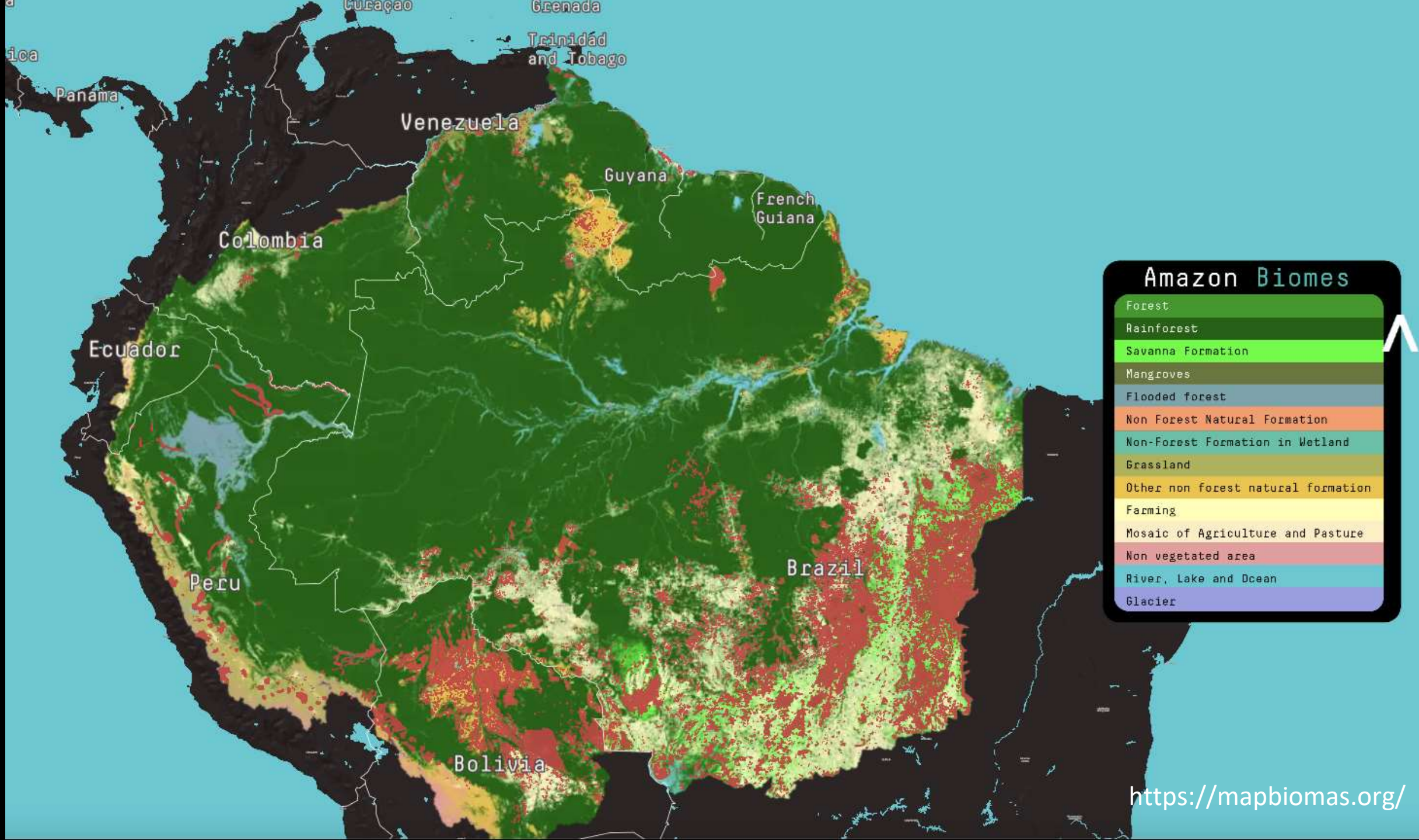
Geography and Tipping points

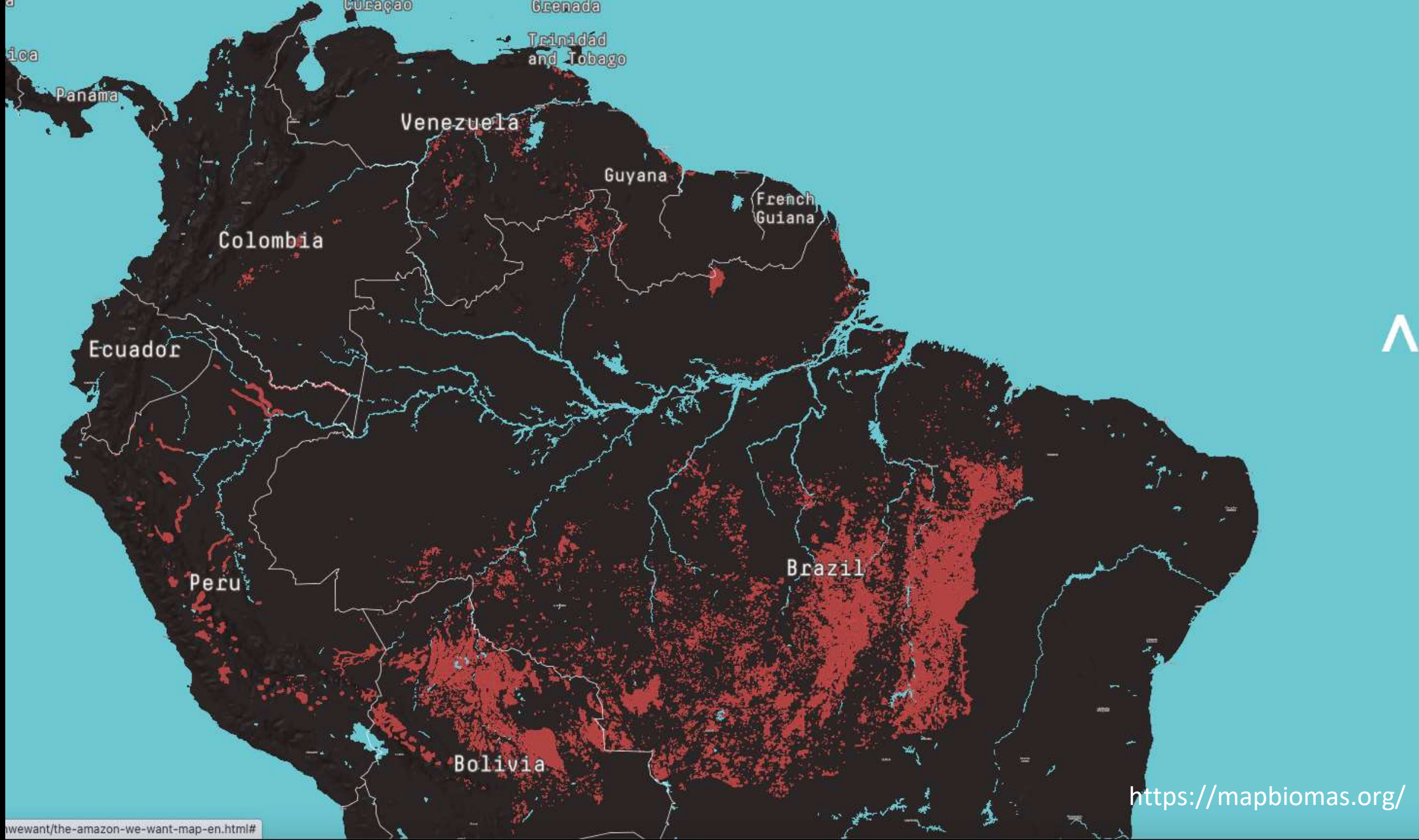


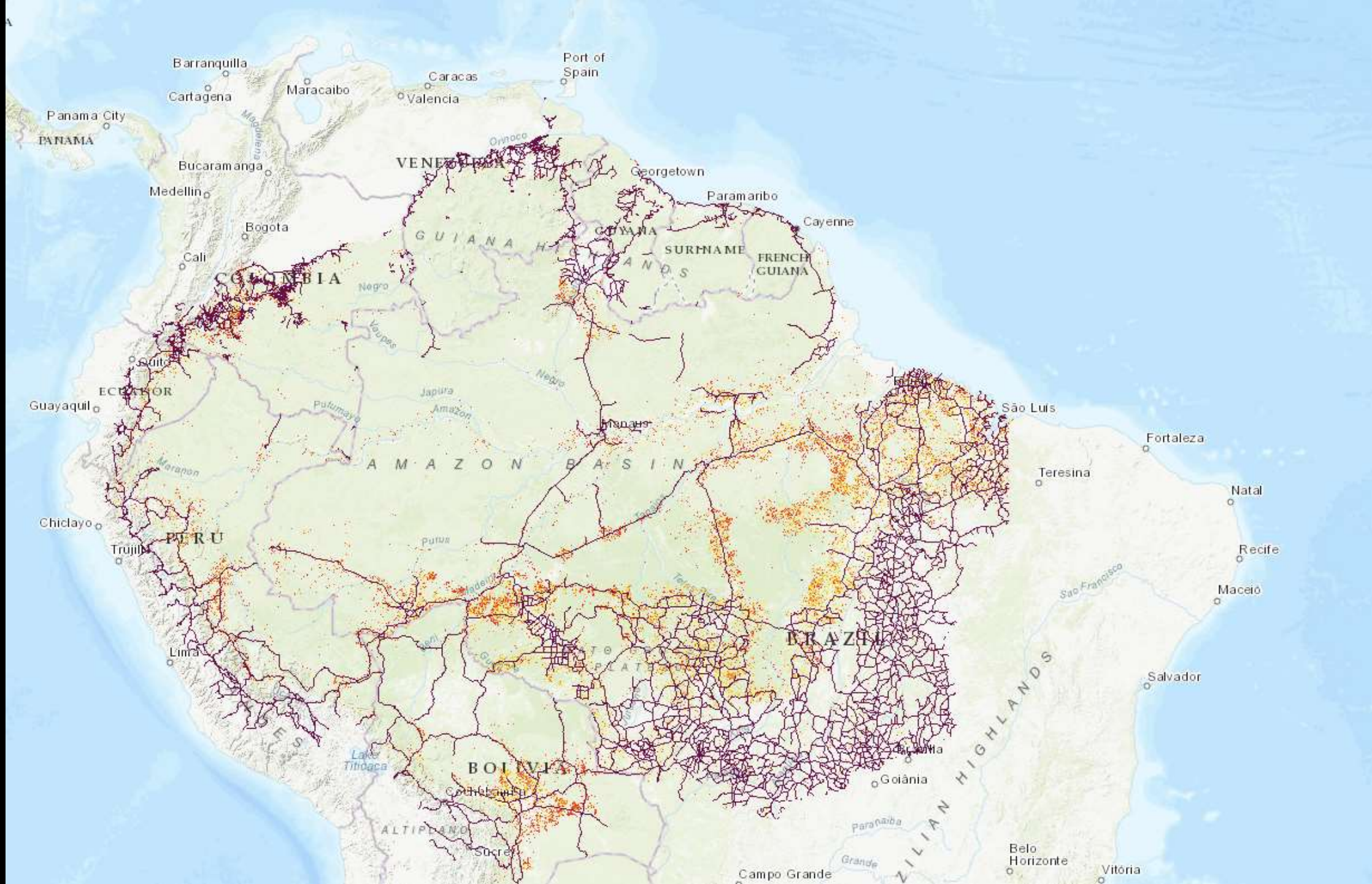
Amazon Biomes

- Forest
- Rainforest
- Savanna Formation
- Mangroves
- Flooded forest
- Non Forest Natural Formation
- Non-Forest Formation in Wetland
- Grassland
- Other non forest natural formation
- Farming
- Mosaic of Agriculture and Pasture
- Non vegetated area
- River, Lake and Ocean
- Glacier

<https://mapbiomas.org/>

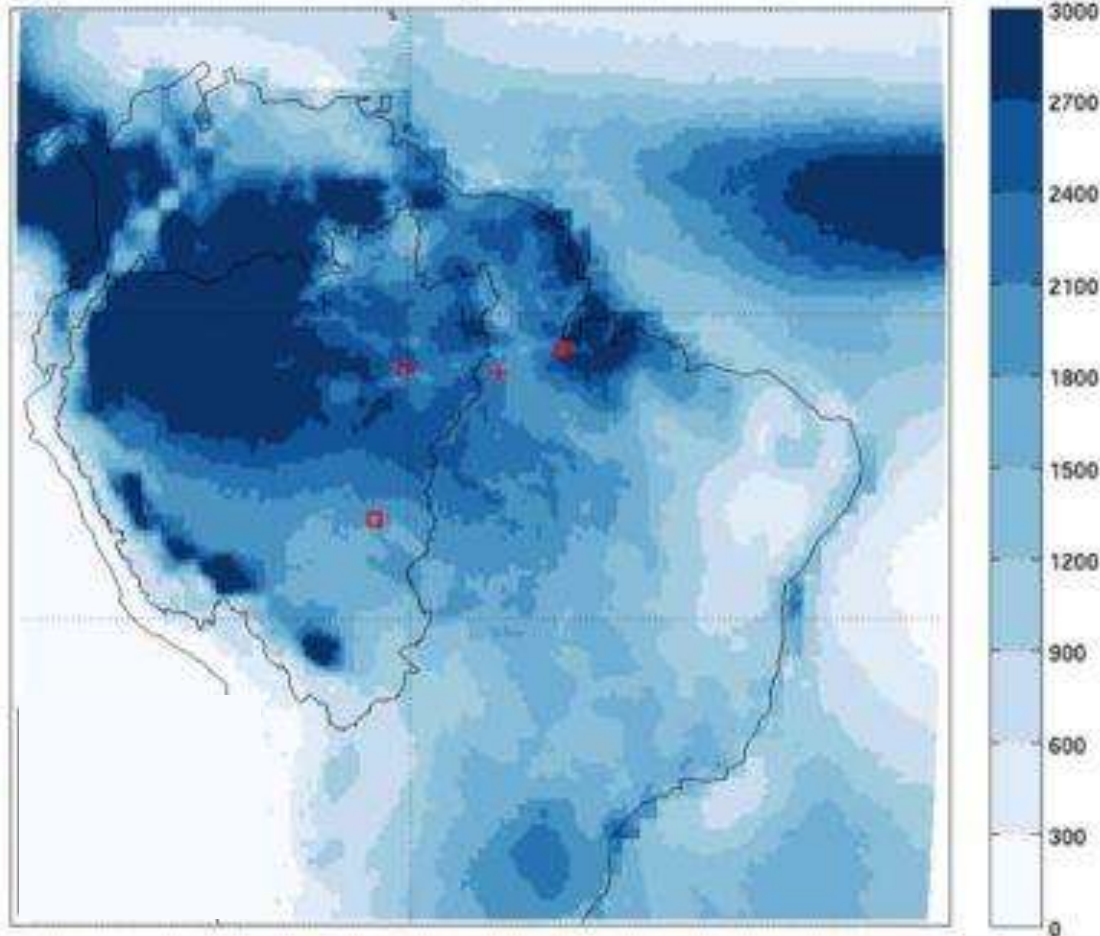




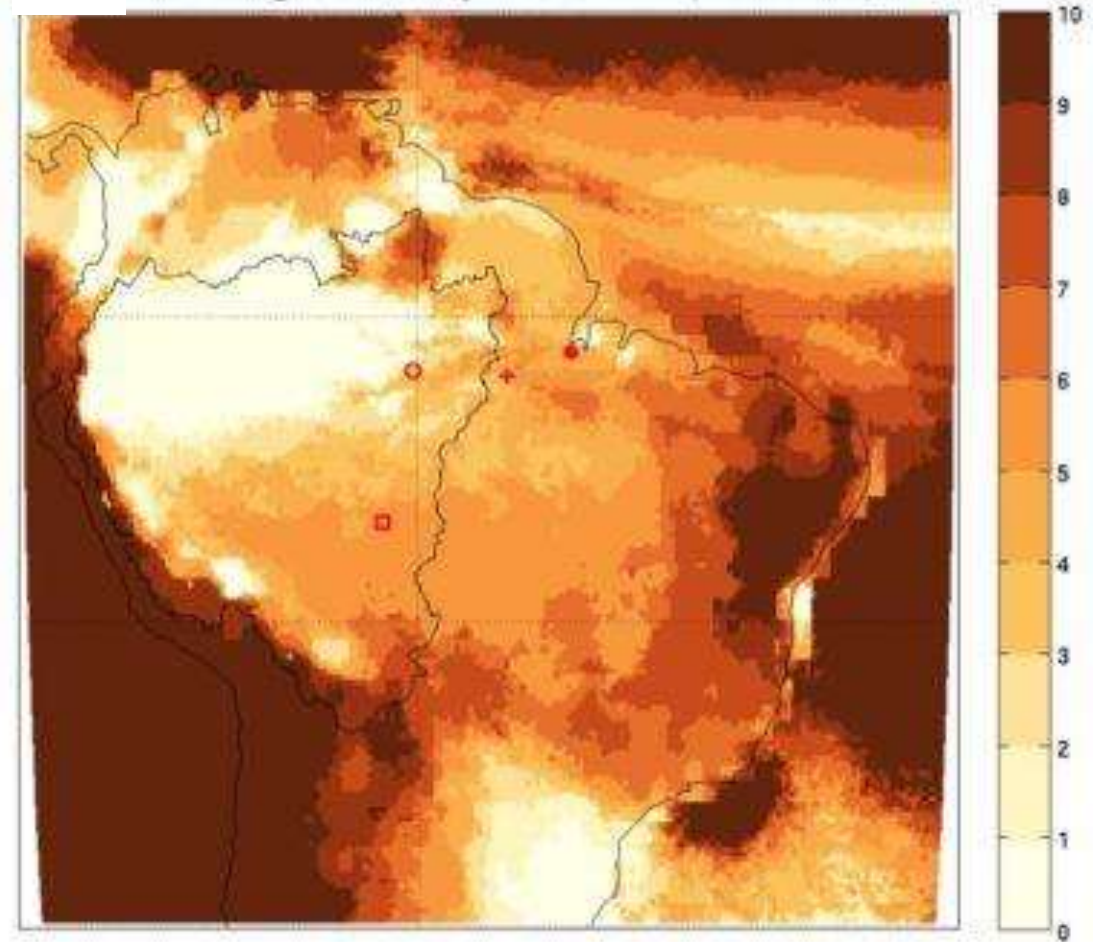


Precipitation and dry season length

Annual Precipitation (mm/yr)

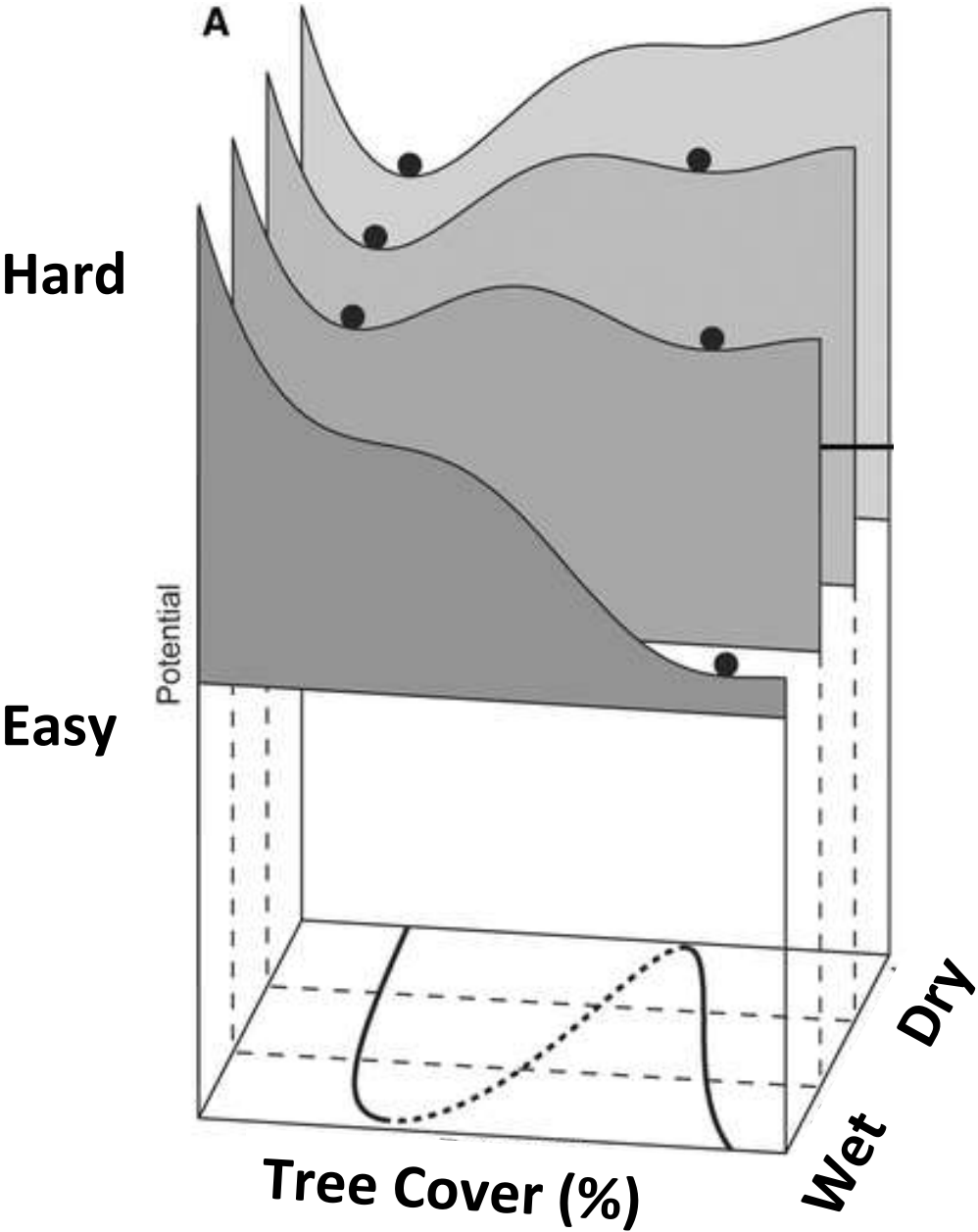


Length of Dry Season (months)



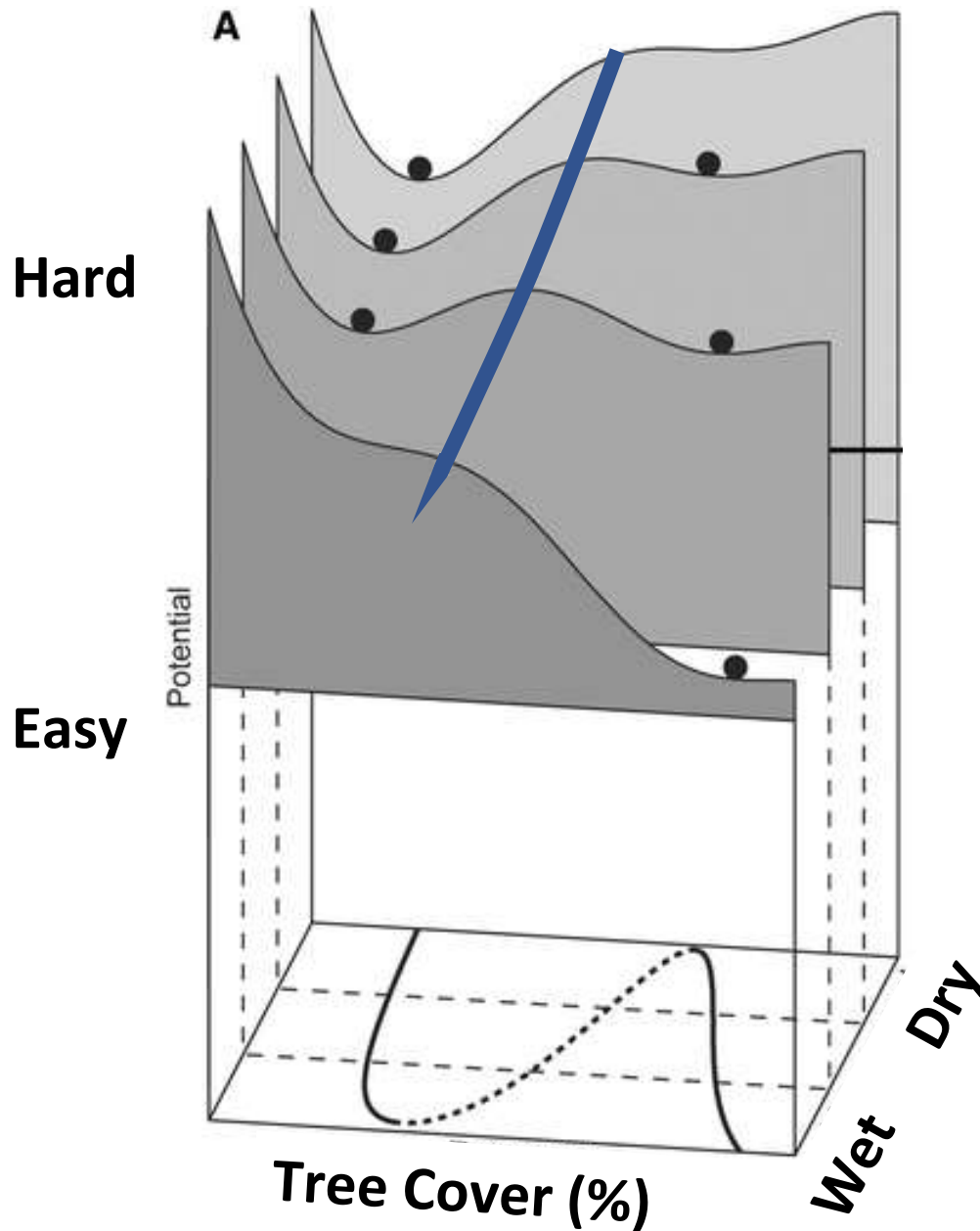
Tipping points and alternate states

How hard
is it to be in
a state?



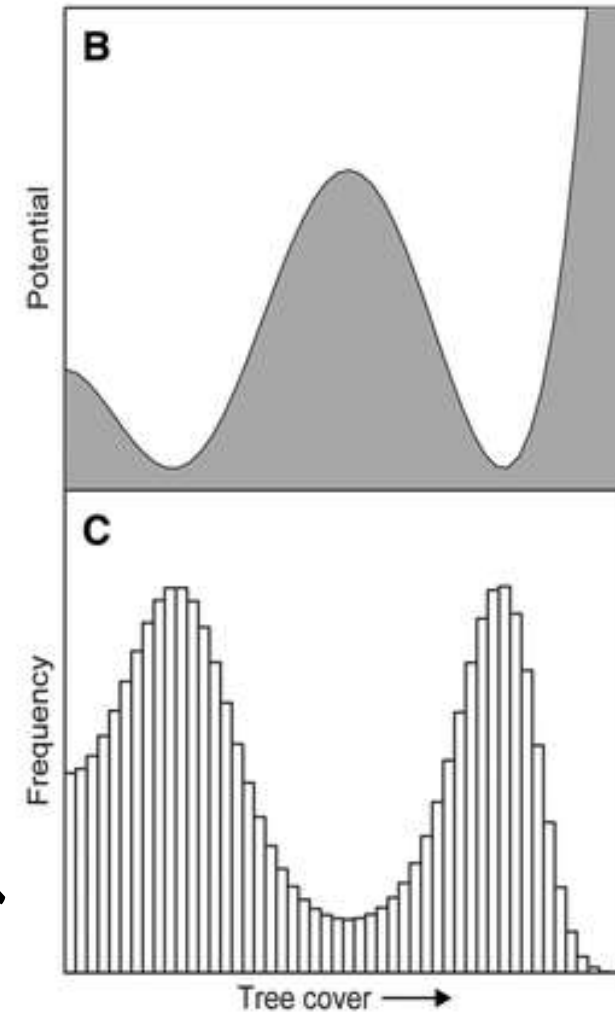
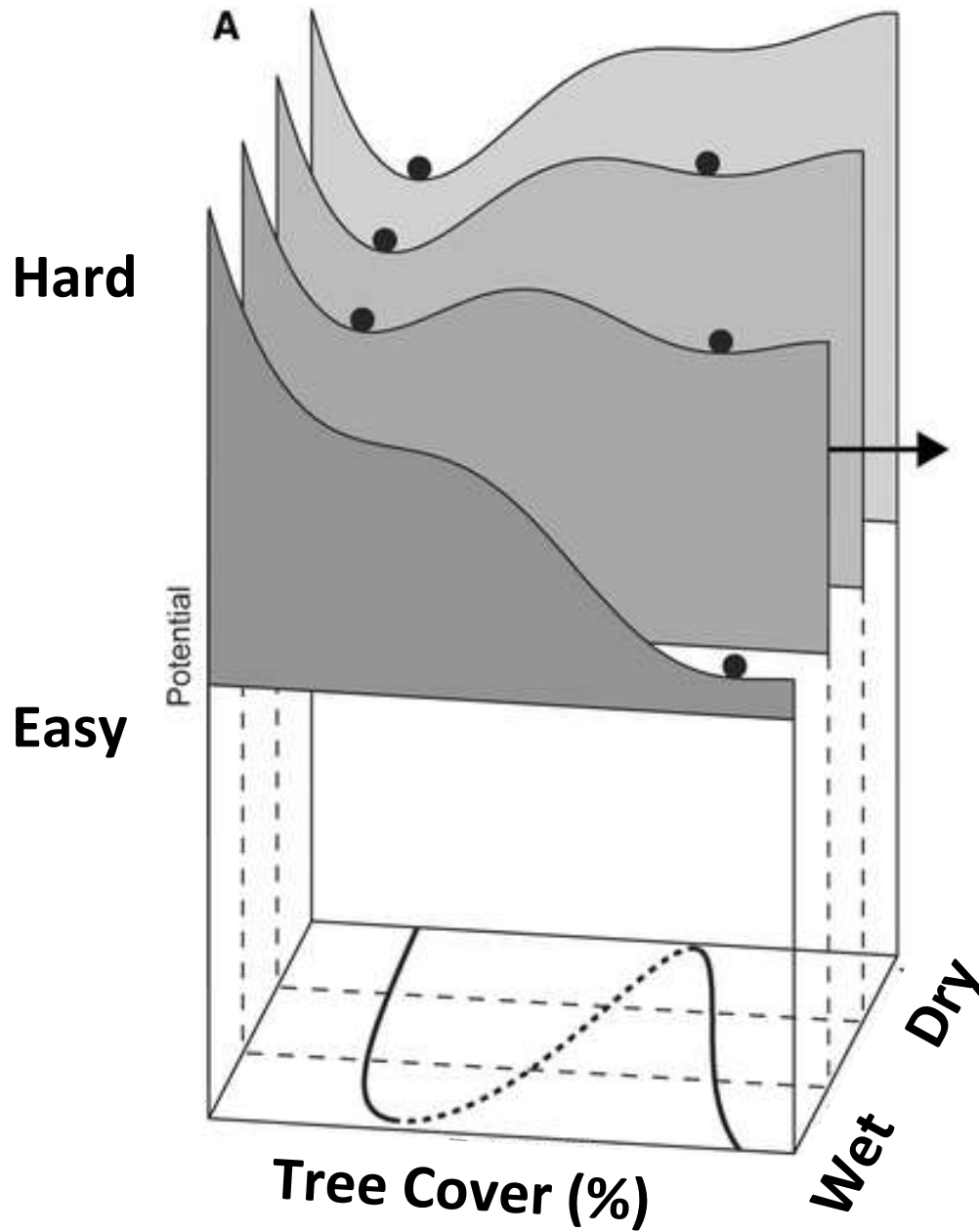
Tipping points and alternate states

How hard
is it to be in
a state?



- **Climate**
(drought, decreased precipitation)
- **Disruption of moisture flows**
(deforestation, land conversion)
- **Land Conversion + Fire**
Agriculture + Fire
Megafauna + Fire

How hard
is it to be in
a state?

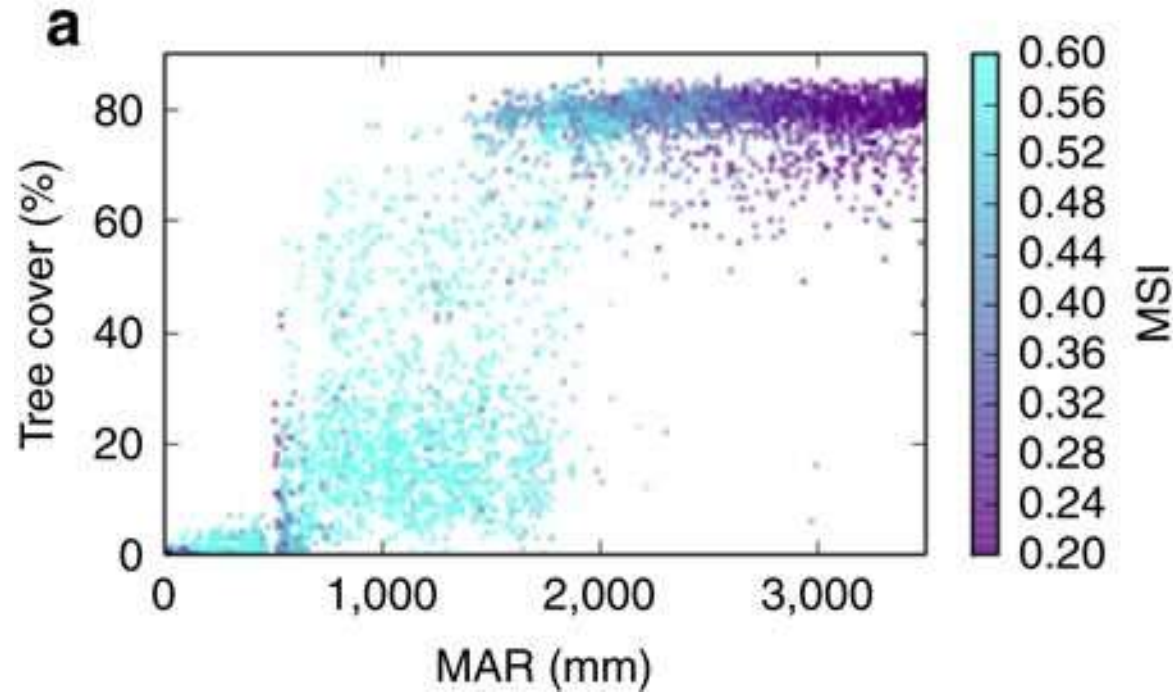


How hard
is it to be in
a state?

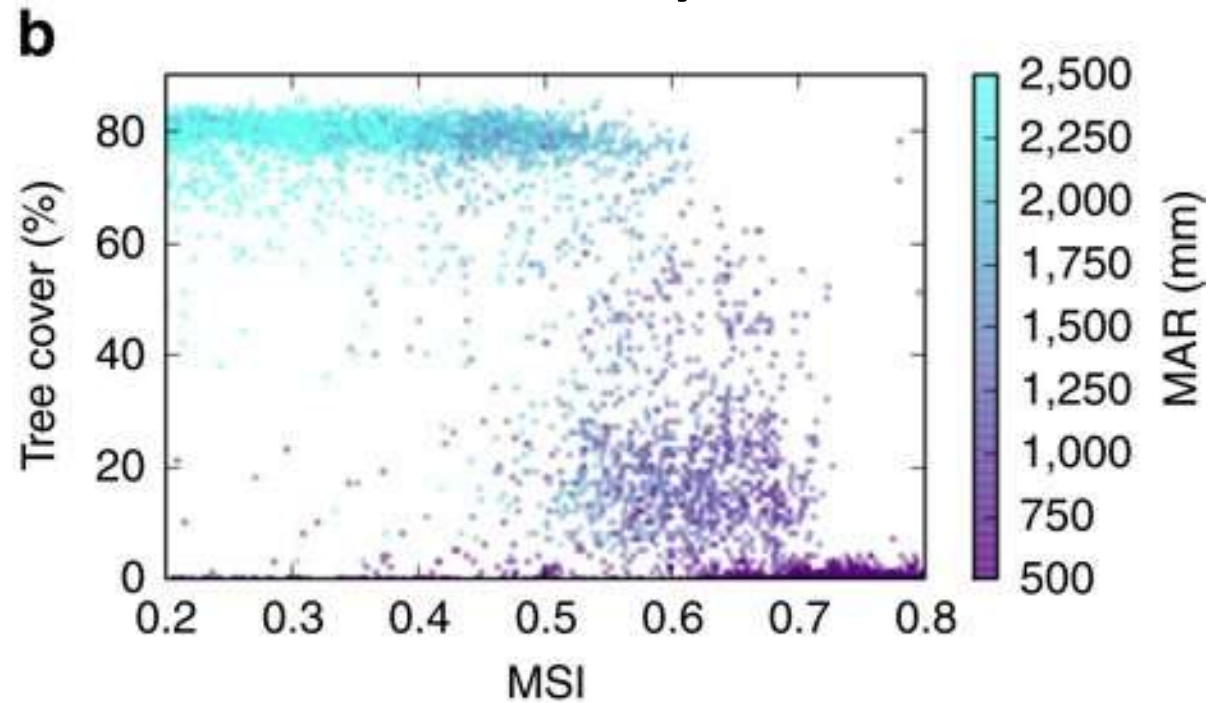
What you
expect to
see

Alternate stable states for forest cover: Bistability

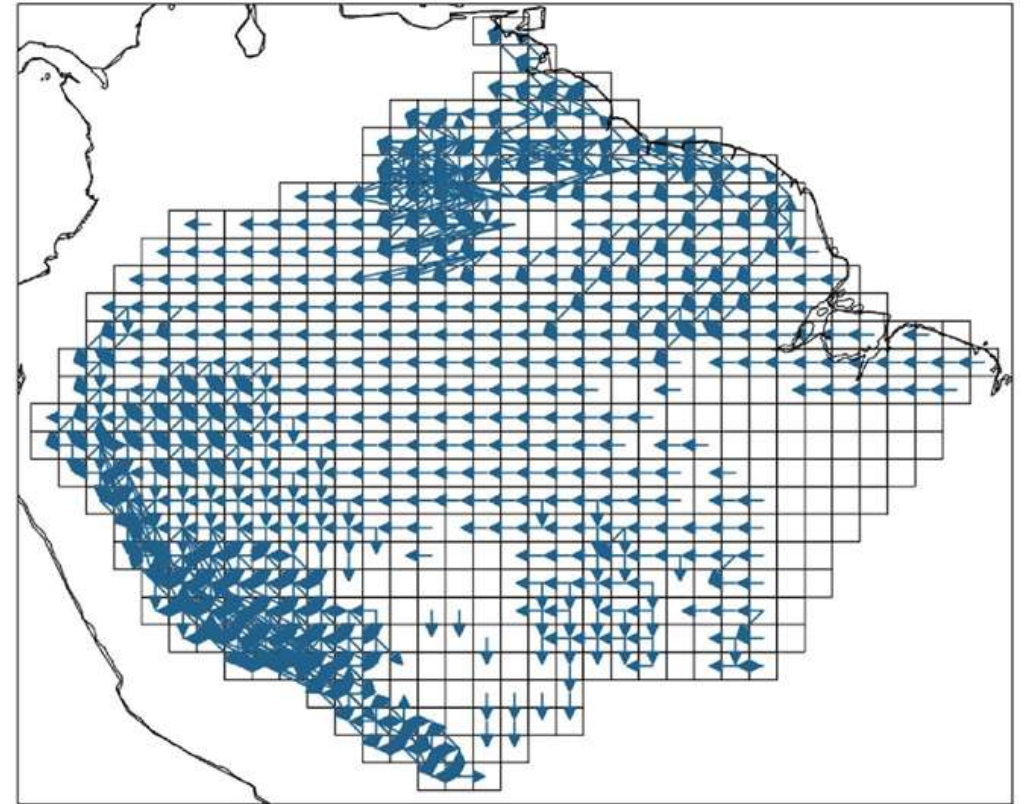
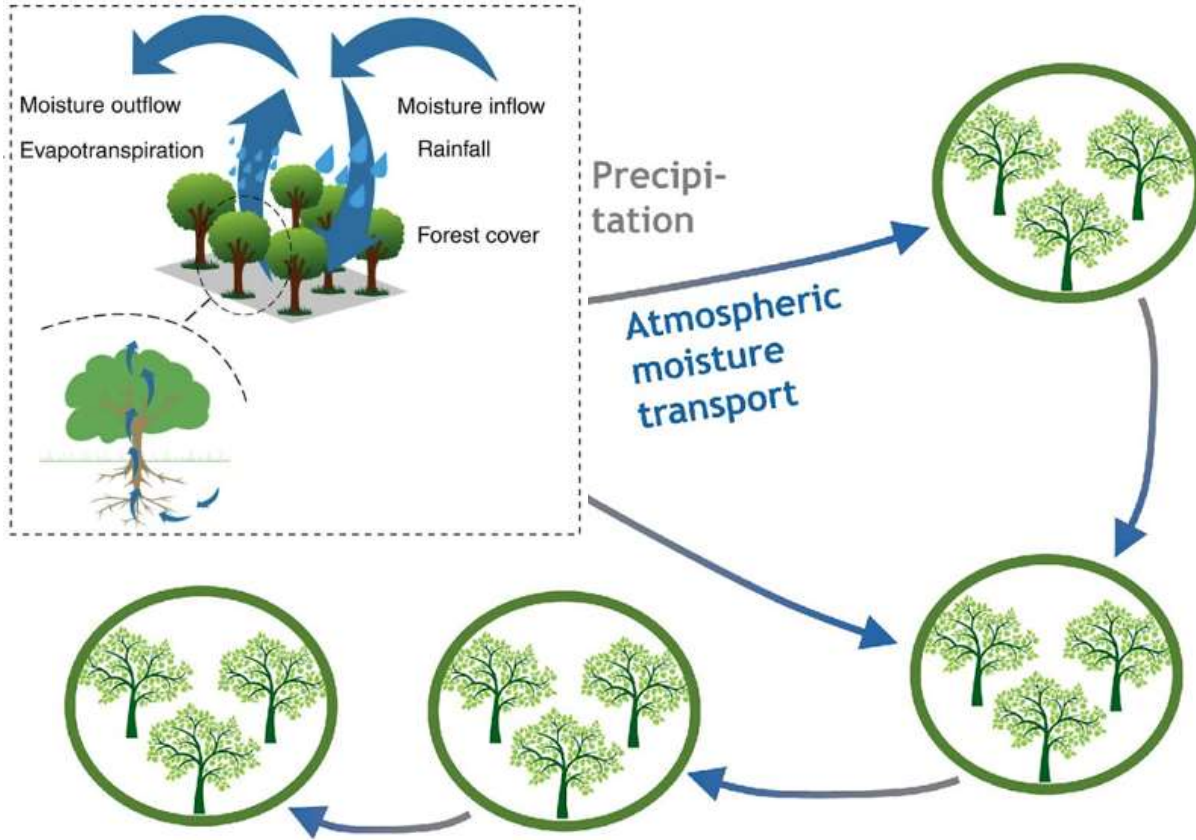
Precipitation



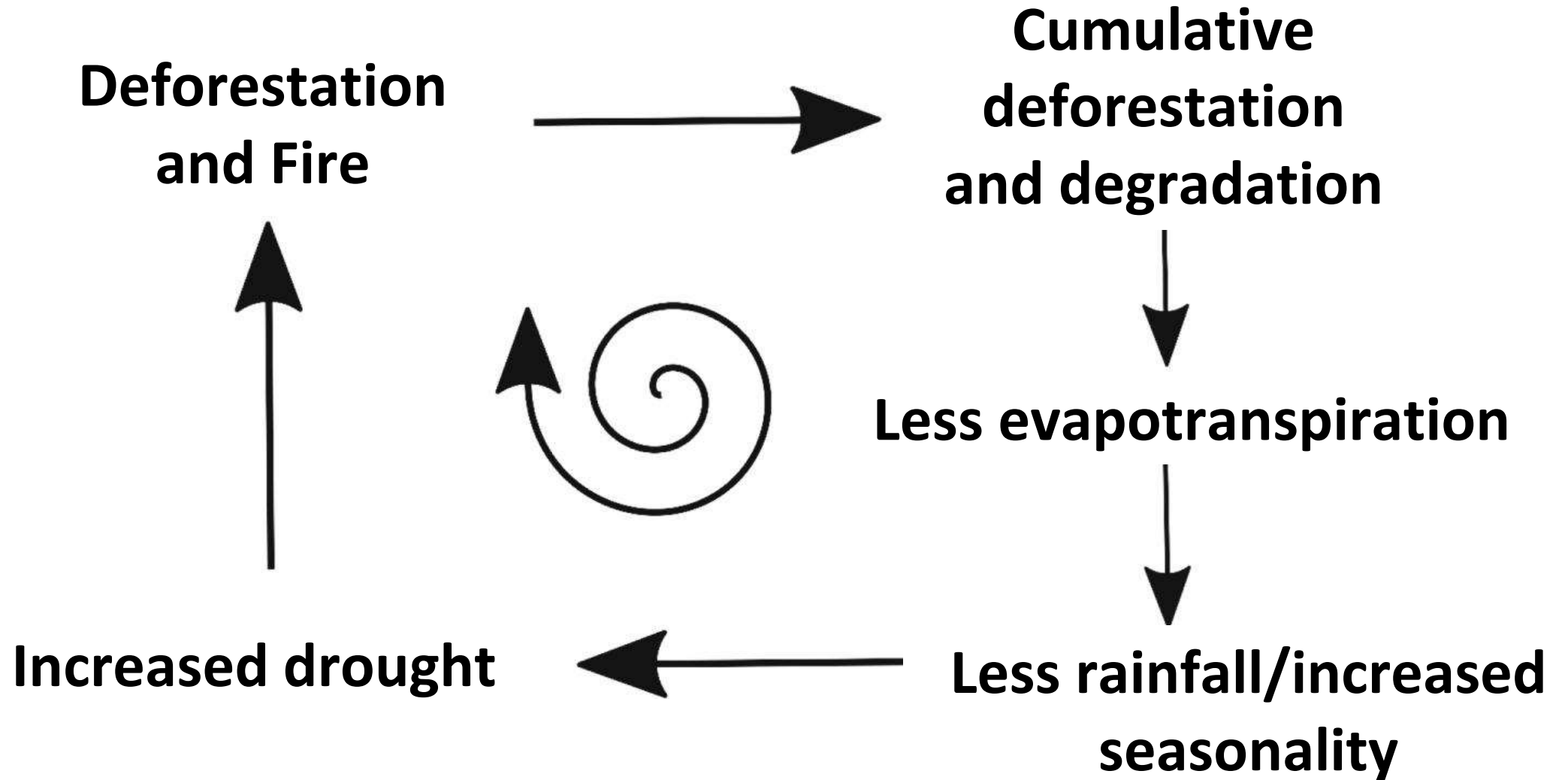
Seasonality



Moisture recycling and tipping vulnerability

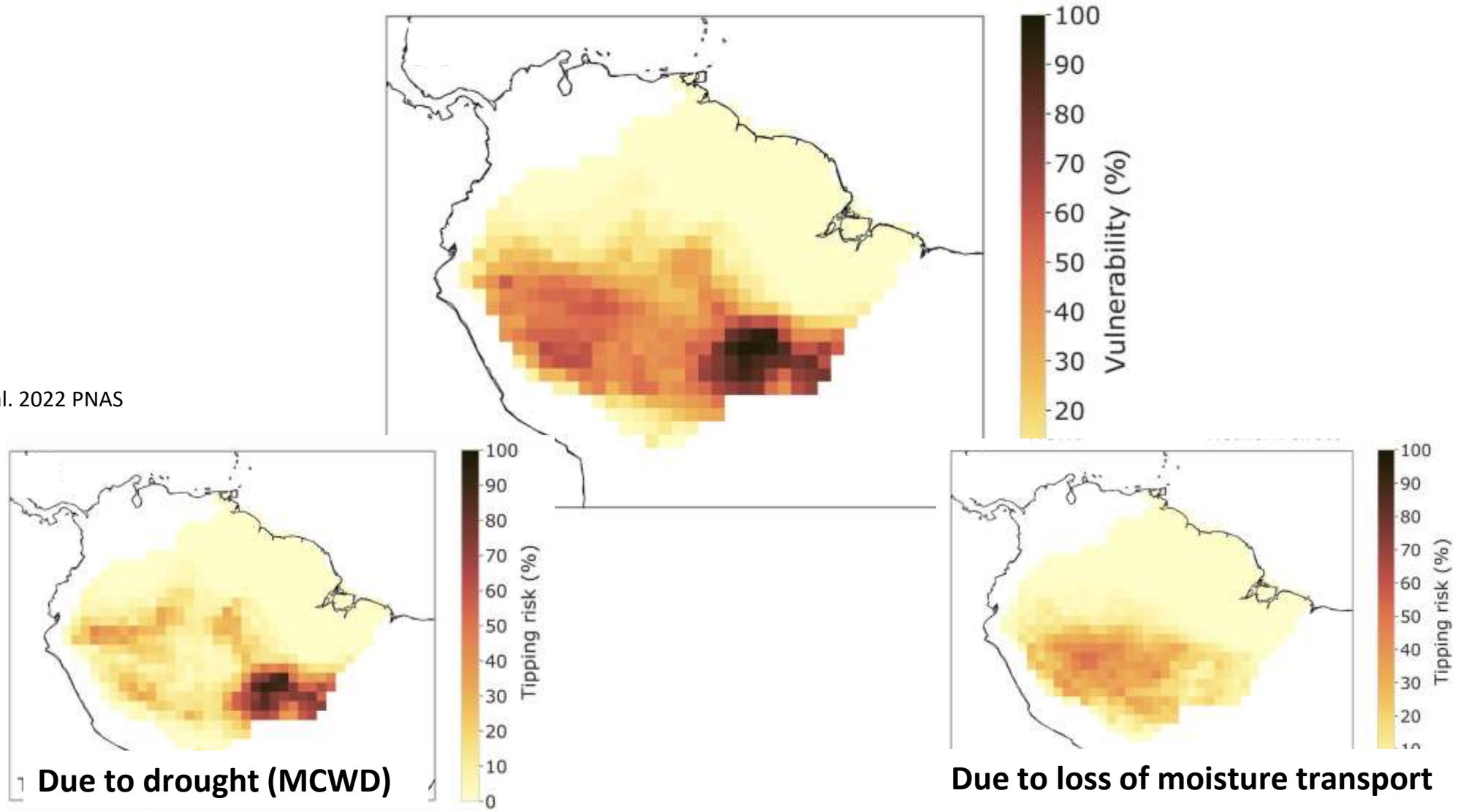


Feedbacks in the Amazon

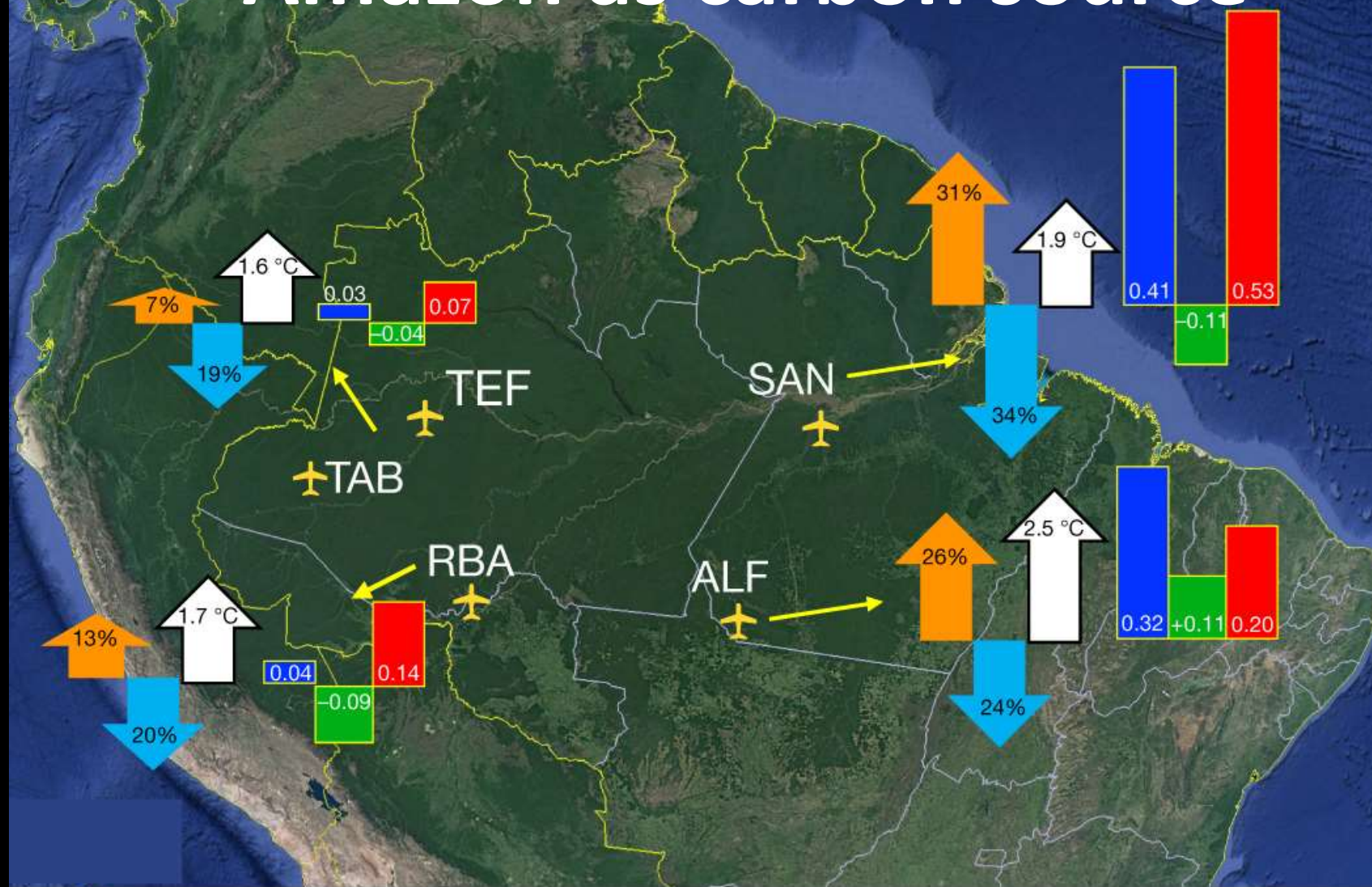


Modeled tipping vulnerability

Wunderling et al. 2022 PNAS



Amazon as carbon source



- ↑ Deforestation
- ↓ Precipitation ASO
- ↑ Temperature ASO

Total C flux ($\text{g C m}^{-2} \text{d}^{-1}$)
NBE C flux ($\text{g C m}^{-2} \text{d}^{-1}$)
Fire C flux ($\text{g C m}^{-2} \text{d}^{-1}$)

Summary and Conclusions

- **The Amazon is vast and has deep global importance**
 - basic functions are under threat in ways that have interacting and cascading effects
- **Deforestation/degradation/fire synergy largest threat now and in near future, robs forest of resilience**
 - Climate change predicted by 2100 can lead to climate driven contractions, similar to Pleistocene
- **Tipping points will be crossed in SE and S Amazon, not North/Central**
- **Deforestation and economy can also drive regime changes**
 - NA was deforested with hand tools in ~150 years
- **The ability to monitor and predict changes to forest cover and climate are central to managing Amazon and constraining future scenarios**

