



**WCRP 40<sup>th</sup> Anniversary Symposium**

**THE AMAZON IS NEAR A TIPPING POINT**

**Forest in the West and Northwest**

**Savannas in the South and East**

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**08 December 2019**



"All the News  
That's Fit to Print"

# The New York Times

## Late Edition

Today, mostly cloudy, passing afternoon showers, high 45. Tonight, partly cloudy, low 30. Tomorrow, plenty of sunshine, a colder day, high 37. Weather map, Page A26.

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VICTOR MORIYAMA FOR THE NEW YORK TIMES

## The Rainforest's Scorched Edges

More than 3,700 square miles of the Amazon have been razed under President Jair Bolsonaro, Brazil's space agency said. Page A12.

07/12/2019

The Amazon Is Completely Lawless': The Rainforest After Bolsonaro's First Year - The New York Times

The New York Times



## The Amazon Is Completely Lawless': The Rainforest After Bolsonaro's First Year

Deforestation in the world's largest rainforest, an important buffer against climate change, has soared under President Jair Bolsonaro of Brazil.

Photographs and Video by Victor Moriyama Written by Matt Sandy

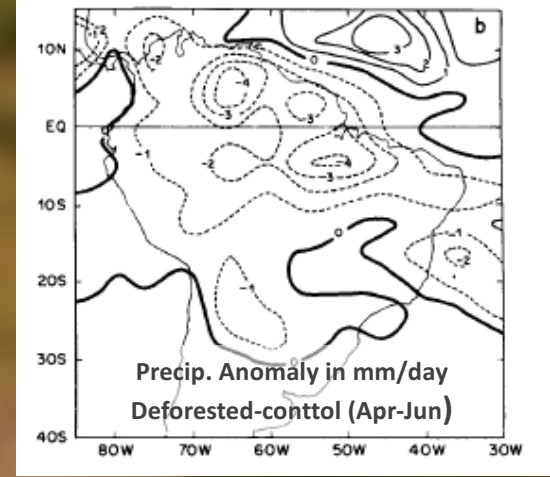
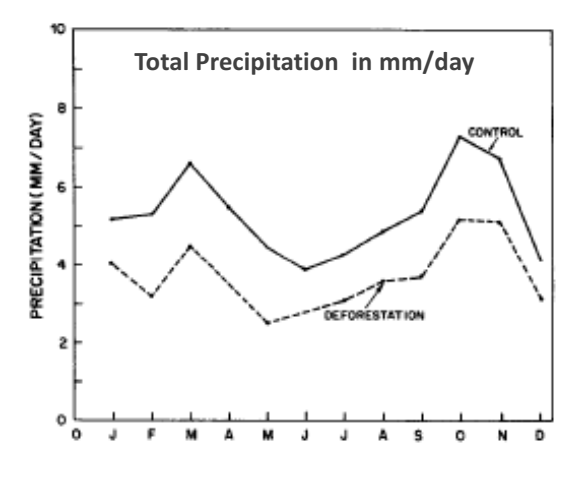
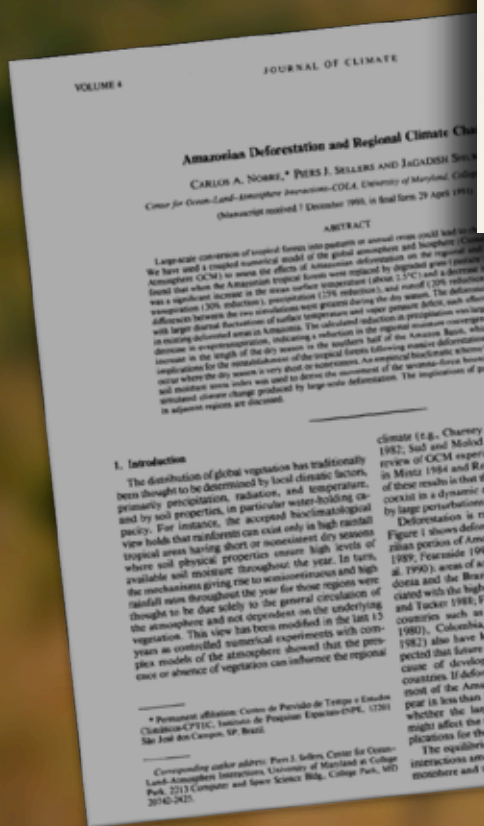
# THE AMAZON "SAVANNANIZATION" HYPOTHESIS WAS POSED IN 1990-1991

## Amazonian Deforestation and Regional Climate Change

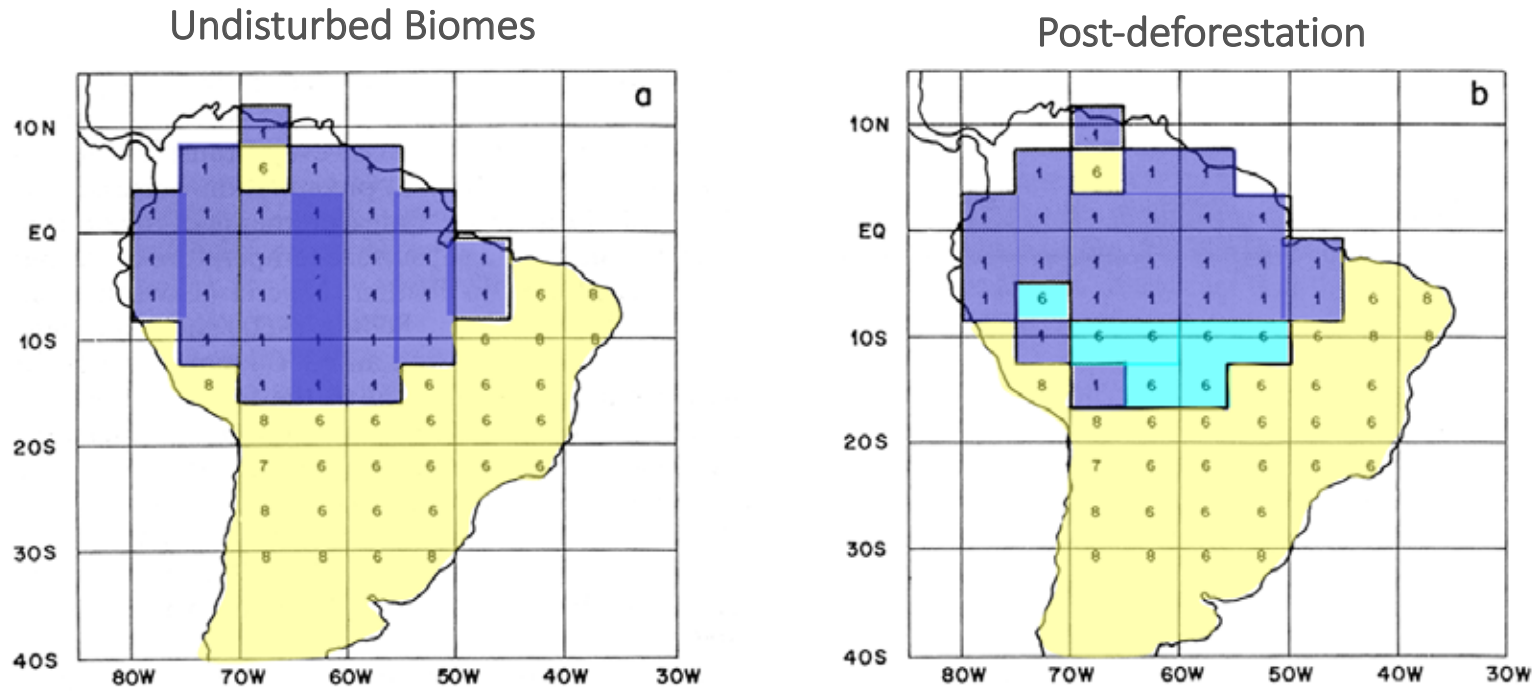
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(Manuscript received 7 December 1990, in final form 29 April 1991)



# THE HYPOTHESIS OF AMAZONIAN ‘SAVANNIZATION’



Bioclimatology for the control case (a, current bioclimatology) associated with deforestation (b, revised bioclimatology after deforestation such as the analysis of the vegetation stress index fields shows). The shaded area with “1” is tropical forest, “6” refers to cerrado. The forest boundary is depicted by the heavy solid line.

- 1 Tropical Forest
- 6 Savanna



# 'TIPPING POINTS' OF FOREST-CLIMATE EQUILIBRIUM IN THE AMAZON

## HOW CLOSE TO AN AMAZON TIPPING POINT?

Tropical forest in equilibrium with historical climate

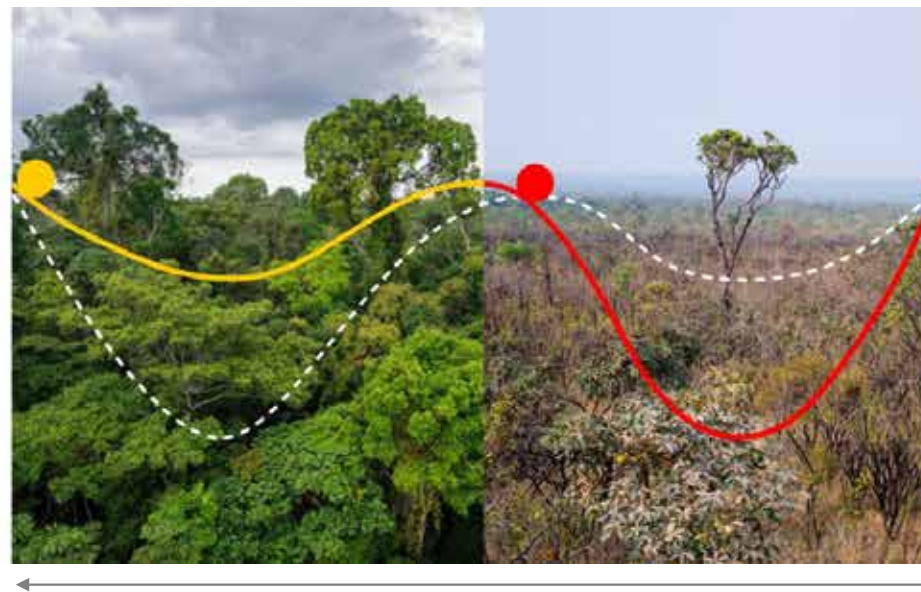
Amazon covered mostly by forests

Savanna state triggered by climate change and/or deforestation and forest fires

Forests in the West and Northwest Savannas in the South and East



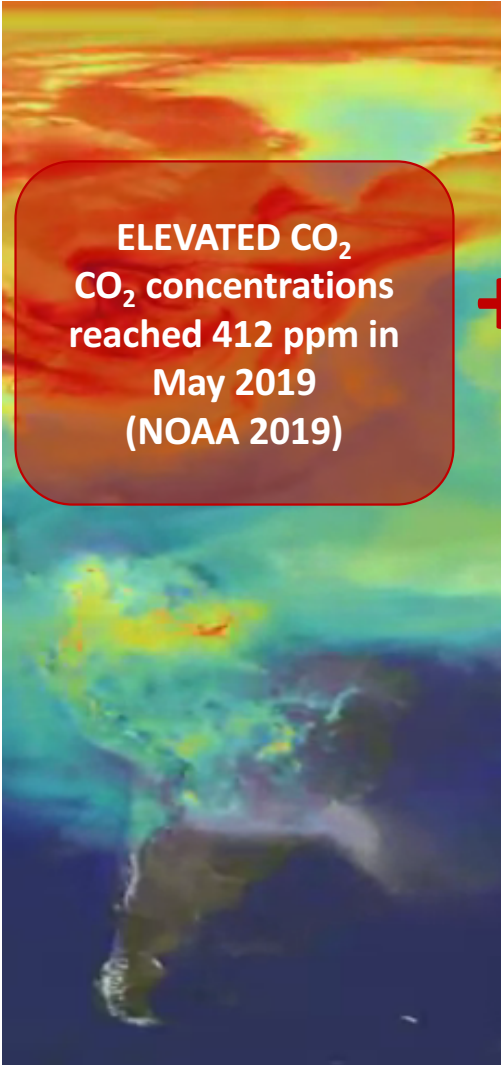
Biome distribution



Biome distribution




# WHAT ARE THE SYNERGISTIC EFFECTS OF ANTHROPOGENIC DRIVERS OF ENVIRONMENTAL CHANGE IN THE AMAZON?



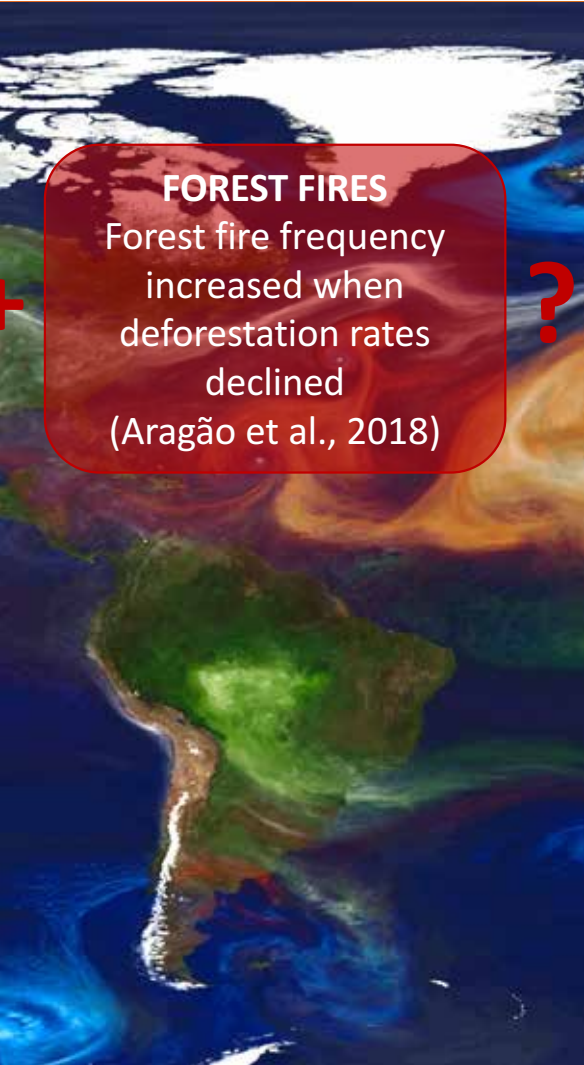
**ELEVATED CO<sub>2</sub>**  
CO<sub>2</sub> concentrations  
reached 412 ppm in  
May 2019  
(NOAA 2019)



**GLOBAL WARMING**  
Warming of 1.2°C in  
Amazonia, 2018  
3°C to 4°C by 2100  
(IPCC AR5 2014)



**DEFORESTATION**  
Total deforested area  
(clear-cutting) is over  
1,00,000 km<sup>2</sup> in the  
Amazon (15%-17%)  
(MapBiomass, 2019)



**FOREST FIRES**  
Forest fire frequency  
increased when  
deforestation rates  
declined  
(Aragão et al., 2018)

# PROJECTED DISTRIBUTION OF NATURAL BIOMES IN SOUTH AMERICA

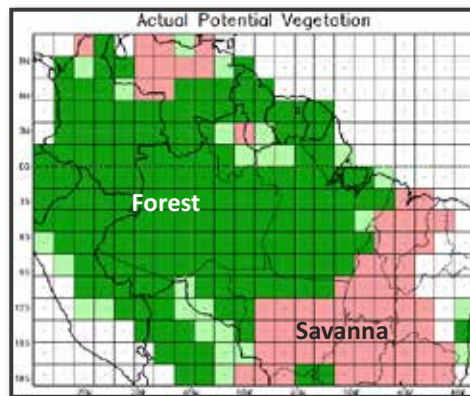
More than 2/3 of the models used ( $\geq 6$  models) coincide for 2050 from 9 Earth System Models for the RCP 8.5 emission scenarios

## COMBINED EFFECTS BY 2050

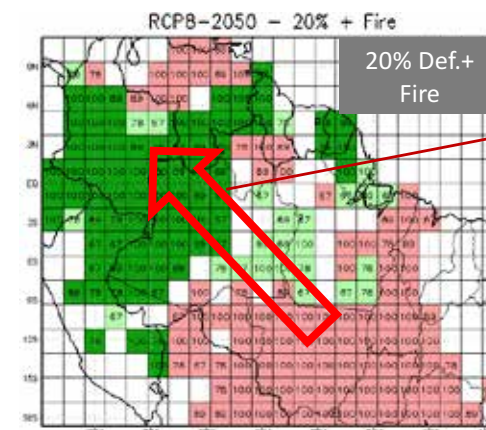
Climate Change (RCP8.5) + Deforestation (20%) + Increased Fire + CO<sub>2</sub> 'Fertilization' effect

SIMULTANEOUS HUMAN DRIVERS OF CHANGE

- Tropical Seasonal Forest
- Savannah
- Tropical Evergreen Forest



Control Simulation



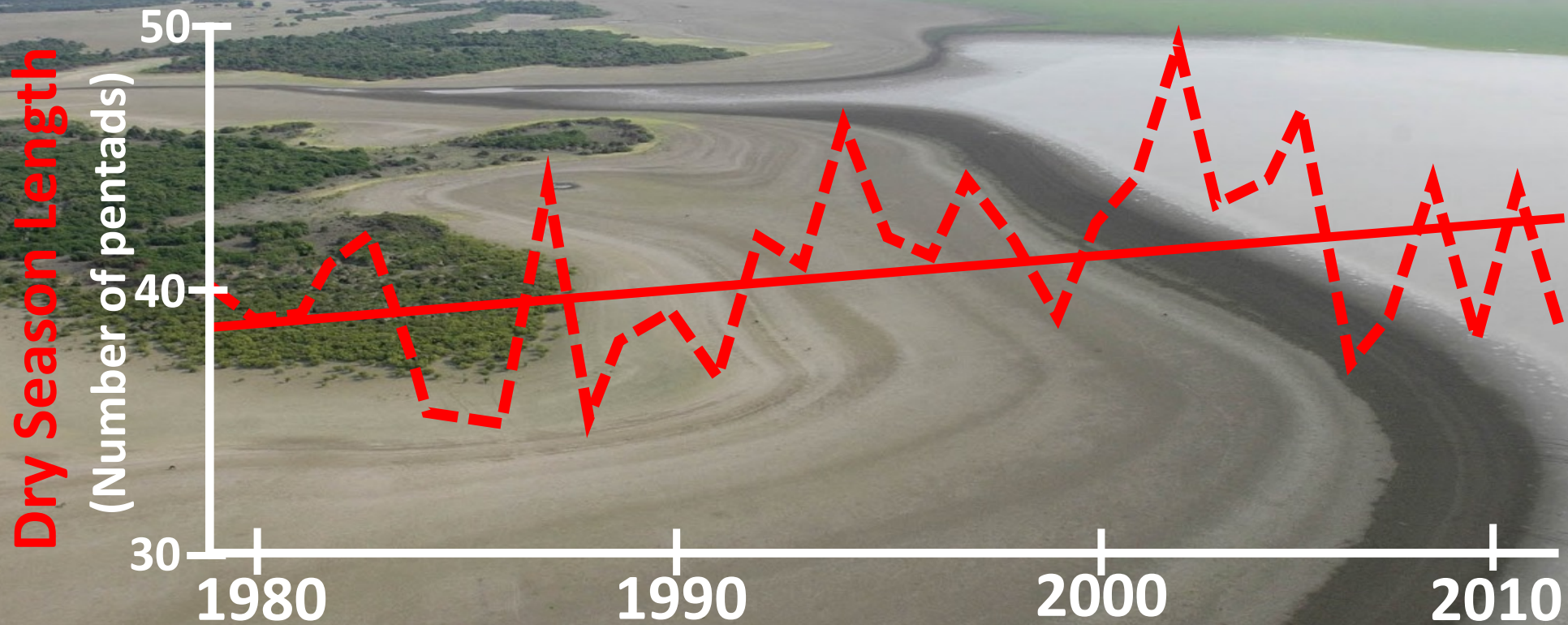
Projected Biome Changes

Forest remains  
In the west of  
the Basin

**Between 50% and  
60% of the forest  
would disappear!**



# IS DRY SEASON LENGTH INCREASING IN THE AMAZON?

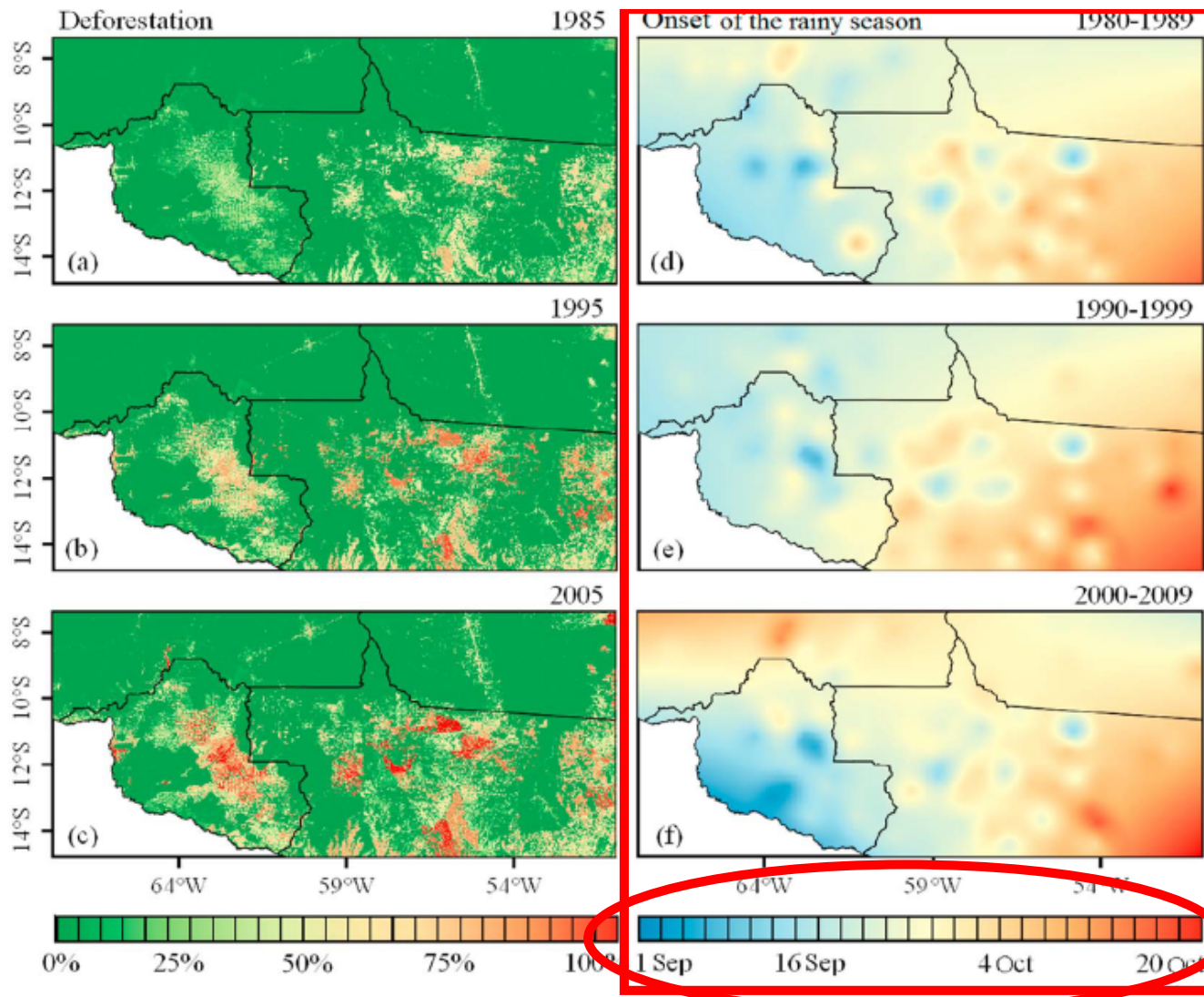


The Dry Season in central-southern Amazon has increased by 6 days per decade since the 1980's.

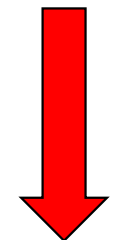
If it becomes longer than 4 months, the risks of savannization increase exponentially!

Fu et al. 2013 (ADAPTED)



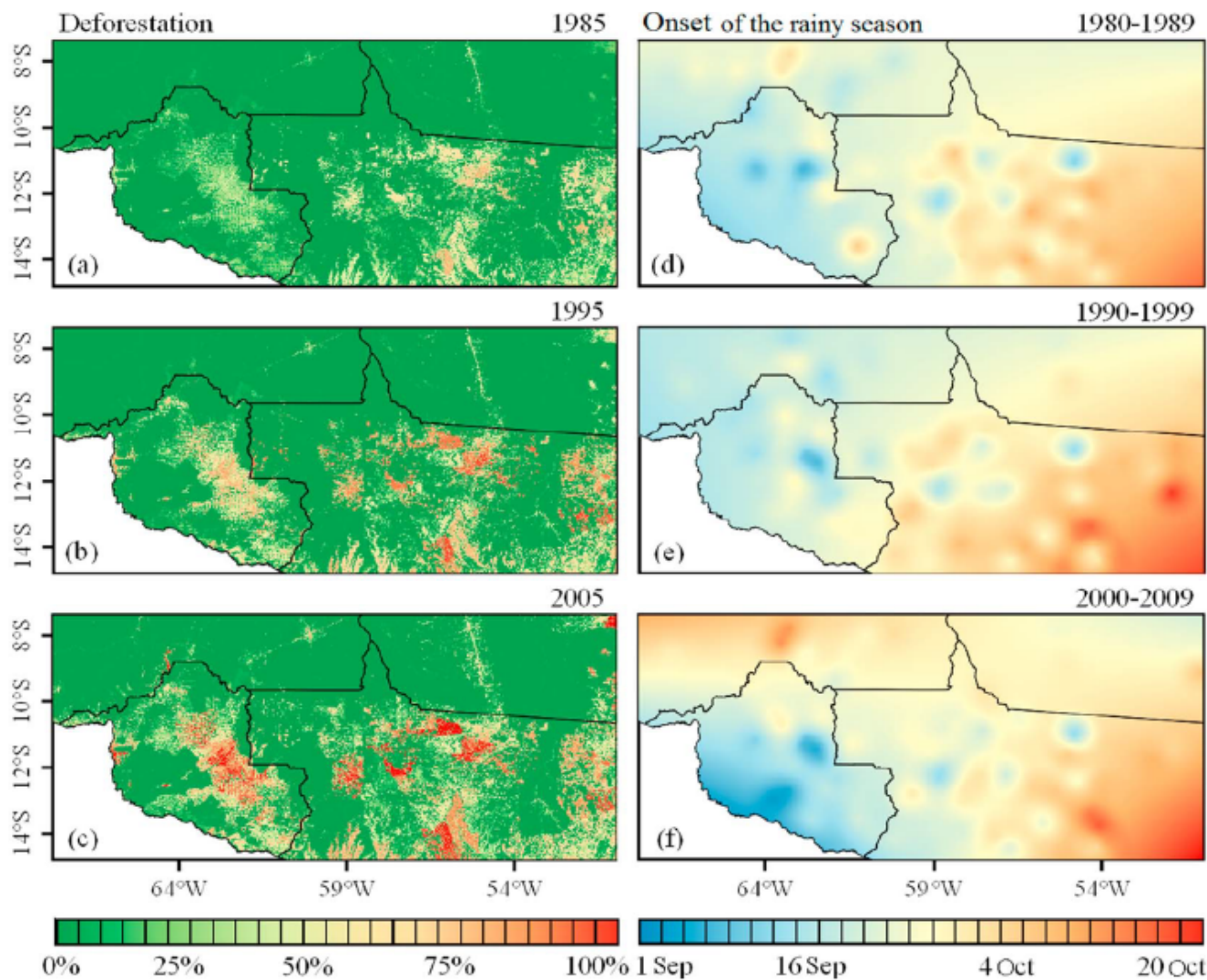


Evolution of Deforestation



Delay of the rainy season, which can reach more than 1 month in some regions!

Leite-Filho et al., 2019 - Effects of deforestation on the onset of the rainy season and the duration of dry spells in southern Amazonia. Journal of Geophysical Research: Atmospheres.



## Other keyfindings

- Areas with greater deforestation also have greater chance to experience **dry spells**.
- Climatic risk to **agriculture** on this region: Double-cropping system, in which soybeans are harvested in time for the second crop to mature while climatic conditions are favorable.

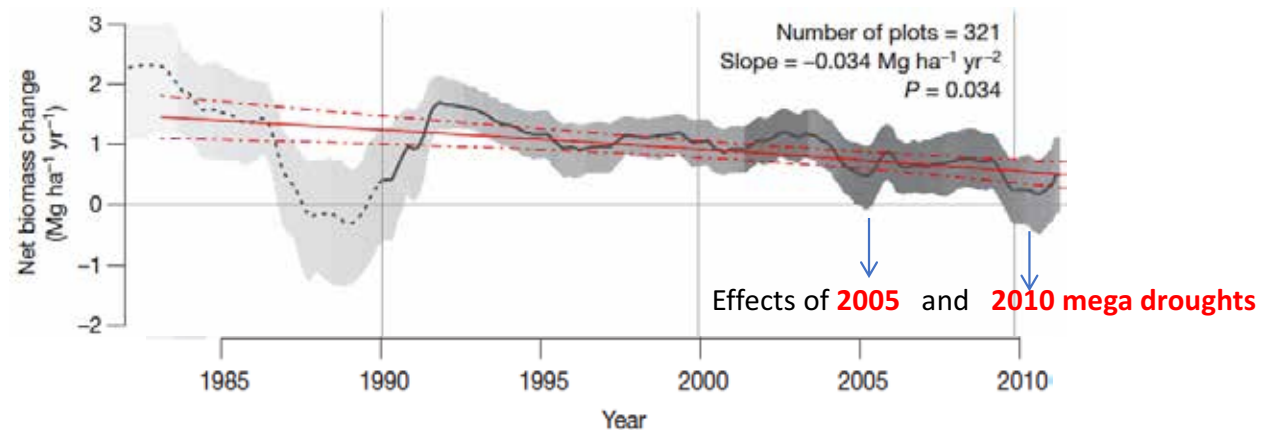
Leite-Filho et al., 2019 - Effects of deforestation on the onset of the rainy season and the duration of dry spells in southern Amazonia. *Journal of Geophysical Research: Atmospheres*.

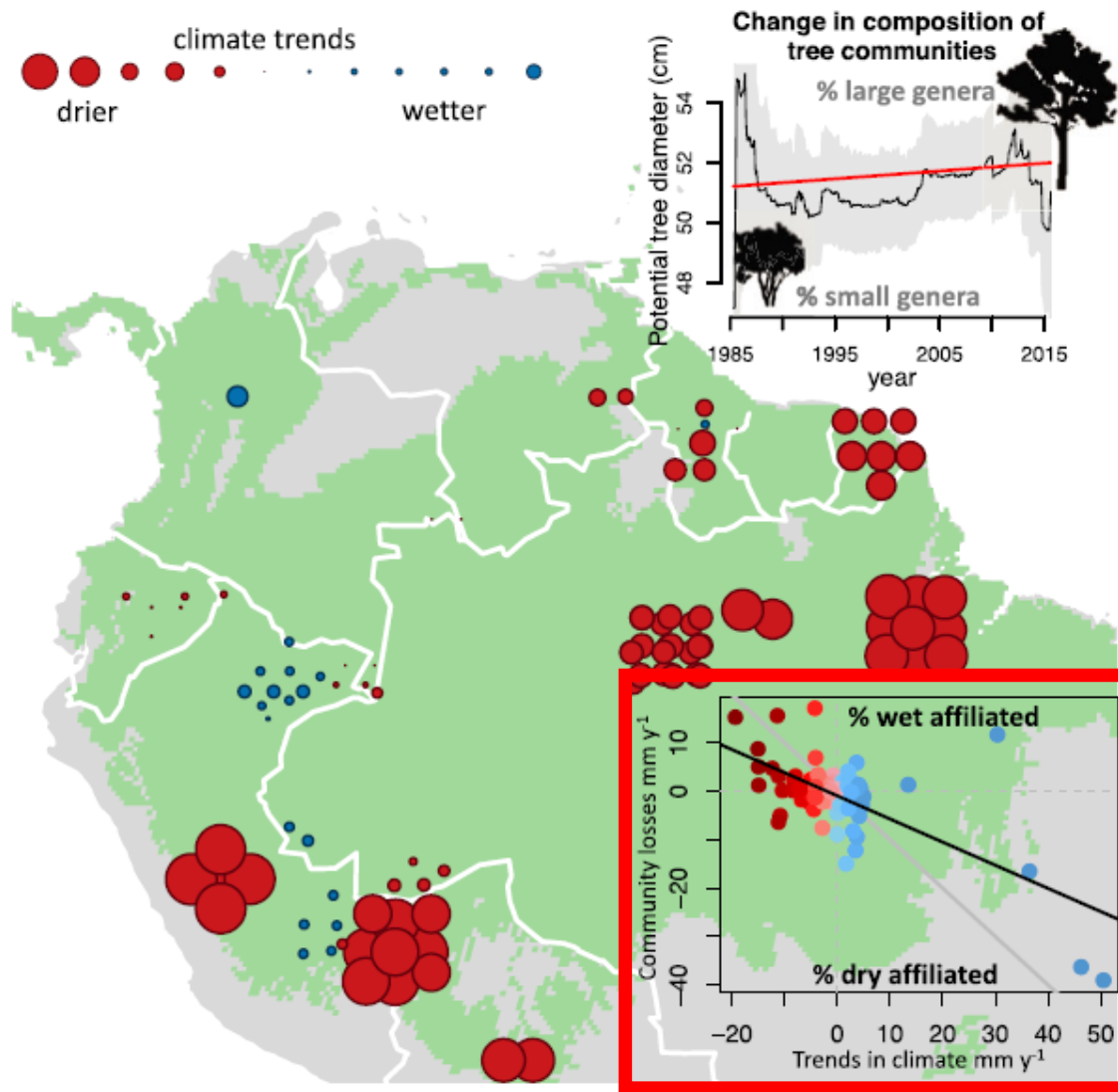


# THE AMAZON FOREST IS A KEY CARBON SINK

- Forest biomass is increasing in the Amazon ( $\sim 1$  tonC/ha/yr) ( $\sim 3.7$  tonCO<sub>2</sub>/ha/yr)
- **This carbon sink capacity has decreased 30% since 1990's**

... and a considerable number of other studies point out the possibility of the Amazon forest dieback (Nobre et al. 2016 PNAS)





**Reduction in wet affiliated Taxa**

**Increase in dry affiliated taxa**

*Esquivel-Muelbert et al. (2018) – Global Change Biology – Compositional response of Amazon Forests to climate change*





SCIENCE ADVANCES | EDITORIAL

# Amazon Tipping Point



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1. E. Lovejoy, A. Dalziel, E. Mielke, J. G. Day, *Resilience of the Amazon*, *Science* **358**, 1225–1228 (2017).
2. S. Solomon, C. M. Beamesderfer, M. R. Conner, P. S. Schimel, *Amazonian Deforestation and the Hydrological Cycle*, *Journal of Climate* **20**, 1775–1787 (2007).
3. T. E. Lovejoy, C. Nobre, *Amazon Tipping Point*, *Sci Adv*, **4**, e1242242 (2018).

- DRIVERS OF CHANGE
- Global Climate Change
- Regional Deforestation
- Increasing forest fires
- CO<sub>2</sub> increase

# Potential tipping point 20% - 25% of total area deforested





**THANKS**

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