Forest Legality Week 2022

The magnitude of the illegality in Amazonia, and implications for climate change in the Basin and at the global scale

Science Panel for the Amazon – SPA

Carlos A. Nobre

Institute of Advanced Studies-University of São Paulo

Co-Chair of SPA

Tuesday, October 18th, 2022

Photo: Marcio Isensee e Sá

When was the modern Amazonian landscape formed?

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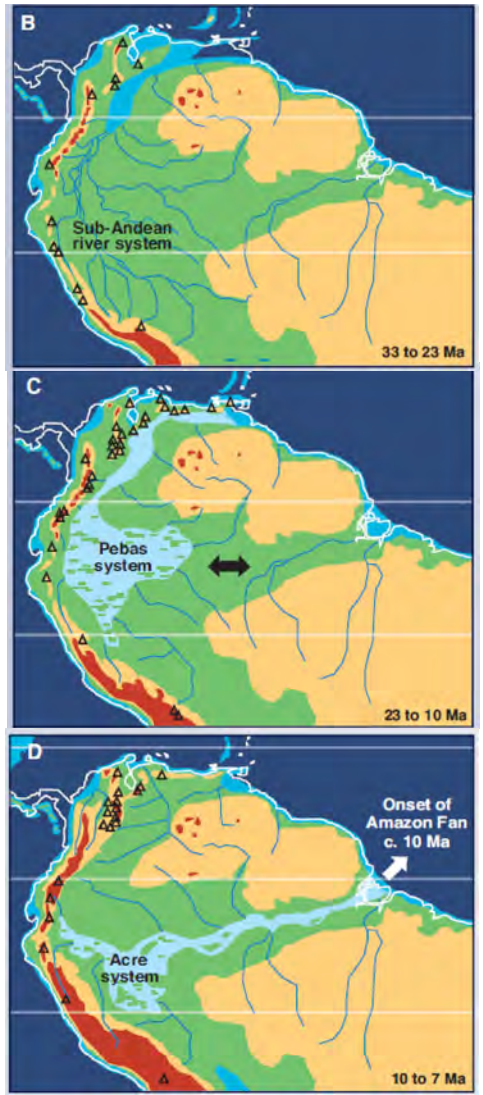
Towards the modern landscape, Neogene (<23 Ma)

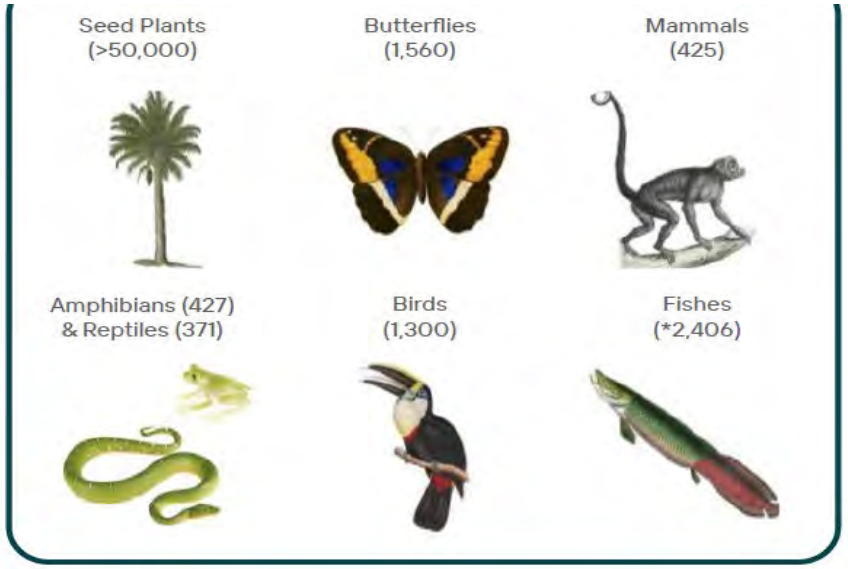
Hoorn et al., 2010



Tens of millions of years of evolution!

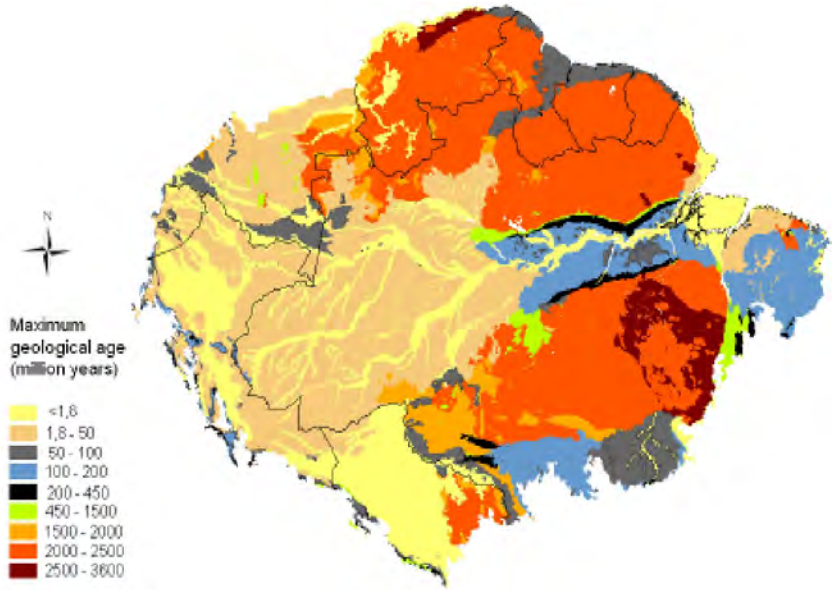
Amazon works as a Species Pump

profound effect of Andes Uplift on Amazon landscape and its biodiversity



~13% of the world's described species compressed into about 0.5% of Earth's land and <0.001% of Earth's water.

Uplift of Andes creates characteristic dichotomy of the landscape

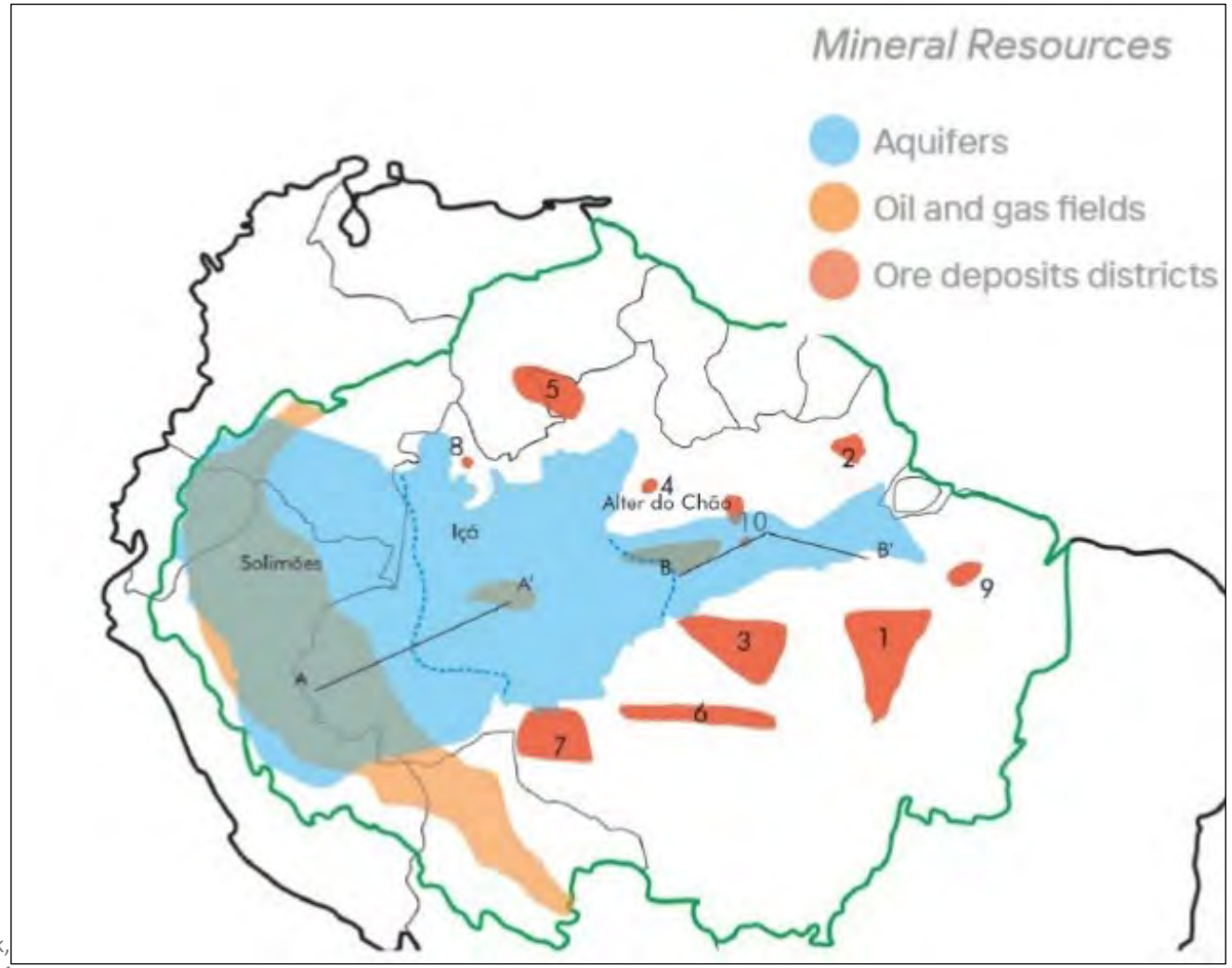


Quesada et al., 2011

Mineral Richness, Hydrocarbons, and Aquifers

The Amazon has an area of high potential for mineral resources and represents one of the last mineral exploration frontiers in the world

- **Ore deposits** in the Amazon Amazonian began as early as the Mesoarchean (c. 3.0 Ga), with geological processes during the Phanerozoic.
- **Oil and gas** are concentrated in the Subandean region, and to a lesser extent in the western and eastern Amazon.
- **Aquifer systems** are found in sedimentary basins along the main stem of the Amazon River.



Source:
Val, P. et al. Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/POFE6241

12,000 years ago in human history!

The Amazon is also home to a notable diversity of sociocultural groups

Yanomami

Xavante

Carajá

- 16th century: **8 to 10 million Indigenous people, speaking more than 1,000 distinct languages**
- Today: **2.2 million** Indigenous people, more than **410 groups**, around 80 of which remain in voluntary isolation.
- About **300 Indigenous languages** spoken in the region

Ecosystem Services: Climate stabilization and Water Recycling

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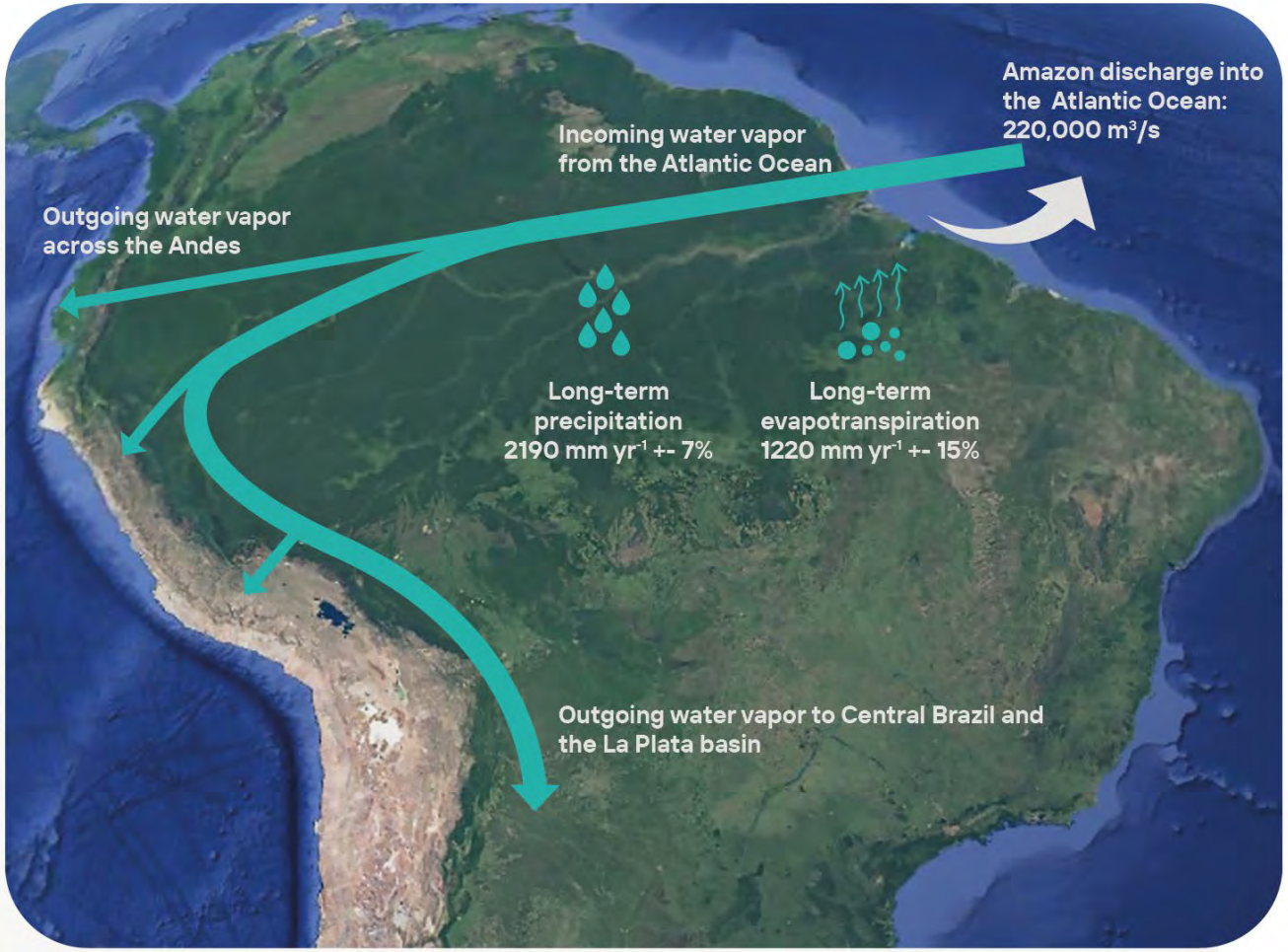


- The Amazon basin is the planet's largest and most intense land-based convective centre, exerting strong influences on atmospheric circulation both within and outside the tropics
- Key heat source for the atmosphere and annual rainfall ~ 2000 to 3000 mm
- Very efficient recycling of water (50% water recycling)
- ~70% of the moisture flow in the La Plata Basin depends on moisture recycled over the Amazon
- Undisturbed Amazon forest has a net removal rate of > 1 billion tonnes/year of carbon dioxide from the atmosphere

Illegal activities in the Amazon region and its implications

- Large-scale deforestation
- Forest degradation
- Massive fires
- Selective Logging
- Unofficial roads and other infrastructure
- Gold mining
- Wildlife Trade

Amazonian Deforestation

18% of Amazon basin is deforested

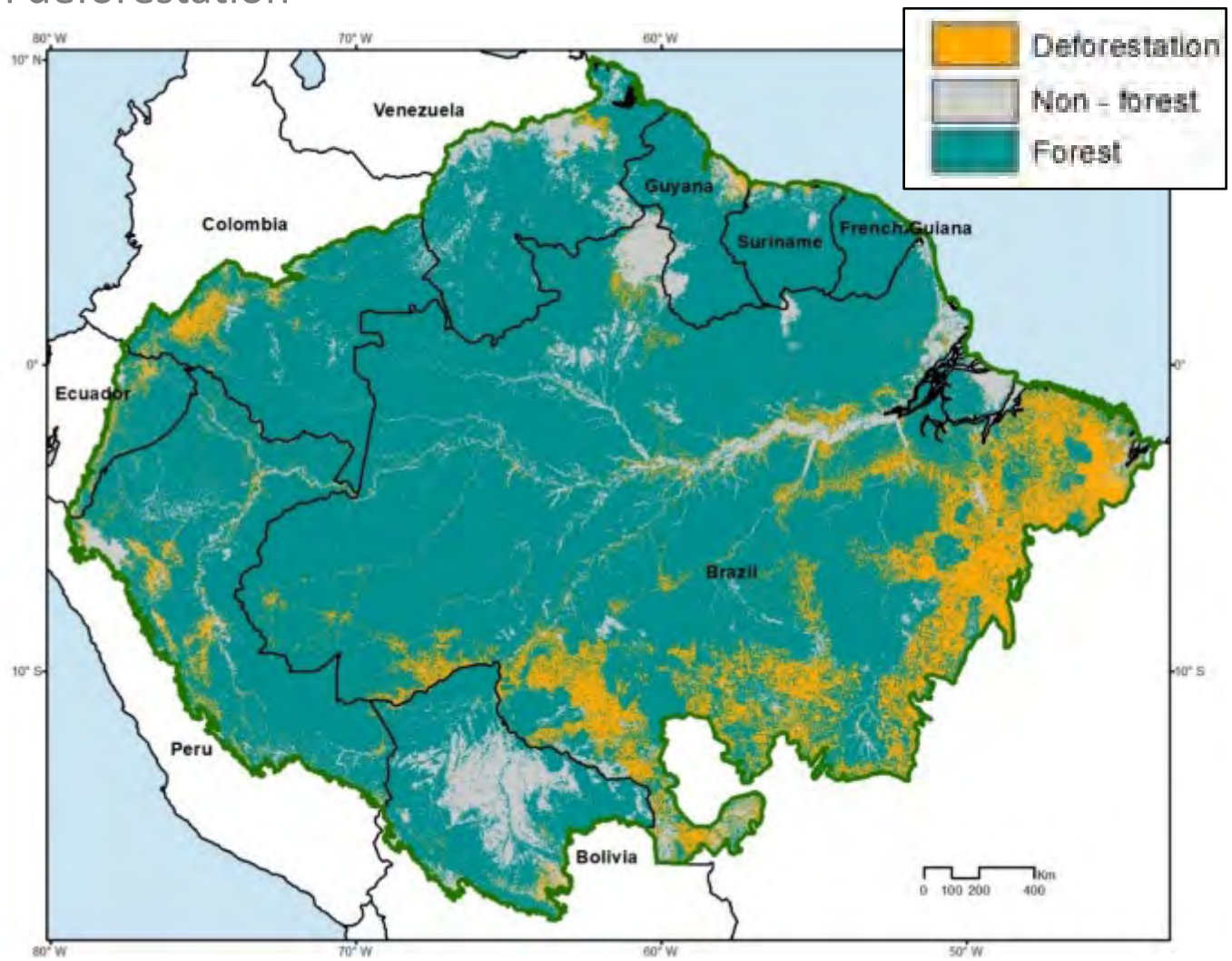
Agricultural expansion, particularly cattle ranching, remains the most important driver of Amazonian deforestation

Average annual deforestation:

- **Across the Amazon biome** (2002-2018)
  ~ 17,000 km^2 yr^{-1}
- **Brazilian Amazon** (1988-2021)
  ~ 14,000 km^2 yr^{-1}

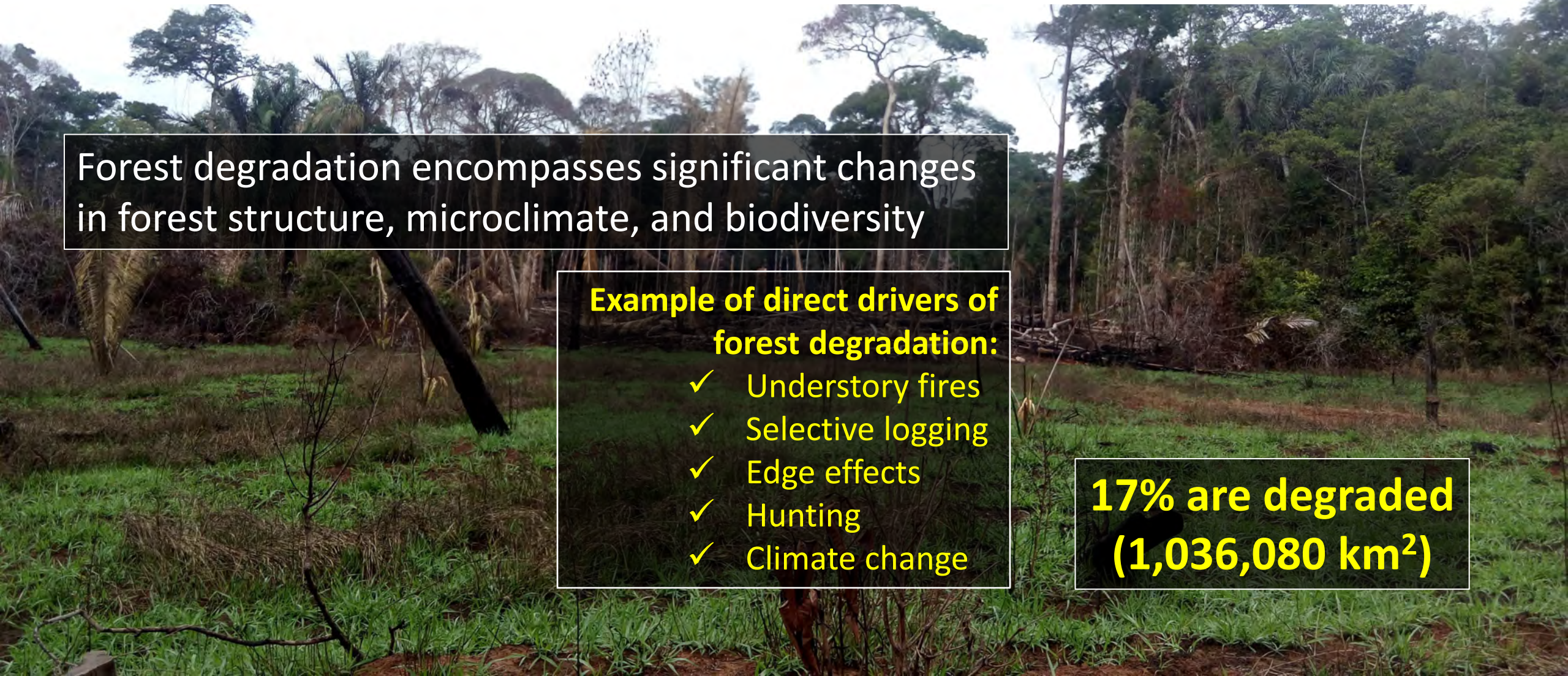
  Accumulated Brazilian Amazon deforestation over 800,000 km^2

More than 90% of the deforested area in the Amazon is ilegal!



Forest degradation

Forest degradation is defined as the reduction of the overall capacity of a forest to supply goods and services, representing a loss in ecological value of the area affected



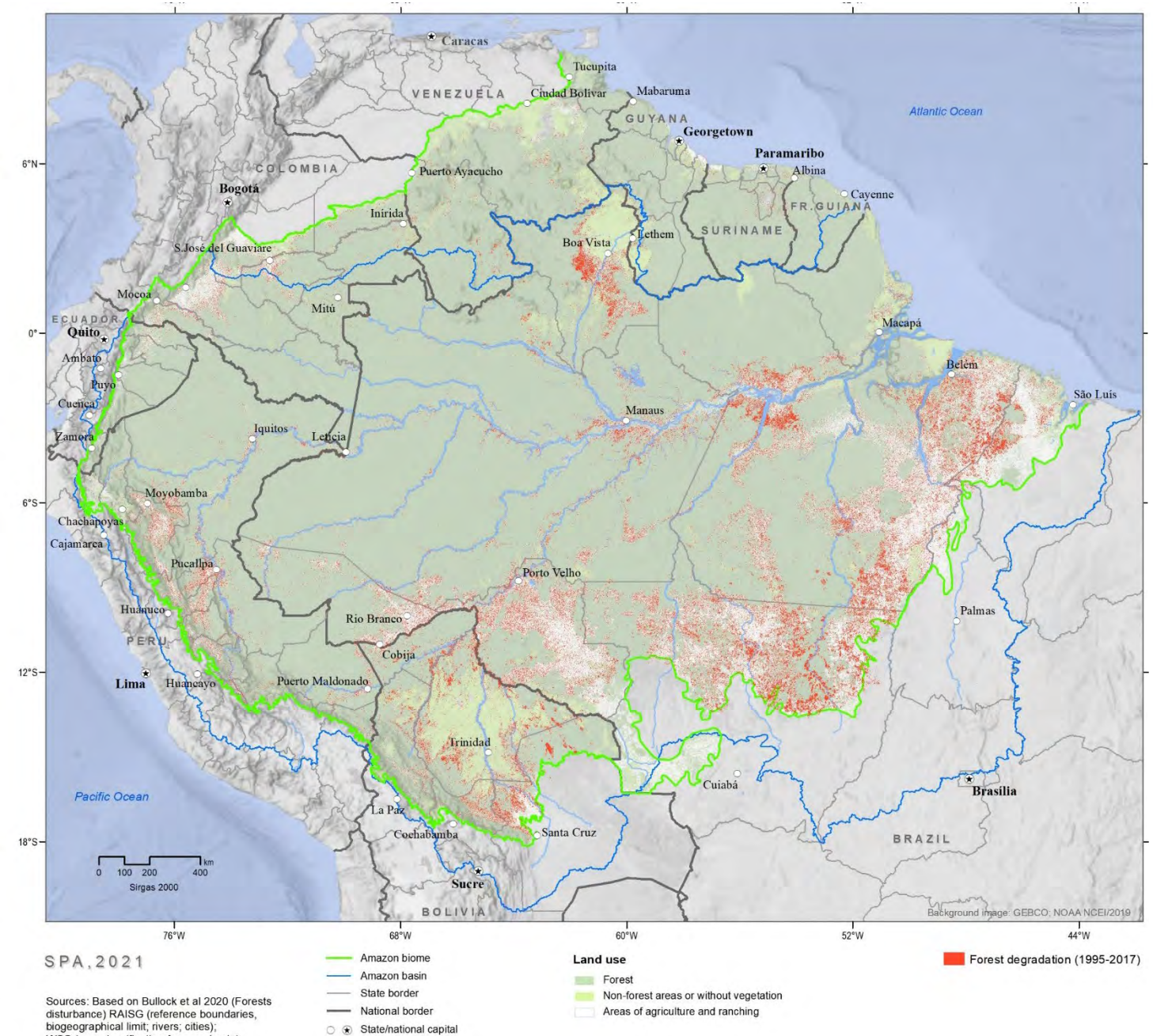
Forest degradation encompasses significant changes in forest structure, microclimate, and biodiversity

Example of direct drivers of forest degradation:

- ✓ Understory fires
- ✓ Selective logging
- ✓ Edge effects
- ✓ Hunting
- ✓ Climate change

17% are degraded (1,036,080 km^2)

Forest degradation in the Amazon (1995-2017) - **17%**



Forest Degradation: large areas of the Amazon rainforest are degraded due to selective logging and fires

Selective logging

Loss of the under canopy

Losses > 90% of the canopy

Losses > 50% of the canopy

Massive Fires

Fires are an intrinsic part of the deforestation process in the Amazon

The occurrence of forest fires has increased and is directly correlated with:

- ✓ Deforestation
- ✓ Climate change
- ✓ Forest degradation
- ✓ Use of fire in agriculture

~ 151,412 ± 62,253 km^2/yr have burned in the last 18 years

Proximity to roads is also highly correlated with forest fires.

Illegal Selective Logging

Selective logging is the clear cut of certain tree species with high demand for export

Increases the risk of commercial extinction of the timber species

Selective logging can be a major driver of forest degradation:

- **Weakens forest resilience to fires.**
- **Reduce the richness of species.**
- **Alter the composition of forest fauna.**

Source:
Fearnside P.M.; Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/IDMB5770

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Roads, deforestation, and the mitigating effect of protected areas in the Amazon

Christopher P. Barber[a,*], Mark A. Cochrane[a], Carlos M. Souza Jr.[b], William F. Laurance[c]

[a] Geospatial Sciences Center of Excellence, South Dakota State University, 1021 Medary Ave, Wecota Hall Box 506B, Brookings, SD 57007, USA
[b] Imazon – Instituto do Homem e Meio Ambiente da Amazônia, Rua Domingos Marreiros, 2020, Belém, Pará CEP: 66.060-162, Brazil
[c] Centre for Tropical Environmental and Sustainability Science (TESS), School of Marine and Tropical Biology, James Cook University, Cairns, Queensland 4878, Australia

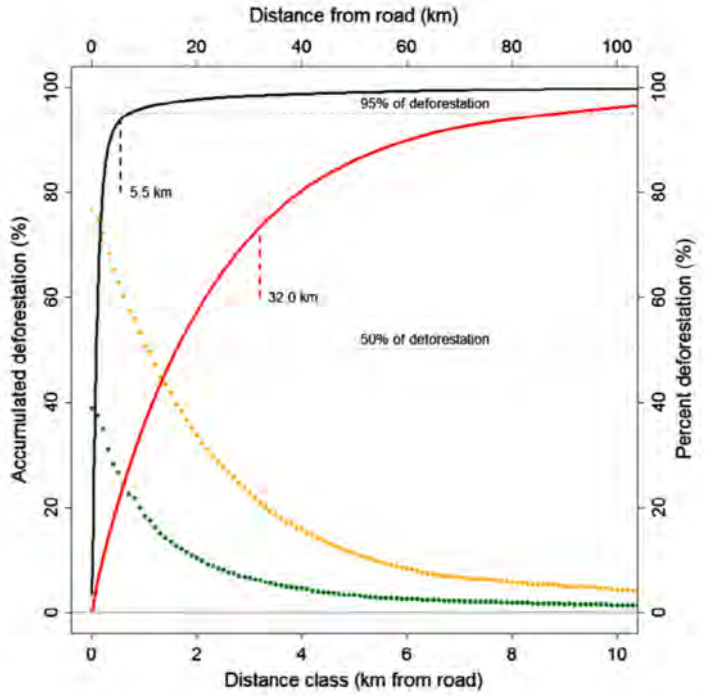


Fig. 1. Accumulation of overall deforestation with respect to distance from roads (left and top axes). Red line is distance to highway network indicating distance at which 95% of deforestation is accounted for and the calculated distance of diminishing influence. Black line indicates same for all official and unofficial roads. The percent deforestation within 100 m distance classes (bottom and right axes) shows relationship between deforestation in protected areas (green) and unprotected forests (orange). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

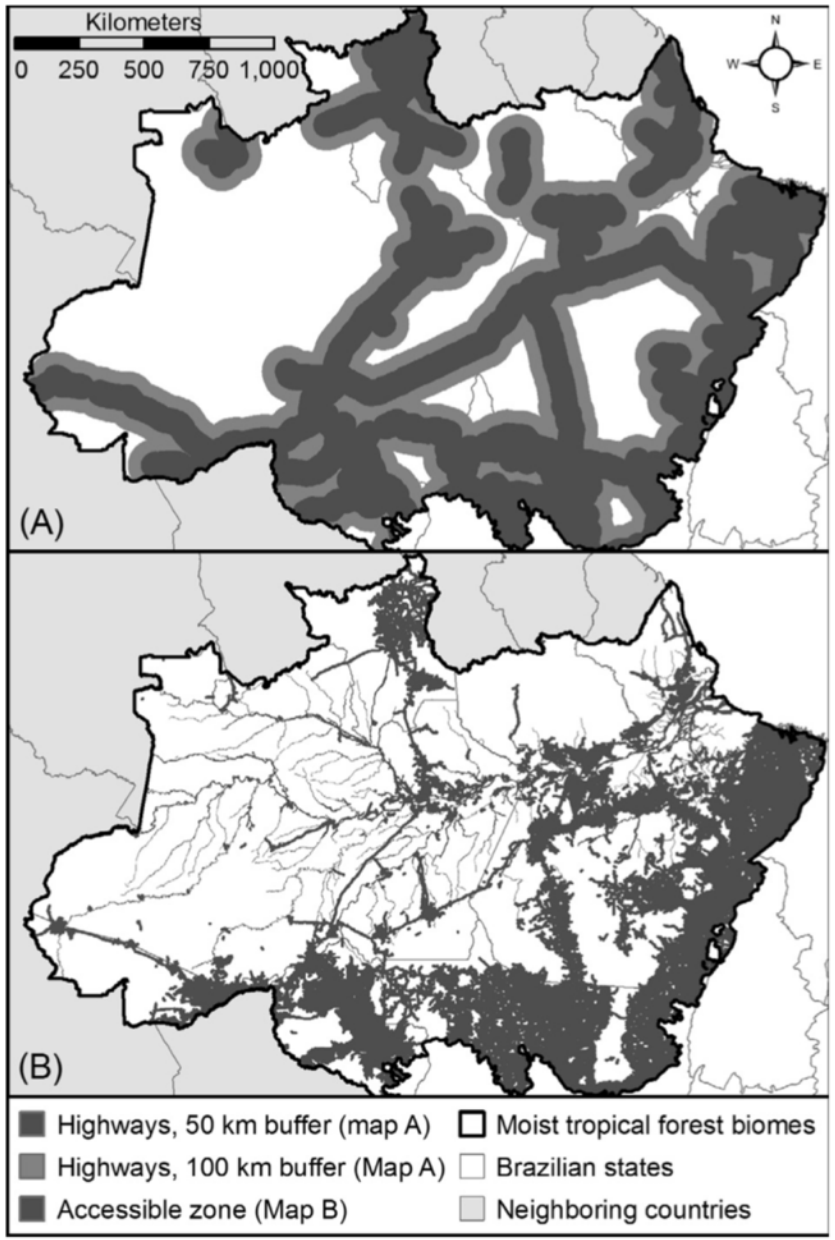


Fig. 2. (A) Commonly used 50 and 100 km distances from main roads represent 40% and 63% of the region, respectively. (B) Accessible regions, defined in this study as ⩽5.5 km from any road or ⩽1.0 km from navigable rivers, cover 35% of the region and incorporate 94.9% of all cleared forests.

95% of deforestation within 5.5 km of roads!

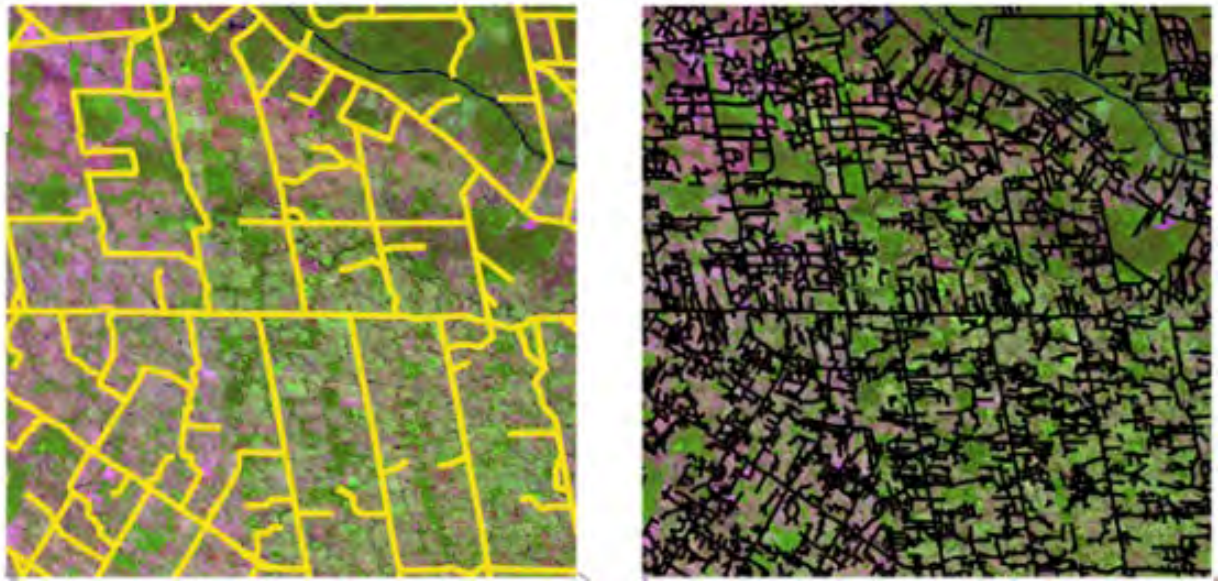
Unofficial rural roads in the Brazilian Legal Amazon

Unofficial roads are built by loggers, goldminers, and land settlements from existing official roads.

- Visual interpretation of the road is underestimated.
- Landsat imagery and Artificial Intelligence (AI) have been combined to detect unofficial roads.
- Expanding over forested areas with 41% cut or within 10 km from the roads.

Visual interpretation (2016)

Detected with the AI (2020)



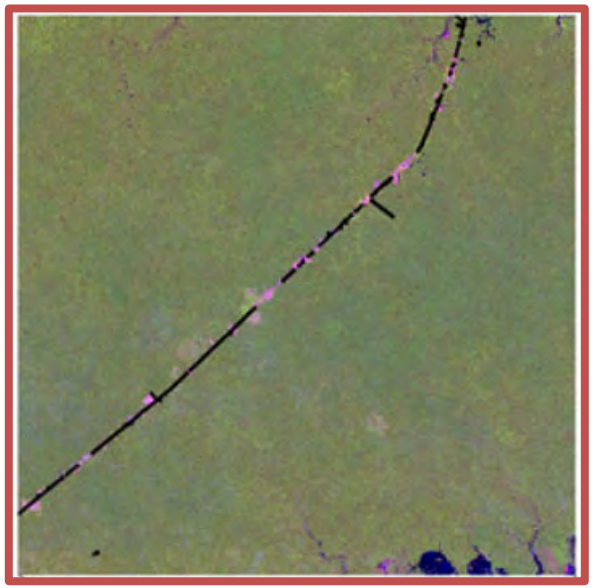
(Rondônia, Brazilian Amazon)

Source:
Botelho, J.Jr. et al. Mapping Roads in the Brazilian Amazon with Artificial Intelligence and Sentinel-2. Remote Sens. 2022 https://doi.org/10.3390/rs14153625

Roads pattern

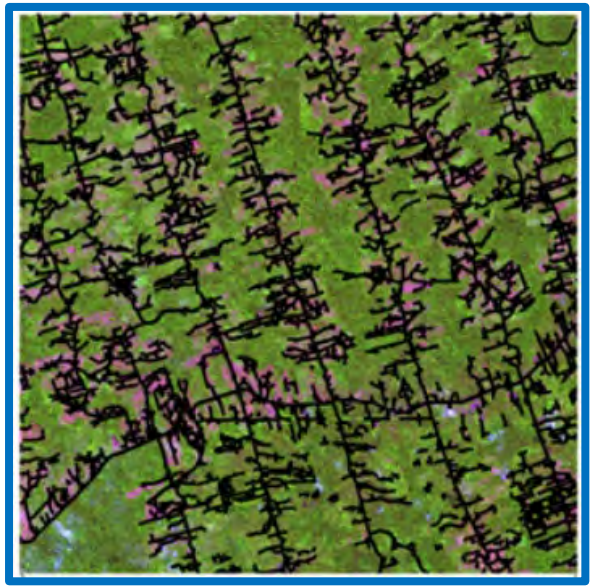
Detected with the AI

Highway with unconnected segments.



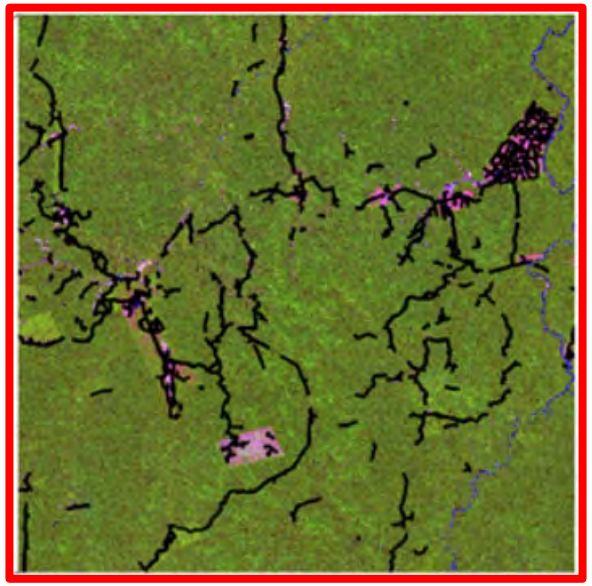
BR-319 (Amazonas)

Fishbone road pattern.



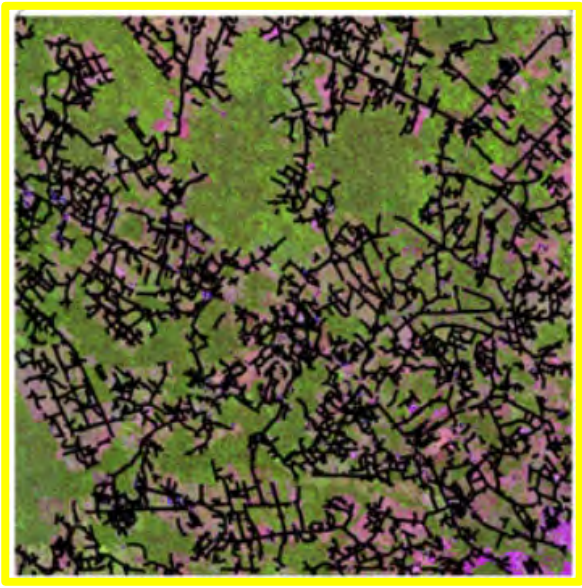
BR-230 (Pará)

Road pattern of selective logging.



(Pará)

Road pattern in agriculture land.



(Acre)

Source:
Botelho, J.Jr. et al. Mapping Roads in the Brazilian Amazon with Artificial Intelligence and Sentinel-2. Remote Sens. 2022 https://doi.org/10.3390/rs14153625

Unofficial rural roads length per state and land category

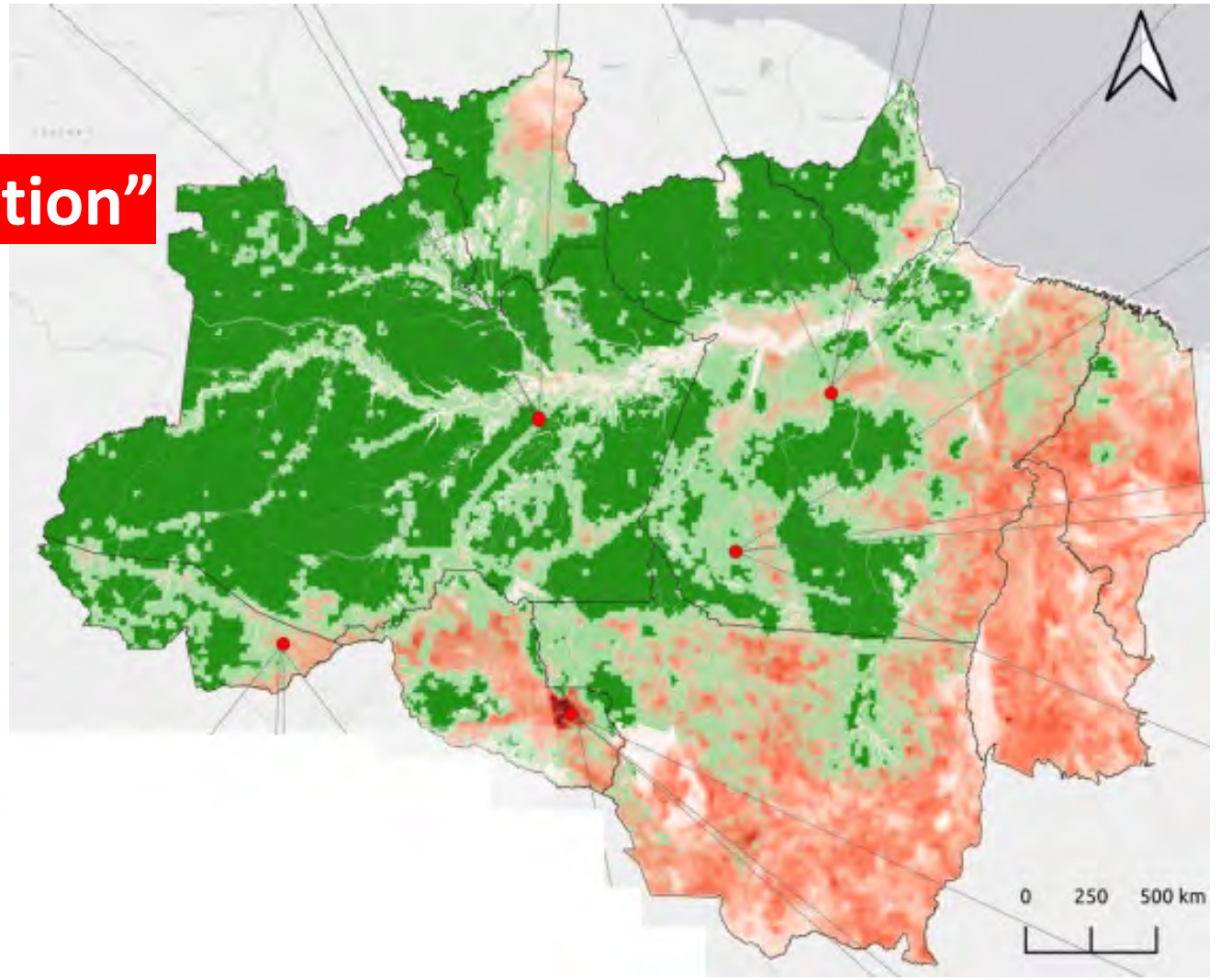
States	Road Length (km)
Acre	53,614
Amazonas	79,801
Amapá	25,010
Maranhão	412,306
Mato Grosso	1,296,946
Pará	715,730
Rondônia	310,119
Roraima	80,025
Tocantins	490,513
Total	3,464,066

Land Category	Road Extent (km)	Relative Extent (%)
Indigenous Land	91,579	2.6%
Federal Protected Area	42,319	1.2%
State Protected Area	141,735	4.1%
Quilombo	4904	0.1%
Military Area	1713	0.0%
Rural Settlement	426,139	12.3%
Public Forest	7660	0.2%
Private Land	1,893,738	54.7%
Public Land	854,279	24.7%
Total	3,464,066	

Source:
Botelho, J.Jr. et al. Mapping Roads in the Brazilian Amazon with Artificial Intelligence and Sentinel-2. Remote Sens. 2022 https://doi.org/10.3390/rs14153625

Unofficial roads density (km of roads per km^2)

Axiom: “have road, have deforestation”



Source:
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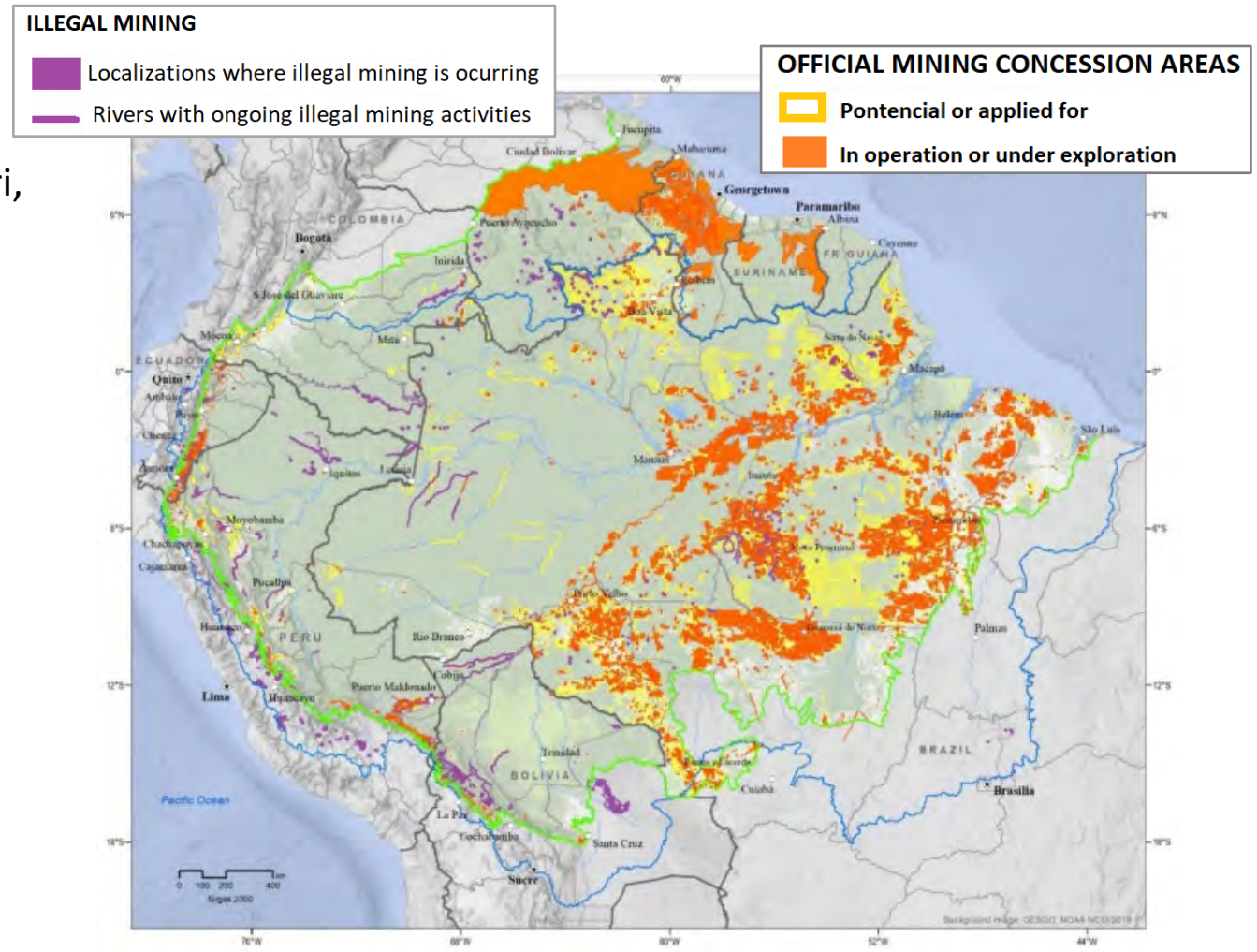
Unofficial roads length > 3,464,066 km

Gold Mining

Mercury contamination from gold mining (legal or not) is a major environmental and public-health concern

Gold mining occurs in rivers such as:

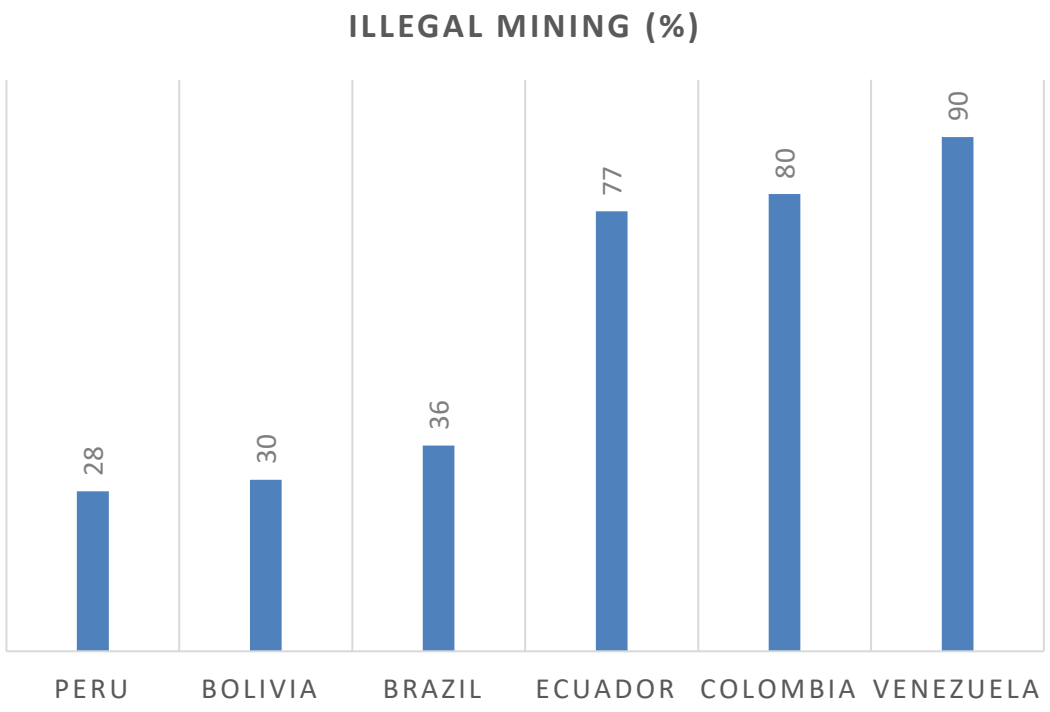
- **Brazil**
  - ✓ Tapajós, Tocantins, Madeira, Xingu, Negro, Amapari, and Solimões or Upper Amazon Rivers.
- **Bolivia**
  - ✓ Madeira, Beni, and Iténez Rivers.
- **Colombia**
  - ✓ Putumayo, Caquetá, Guanía, Vaupés, and Inirída Rivers.
- **Ecuador**
  - ✓ Nambija River.
- **French Guiana**
  - ✓ Along the tributaries of the Black River.



Source:
Fearnside P.M.; Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/IDMB5770

Percentage of gold considered ‘extracted illegally’

Gold mining is estimated to account for 64% of the mercury entering Amazonian aquatic systems



Source:

Costa F.A. et al. Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/CGAP7652

Bioaccumulate mercury

Methylmercury enters aquatic food webs and bioaccumulates in successively higher trophic levels

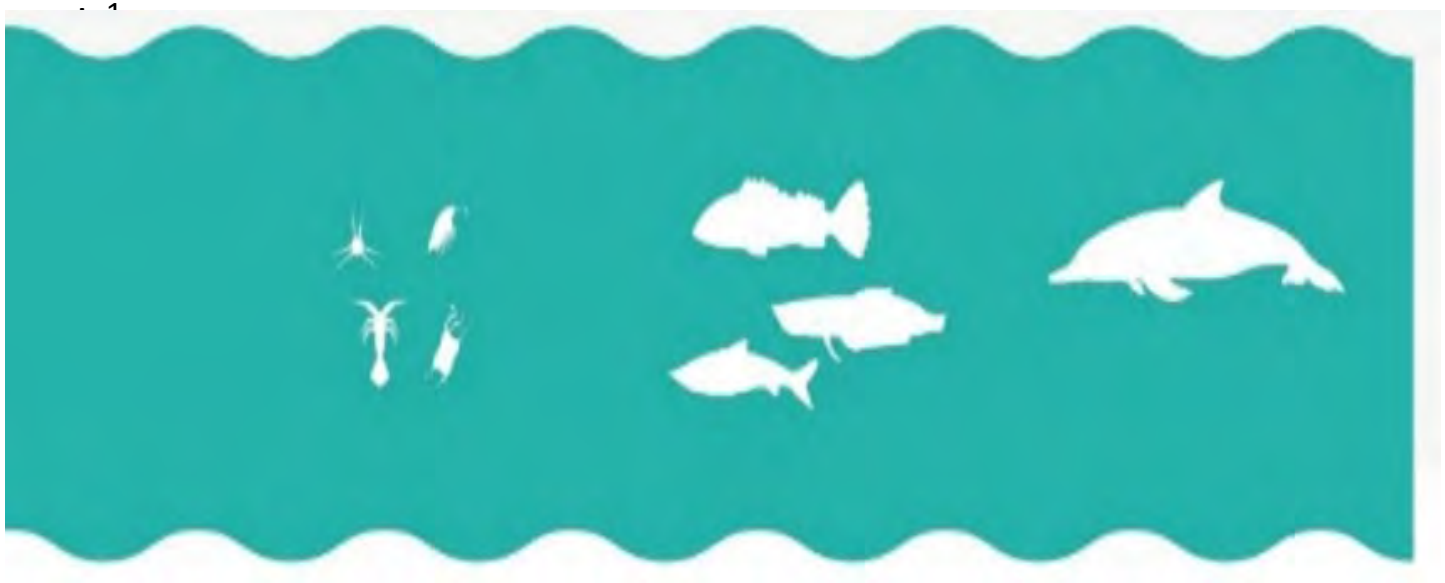
Elemental **mercury (Hg) can be turned into toxic methylmercury (MeHg)** in anoxic environments, such as those created at the bottom of reservoirs.

Water
0.07±0.03

Plankton
65±26 µg.kg^{-1}

Fish
435±340 µg.kg^{-1}

Dolphin
6,979 µg.kg^{-1}



Fish consumption by the Amazon's human communities causes some of the world's highest recorded mercury levels in human hair.

Source:
Fearnside P.M.; Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/IDMB5770

Illegal Wildlife Trade

Domestic and international trafficking remains the main driver of decline for aquatic and terrestrial species with significant consequences for ecosystem function and services, particularly carbon storage

The population of the Great-billed Seed-Finch (bicudo in Portuguese) is critically endangered in Brazil.

However, it is still encountered in trade.

Source:
Fearnside P.M.; Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/IDMB5770

Imagem Source: https://www.wikiaves.com.br/wiki/bicudo

(Cimi 2021)

Agribusiness, logging, and mining interests have lobbied to undermine the established protected lands, leading to a new wave of conflict, rights violations, invasions, illegal deforestation, and violence against Indigenous peoples, Afro-descendant populations, and other local communities

355 cases of violence against indigenous people in 2021, the highest number recorded since 2013

176 indigenous killed in 2021

(Cimi 2021)

(Cimi 2021)

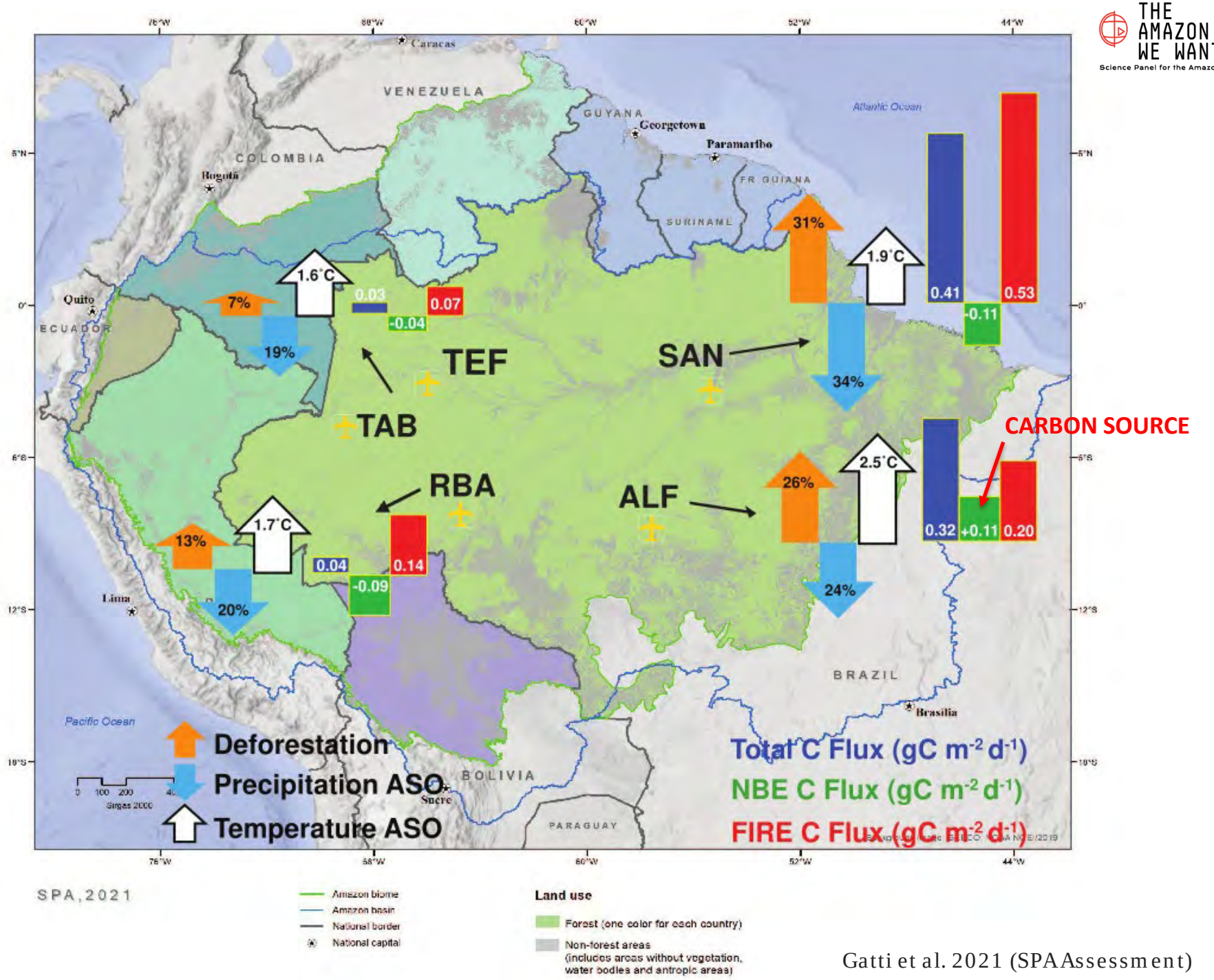
Implications for climate change in the Amazon and at the global scale

Carbon Fluxes 2010-18

- Total: dark blue bars
- Net Biome Exchange (NBE): green bars
- Fire: red bars

The Forest in southern Amazon is becoming a carbon source.

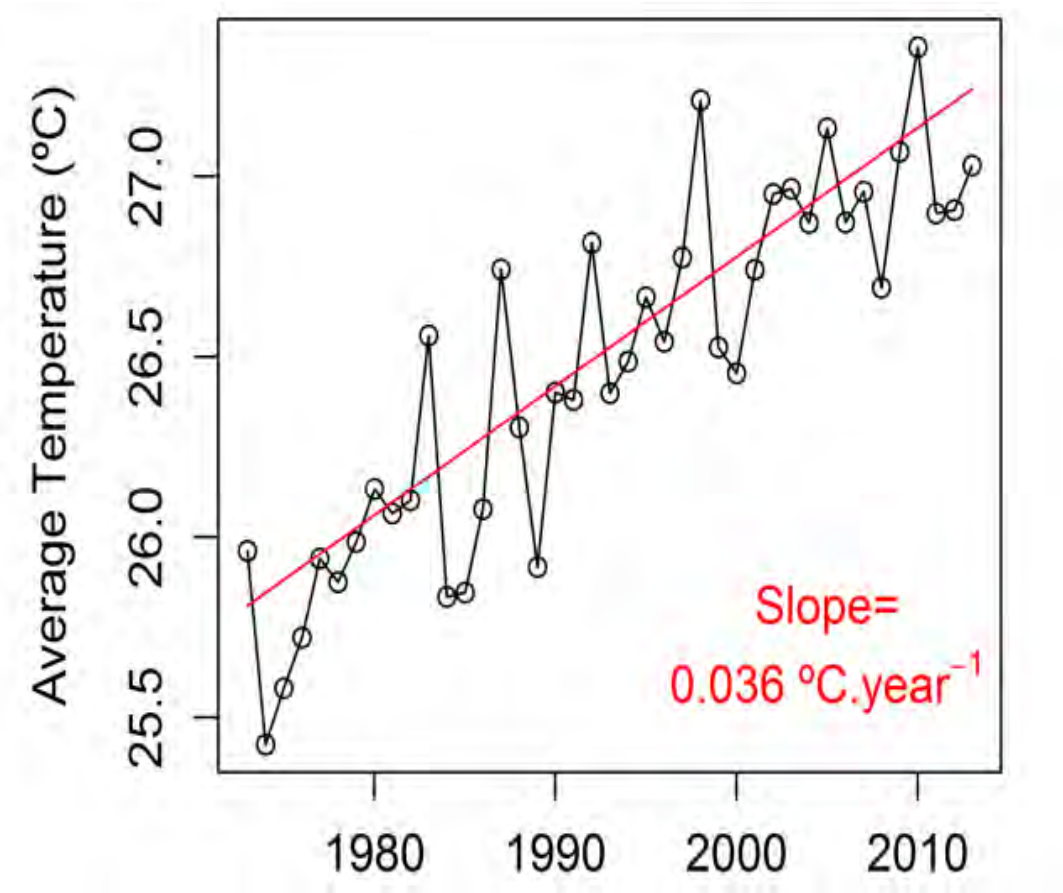
Eastern Amazon may suffer up to 95% of forest loss by 2050

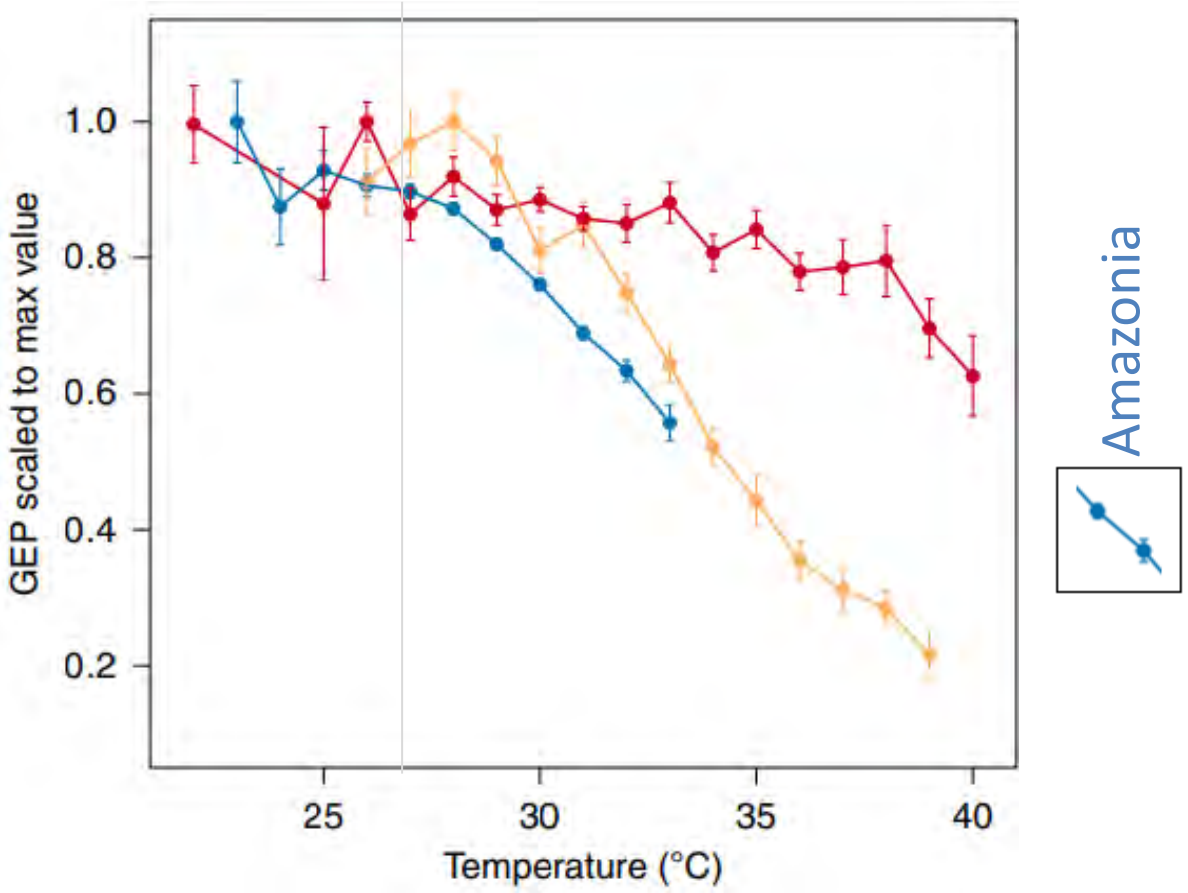


Gatti et al. 2021 (SPA Assessment)

Temperature trend and Gross Ecosystem Productivity

The average temperature in the Amazon is currently 28 °C, and gross ecosystem productivity is known to decrease at temperatures above 27 °C



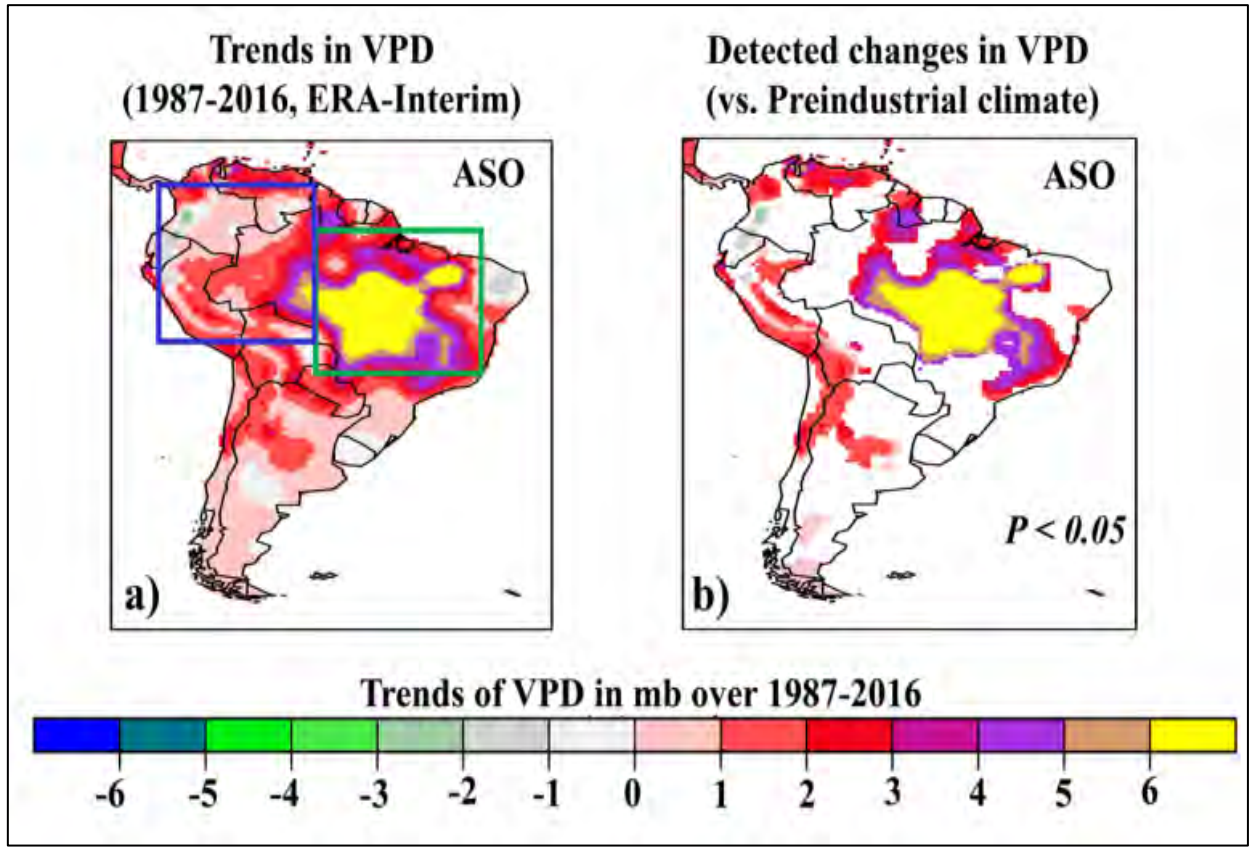


ALMEIDA, C.T. et al. **Spatiotemporal rainfall and temperature trends throughout the Brazilian Legal Amazon**, 1973-2013. International Journal of Climatology (37): 2013–2026, 2016.

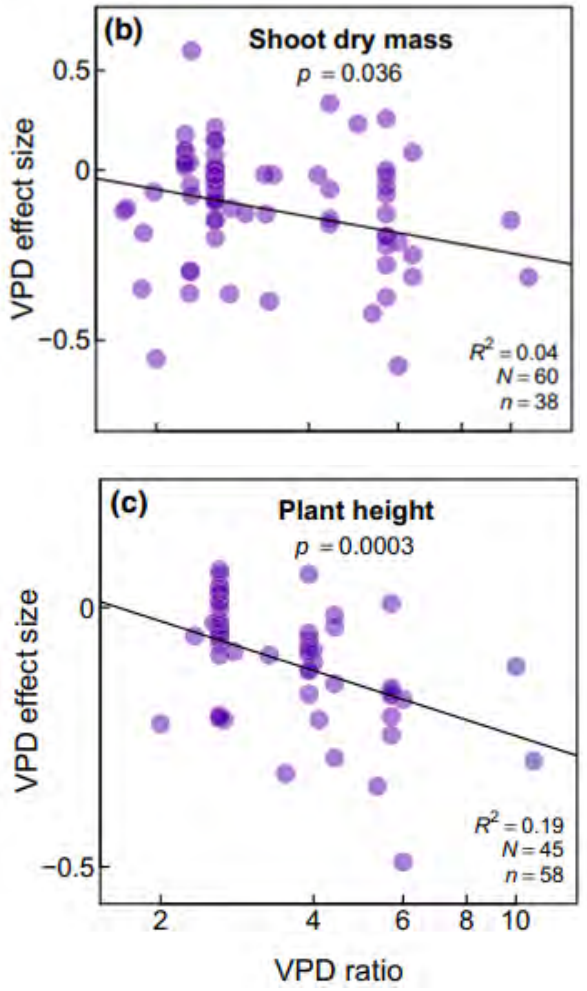
SMITH, M.N. et al. **Empirical evidence for resilience of tropical forest photosynthesis in a warmer world**. Nature Plants (6):125-1230, 2020.

Effects of rising atmospheric vapor pressure deficit (VPD) on plant physiology

Globally, the vast majority of species (84%) exhibited a significant response to VPD

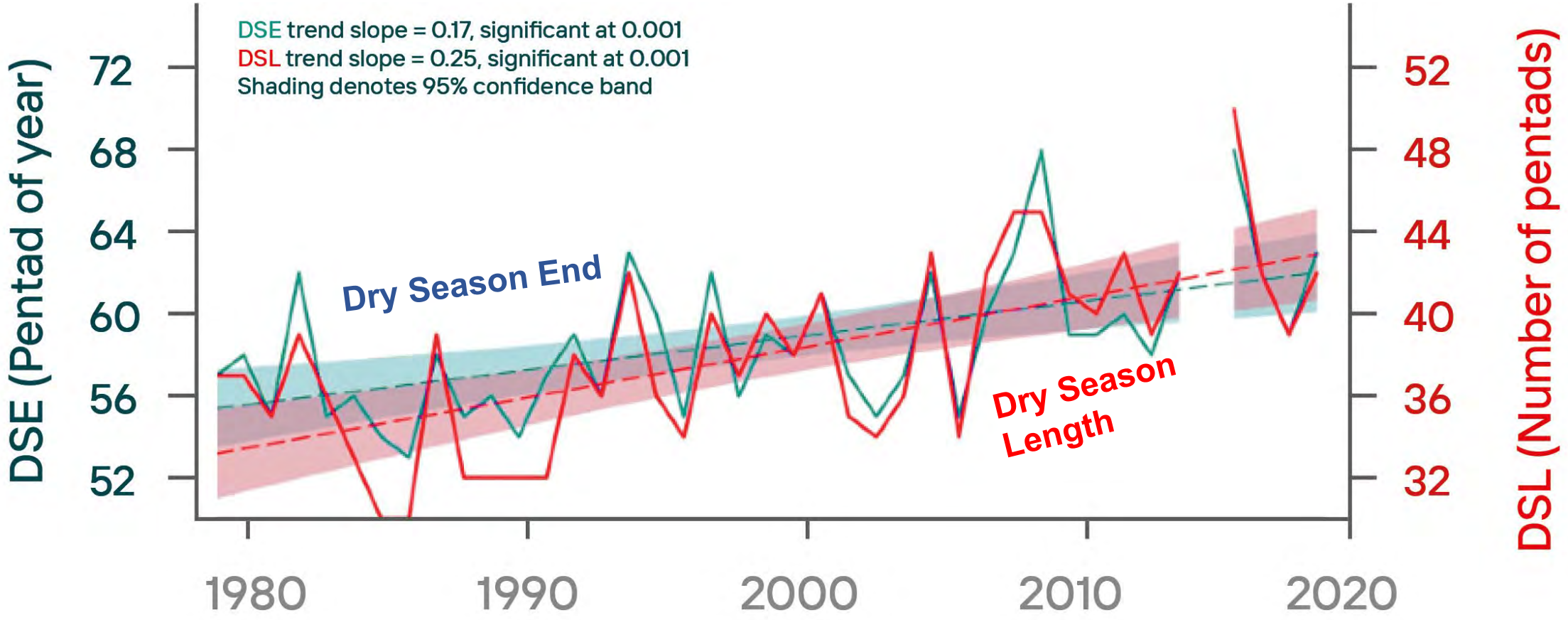


BARKHORDARIAN, A. et al. **A Recent Systematic Increase in Vapor Pressure Deficit over Tropical South America**. Scientific Reports (9): 15331, 2019



LÓPEZ et al. **Systemic effects of rising atmospheric vapor pressure deficit on plant physiology and productivity.** Global Change Biology (27):1704-1720, 2021

Dry Season Length



Southern Amazon Dry Season Length (DSL, red line)

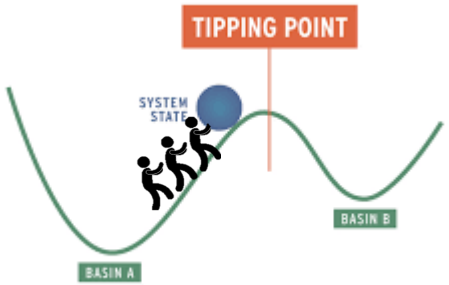
Increased 4-5 weeks in the last 40 years!

The Amazon is about 1.2°C warmer

2-3 °C warmer in the dry season of southern Amazonia

Marengo et al. 2021 (SPA Assessment).

Derived from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC)



HOW CLOSE TO A TIPPING POINT IN AMAZONIA?

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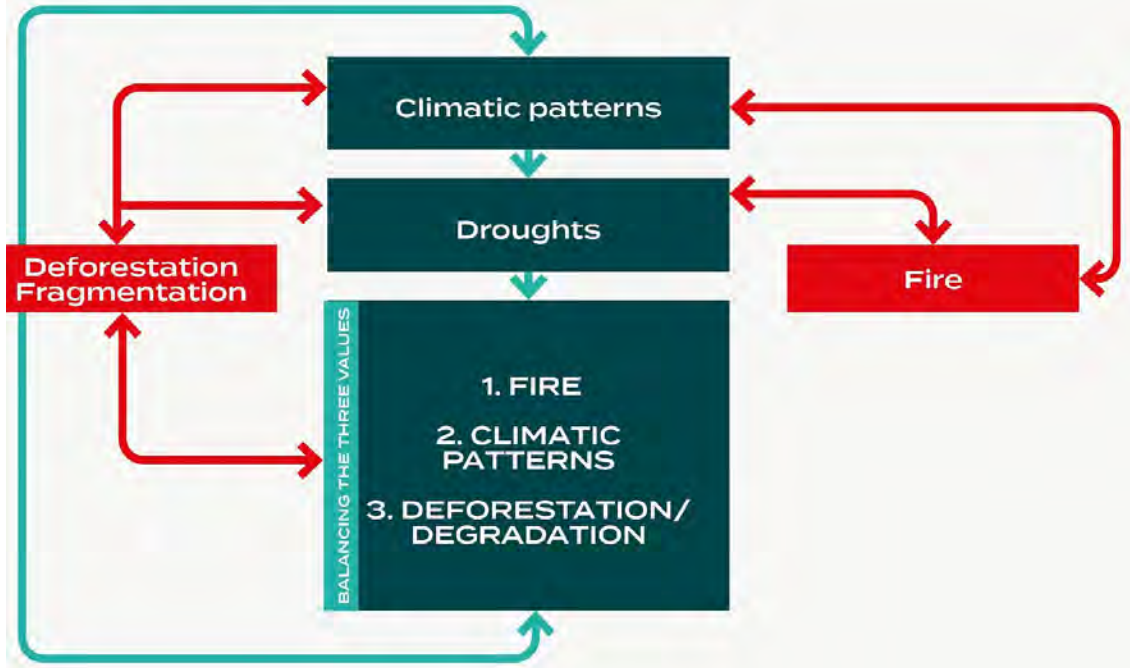
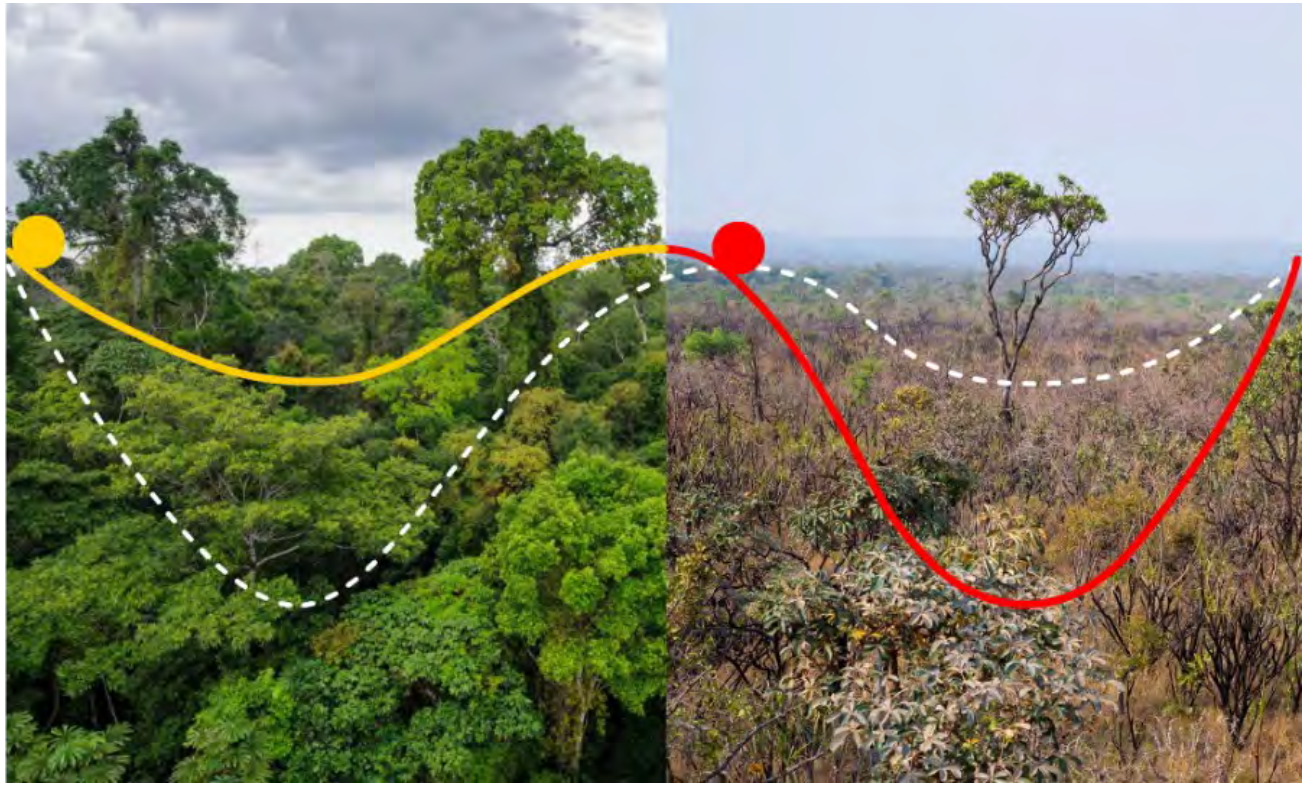
- Tipping points
- Potential new states

Warming of **4ºC** due to Global Climate Change **or** Deforestation of **40%**
or
Deforestation of **20-25% +** Warming of **2.5ºC**

Feedback Mechanisms trap rainforests into different potential states





Southern and Southeastern Amazon is very close to a tipping point!

Adapted from Nobre et al., 2016

Impacts of Deforestation and Degradation on Climate and Biodiversity

LOCAL

BIODIVERSITY

- Population declines
- Population isolation
- Compositional shift
- Funcional shift
- Extinction

CLIMATE

- Temperature change
- Precipitation change

LANDSCAPE

- Configuration
- Fragmentation
- Fragment isolation

REGIONAL

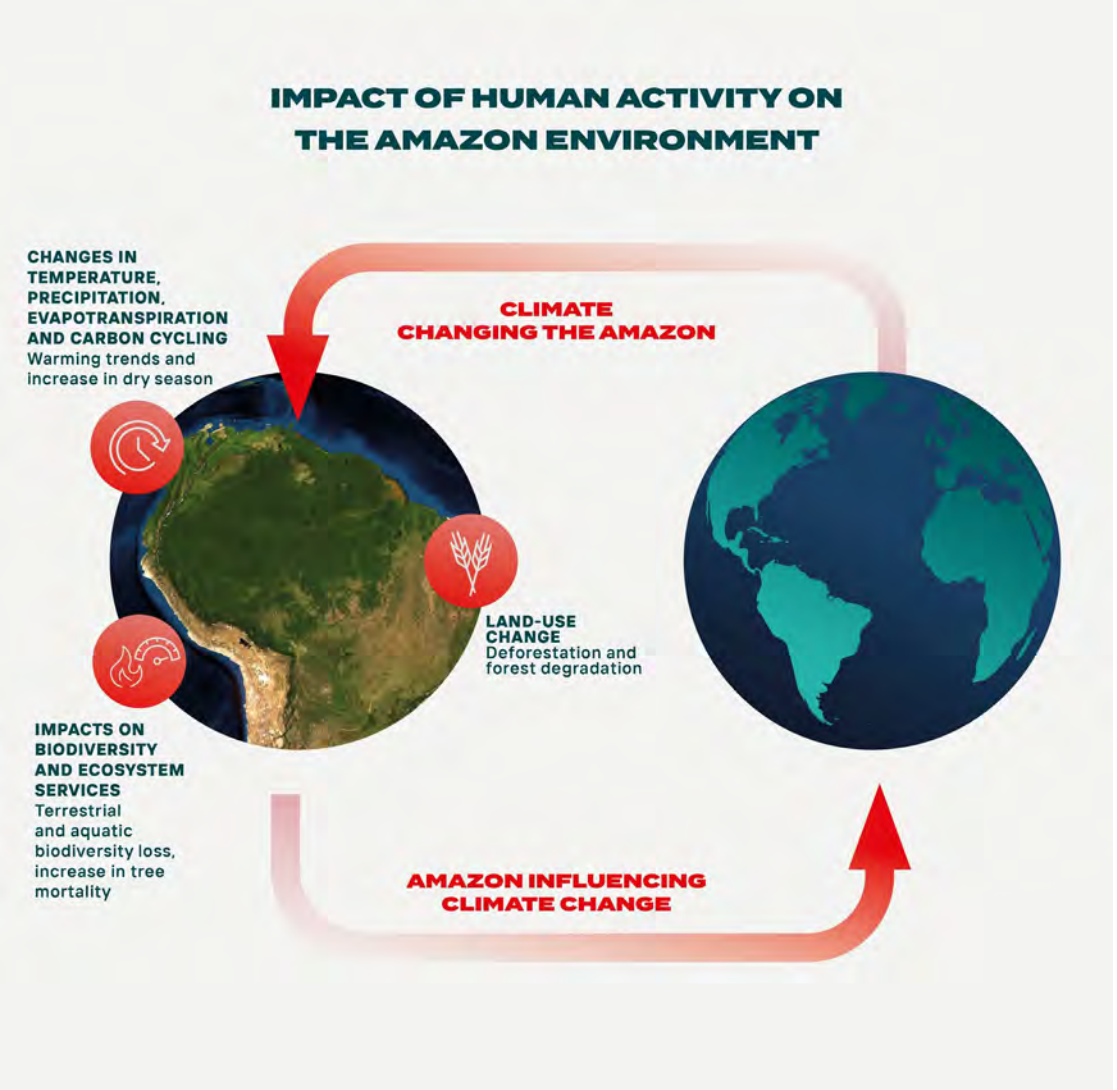
HYDROCOLOGICAL CYCLES

- Precipitation change
- Melting of Andean glaciers
- Sargassum boom in the Caribbean

GLOBAL

CLIMATE

- Emission of greenhouse gases (global warming)



Implications for climate change in the Amazon and at the global scale

Conservation, restoration and remediation

"THERE IS NO TIME TO WASTE!"

Living Amazon Vision

Objective

Ensure measures to conserve, restore and remediate terrestrial and aquatic ecosystems

Strategy 1

Cease deforestation, degradation and contamination of terrestrial and aquatic ecosystems

Strategy 2

Implement global and regional incentives for conservation, restoration and remediation

Strategy 3

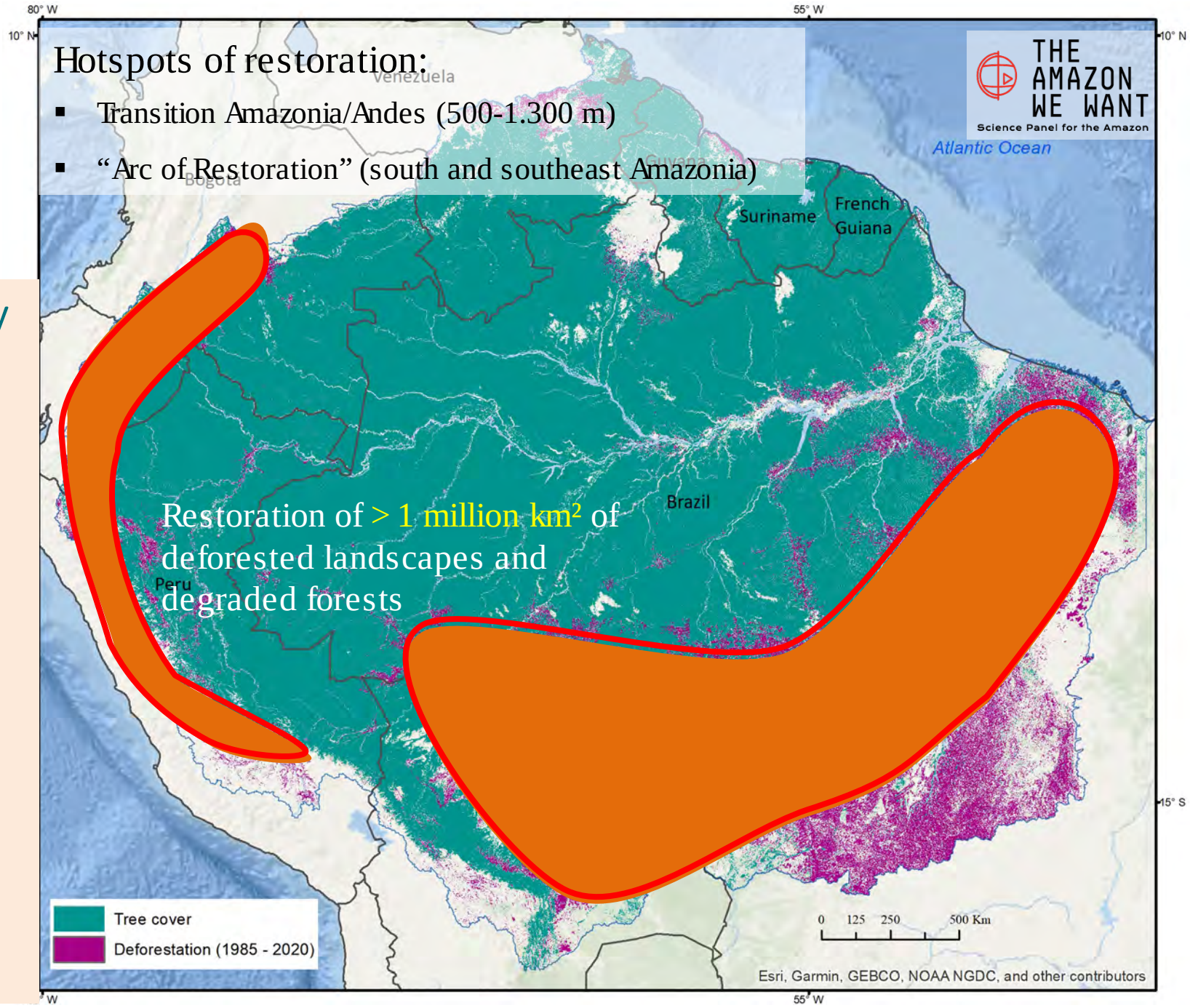
Expand, consolidate and secure protected áreas as sustainable conservation strategies

https://www.theamazonwewant.org/

"Arc of Deforestation"

"Arc of Restoration"

- Network of Protected areas effectively managed.
- Innovative approaches for conservation and restoration implemented.
- Aquatic and terrestrial ecosystems are conserved, restored and sustainably used.
- Resilience and landscape connectivity restored and maintained.
- Provides benefits to people.



Peoples empowerment and governance

"THERE IS NO TIME TO WASTE!"

Living Amazon Vision

Objective

Strengthen Amazon citizenship and governance

Strategy 1

Promote political inclusion and engage IPLCs in planning policies regarding bioeconomy and territorial and natural resource use

Strategy 2

Promote knowledge recognition and sharing for a critical Amazon citizenship

Strategy 3

Implement Bioregional and Bio Diplomacy governance system to strenthen territorial rights

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Sustainable Bioeconomy

"THERE IS NO TIME TO WASTE!"

Living Amazon Vision

Objective

Develop sustainable and circular bioeconomy of standing forest and flowing rivers

Strategy 1

Create fiscal incentives to engage private sector and multilateral institutions on innovation of Amazonian products

Strategy 2

Invest in research, marketing and productivity of Amazonian sociobiodiversity products

Strategy 3

Invest in infrastructure that enables Amazonians to benefits from the bioeconomy

Strategy 4

Promote job creation and capacity-building on bioeconomy

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LET’S SAVE AMAZONIA.
LET’S SAVE THE AMAZONIAN POPULATION!
THE AMAZON WE WANT!

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Science Panel for the Amazon

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THANK YOU!
GRACIAS!
OBRIGADA!