

# **Spatial patterns of fire in the Atlantic Forest of Bahia: analysis of driving factors and risk scenarios**

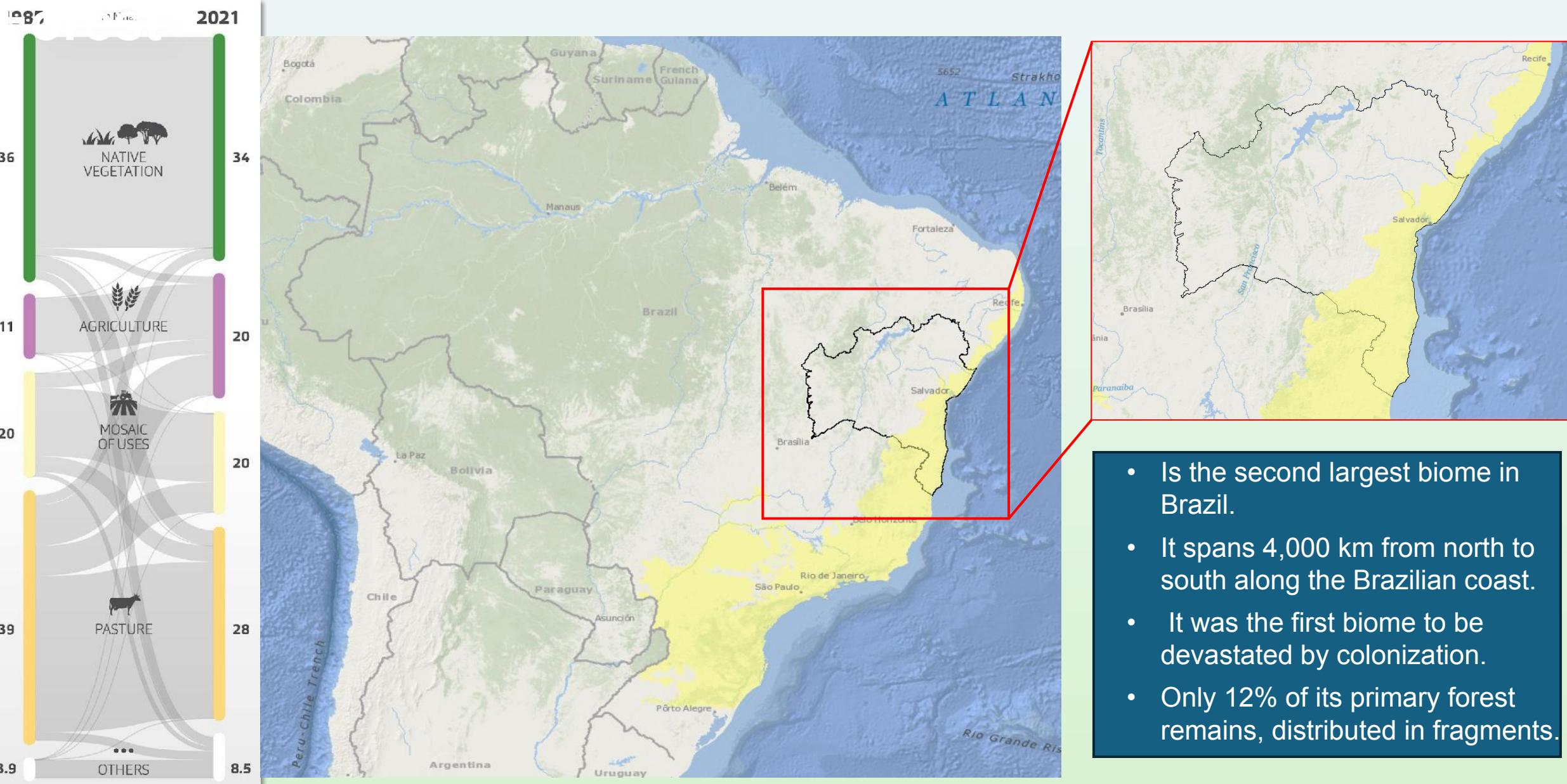
Nathália Nascimento

Porto Seguro, July 3rd

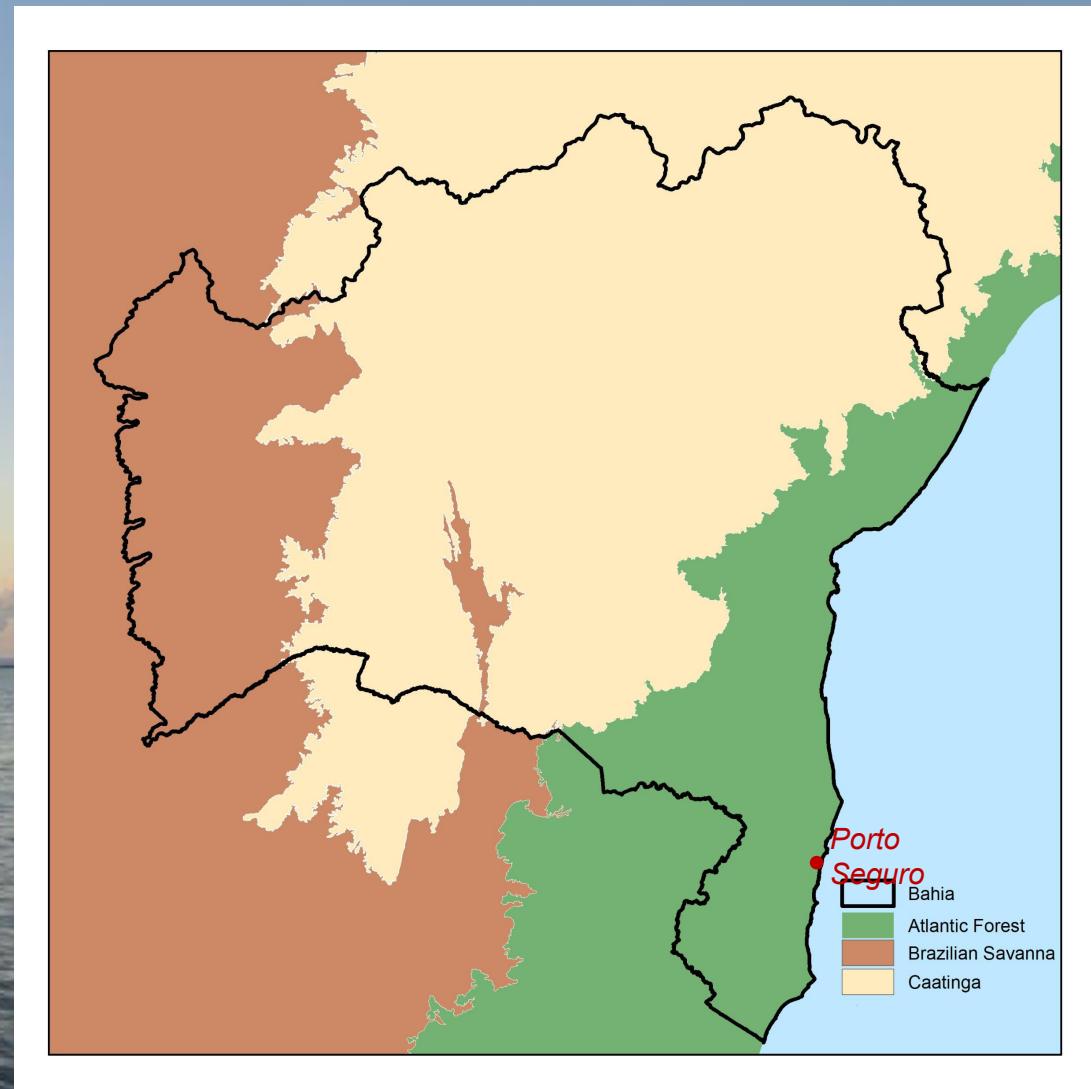


**ESALQ**  
Luiz de Queiroz College of Agriculture  
University of São Paulo

# Atlantic

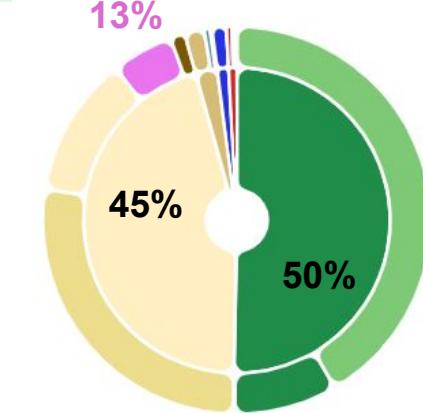
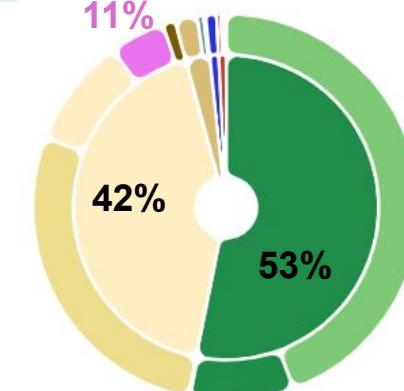
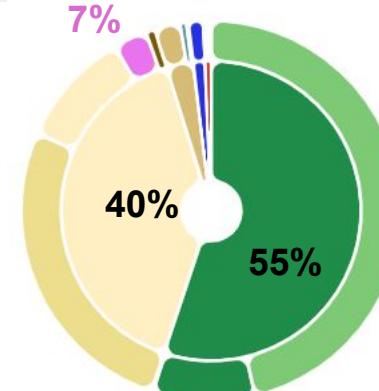
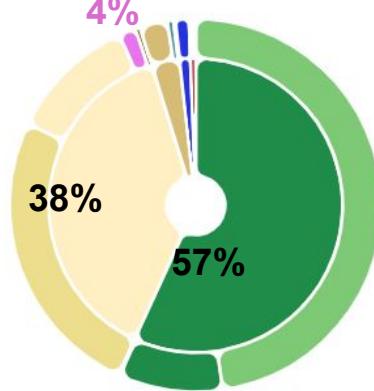
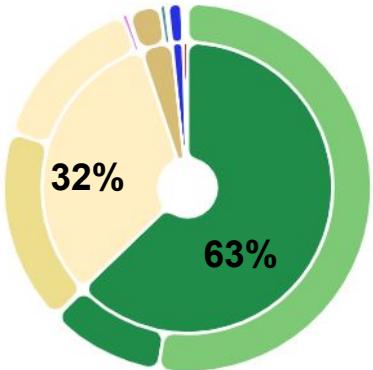
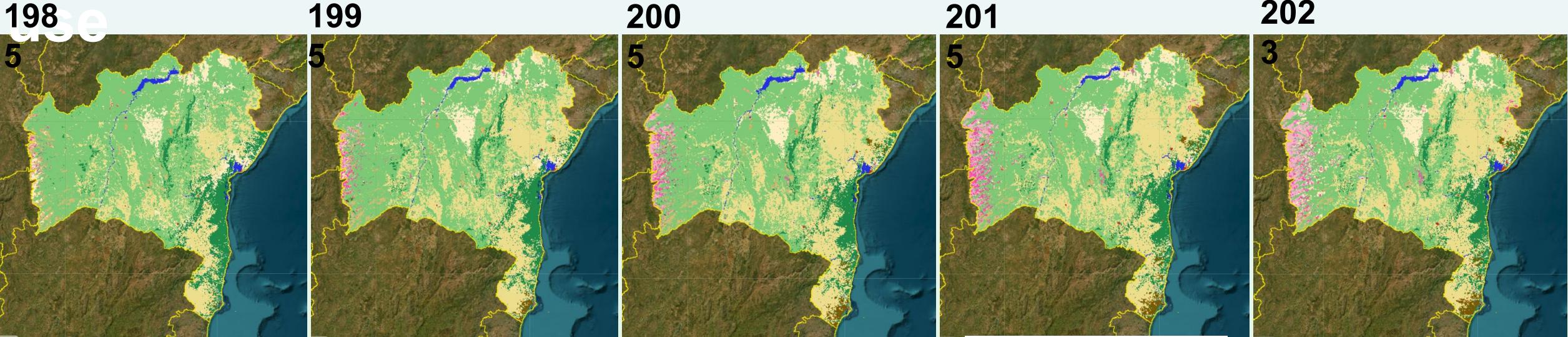


# Bahia state



# Bahia land

use



## Legend

- Forest Formation
- Savanna Formation
- Mangrove
- Floodable Forest (beta)

- Pasture
- Agriculture
- Forest Plantation
- Mosaic of Uses

- River, Lake and Ocean

**Bahia has an area of 567,295 km<sup>2</sup>**  
**It is the fourth most populous in Brazil: 14,930,634 inhabitants**

An aerial photograph showing a river winding its way through a vast landscape. The river is a light blue-grey color. The surrounding land is a mix of dark brown and green areas, likely representing different types of vegetation or soil. In the distance, there are low hills or mountains under a clear sky.

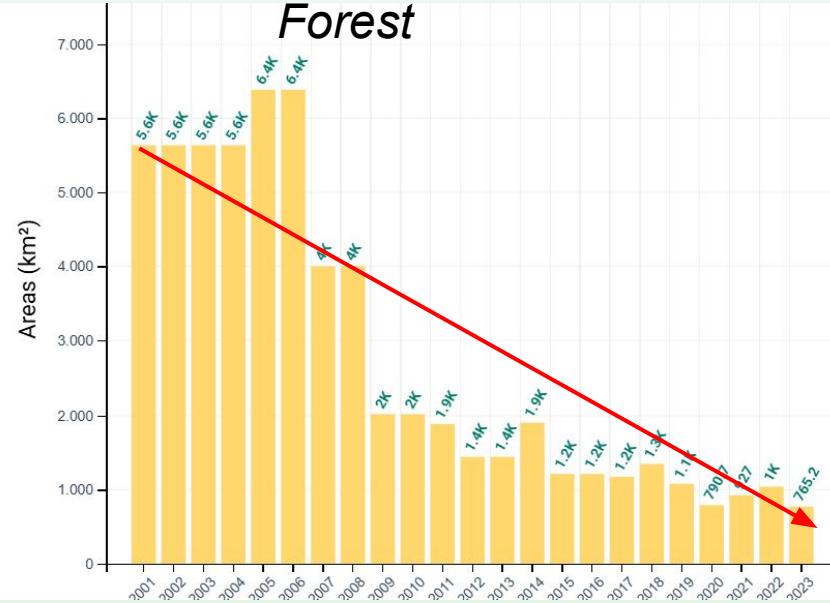
Why is it urgent  
to study fire in  
Brazil?

*Photo Araquém  
Alcântara*

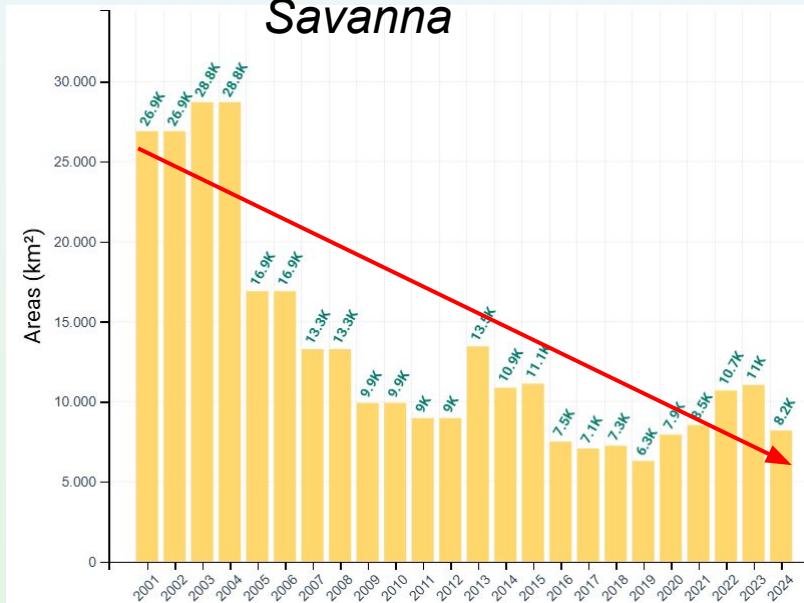
# Deforestation

N

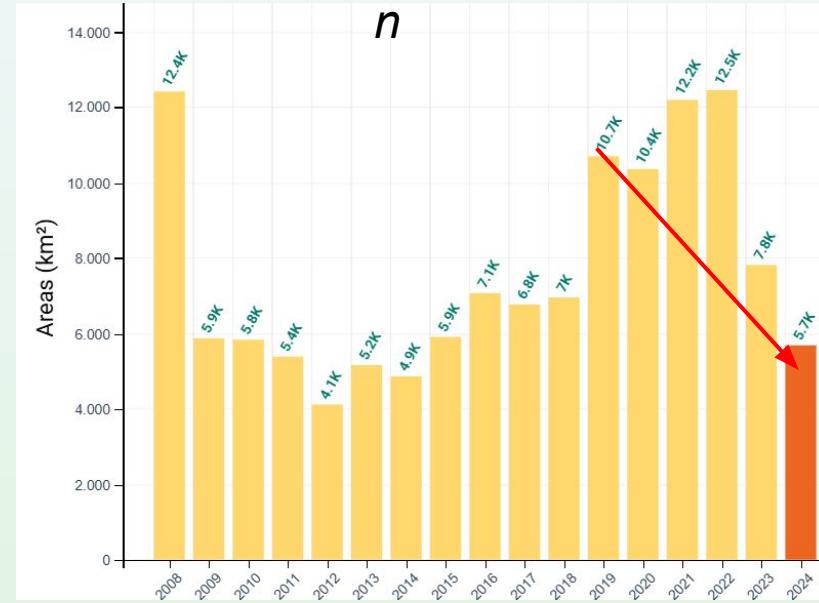
## Atlantic Forest



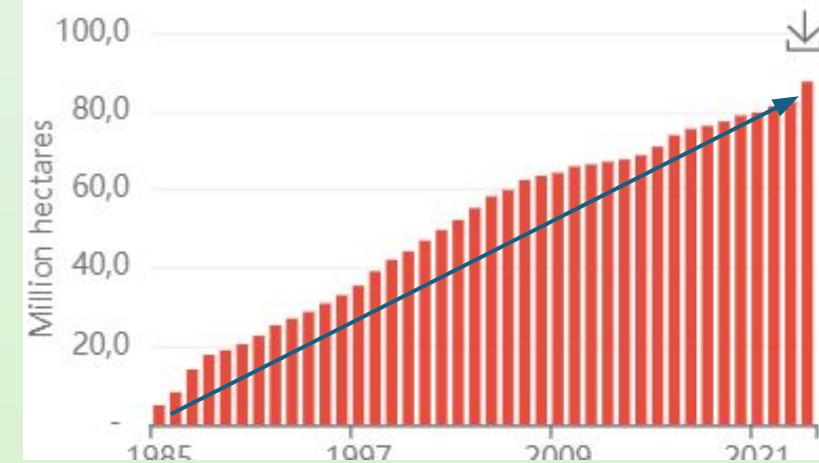
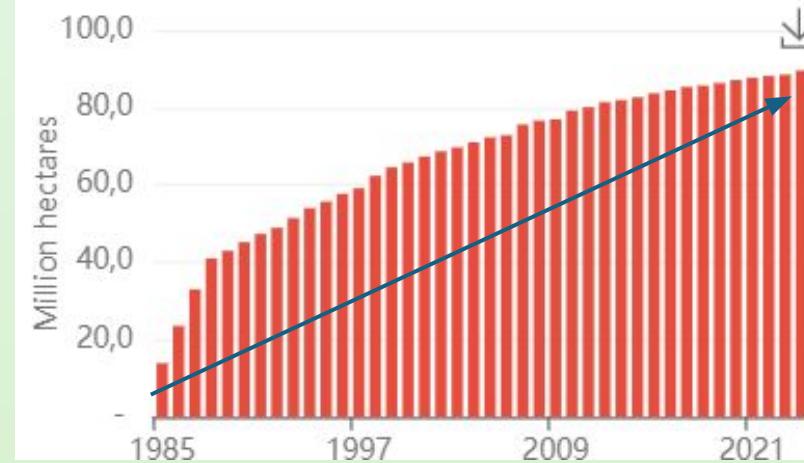
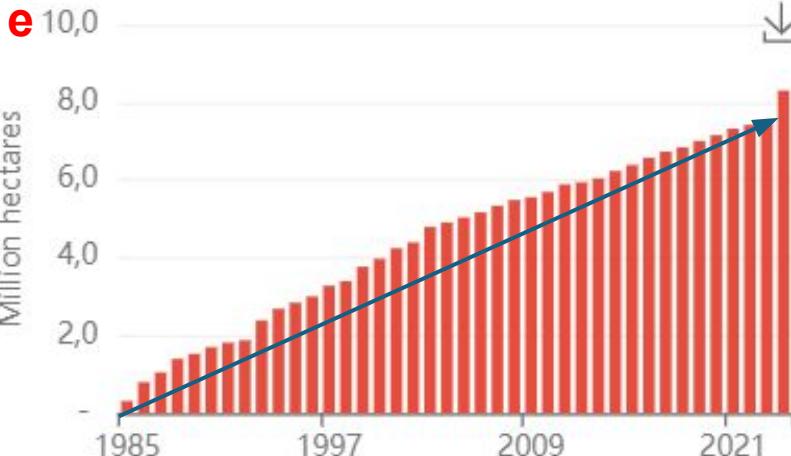
## Brazilian Savanna



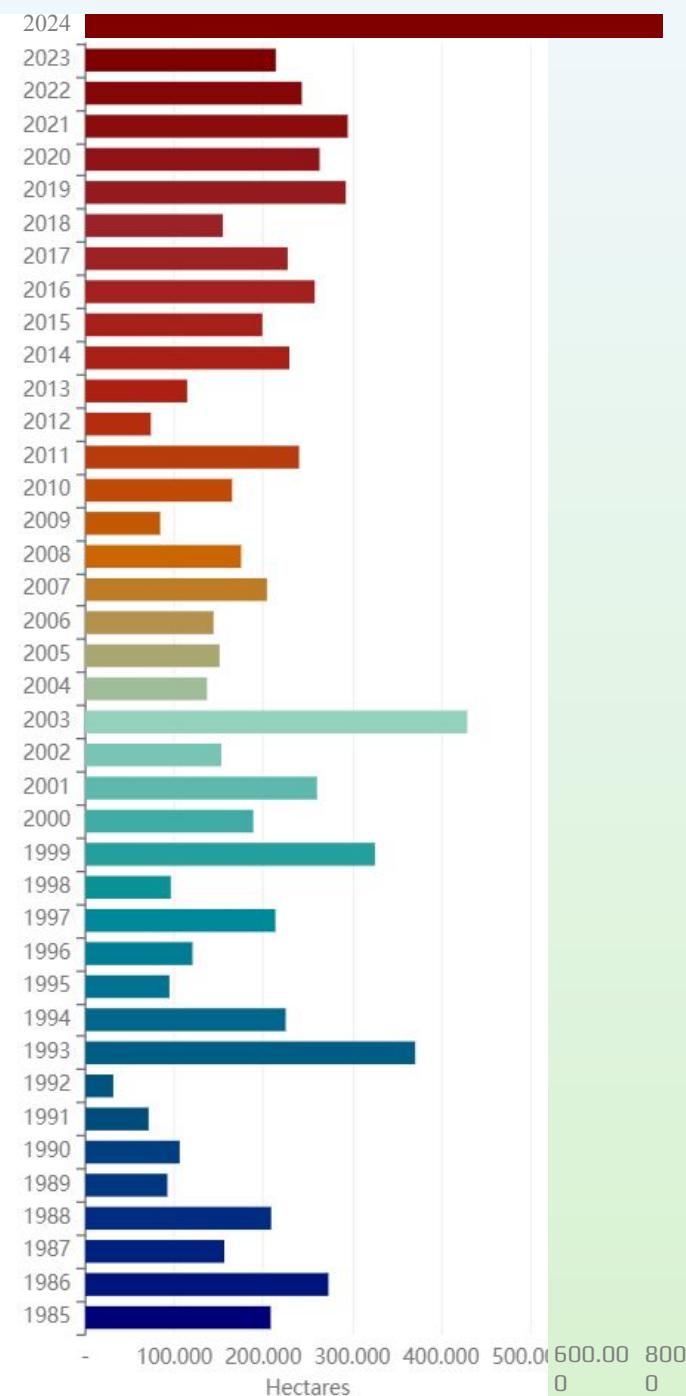
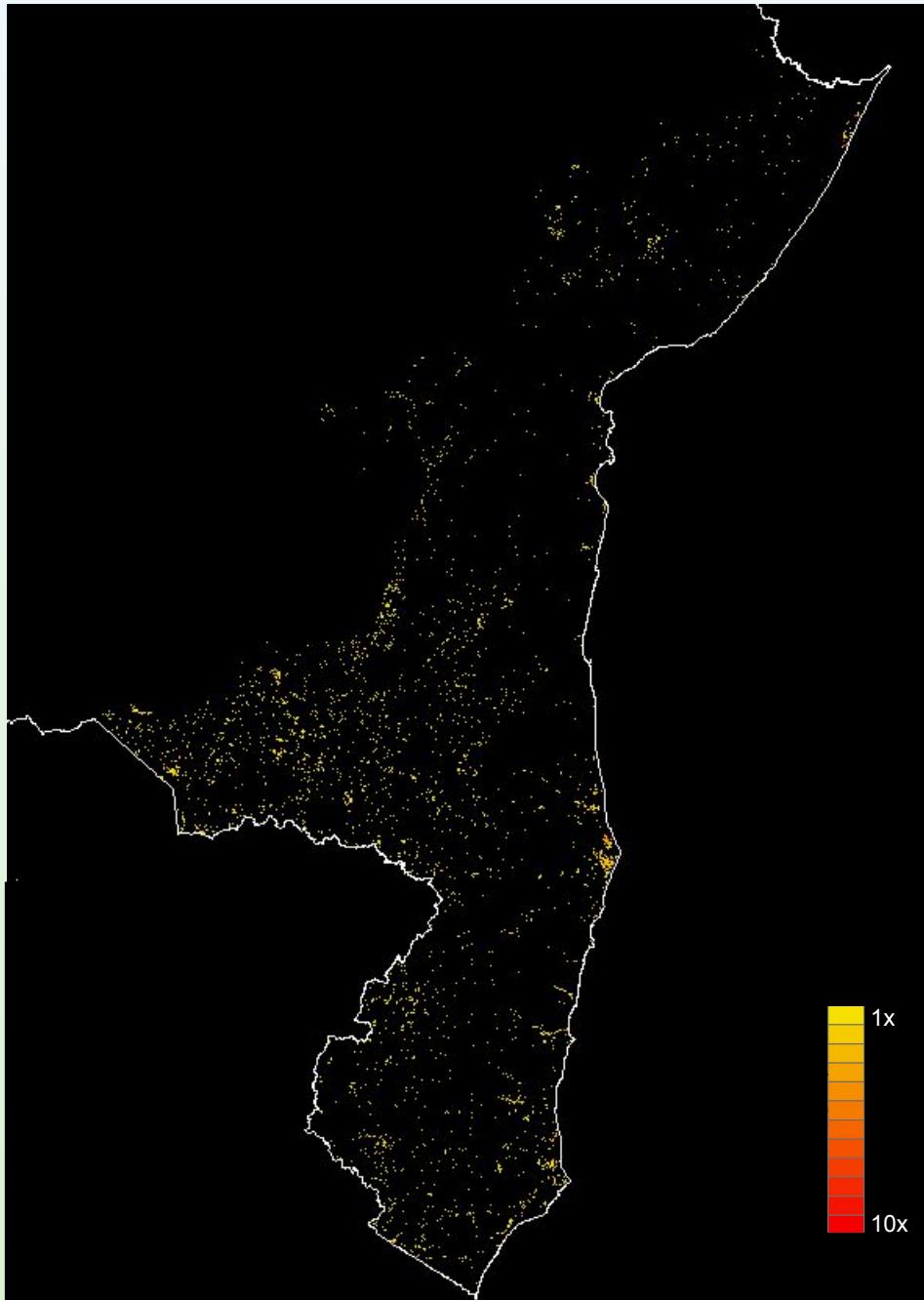
## Amazon



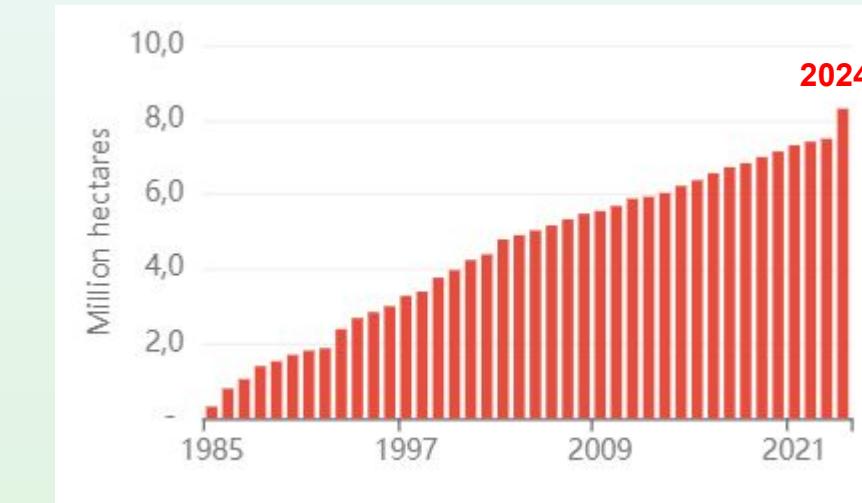
Fir



# Atlantic Forest



Burnt area accumulated in the period  
8.297.366 ha  
Total burned accumulated in the period



Area frequency (ha)



**The year 2024 represented a record for fires in the Atlantic Forest. The 1.2 million hectares affected by fire last year, which were 261% above the historical average for the biome**

(Mapbiomas, 2025)



*Photo Araquém  
Alcântara*

**The forest fires that devastated more than 30 million hectares in the country over the past year were largely caused by criminal activity. "Ibama has identified and is punishing 242 people for these major criminal fires in 2024. Other cases are still under analysis.**

(IBAMA, 2025)

**Fire is a  
socio-ecological  
issue and requires  
multidisciplinary  
research and  
targeted public  
policies.**



**Presidência da República**  
**Casa Civil**  
**Secretaria Especial para Assuntos Jurídicos**

**LEI Nº 14.944, DE 31 DE JULHO DE 2024**

Institui a Política Nacional de Manejo Integrado do Fogo e altera as Leis nºs 7.735, de 22 de fevereiro de 1989, 12.651, de 25 de maio de 2012 (Código Florestal), e 9.605, de 12 de fevereiro de 1998 (Lei dos Crimes Ambientais).

**O PRESIDENTE DA REPÚBLICA** Faço saber que o Congresso Nacional decreta e eu sanciono a seguinte Lei:

**CAPÍTULO I**

**DISPOSIÇÕES GERAIS**

Art. 1º É instituída a Política Nacional de Manejo Integrado do Fogo, com o objetivo de disciplinar e promover a articulação interinstitucional relativa:

I - ao manejo integrado do fogo;

II - à redução da incidência e dos danos dos incêndios florestais no território nacional;

III - ao reconhecimento do papel ecológico do fogo nos ecossistemas e ao respeito aos saberes e às práticas de uso tradicional do fogo.

Parágrafo único. A Política Nacional de Manejo Integrado do Fogo será implementada pela União, pelos Estados, pelo Distrito Federal, pelos Municípios, pela sociedade civil e por entidades privadas, em regime de cooperação e em articulação entre si.

# Data

## Guiding question: Where and how often does fire occur in the state?

Burned areas and fire

frequency

30m resolution

5-year period 2019 – 2023

Land use maps

## Guiding question: What factors can influence the occurrence of fire?

### Continuous:

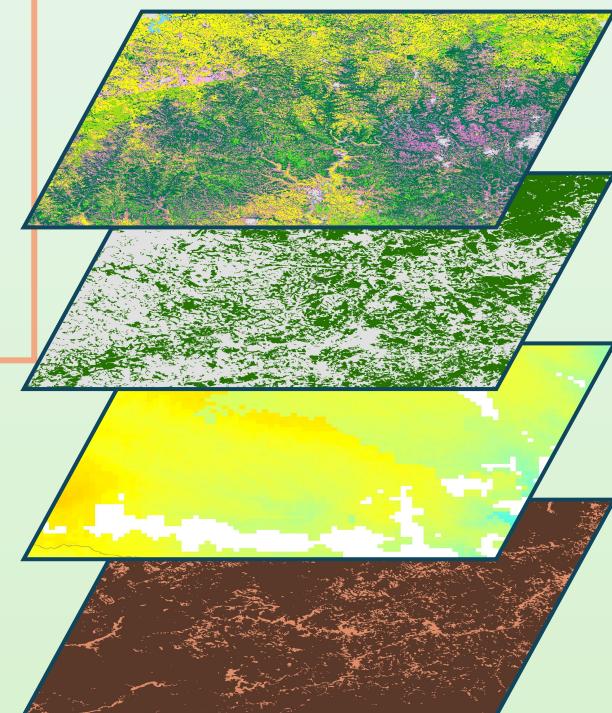
Distance to rivers,  
highways and  
agricultural areas  
and burned areas

### Static:

Tenure: Boundaries of Private Properties (4 categories)  
Indigenous Territories and Protected Areas  
Altitude and slope

### Climate data (historical data):

Average and maximum temperature  
Moisture  
Solar radiation  
Precipitation  
Water Deficit



All data is aggregated into a cube of raster

# Methodology

## Modeling Environmental Dynamics



Free software from  
University of Minas  
Gerais- Brazil

**STEP**  
**Transition matrix**

**STEP**  
**Weights Of Evidence Ranges**

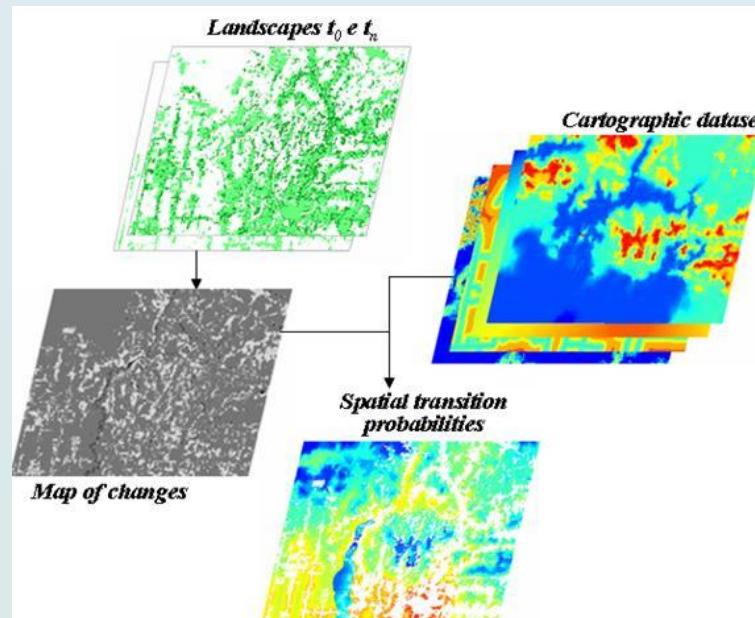
**Method developed by Agterberg & Bonham-Carter (1990)**  
Represent each variable's influence on the spatial probability

$$(1) \quad O\{D|B\} = \frac{P\{D|B\}}{P\{\overline{D}|B\}}$$

$$(2) \quad \log\{D|B\} = \log\{D\} + W^+$$

Where  $W^+$  is the Weight of Evidence of occurring event D, given a spatial pattern B. The post-probability of a transition i j, given a set of spatial data (B, C, D, ..., N), is expressed as follows:

$$P\{i \Rightarrow j | B \cap C \cap D \dots \cap N\} = \frac{e^{\sum W_N^+}}{1 + e^{\sum W_N^+}}$$

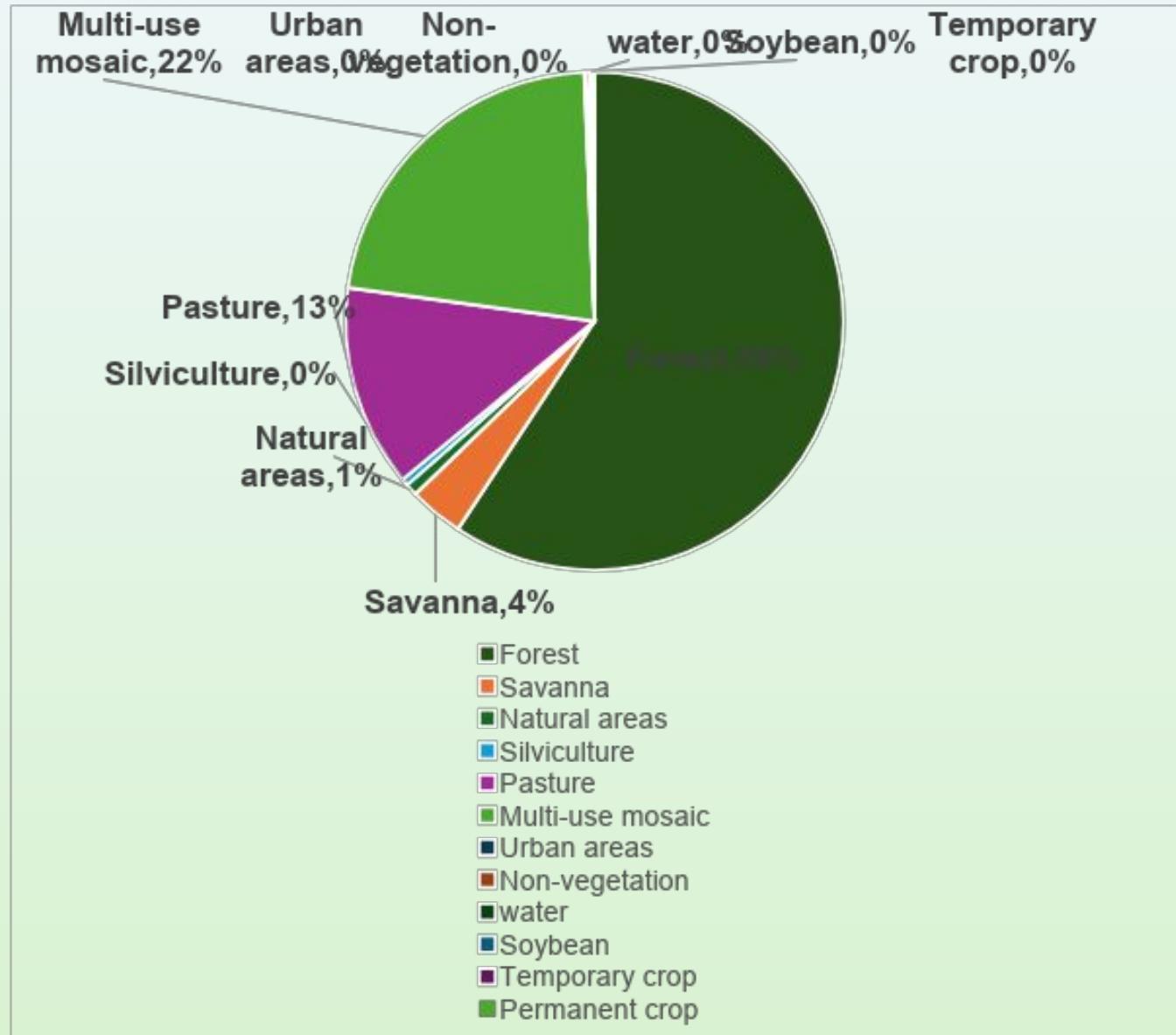


for more details



# Results

**Percentage of area  
burned by land  
use between 2019  
and 2023 in Bahia**



## Concentration of burned pixels per month

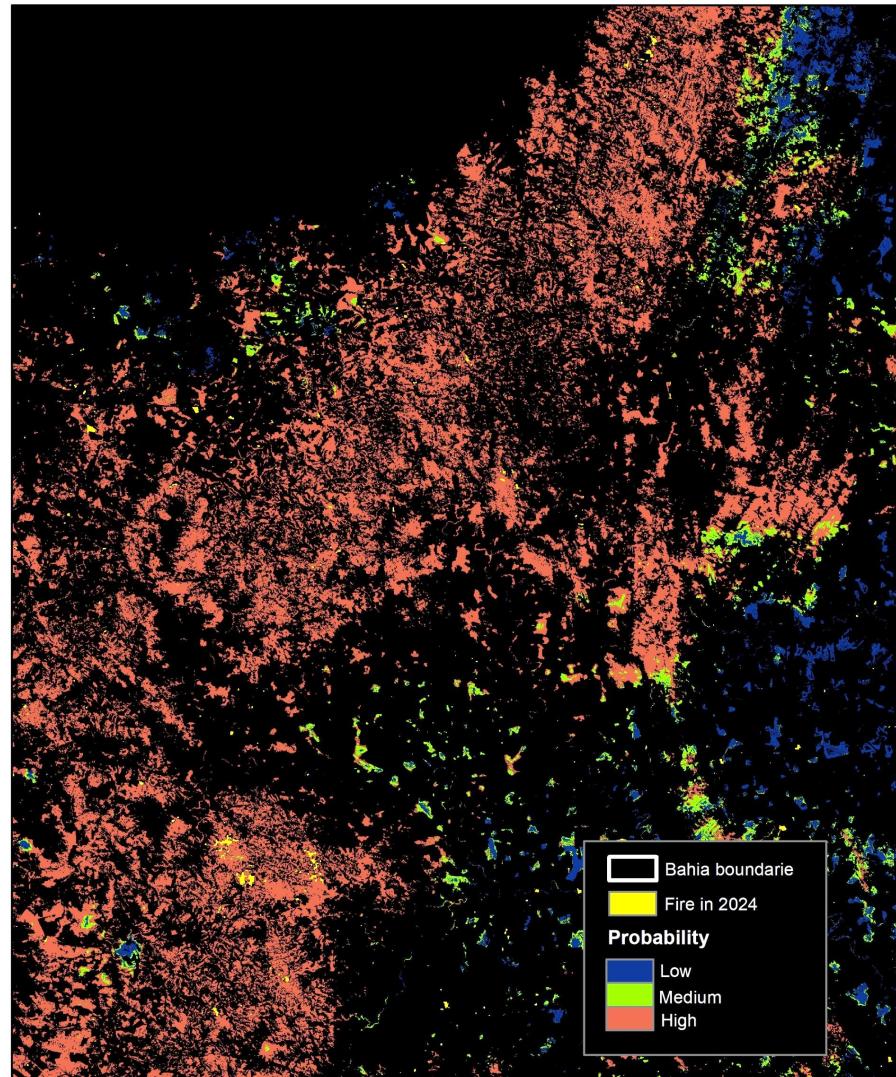
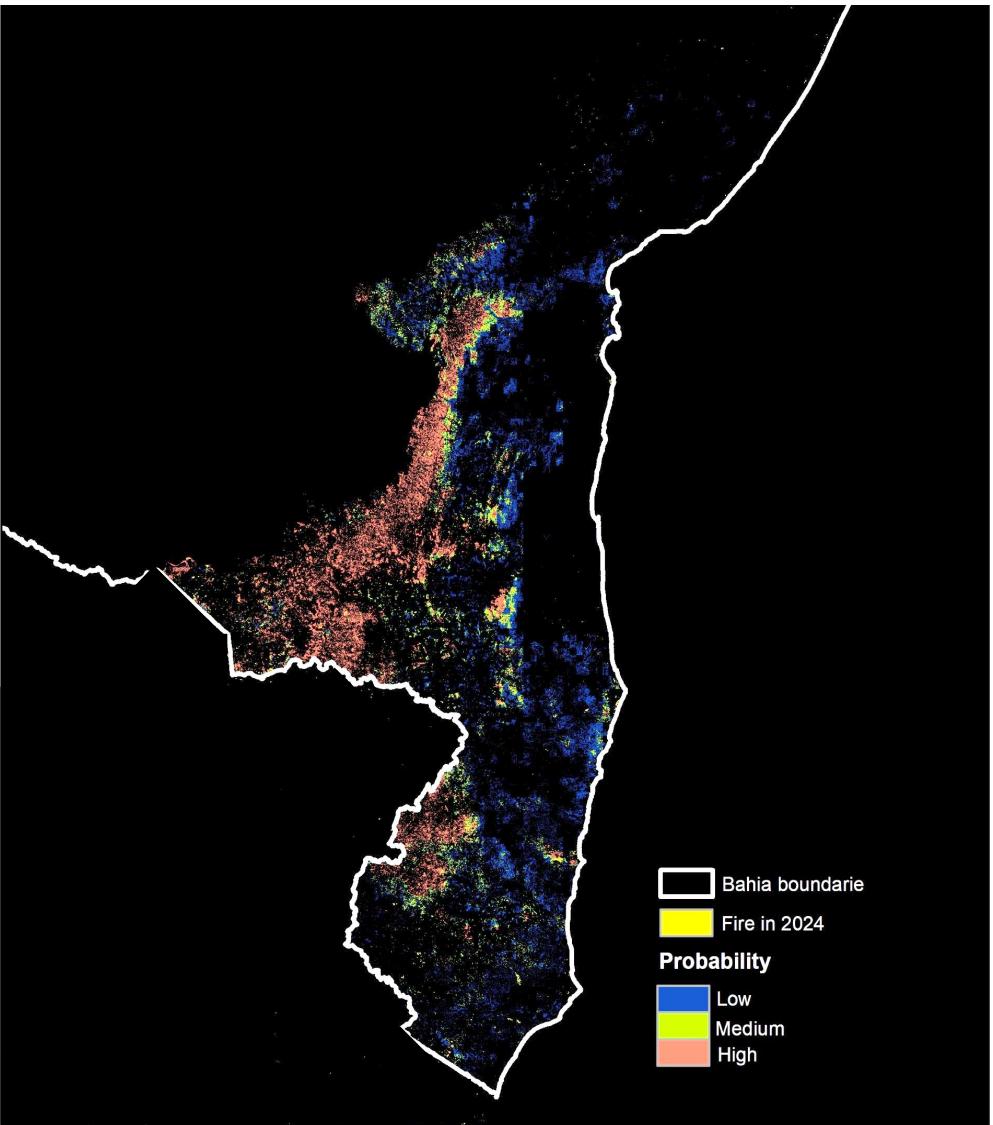


BAHIA	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
2019	16759	36869	84494	46598	16449	34896	4743	10457	19162	26868	25319	92381
2020	19917	42143	406	8464	8559	7508	10471	2063	4861	26014	14473	7648
2021	8819	10028	43333	34323	23964	23577	60372	19253	61103	92176	8033	6861
2022	5447	7847	2036	7952	395	18667	8877	31596	36884	36354	5837	5904
2023	3894	9920	5312	9321	4347	7701	4636	5510	21012	29419	204097	160574
<b>TOTAL</b>	<b>54836</b>	<b>106807</b>	<b>135581</b>	<b>106658</b>	<b>53714</b>	<b>92349</b>	<b>89099</b>	<b>68879</b>	<b>143022</b>	<b>210831</b>	<b>257759</b>	<b>273368</b>

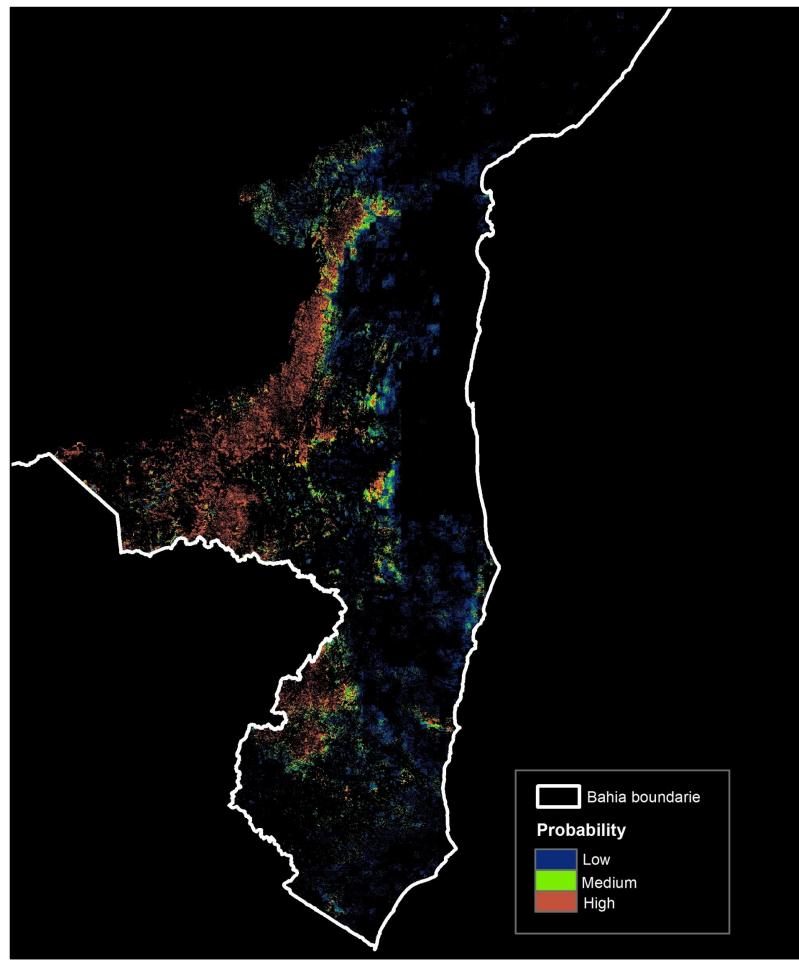
# Results - Weight of Evidence

Favors the occurrence of fire	Makes it difficult for fire to occur
Distance of 200 m from pasture	Protected areas
Distance of 95 m from the mosaic of uses	Indigenous lands
Below 200 m altitude	Medium and large Properties
2 km along highways	1 km along river banks
Water deficit above 7 mm	Above 45°
Below 23 Celsius degrees	Solar radiation above 137 (W/m <sup>2</sup> )
Precipitation below 75mm	Humidity below 78 (g/m <sup>3</sup> )
Favors the occurrence of fire (2 times)	Makes it difficult for fire to occur (2 times)
Proximity if bunerd área	Protected areas
1 km along highways	Indigenous lands
Favors the occurrence of fire (3 times)	Makes it difficult for fire to occur (3 times)
Proximity if bunerd área	

# Results – Fire risk probability map



# Fire risk scenarios



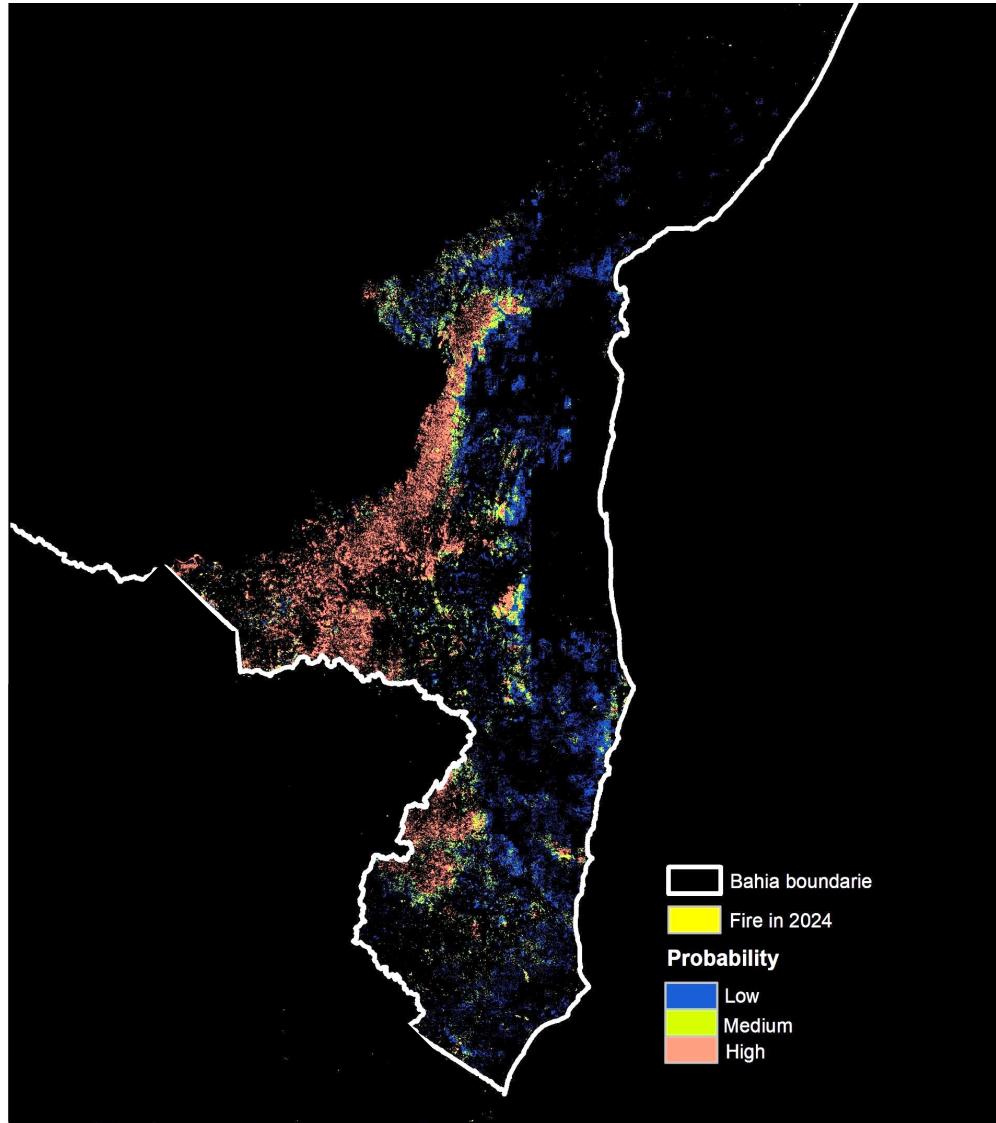
1  
time



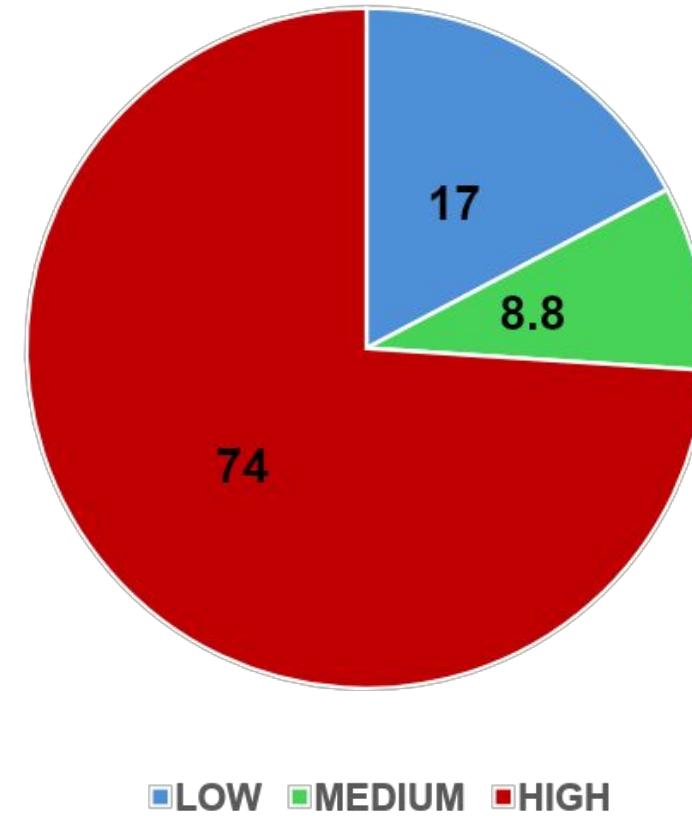
2  
times



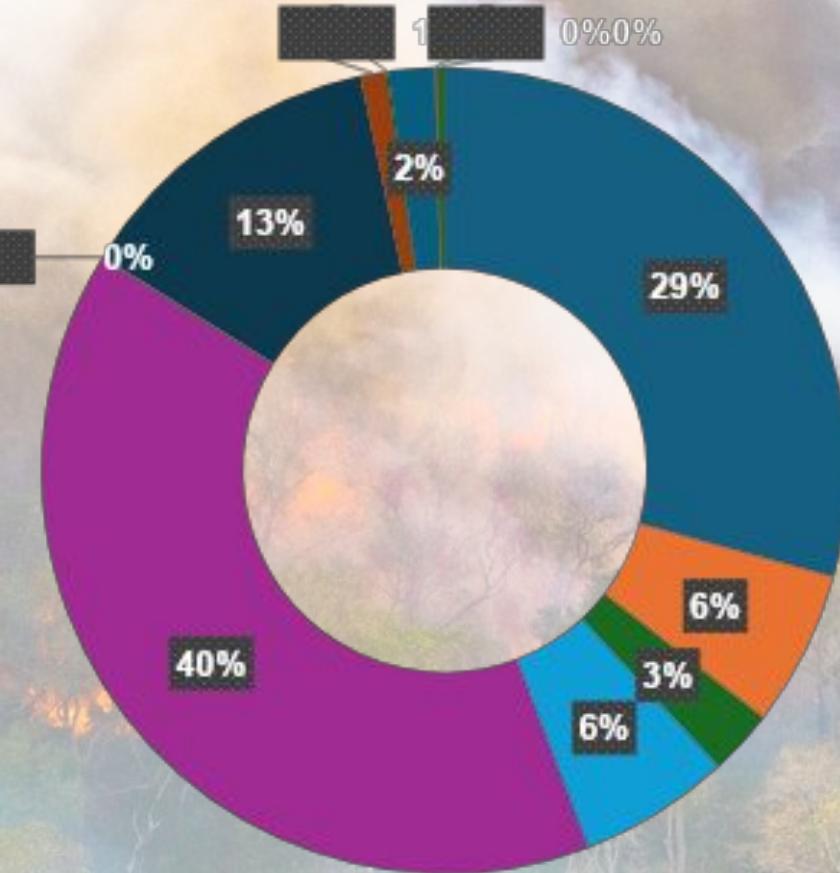
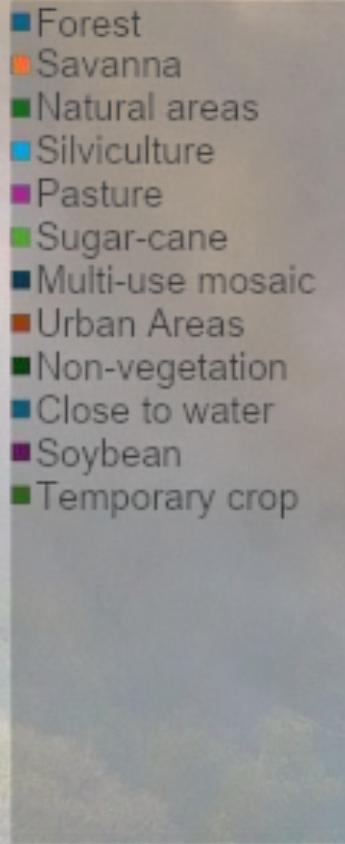
3  
times



**Fire distribution (2024) by risk classes (%)**



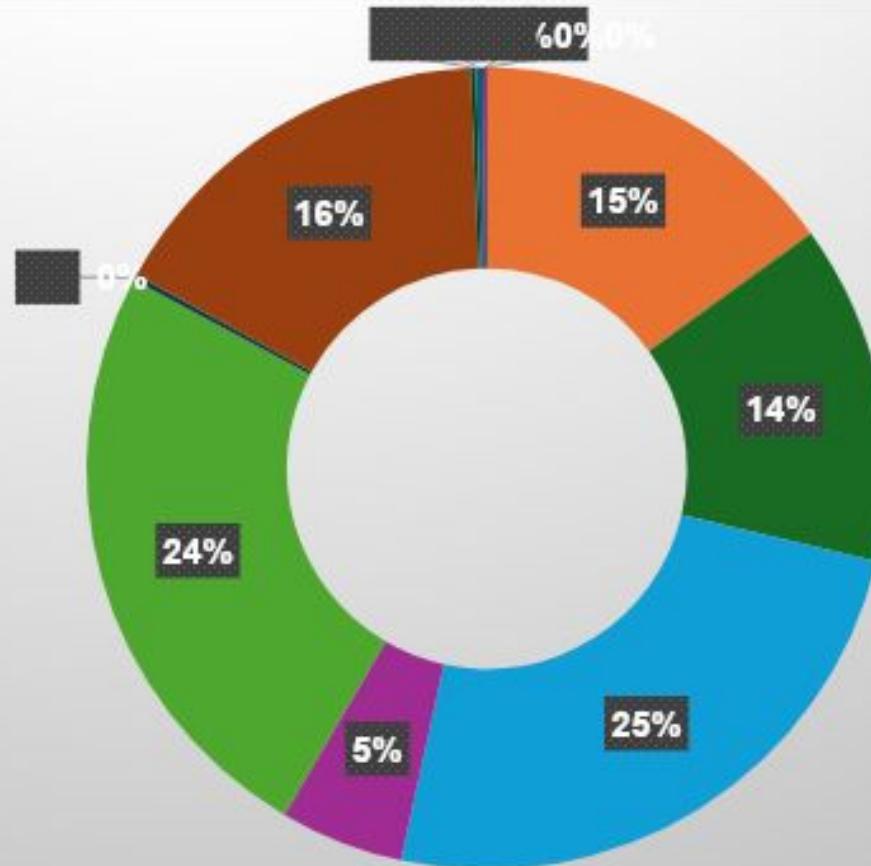
# Exploring the 2024 fire



Forest	29,3
Savanna	6,2
Natural areas	2,6
Silviculture	6,1
Pasture	39,6
Sugar-cane	0,0
Multi-use mosaic	12,8
Urban Areas	1,0
Non-vegetation	0,1
Close to water	1,8
Soybean	0,1
Temporary crop	0,3
Permanent crop	0,0

# Exploring the 2024 fire in previously burned area

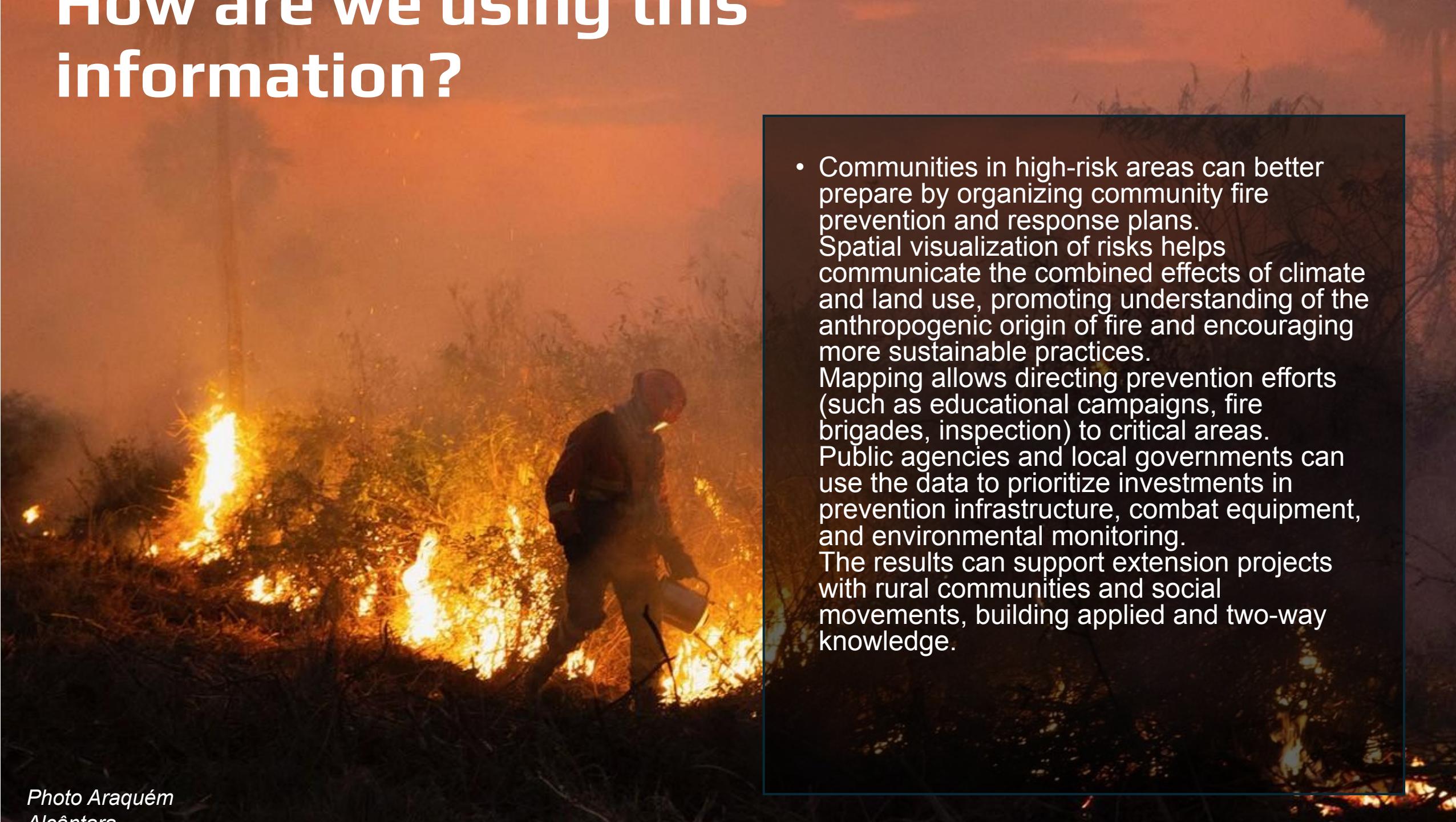
- Forest
- Savanna
- Natural areas
- Silviculture
- Pasture
- Sugar-cane
- Multi-use mosaic
- Urban Areas
- Non-vegetation
- Close to water
- Temporary crop



Forest	0,0
Savanna	15,0
Natural areas	13,7
Silviculture	24,7
Pasture	5,0
Sugar-cane	24,4
Multi-use mosaic	0,3
Urban Areas	16,3
Non-vegetation	0,2
Close to water	0,3
Temporary crop	0,2

The burned area again represents less than 1% of the total burned in 2024

# How are we using this information?



- Communities in high-risk areas can better prepare by organizing community fire prevention and response plans. Spatial visualization of risks helps communicate the combined effects of climate and land use, promoting understanding of the anthropogenic origin of fire and encouraging more sustainable practices. Mapping allows directing prevention efforts (such as educational campaigns, fire brigades, inspection) to critical areas. Public agencies and local governments can use the data to prioritize investments in prevention infrastructure, combat equipment, and environmental monitoring. The results can support extension projects with rural communities and social movements, building applied and two-way knowledge.



*Photo Araquém  
Alcântara*

USP

ESALQ

Thank you!  
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