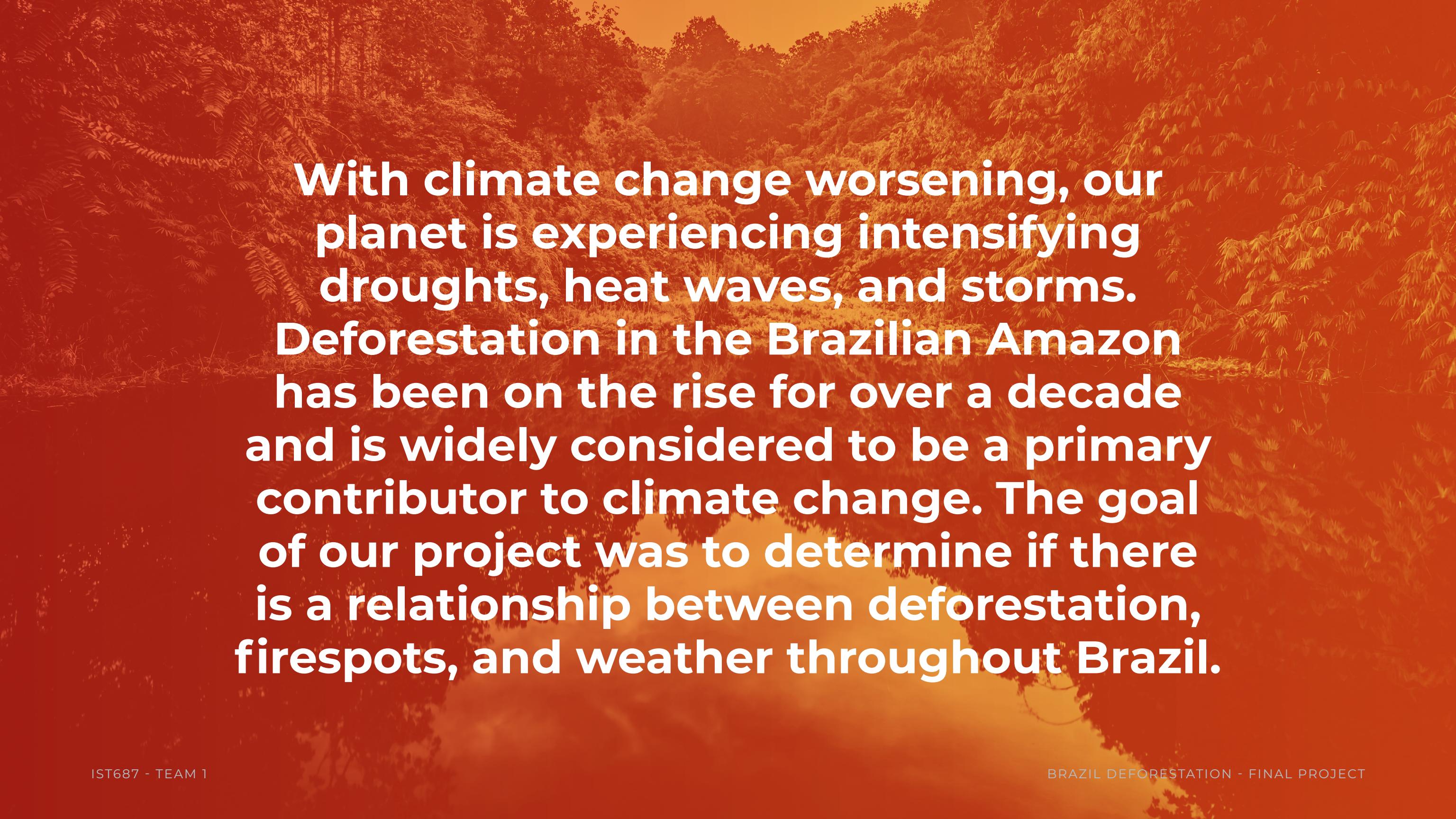




IST 687 - TEAM 1  
**BRAZIL**  
**DEFORESTATION**  
FINAL PROJECT

LEI CHENG  
KATIE HAUGH  
GAREN MOGOYAN  
SANDY SPICER  
KARL TREEN

The background of the slide is a photograph of a lush, green tropical forest. A river or stream is visible winding its way through the trees. The lighting suggests it might be sunset or sunrise, with warm tones filtering through the canopy.

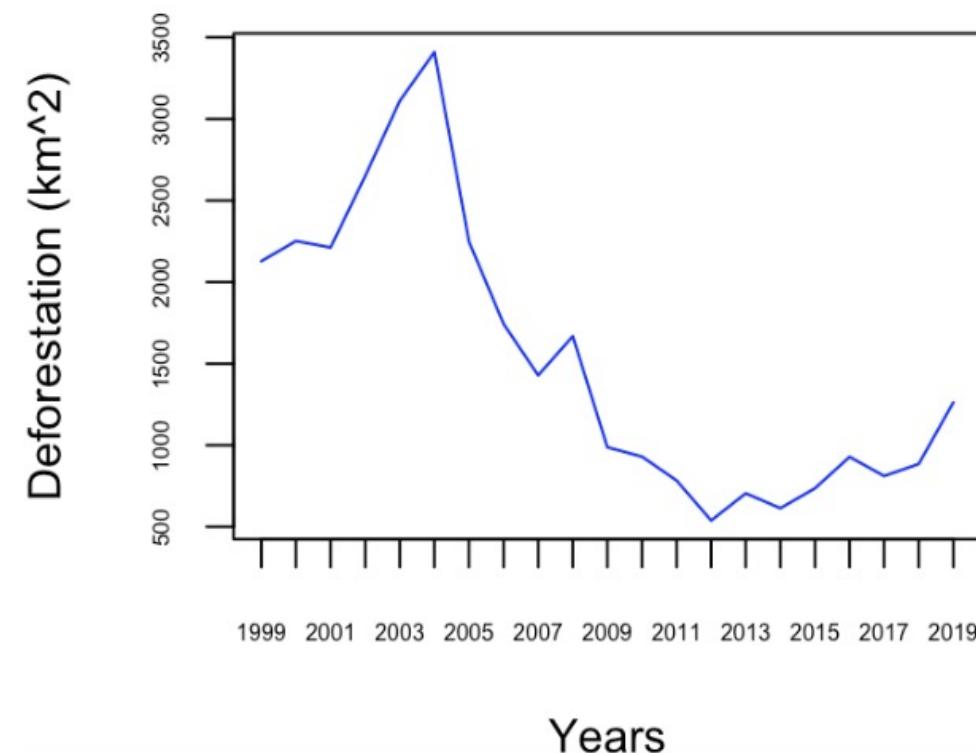
**With climate change worsening, our planet is experiencing intensifying droughts, heat waves, and storms. Deforestation in the Brazilian Amazon has been on the rise for over a decade and is widely considered to be a primary contributor to climate change. The goal of our project was to determine if there is a relationship between deforestation, firespots, and weather throughout Brazil.**

# AVERAGE DEFORESTATION

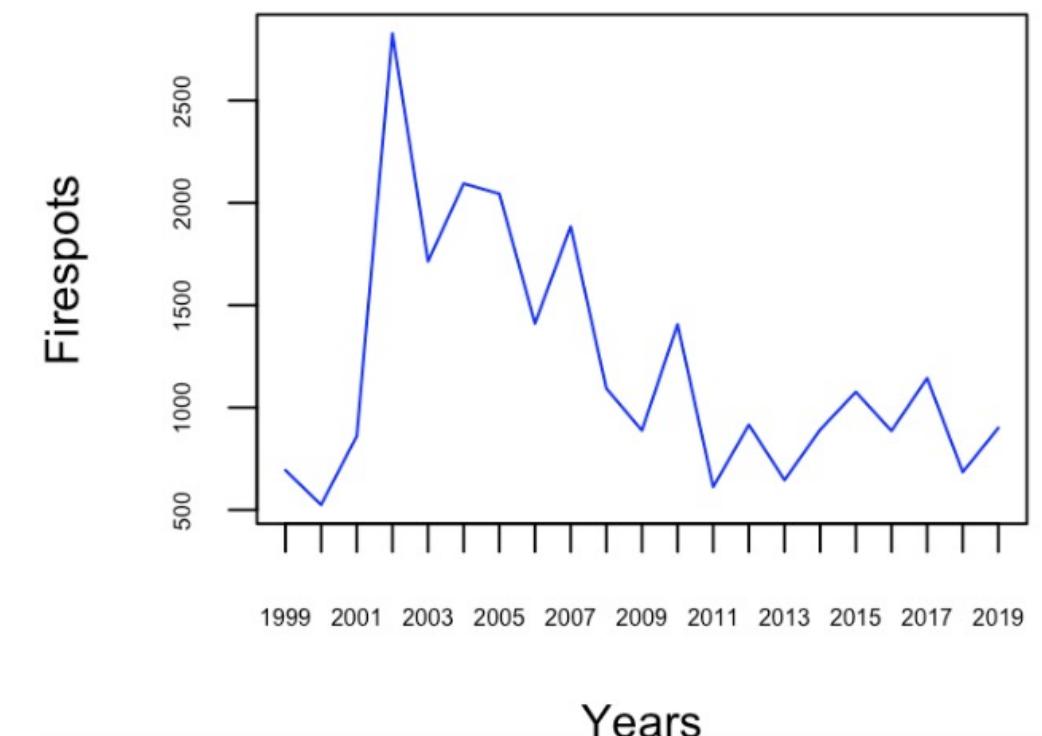
VS

# AVERAGE FIRESPOTS

Deforestation from 1999-2019



Firespots from 1999-2019



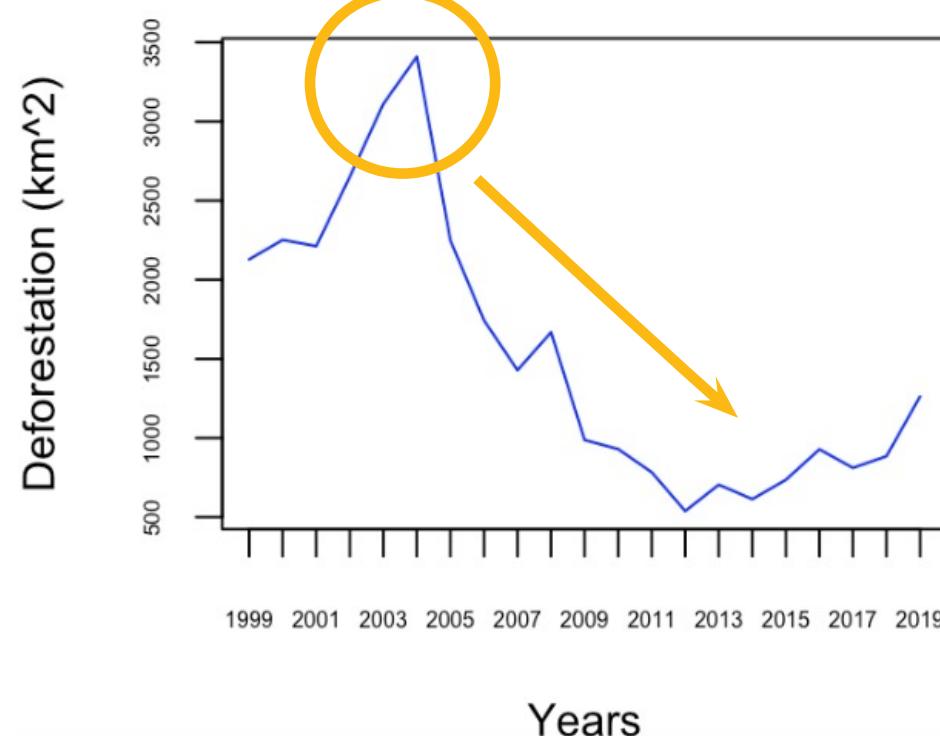
# AVERAGE DEFORESTATION

VS

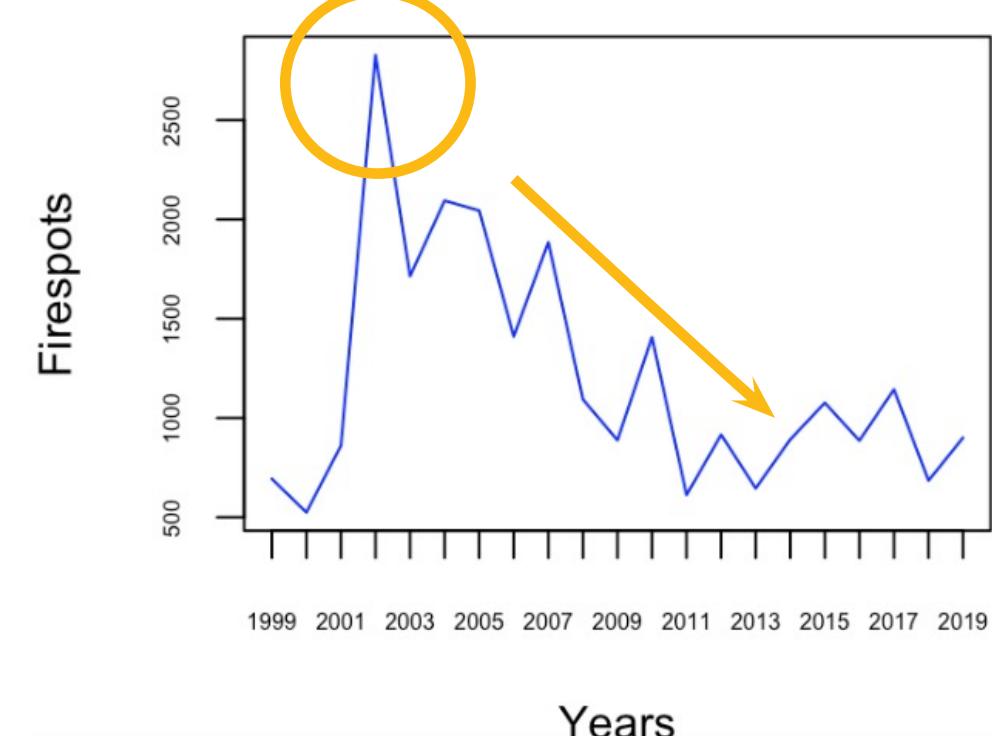
# AVERAGE FIRESPOTS

Both firespots and deforestation peak in the early 2000s and slowly drop off overtime

Deforestation from 1999-2019



Firespots from 1999-2019



# TOP 10 DEFORESTATION

Year	State	Deforestation (km <sup>2</sup> )
2004	MT	11814
2003	MT	10405
2004	PA	8870
2002	MT	7892
2001	MT	7703
2002	PA	7510
2005	MT	7145
2003	PA	7145
1999	MT	6963
2000	PA	6671

Mato Grosso (MT)

**60%**  
OF TOP SPOTS

Pará (PA)

**40%**  
OF TOP SPOTS

# TOP 10 FIRESPOTS

Year	State	Firespots
2002	PA	8904.08333
2002	MT	6640.00000
2004	PA	6184.50000
2005	PA	5956.41667
2004	MT	5868.50000
2007	PA	5707.58333
2010	PA	4766.33333
2006	PA	4653.33333
2005	MT	4457.41667
2003	PA	4420.00000

Mato Grosso (MT)

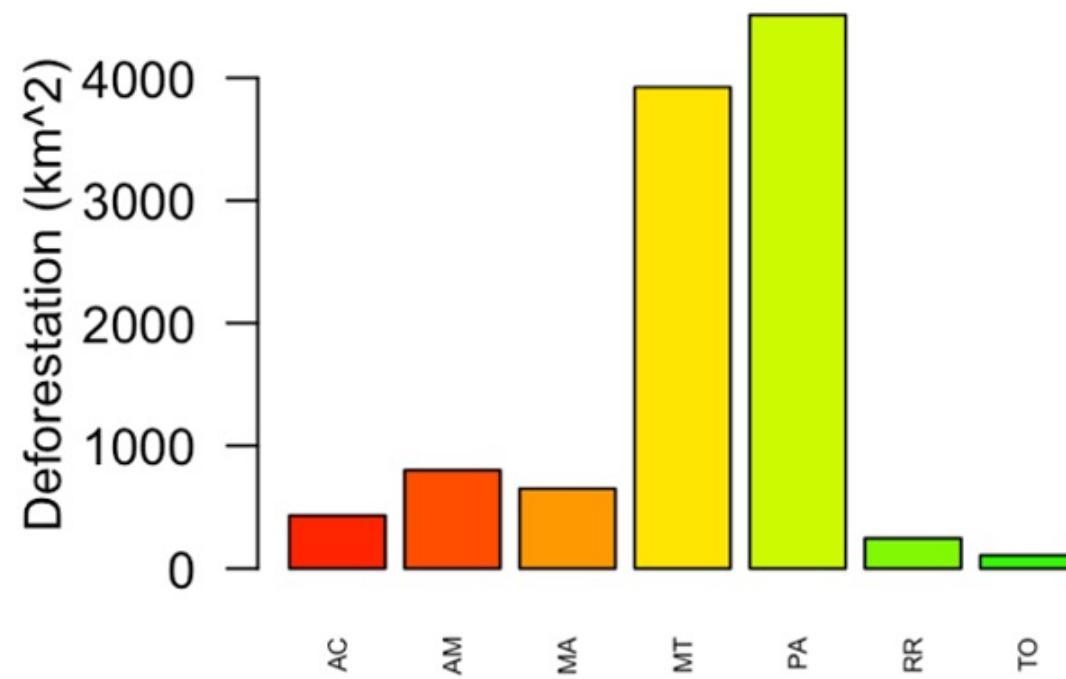
Pará (PA)

**30%**  
OF TOP SPOTS

**70%**  
OF TOP SPOTS

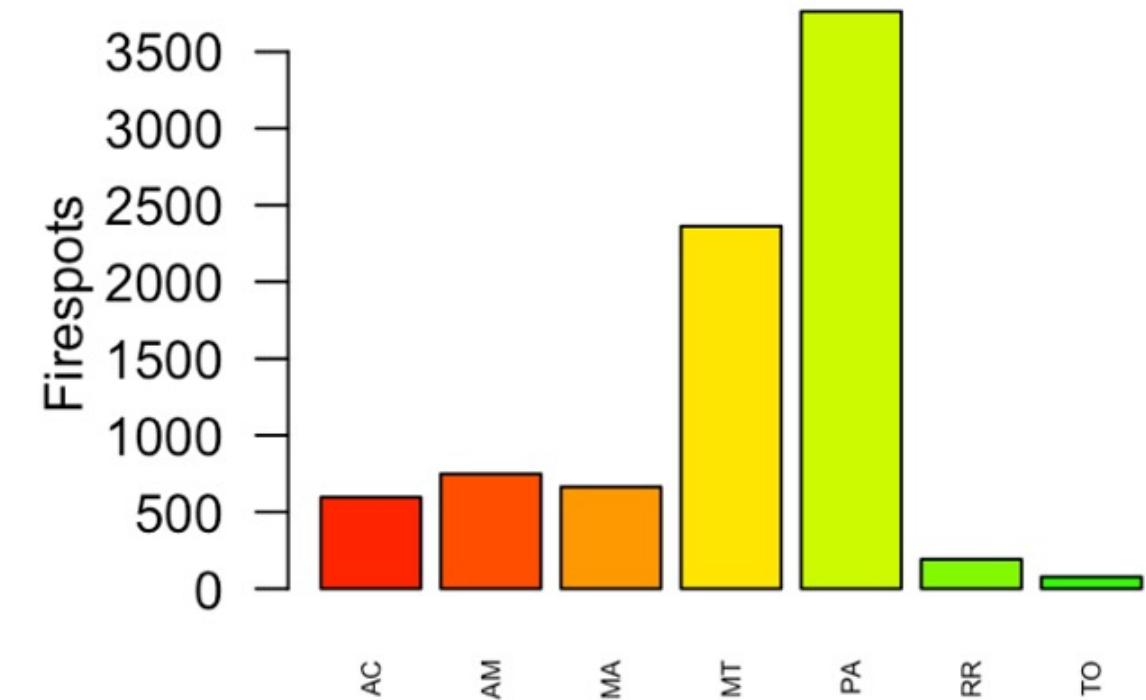
# DEFORESTATION BY STATE

Deforestation by State



# FIRESPOTS BY STATE

Firespots by State



# STATES OF FOCUS

We decided to focus our analysis on states with diverse levels of firespots and deforestation

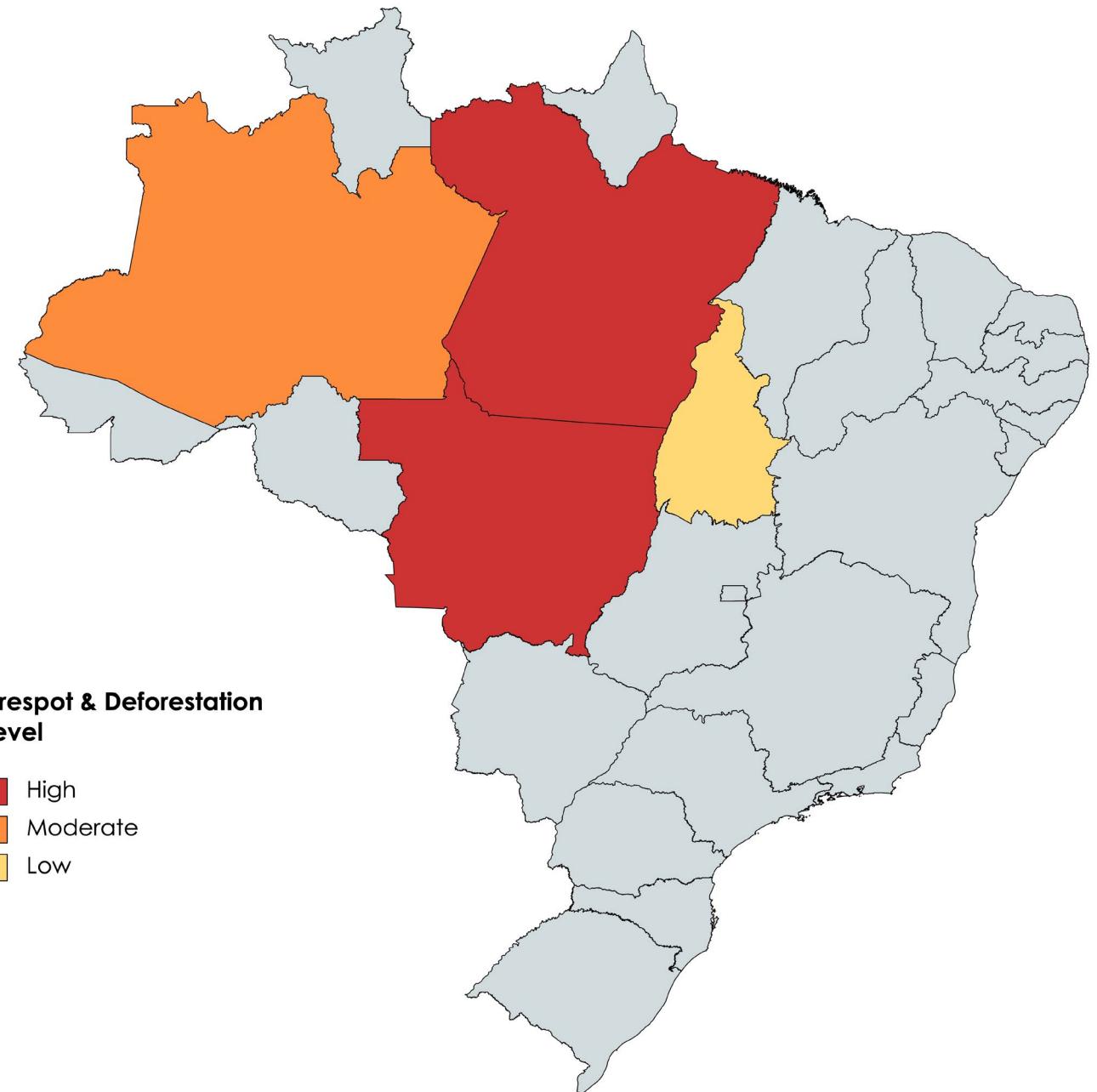
We chose the following states:

Para (High)

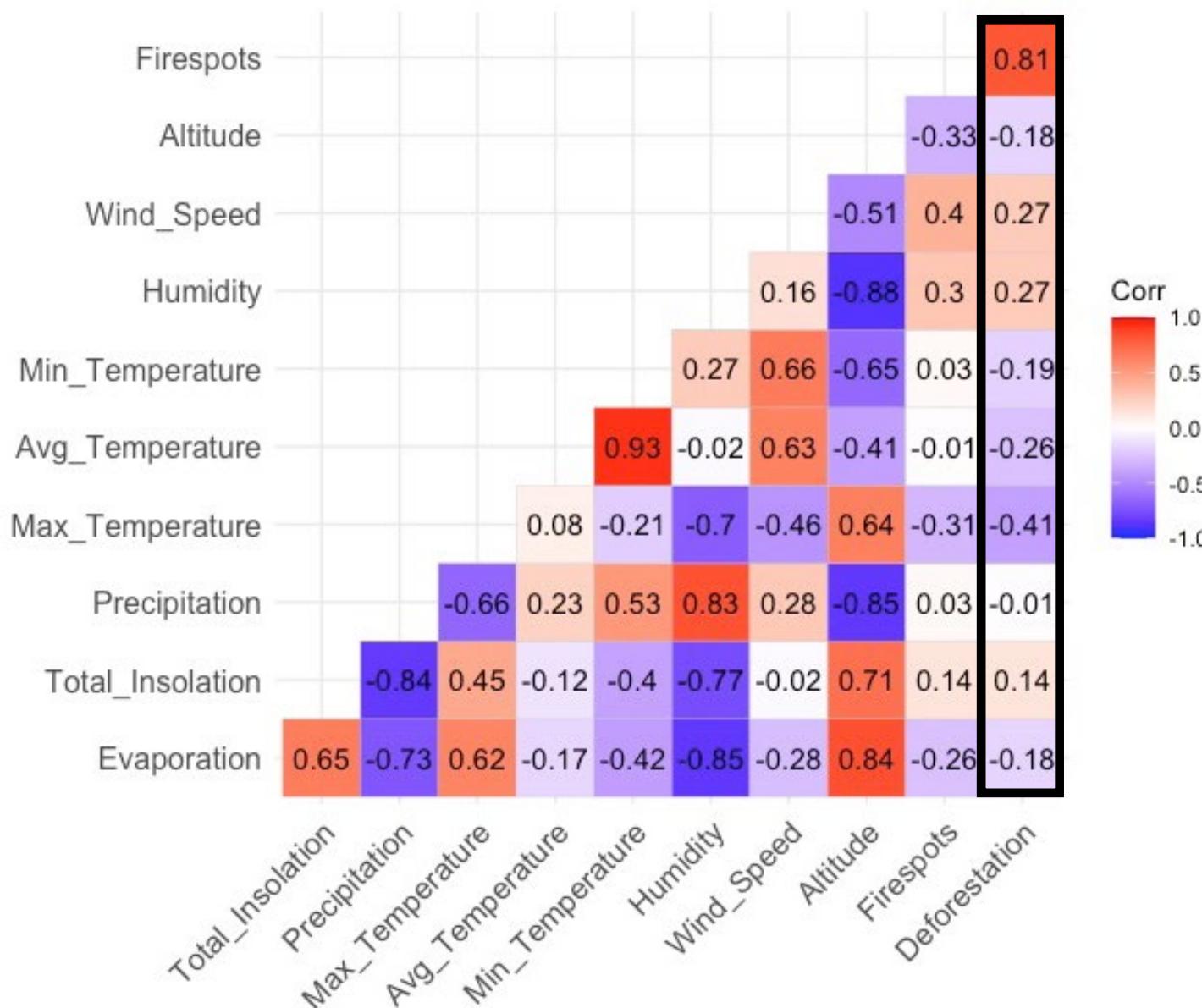
Mato Grosso (High)

Amazonas (Moderate)

Tocantins (Low)



# CORRELATION



Strongest Positive Correlation

**0.81 FIRESPOTS**

Strongest Negative Correlation

**-0.41 MAX TEMPERATURE**

The only significant correlation with deforestation in the dataset is **firespots**.

# DEFORESTATION REGRESSION

```
lm(formula = Deforestation ~ Humidity + Wind_Speed + Altitude  
+ Firespots, data = yearlySummaryRefined)
```

Residuals:

Min	1Q	Median	3Q	Max
-3078.3	-887.5	-101.1	663.3	3952.6

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-3.661e+04	6.581e+03	-5.563	3.50e-07 ***
Humidity	3.632e+02	6.472e+01	5.612	2.86e-07 ***
Wind_Speed	4.466e+03	1.076e+03	4.152	8.27e-05 ***
Altitude	2.268e+01	3.944e+00	5.749	1.62e-07 ***
Firespots	1.044e+00	9.332e-02	11.184	< 2e-16 ***

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1385 on 79 degrees of freedom

Multiple R-squared: 0.7607, Adjusted R-squared: 0.7486

F-statistic: 62.8 on 4 and 79 DF, p-value: < 2.2e-16`

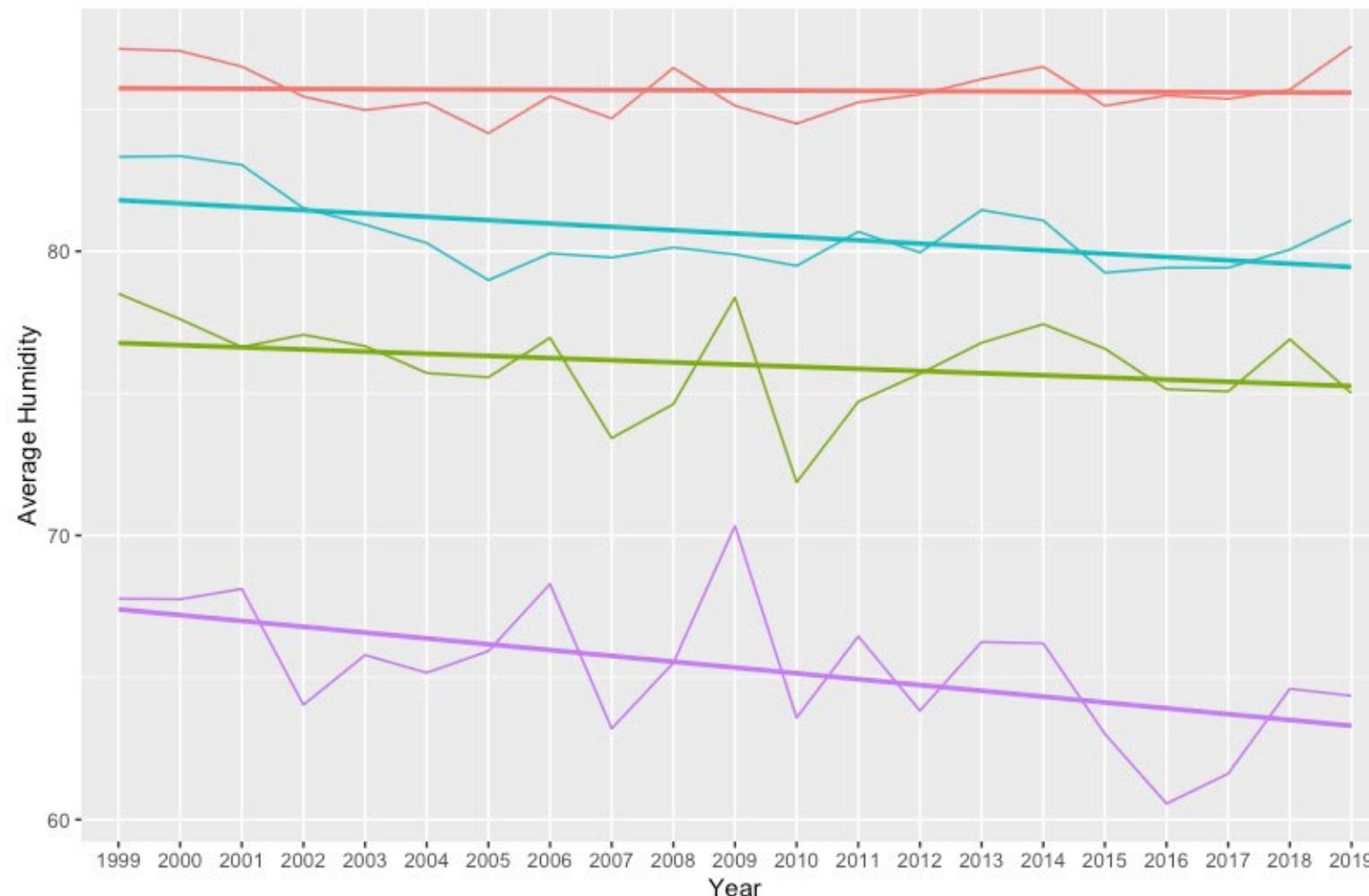
Input Variables

~~TOTAL INSOLATION~~  
~~MIN\_TEMPERATURE~~  
~~AVG\_TEMPERATURE~~  
~~EVAPORATION~~  
~~PRECIPITATION~~  
~~MAX\_TEMPERATURE~~  
~~HUMIDITY~~  
**WIND\_SPEED**  
**ALTITUDE**  
**FIRESPOTS**

**Deforestation** ~  
Humidity + Wind\_Speed  
+ Altitude + Firespots

# DEFORESTATION ~ HUMIDITY

Average Humidity by State from 1999-2019



Amazonas (AM)

**SLOPE: -0.00775**

Mato Grosso (MT)

**SLOPE: -0.0758**

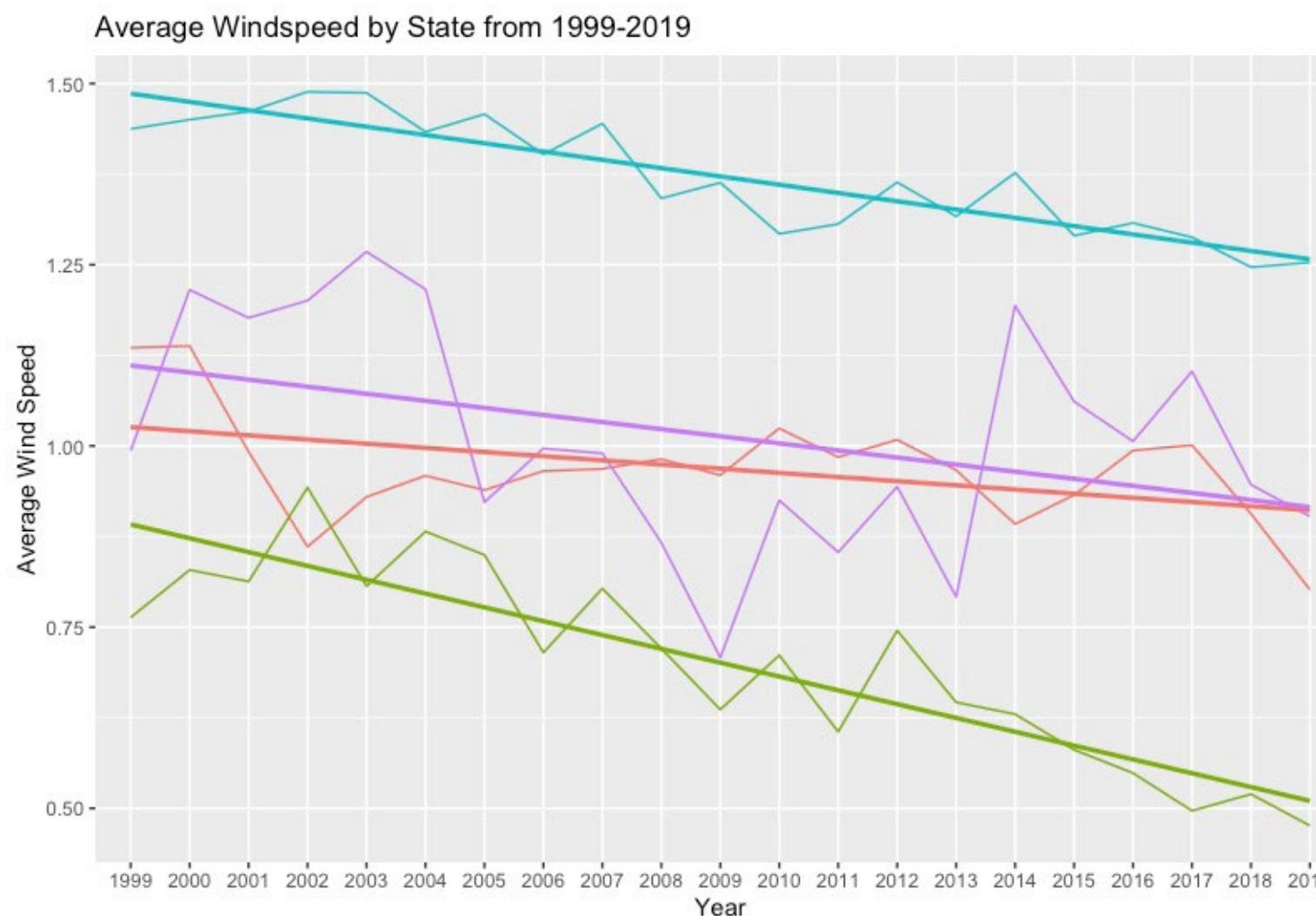
Pará (PA)

**SLOPE: -0.118**

Tocantins (TO)

**SLOPE: -0.205**

# DEFORESTATION ~ WIND\_SPEED



Amazonas (AM)

SLOPE: -0.00574

Mato Grosso (MT)

SLOPE: -0.0191

Pará (PA)

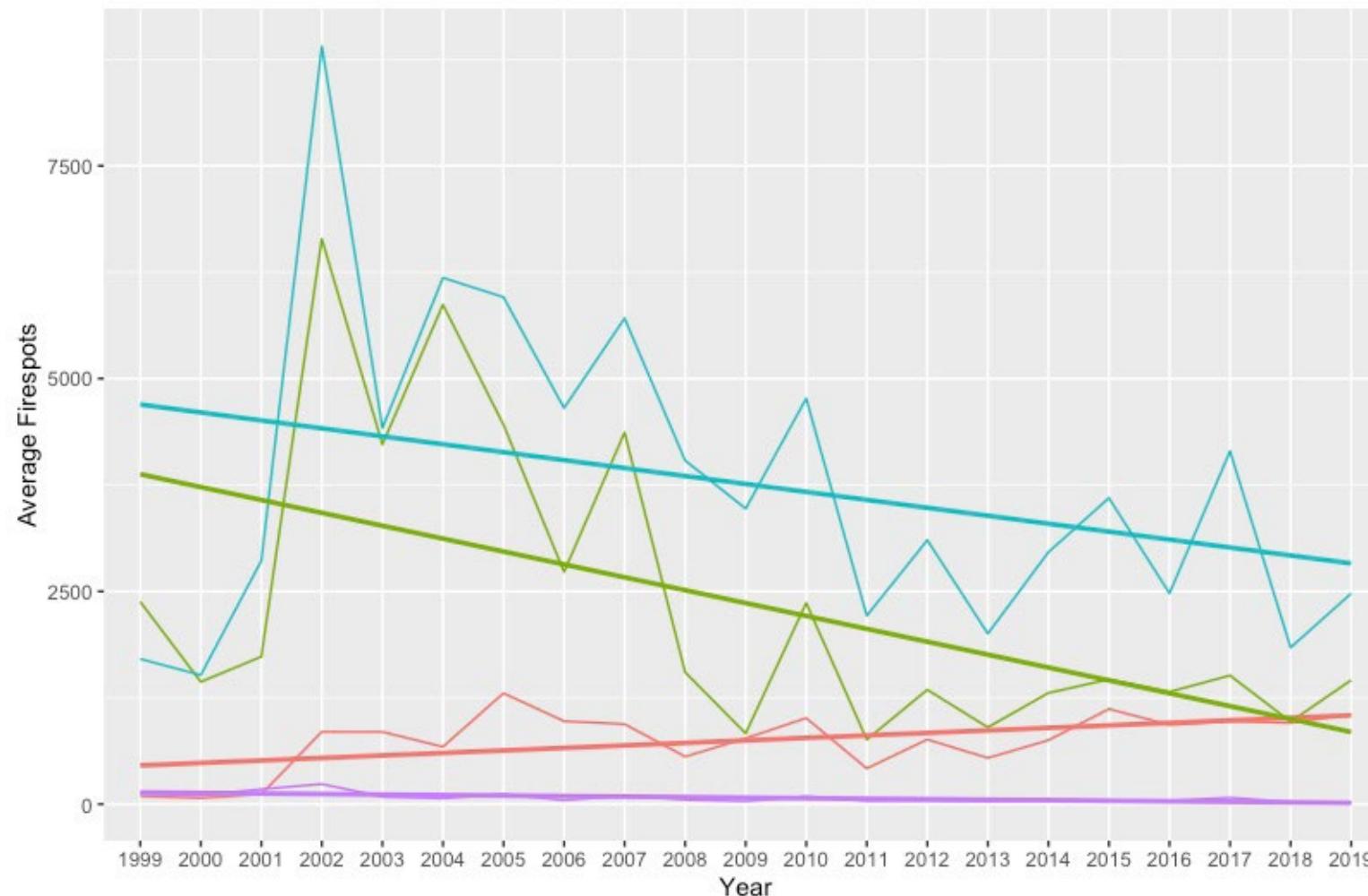
SLOPE: -0.0114

Tocantins (TO)

SLOPE: -0.00977

# DEFORESTATION ~ FIRESPOTS

Average Firespots by State from 1999-2019



Amazonas (AM)

**SLOPE: 29.4**

Mato Grosso (MT)

**SLOPE: -151.0**

Pará (PA)

**SLOPE: -93.3**

Tocantins (TO)

**SLOPE: -6.1**

# CUMULATIVE FIRESPOTS

2005 - 2007

**140,141**

2005 - 2007

**467,603**

2008-2010

**375,968**

2011-2013

**234,389**

2014-2016

**145,697**

2014-2016

**192,642**

2017-2019

**185,958**

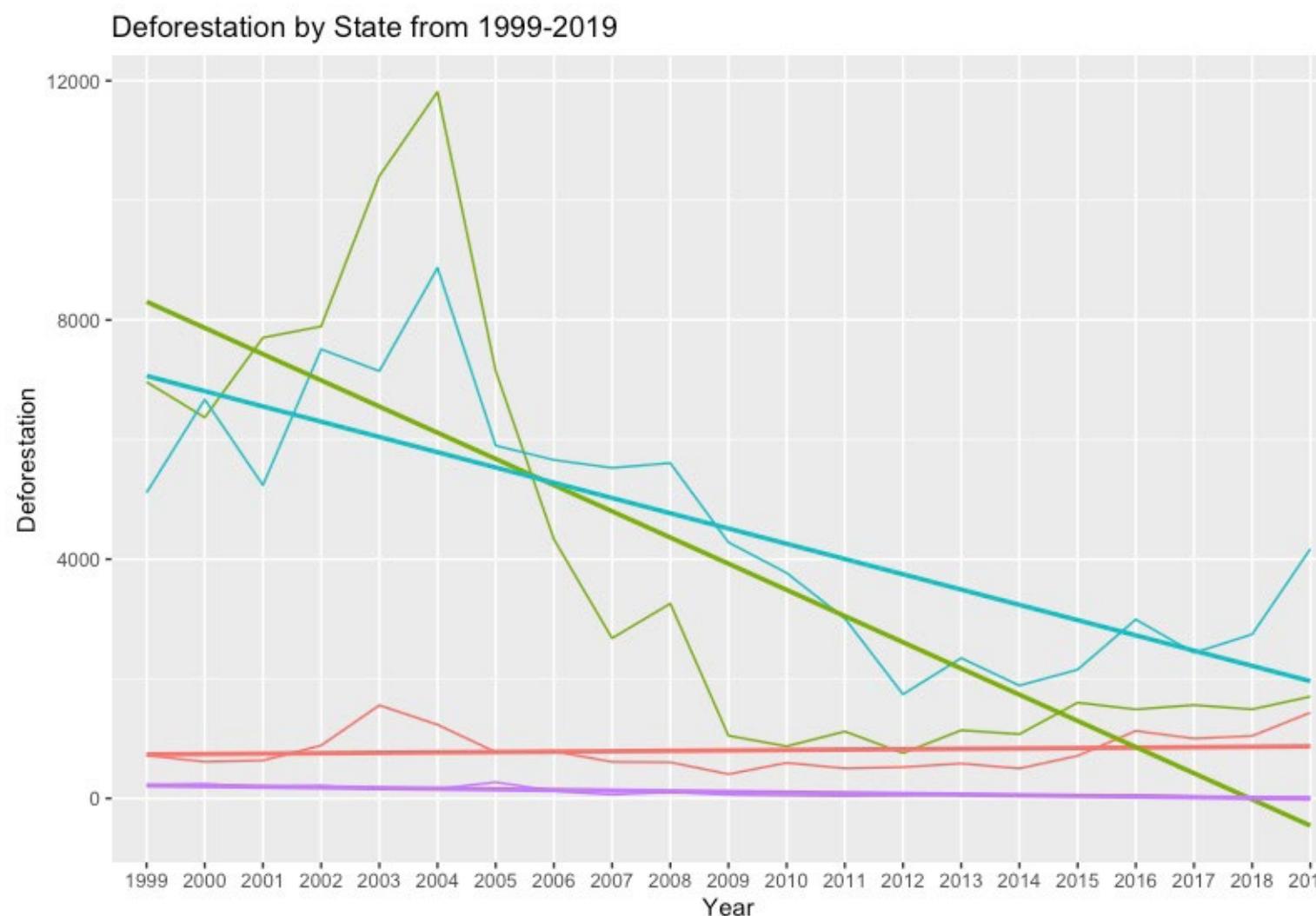
Brazil Firespots (Amazonas, Mato Grosso, Para, Tocantins)



**Brazilian Amazon Total (2005 - 2019)**

**1,742,398**

# YEARLY DEFORESTATION



Amazonas (AM)

SLOPE: 6.7

Mato Grosso (MT)

SLOPE: -438

Pará (PA)

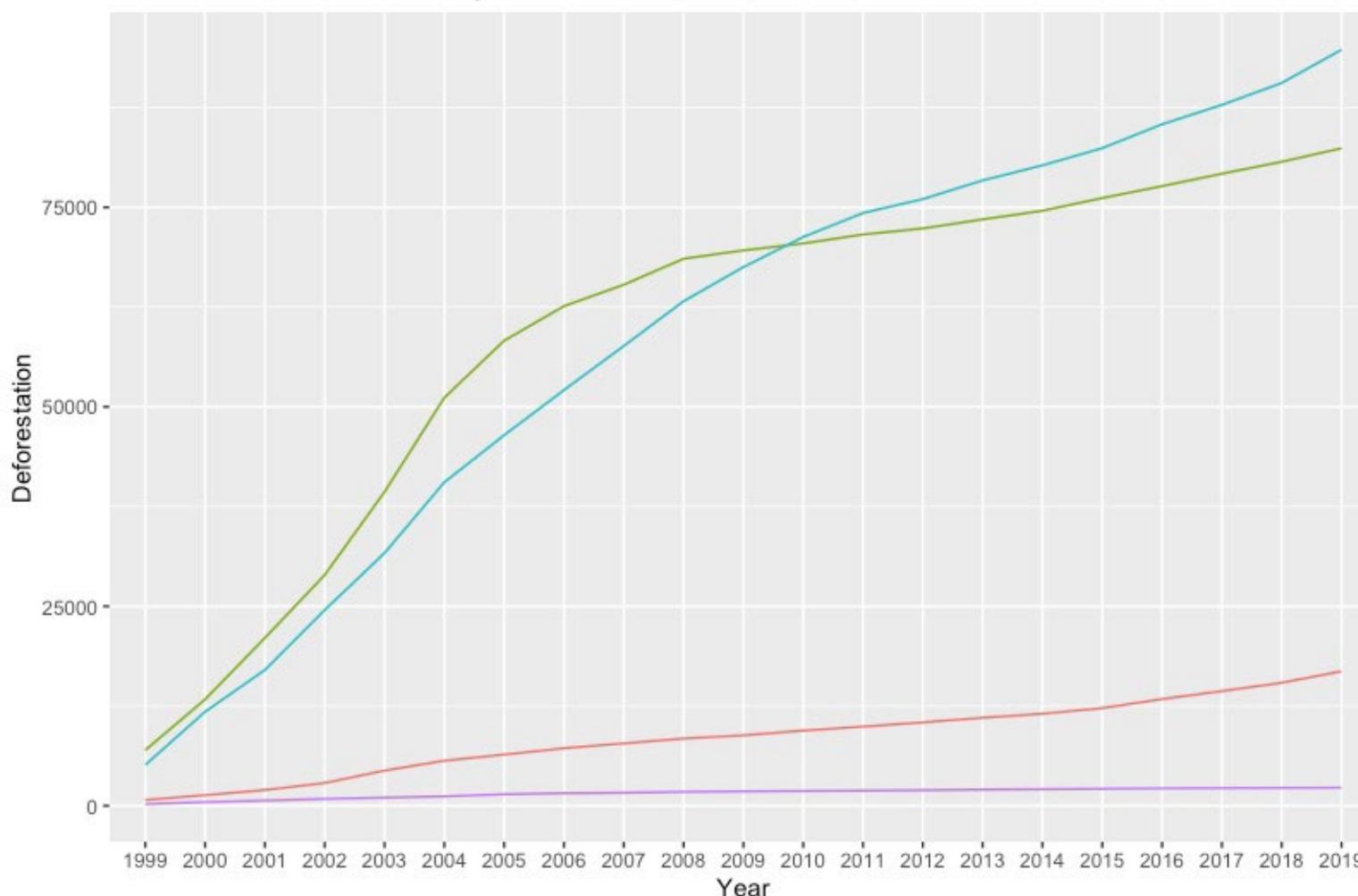
SLOPE: -255

Tocantins (TO)

SLOPE: -11

# CUMULATIVE DEFORESTATION

Cumulative Deforestation by State from 1999-2019



# 21-YEAR TOTALS

Amazonas (AM)

**16,847 KM<sup>2</sup>**

Mato Grosso (MT)

**82,414 KM<sup>2</sup>**

Pará (PA)

**94,762 KM<sup>2</sup>**

Tocantins (TO)

**2,260 KM<sup>2</sup>**

**Deforestation**  
is **increasing**, but at a  
**decreasing** rate since 2010

# CUMULATIVE DEFORESTATION

2005 - 2007

**37,945 KM<sup>2</sup>**

2008-2010

**25,099 KM<sup>2</sup>**

2011-2013

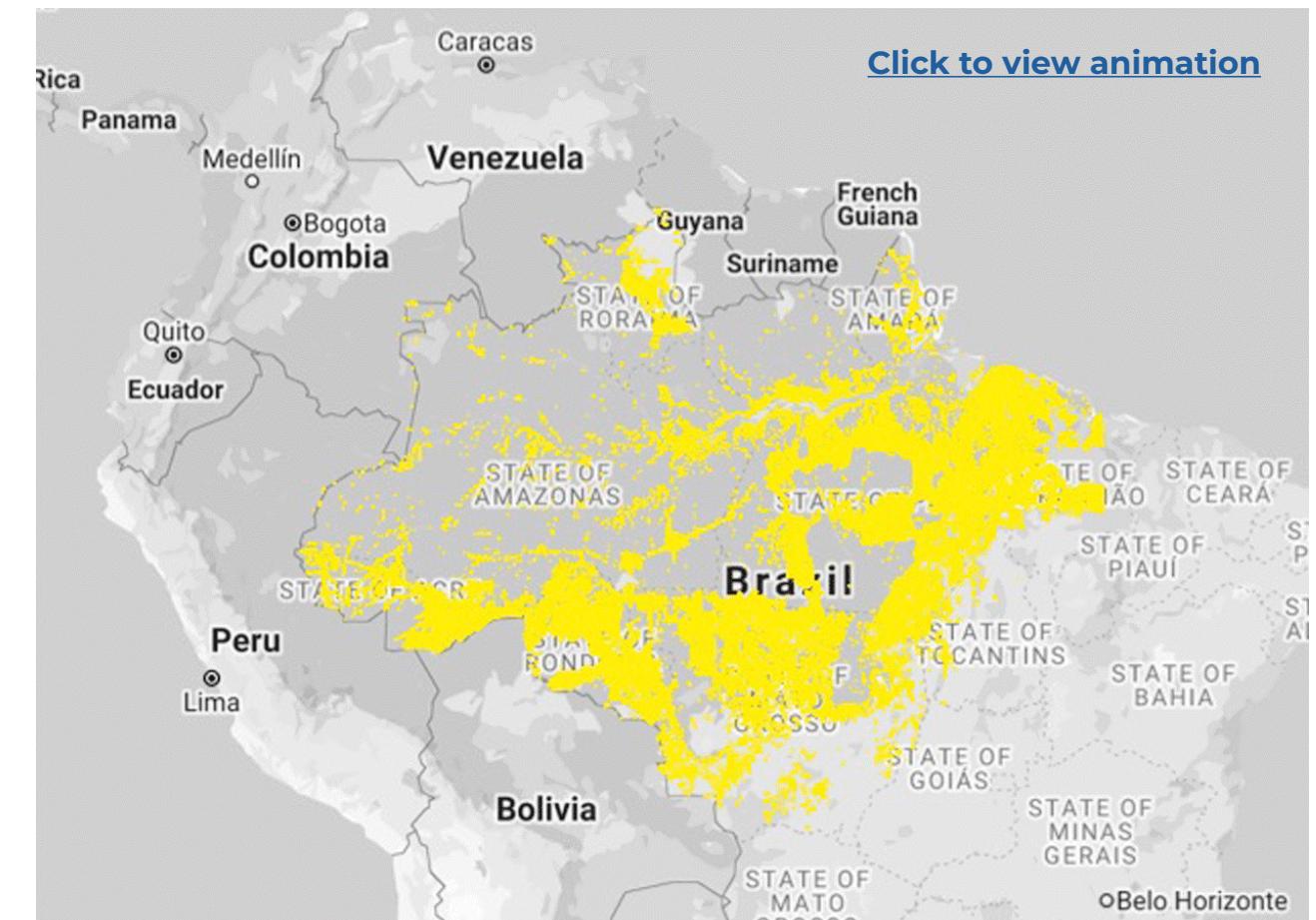
**14,194 KM<sup>2</sup>**

2014-2016

**15,949 KM<sup>2</sup>**

2017-2019

**20,716 KM<sup>2</sup>**



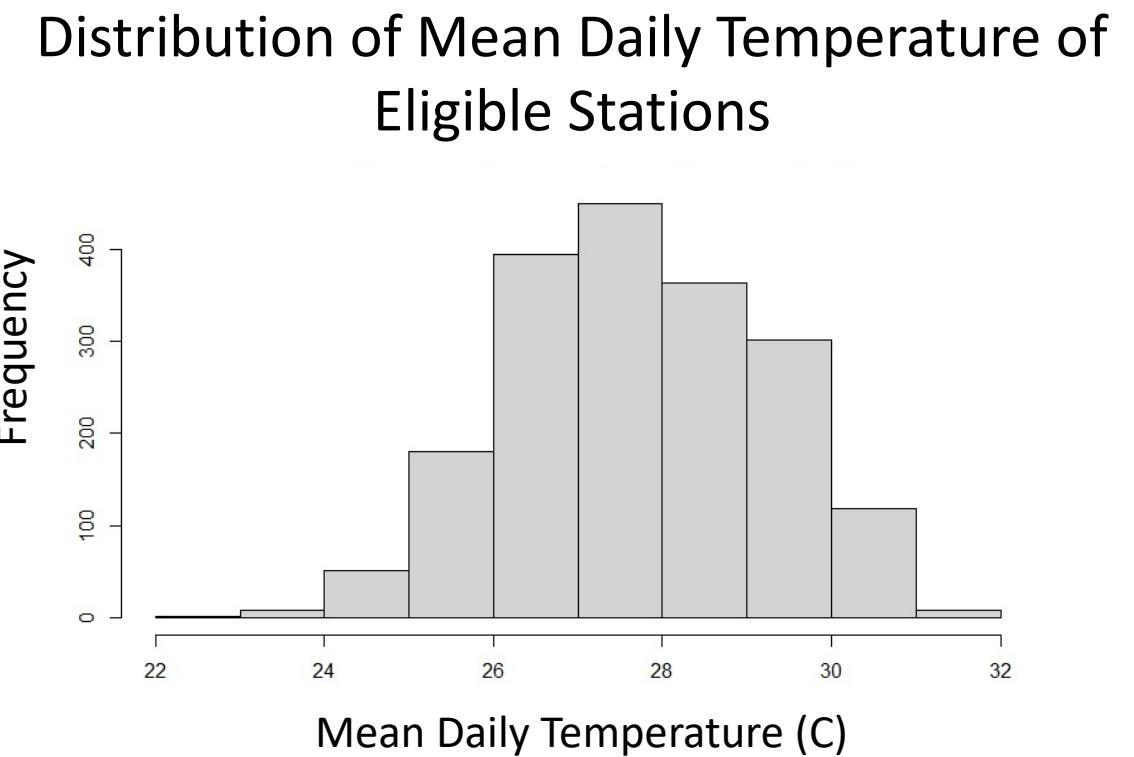
2005 - 2007

**Brazilian Amazon Total (2005 - 2019)**

**224,243 KM<sup>2</sup>**

# TESTING FOR TEMPERATURE CHANGE

- Aggregating all daily temperature data to seasonal levels (Winter, Spring, Summer, Fall)
- Filtering to make sure all station-seasons have at least 75 days per season
- Filtering to make sure all station-seasons are not missing any years
- Final Dataset with 68 stations

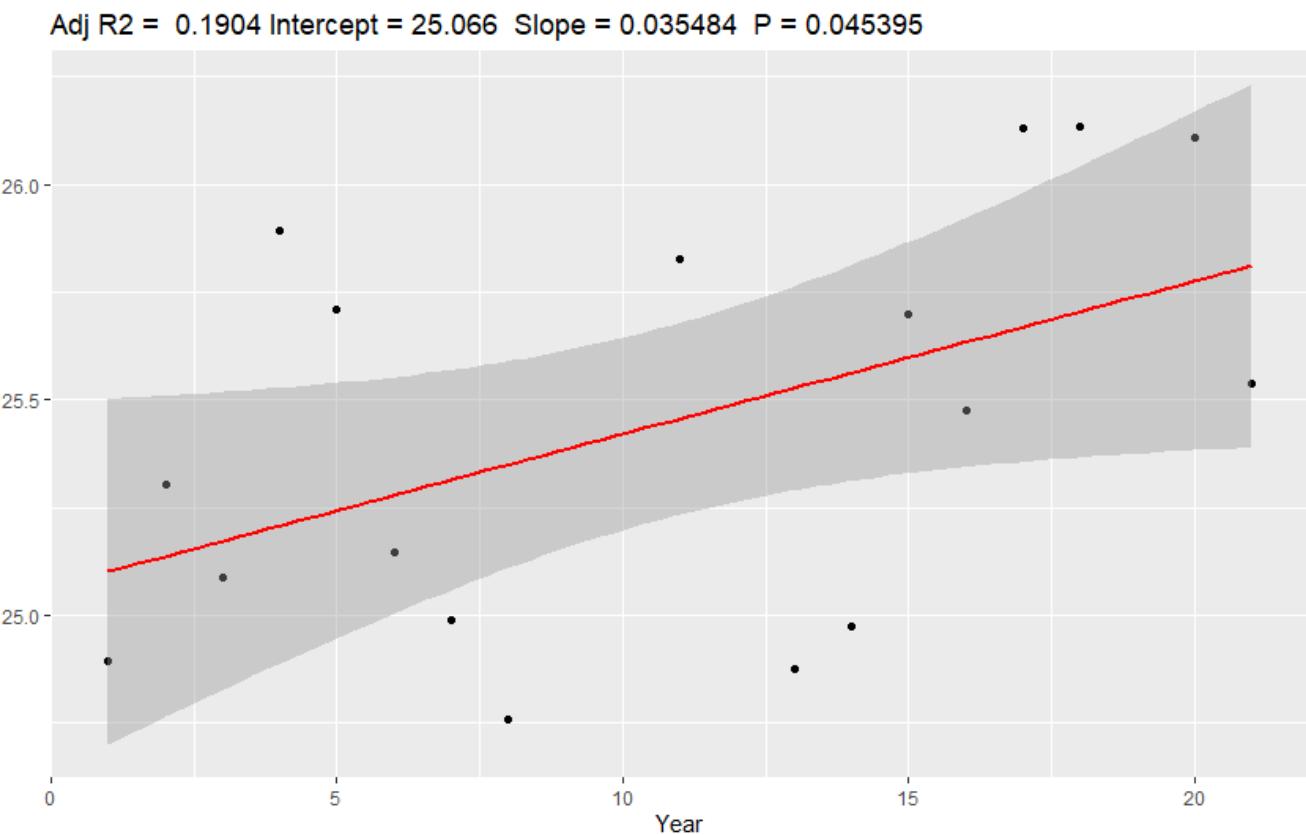


# SIGNIFICANCE TESTING OF STATION-SEASON SLOPES

Involves a 1 sample T-test per station-season:

- **H<sub>0</sub>: Regression slope is 0, H<sub>a</sub>: Regression slope is greater than 0**
- **Regression line is drawn through each station-season**
- **T-Stat = Slope/Standard Error**
- **For each Station-Season, P-value is calculated from T-stat at  $\alpha = .05$**

**Example Linear Model  
(Station: 82886, Season: Winter)**



# SIGNIFICANCE TESTING RESULTS

68

**ELIGIBLE STATIONS  
(75 DAYS OF DATA  
EACH SEASON)**

58

**STATIONS WITH AT  
LEAST ONE SEASON  
WITH SIGNIFICANT  
TEMPERATURE CHANGE**

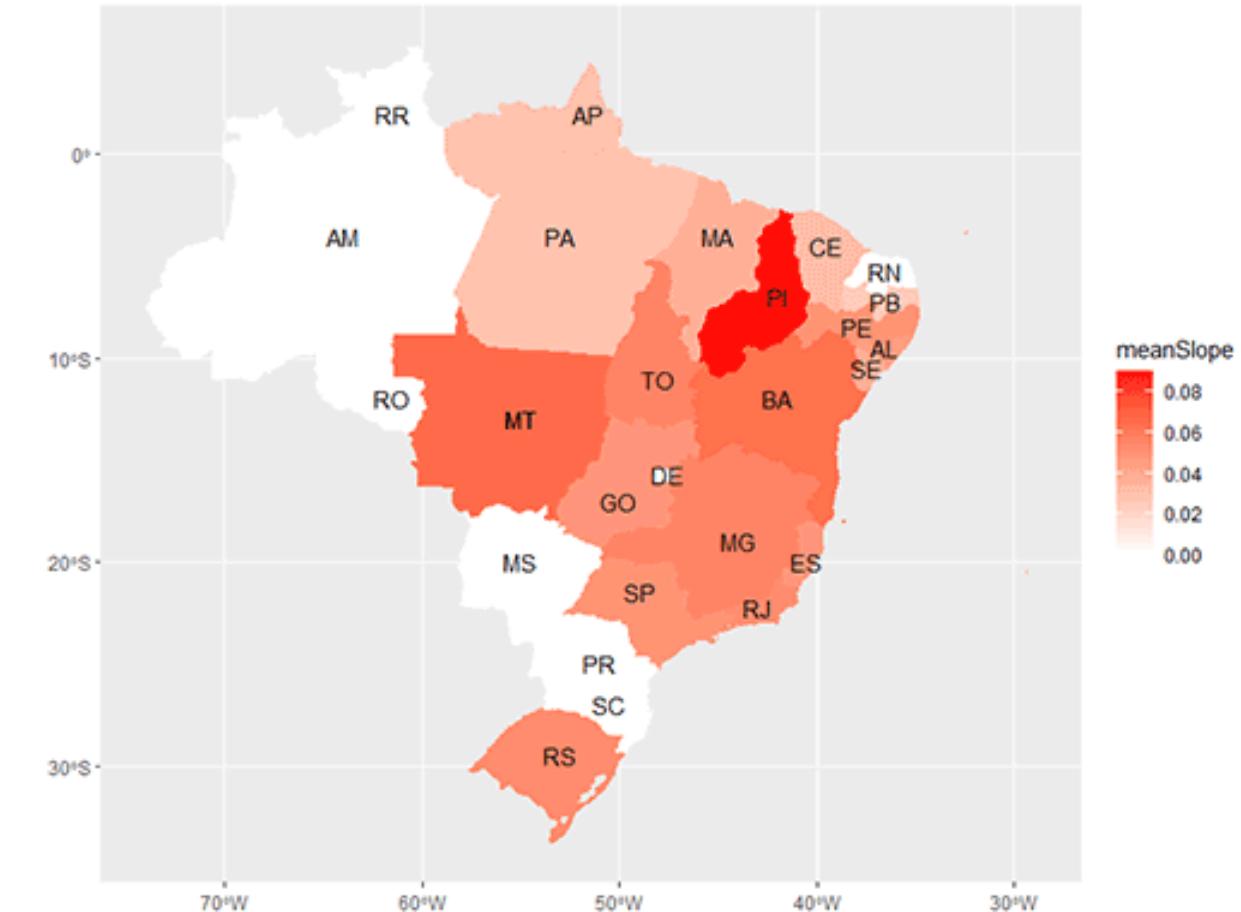
Station	Season	slope	std_err	degf	t_stat	p_val	significant
82098	Winter	0.0302934550403131	0.0077472786778239	20	3.9102059	4.339137e-04	Yes
82181	Summer	0.0039000453443465	0.0169302629001726	20	0.2303594	4.100762e-01	No
82181	Fall	0.0243330384630873	0.0102975626679128	20	2.3629901	1.418481e-02	Yes
82184	Summer	0.0219232386660961	0.0115933086846064	20	1.8910252	3.659811e-02	Yes
82191	Spring	0.0230909215008594	0.00960068615981782	20	2.4051324	1.298334e-02	Yes
82191	Summer	0.022372104475125	0.0141772074124319	20	1.5780332	6.512223e-02	No
82191	Fall	0.0321562284076802	0.00997699432585189	20	3.2230377	2.132882e-03	Yes
82191	Winter	0.033818180320429	0.0106401918726053	20	3.1783431	2.361942e-03	Yes
82198	Spring	0.0267329851411852	0.00745219723801179	20	3.5872622	9.210175e-04	Yes
82263	Fall	0.0371068215893256	0.0107186552373898	20	3.4618915	1.231491e-03	Yes
82376	Spring	0.0325303867888092	0.0130545165159191	20	2.4918875	1.080218e-02	Yes
82382	Spring	0.0329118418033435	0.0118011203784171	20	2.7888743	5.666164e-03	Yes

# VISUALIZING REMAINING FOREST & SIGNIFICANT TEMPERATURE CHANGE

## **Remaining Brazilian Rainforest**



## Brazilian States with Significant Change in Yearly Temperature Slope of Change from 1999 to 2019



**Click to view animation**

# SUMMARY

Using our data set, 74% of deforestation can be explained by climate (humidity, wind), firespots and altitude.

As future steps, we would recommend looking into human factors as well:

## Economics:

- Agriculture
  - Soybean
  - Beef
- Mining

## Political:

- Bolsonaro presidency

