Modeling Forest Fires Using Bayesian Regression

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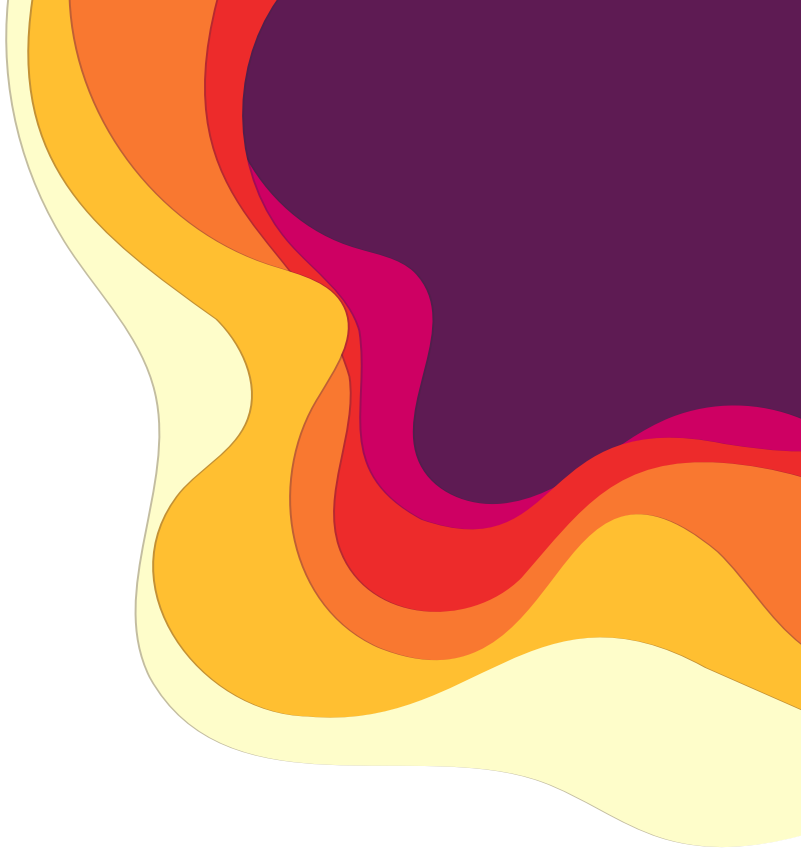
Outline

Problem Description

Mathematical Linkage

Bayesian Method(s) Used

Results and Conclusions



Background

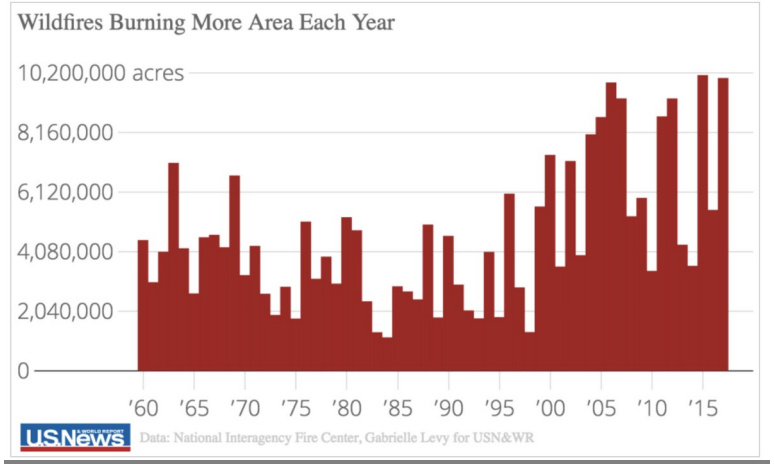
Source: VectorStock

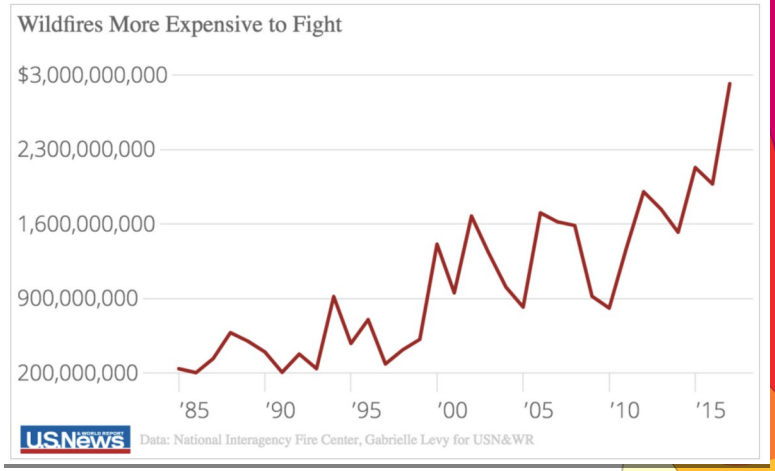
Source: SaukValley.com

Source: Gallery Yopriceville

On average, forest fires in the US burn **7 million acres** per year and cost taxpayers upwards of **$2.4 billion** in prevention and maintenance.

Additional Information About Forest Fires





Goal

Analyze various weather, climate, fuels, and fire activity factors to **model the probability of the occurrence and the burn area of a forest fire**.

Source: NetClipart

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Results can inform pre-positioning of firefighting assets and fire management strategies

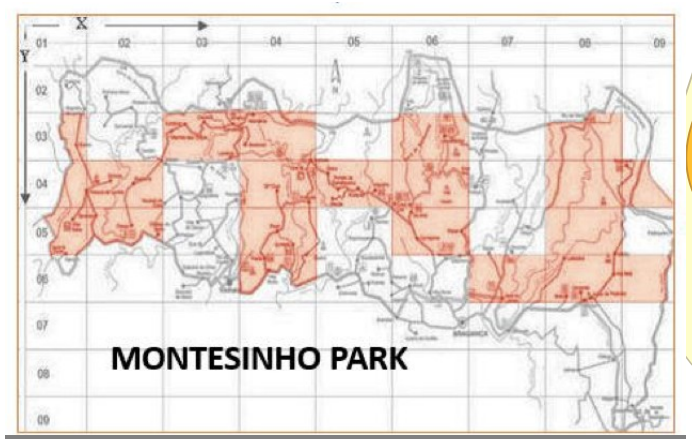
Where Our Data Is From

Data

***Response**: Burn area of forests in Montesinho National Park (NE Portugal) from January 2000 - December 2003*

***Predictors**: Fire Weather Index, Canadian system for quantifying fire danger*

Attribute name	Description	Unit
FFMC	Fine Fuel Moisture Code	--
DMC	Duff Moisture Code	--
DC	Drought Code	--
ISI	Initial Spread Index	--
Temp	Temperature	°C
RH	Relative Humidity	%
Wind	Wind speed	km/h
Rain	Rain volume	mm/m^2
Area	Total burned area	ha

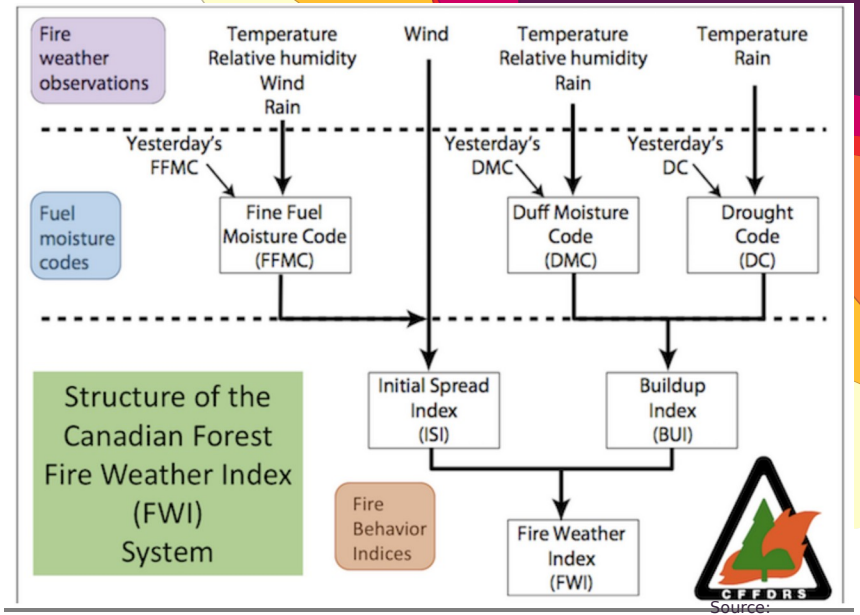


Source:
supportsas

Fire Weather Index

Basic Description (Continued)

- Predictors:
  - FFMC: A numerical rating of the moisture content of litter and other cured fine fuels: 18.7 to 96.2
  - DMC: A numerical rating of the average moisture content of loosely compacted organic layers and medium-size woody material: 1.1 to 291.3
  - DC: A numerical rating of the average moisture content of deep, compact, organic layers: 7.9 to 860.6
  - ISI: A numerical rating of the expected rate of fire spread: 0.0 to 56.10
  - Month: month of the year: 1 to 12
  - Day: day of the week: 1 to 7
  - Temp: temperature in Celsius degrees: 2.2 to 33.30
  - RH: relative humidity in %: 15.0 to 100
  - Wind: wind speed in km/h: 0.40 to 9.40
  - Rain: outside rain in mm/m2: 0.0 to 6.4



Source: nwcg.gos

Bayesian Methods Used

Quantify uncertainty in response given the predictor data and prior

Bayesian Logistic Regression:

Did a forest fire occur or not

Bayesian Linear Regression:

Total burn area of forest fire

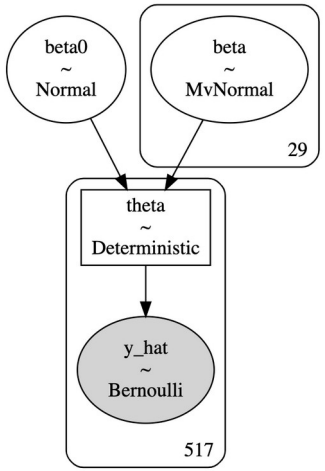
Mathematical Linkage
Bayesian Regression

Loss Function

$$-\left(\sum_{i=1}^{N} log(f(y_i|X,\theta)) + (\lambda * |\theta|^2)\right)$$

Logistic

$$p(y|X) = 1 / 1 + e^{-(\theta_0+\theta_1 X)}$$

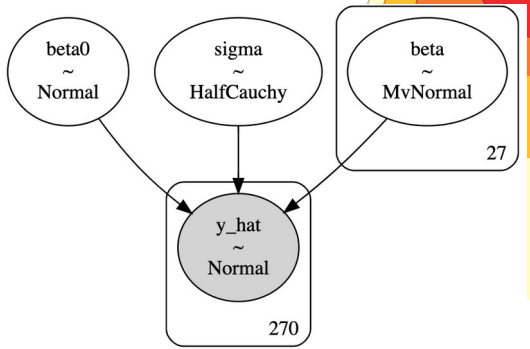


Linear

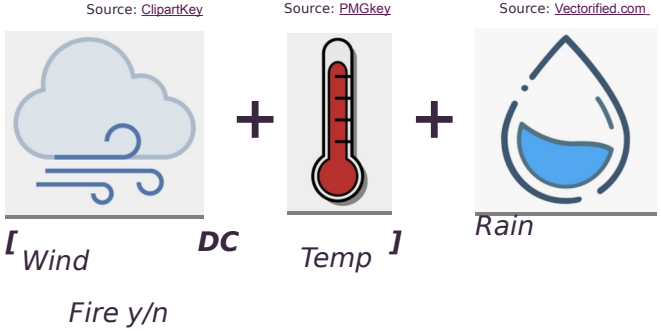
$$log(y) = X\theta + \varepsilon, \text{ where } y \sim N(X\theta, \sigma^2_\varepsilon \mathbf{I})$$

where the posterior theta is estimated using:

$$p(\theta \mid X, y) = (p(X, y \mid \theta)p(\theta)) / p(X, y)$$



Results: Logistic Model



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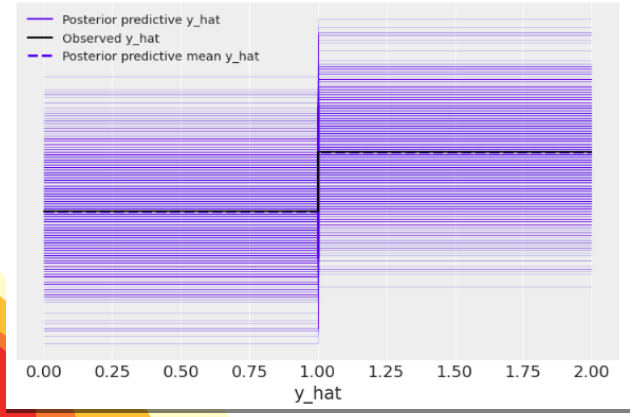

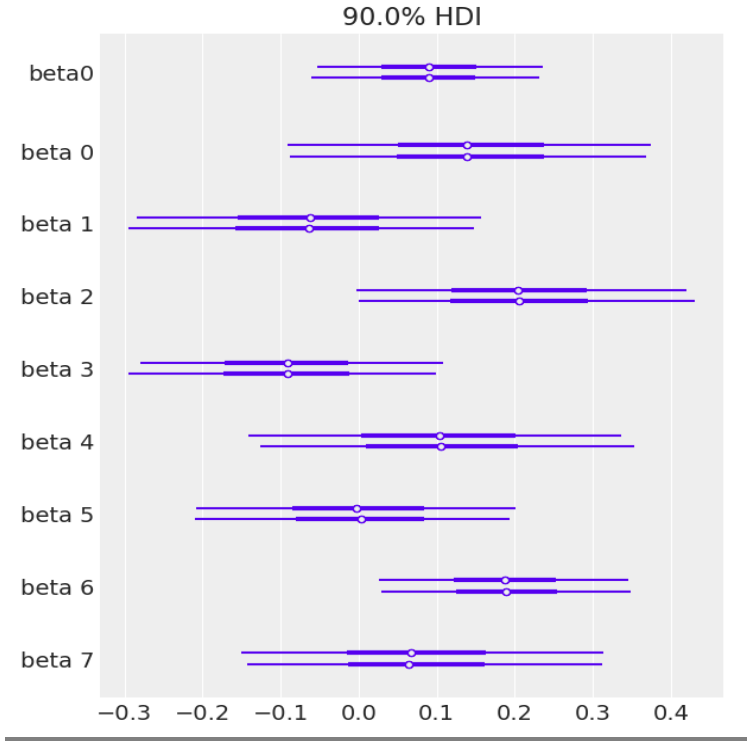

Results: Linear Model

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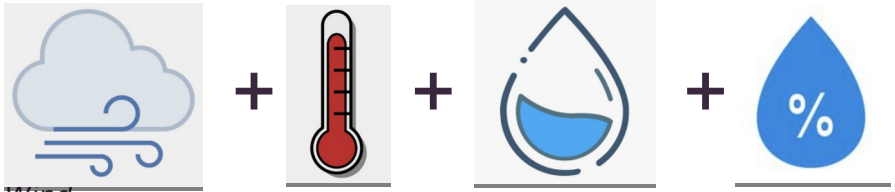
Source: PMGkey

Source: Vectorified.com

Source: Vecteezy



Wind + *Temp* + ***DMC,*** *Rain* + ***RH:*** *Humidity*

[ISI]

Fire Burn Area

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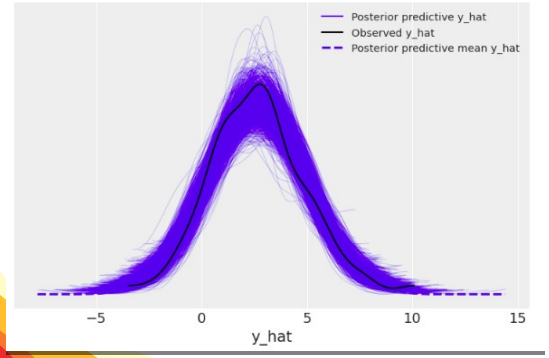

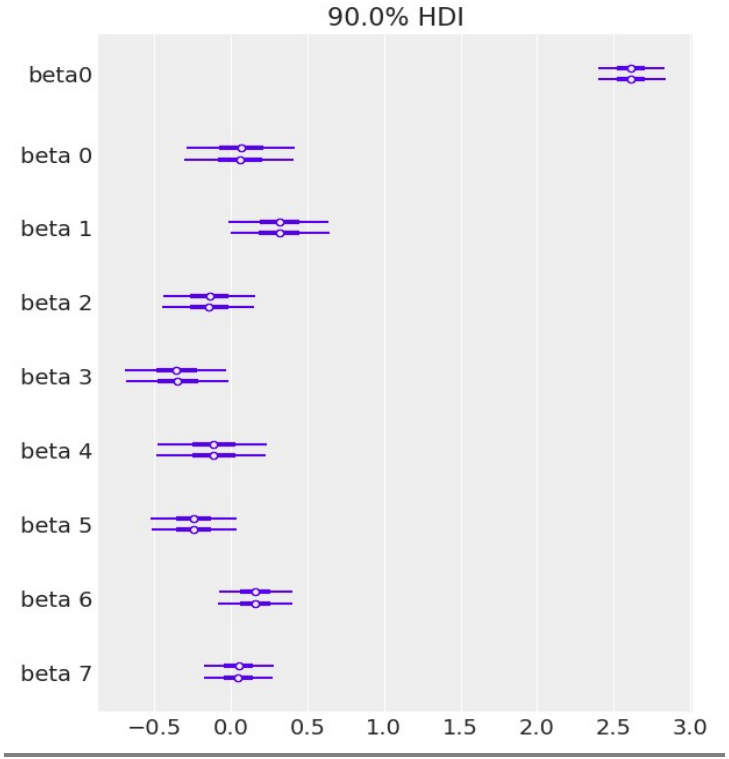

Intercept

DMC

ISI

RH

Conclusion

It is possible to model the probability of burn area and general occurrence of forest fires using Fire Weather Index Factors

Next steps:

- Collect data about **first responder** resources to inform burn area analysis
- **Hierarchical model** to accommodate diverse landscapes in regions of the park


Questions?