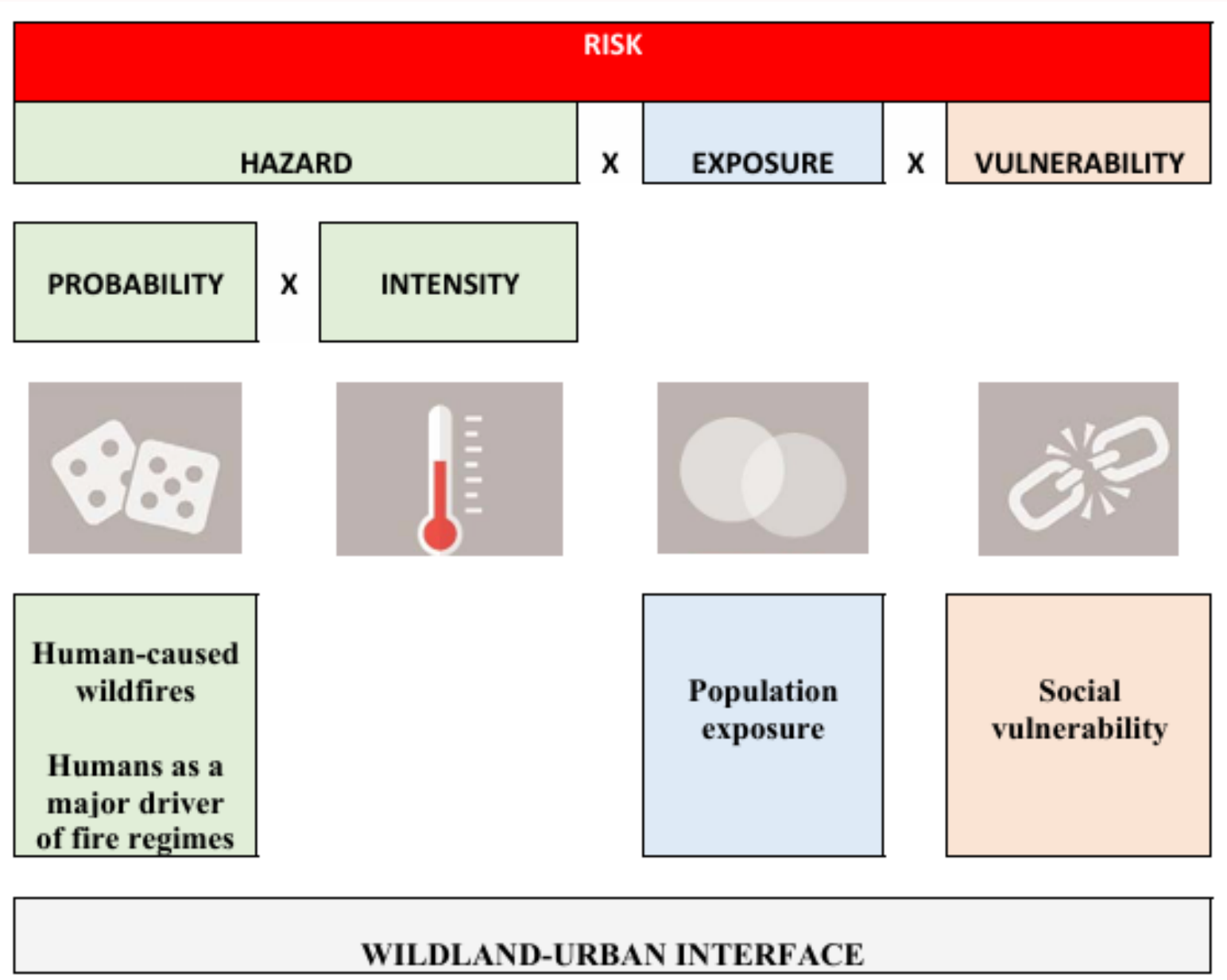
Socioeconomic analysis of the wildland-urban interface

Marisa Chas-Amil
University of Santiago de Compostela, Spain

International Workshop on Wildfire Modeling & AI
Session 4
Madrid, March 17 - 18, 2025

Wildfire risk



Human-caused wildfires

Key questions

- Can Do **law enforcement efforts** (arrests) help to explain wildfire occurrence?

- Can we detect **serial** and **copycat** behaviour?

- Is there evidence for **displacement or diffusion effects** of law enforcement in intentional outdoor firesetting?

- Is there a significant relationship between firesetting and **election cycles (political dimension)**?

Policy-relevance:

- May intentional fires be predictable?

- Design of effective policing strategies in response to firesetting

Prestemon et al. International Journal of Wildland Fire, 2012
Prestemon et al. International Journal of Wildland Fire, 2019

Methodology

- Model structure is based on an economic model of crime (Becker 1968):
A potential criminal compares the expected benefits of a criminal action with the expected costs of this action.

- **Prestemon et al. (2012).** Poisson autoregressive models of order p, PAR(p):

$$E[y_{j,t} \mid Y_{j,t-1}] = \sum_{i=1}^{p} \rho_{j,i} y_{j,t-i} + \left(1 - \sum_{i=1}^{p} \rho_{j,i}\right) \exp(\mathbf{x}'_{j,t} \boldsymbol{\beta}_j)$$

Probability of arson occurrence in distric j and day t

arson occurrences in last days

Other covariates based on the expected cost of commiting a crime

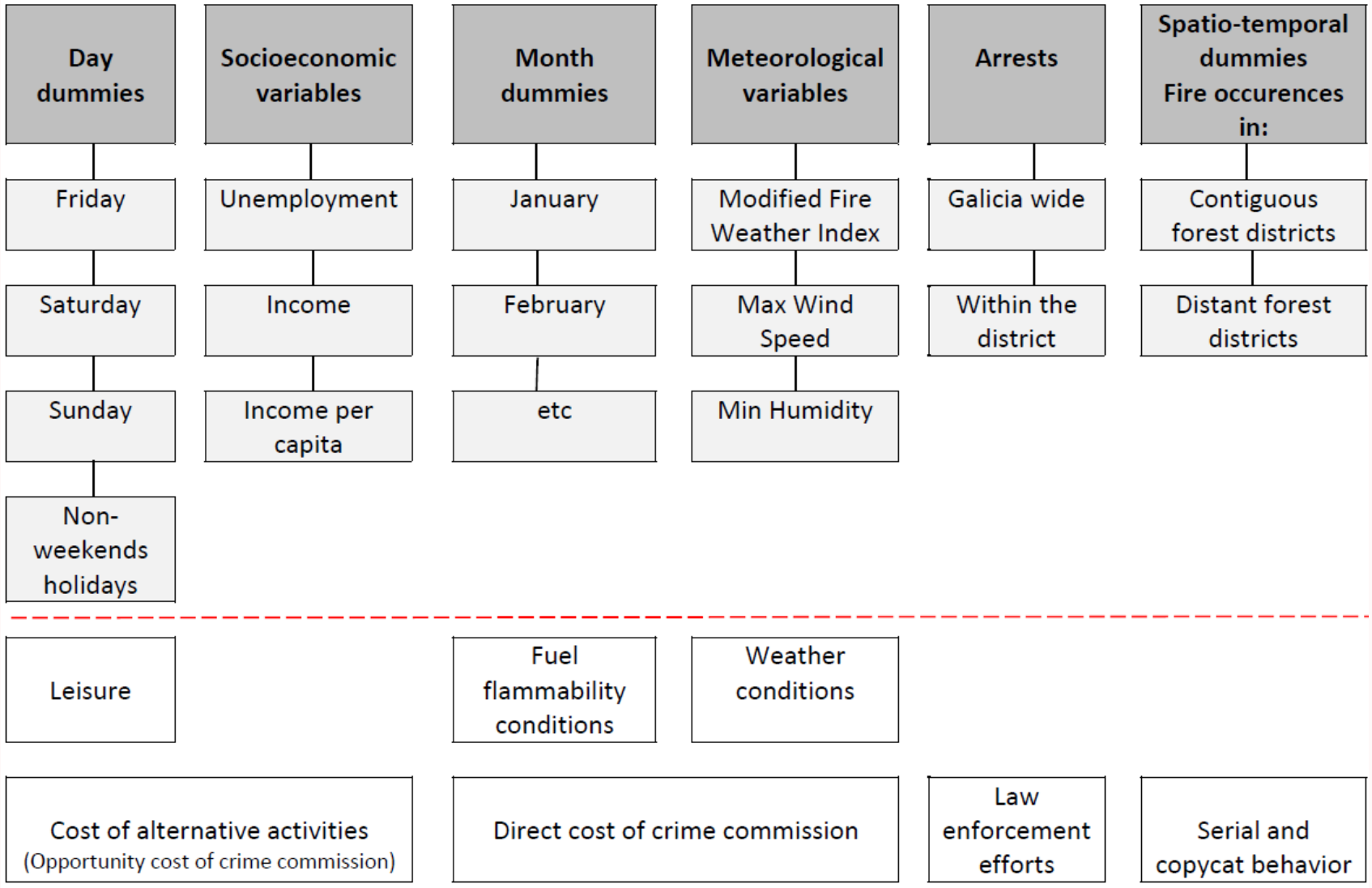
where:

$\rho_{j,i}$ represents a *p*-order vector of autoregressive parameters
$\boldsymbol{\beta}_j$ contains the parameters of this process in location *j*.
$\mathbf{x}_{j,t}$ is a vector containing the covariates of the intentional occurrence process in location *j* in time *t*.

- **Prestemon et al. (2019).** Different model specifications were estimated with different covariates:
  - Fixed effects negative binomial models (FENB)
  - Random effects negative binomial models (RENB)
  - Zero-inflated negative binomial (ZINB) models with intercept-shifting municipality dummy variables.

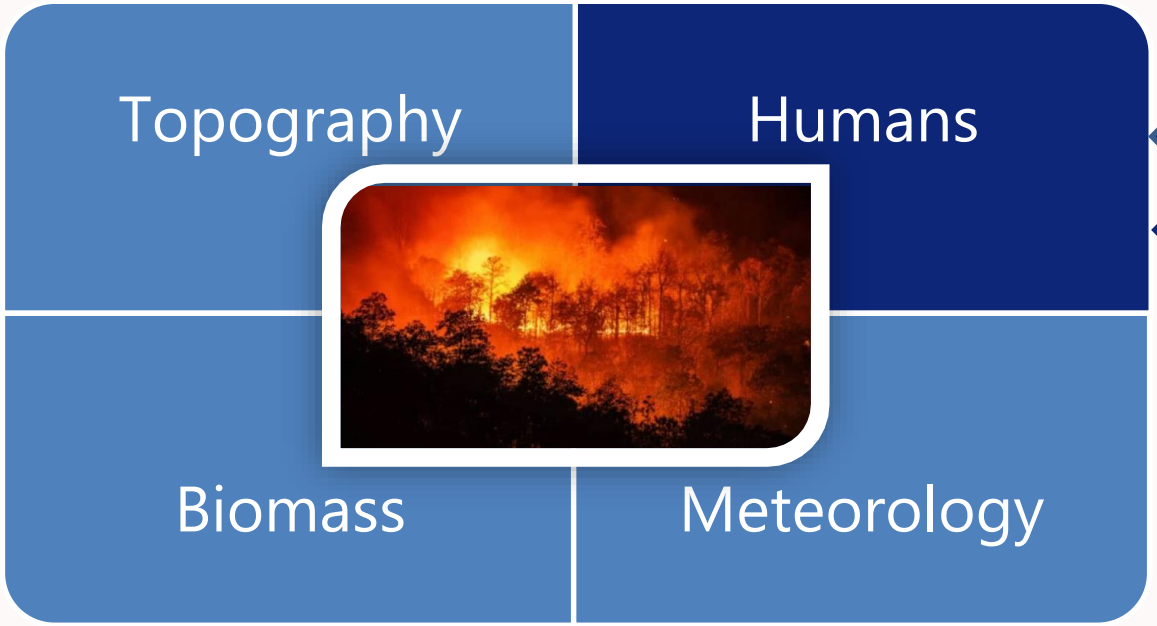
Methodology

Example of covariates included in the analysis:



Prestemon et al. International Journal of Wildland Fire, 2012

Humans as a major driver of fire regimes



- Rural abandonment
- WUI
- Land uses
- Forest management
- Land owernship
- Labor market
- Farming activity
- Human presence
- etc, etc

Key questions

- How do human factors explain the **spatial pattern** of wildfire ignitions (i.e., **WHERE** fires occur)?

- How does wildfire occurrence would **change with policy measures**?

    - Regulation on forest ownership.

    - Regulation on the expansion of urban uses.

Policy-relevance:

Why people “choose” to set forest fires in certain areas and how alternative policies can affect this?

Chas-Amil et al. Applied Geography, 2015

Methodology

Generalised linear model (GLS) **NB2 negative binomial** specification with a log-link function, which allows the mean to differ from the variance:

$$Var(y_i) = \mu_i + \alpha\mu_i^2$$

$$\log(\mu_i) = \log(F_i) + \sum_{k=0}^{K} \beta_k x_{ik}$$

Expected number of wildfires per parish

parish's forest area (exposure variable)

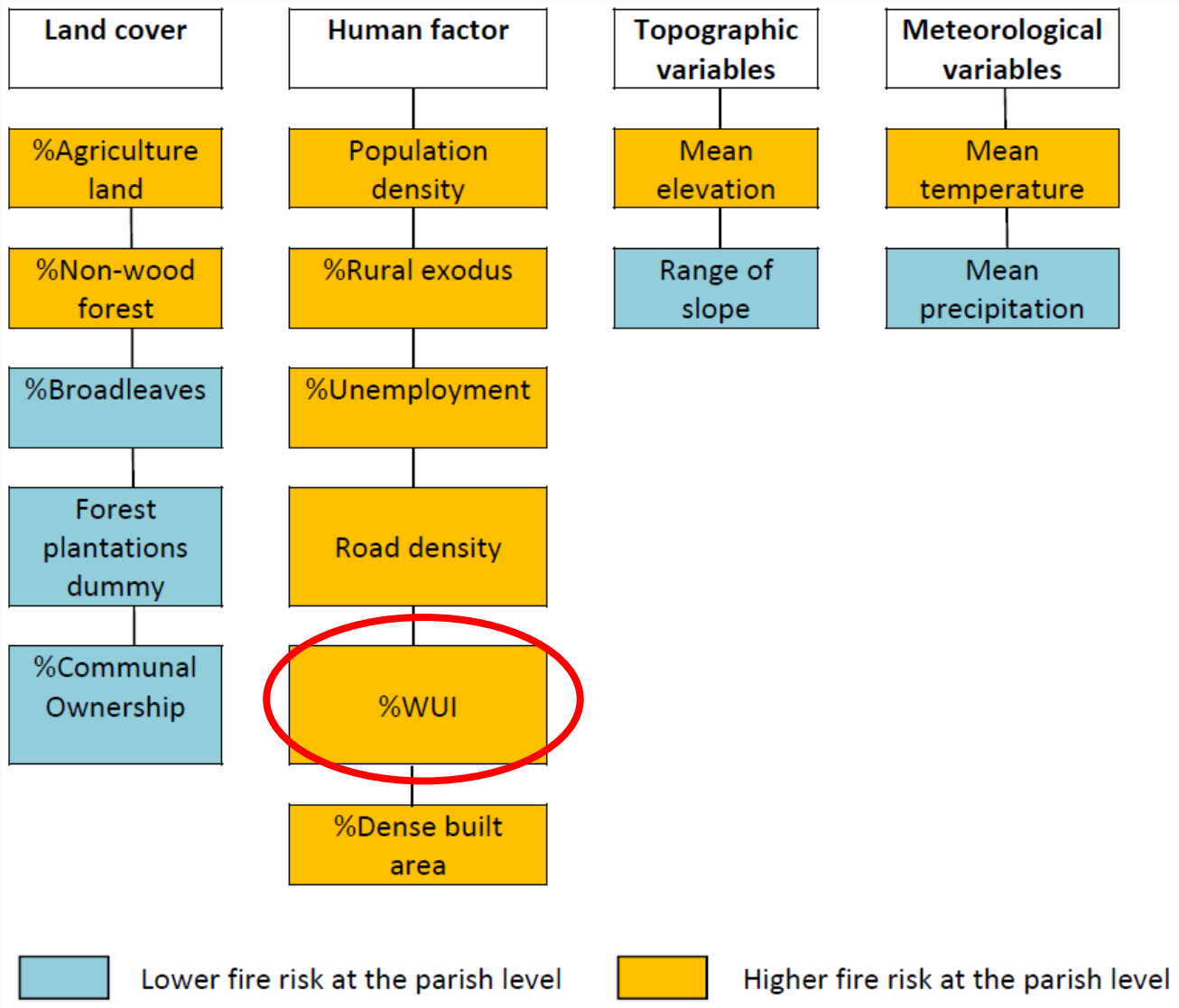
Independent variables (Land cover, human factors, topographic and meteorological variables)

- Policy shifts: Sensitivity analysis.

Chas-Amil et al. Applied Geography, 2015

Methodology

Covariates included in the analysis:



Chas-Amil, et al. Applied Geography, 2015

Wildfires in the wildland-urban interface

Wildland-urban interface (WUI) is crucial in fire risk management because the presence of population living close to forestlands **increases**:

- **ignition risk** as a consequence of human activities.

- **the probability of damage to human lives and properties.**

Key questions

- Is **fire risk** higher in the **WUI**?

- Do **spatial distribution of population** and **forest fragmentation** influence in fire risk?

- Do WUIs affect the risk associated to land covers?

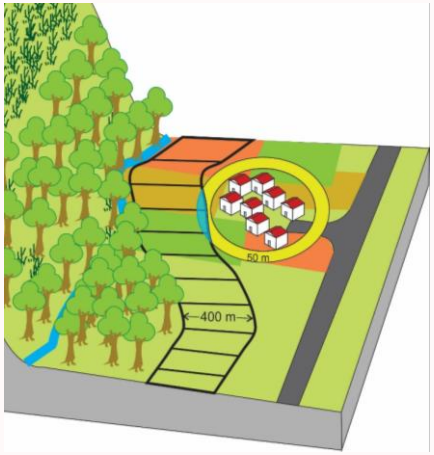
-Do fire causes differed depending on the type of vegetation and the WUI?

Policy-relevance:

Can we obtain high risk areas in order to develop plans for protection of human life, homes and economic activities?

Chas-Amil et al. Applied Geography, 2013
Calviño et al. Forest Ecology and Management , 2016, 2017

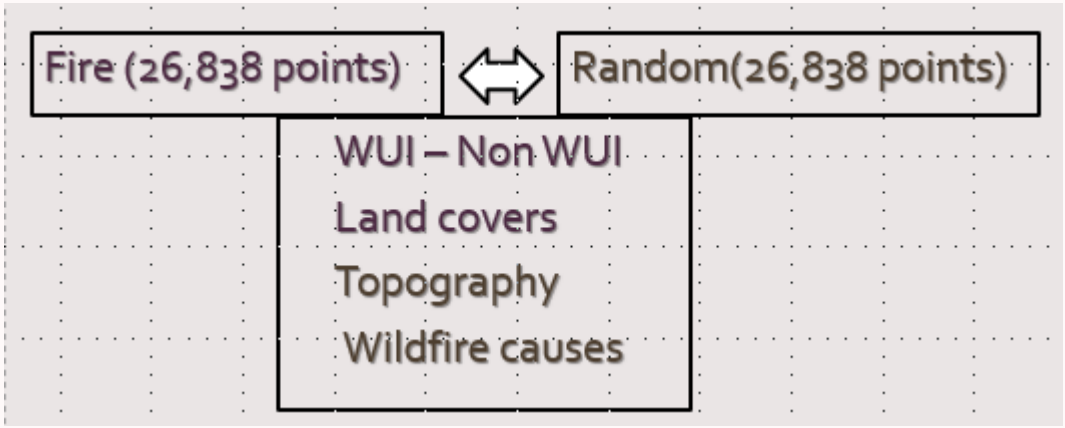
Methodology



1.- **Chas-Amil et al. (2013):** Spatial delimitation of WUI

2- **Calviño et al. (2016, 2017):**

We tested whether fires occurred at random in the landscape.



Chas-Amil et al. Applied Geography, 2013
Calviño et al. Forest Ecology and Management , 2016, 2017

Population exposure to wildfires

Key questions

- How much **burnt area** has occurred within the **wildland-urban interface**?
- Which **land cover** is most affected by wildfires, specifically in WUI areas?
- How many **population and buildings** have been at risk during this wildfire outbreak?

Policy-relevance:

Better estimation of economic damage and population vulnerability provoked by wildfires

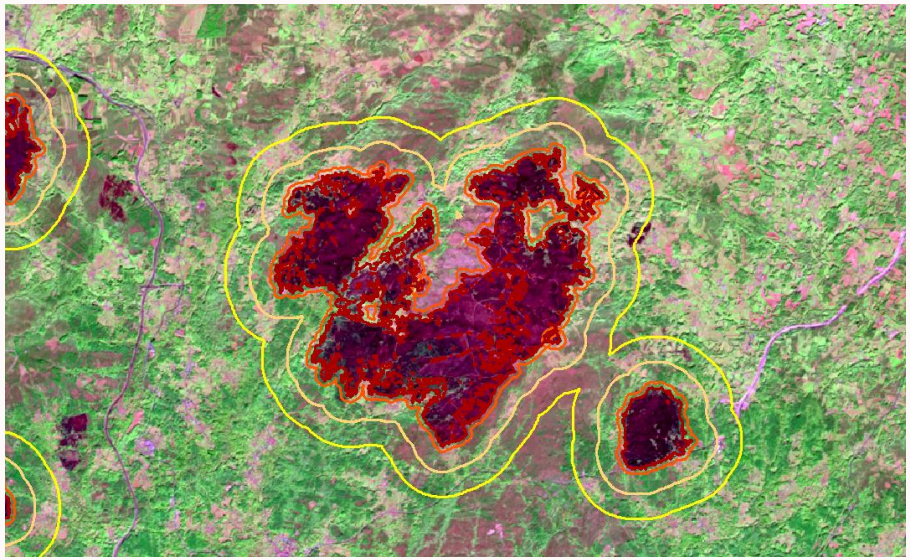
Chas-Amil et al. International Journal of Disaster Risk Reduction, 2020

Methodology

- Delimitation of burnt area (wildfires October 2017)
- Wildfire preference by land cover type (Jacobs' selectiviyt index).
- Population presence:

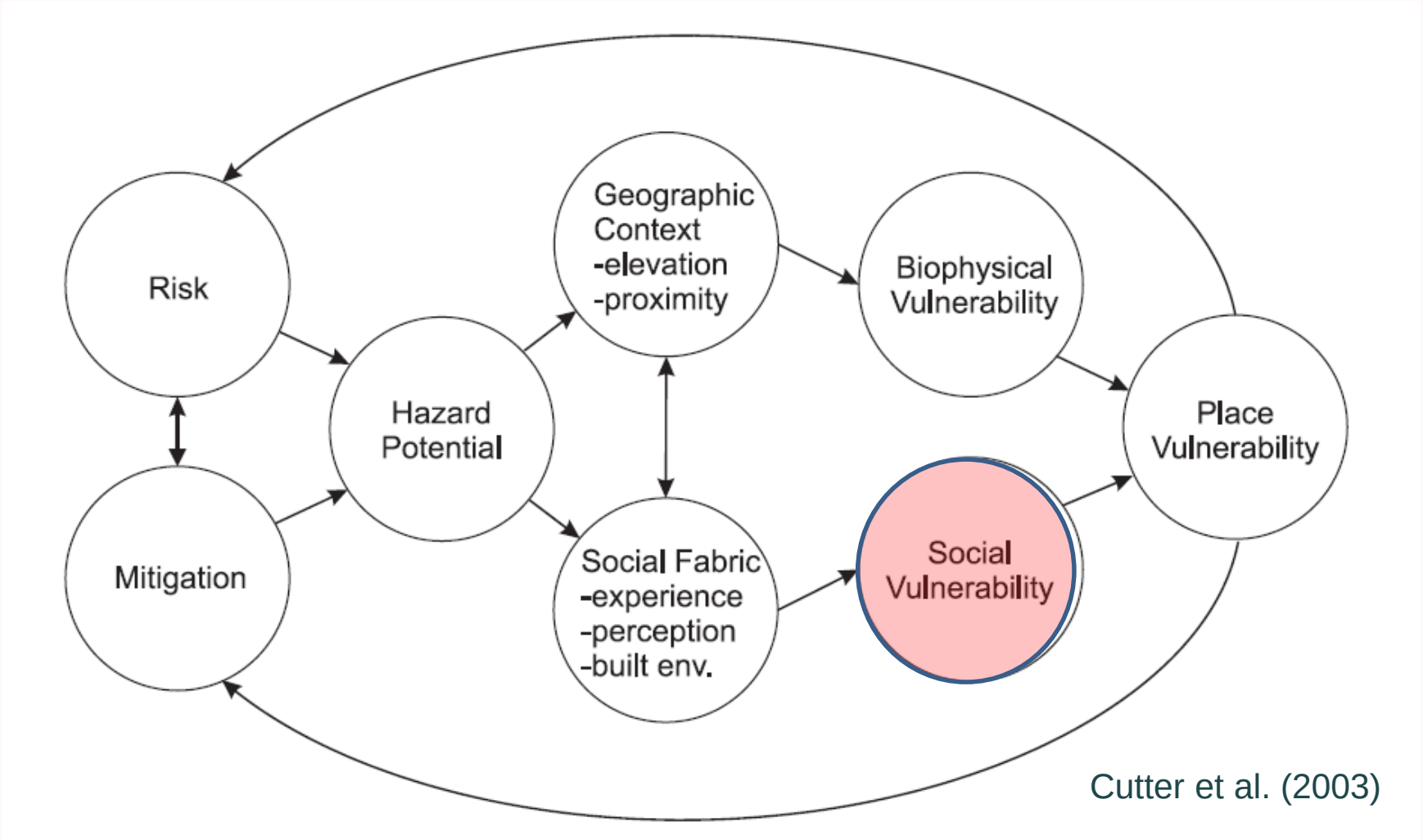
Identification of population, buildings and built area within wildfire perimeters plus that situated 1000 m apart:

- Inside wildfire perimeters
- Progressively farther "donuts" around



Chas-Amil et al. International Journal of Disaster Risk Reduction, 2020

Social vulnerability



Cutter et al. (2003)

Key questions

- Can we spatially identify the vulnerability of the population to forest fires?

Policy-relevance:

Identify specific locations where improvements in preparedness and suppression capacity may yield the largest gains in social resilience to natural risks.

Chas-Amil et al. Landscape and Urban Planning, 2022

Methodology

Chas-Amil et al. (2022):

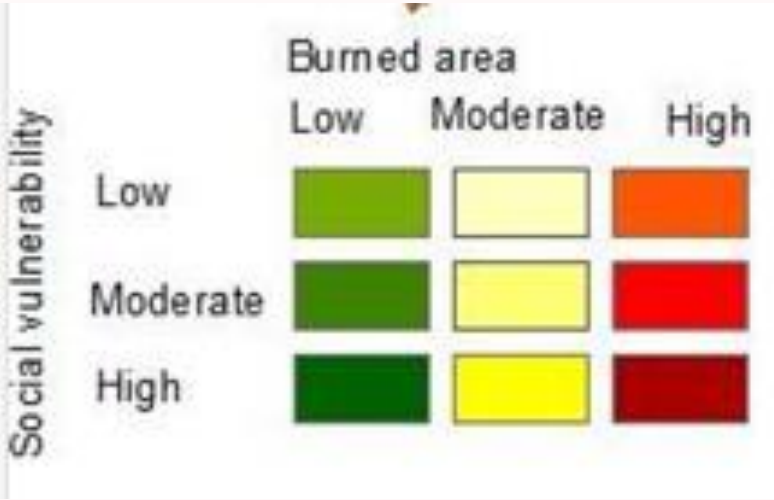
Quantify social vulnerability: **Social vulnerability index (SoVI):**

- Principal Components Analysis (PCA): To reduce a large matrix of data to a single index of vulnerability.

- Mapping SoVI → identify most vulnerable municipalities

Identify wildfire risk

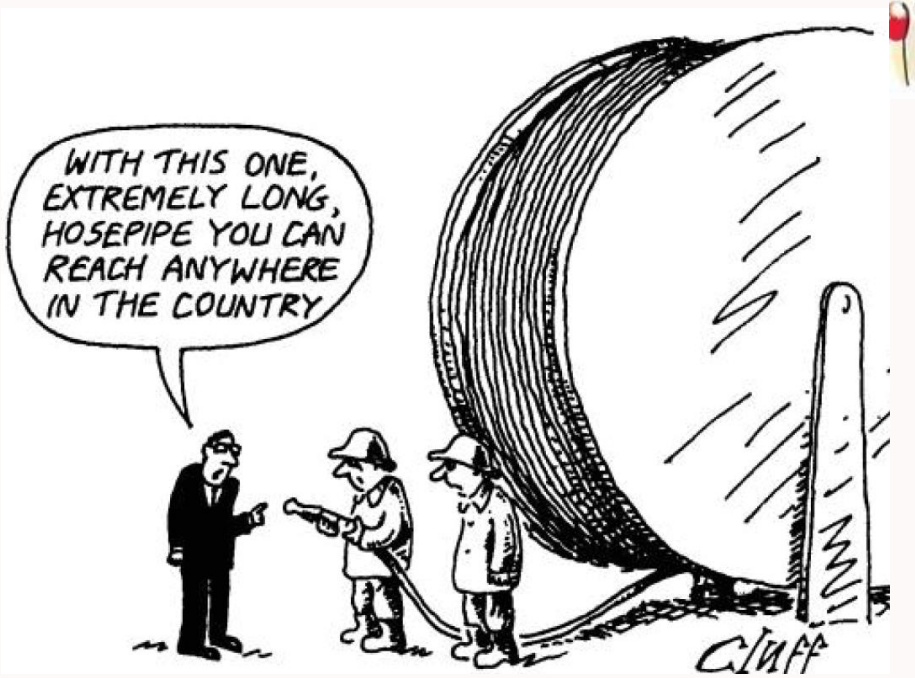
Combine social vulnerability and wildfire risk



Chas-Amil et al. Landscape and Urban Planning, 2022

Work in progress

Risk perception and social awareness



Firefighting costs


THANK YOU FOR YOUR ATTENTION!!