



Centre for the Research and Technology of Agro-  
Environmental and Biological Sciences

## FOREST FIRE RISK IN PORTUGAL

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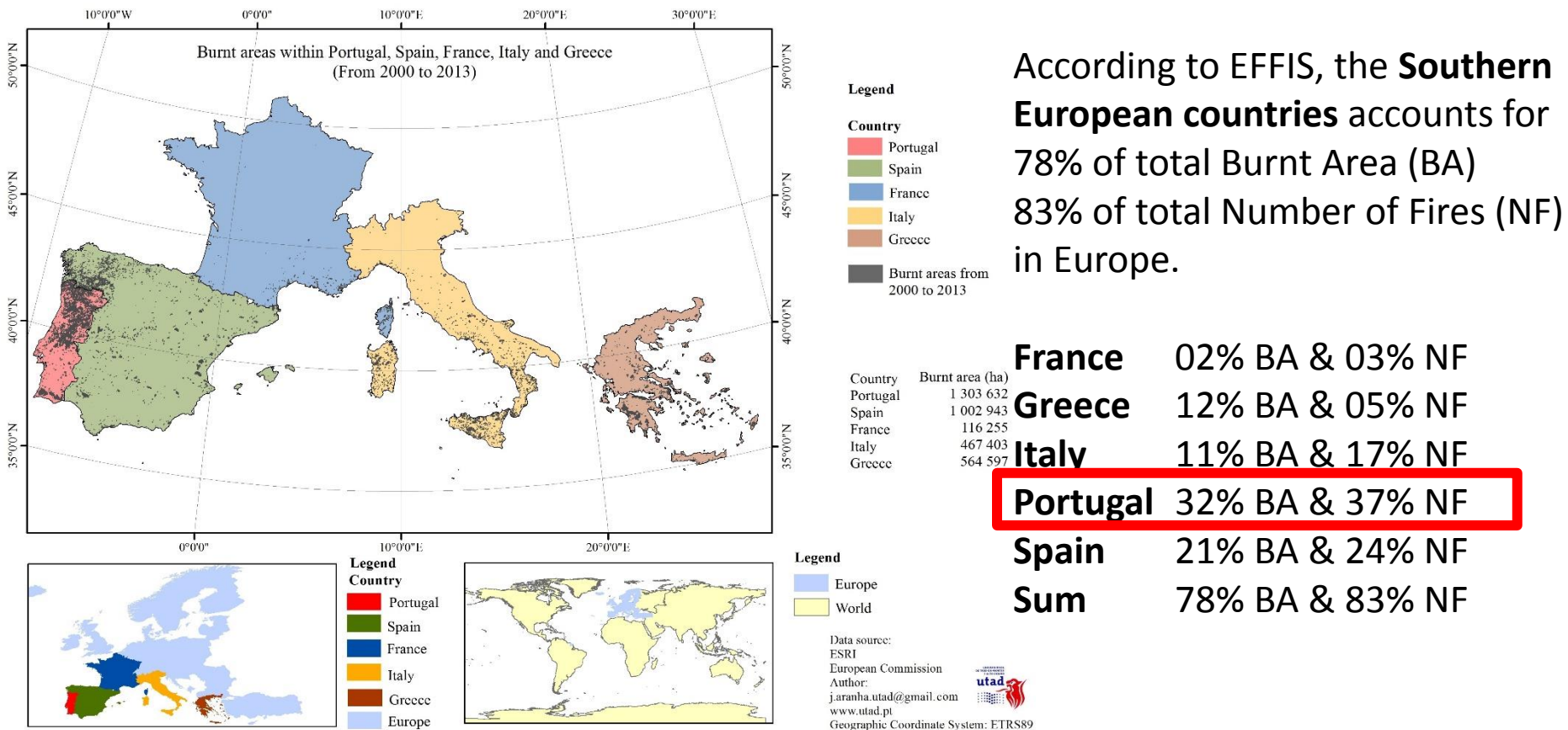
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## Outline

1. Motivation
2. Objectives
3. Materials and Methods
4. Results
5. Conclusions
6. Future work

# 1. Motivation: Why forest fires in Portugal?

Portugal is the European country most affected by wildfires.



**Fig.1** - Perimeters of area burnt by fires in the five most affect Mediterranean countries of Europe in the 2000-2013 period.  
Adapted from Pereira et al., 2014.

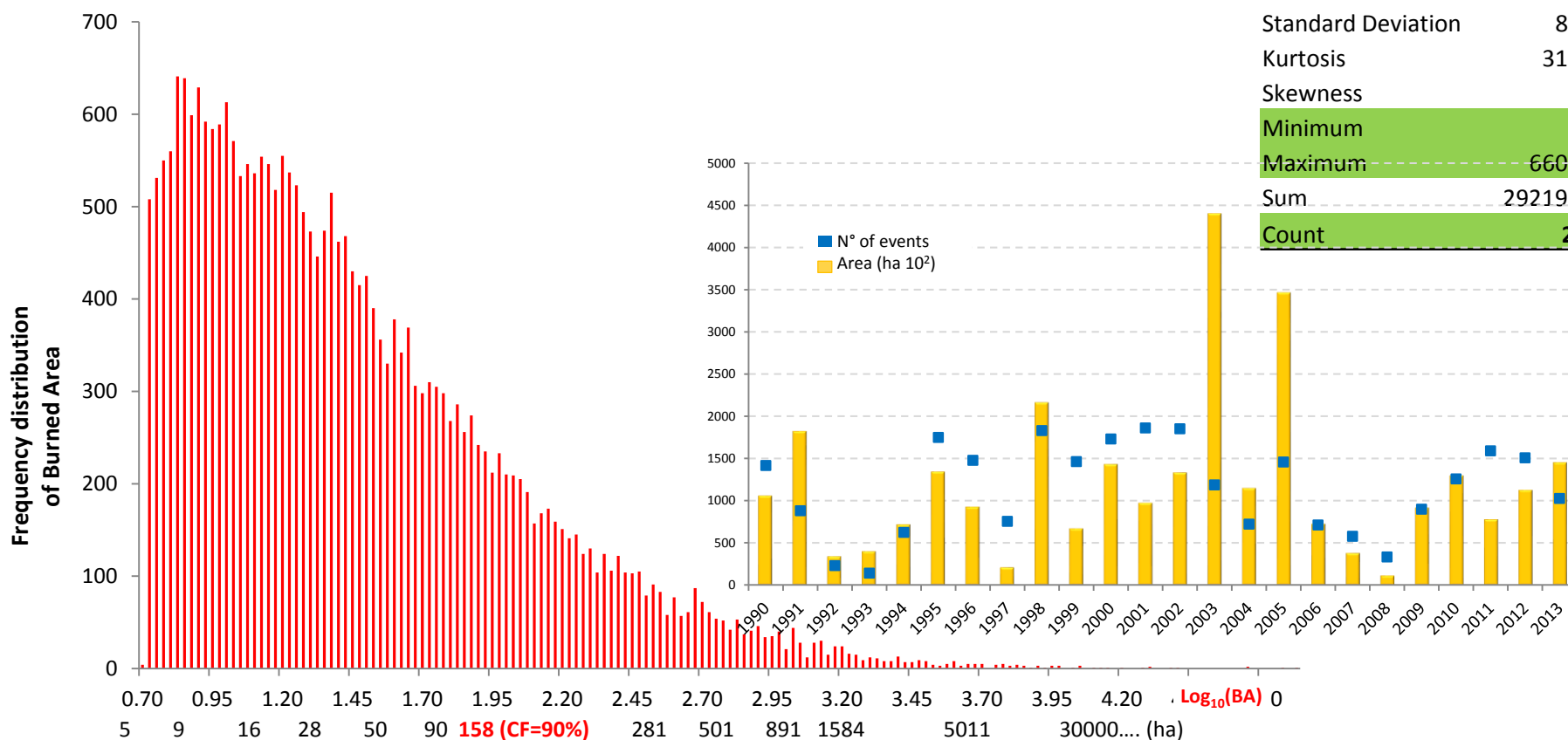
# 1. Motivation: Why forest fires in Portugal?

High variability

## Summary Statistics

Area\_ha

|                    |            |
|--------------------|------------|
| Mean               | 107.14     |
| Standard Deviation | 810.93     |
| Kurtosis           | 3182.72    |
| Skewness           | 48.67      |
| Minimum            | 5          |
| Maximum            | 66070.63   |
| Sum                | 2921956.99 |
| Count              | 27273      |



**Fig.2** – Total anual number of fires and área burnt by fires in Portugal during the 2000 – 2013 period  
Adapted from Tonini et al., 2015

# 1. Motivation: **Why fire risk?**

Verde and Zezere (2010) Assessment and validation of **wildfire susceptibility and hazard in Portugal**

Assessment of **Forest Fire Hazard** is also provided in the Institute for the Conservation of Nature and Forests (ICNF) web site.

The IPMA provide a daily forest fire risk index which is a combination of two indices: the meteorological index of forest fire danger, FWI and a structural risk index.

Antunes et al. (2011) Forest **Fire Risk Assessment** in the municipality of Arganil.

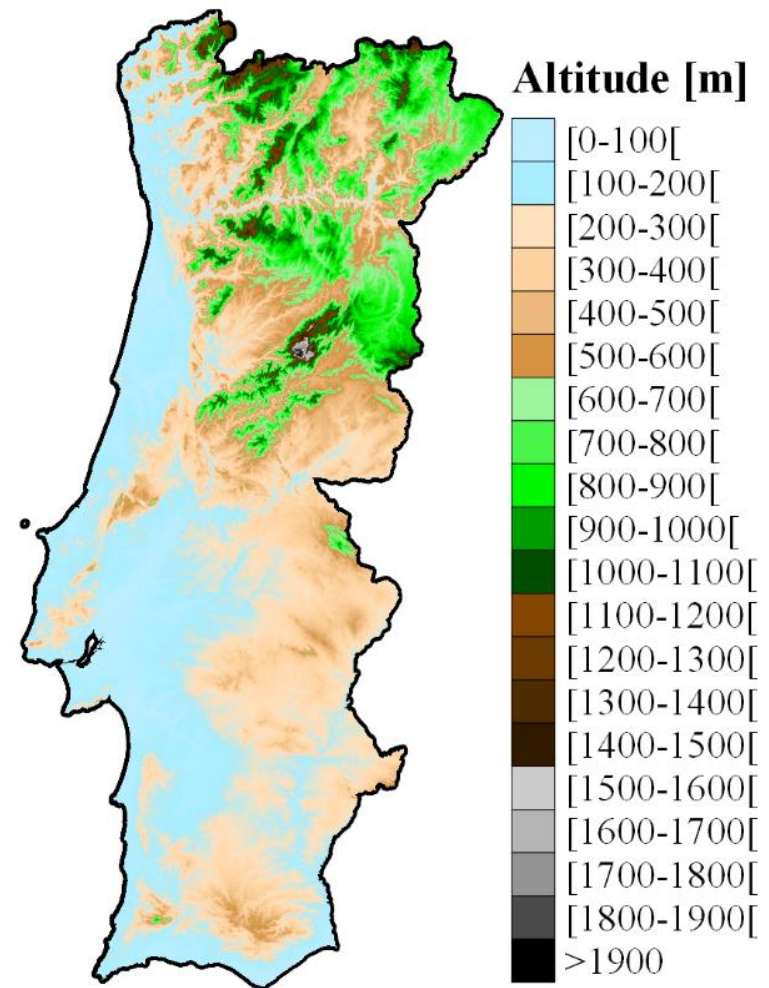
**But, there is no HIGH RESOLUTION DYNAMICAL FIRE RISK map for entire Portugal**

## 2. Objectives

- ❖ **Develop a dynamical fire risk map**
- ❖ **Assess the structural forest fire risk in Portugal**
  - ❖ **higher spatial resolution (80 m to 25 m)**
  - ❖ **updated vegetation cover (CLC2006)**
  - ❖ **longer fire history (from 1975-2004 to 1975-2013)**
  - ❖ **focused on the potential economic damage.**

### 3. Materials and Methods: Data

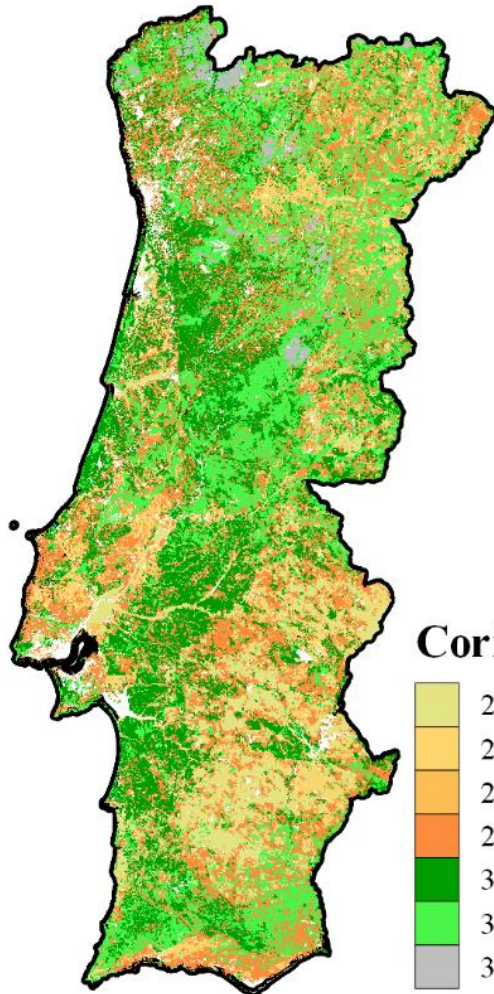
- Digital elevation model derived from the Shuttle Radar Topographic Mission in a resolution of 1 arc-seconds (DEM-SRTM 25 m) provided by J. Gonçalves (Gonçalves and Fernandes 2005; Gonçalves and Morgado 2008 (<http://www.fc.up.pt/pessoas/jagoncal/srtm/>)):
- altitude, slope
- > 140 million pixels!



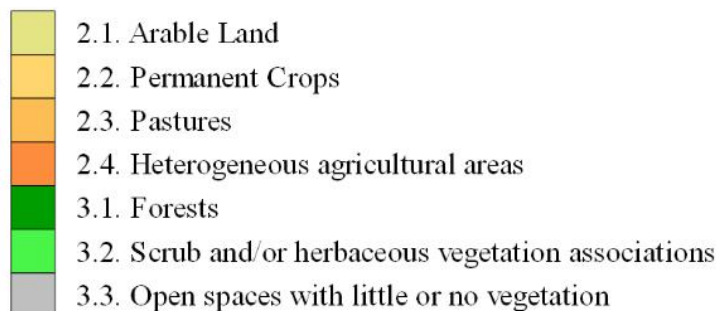


## 3. Materials and Methods: Data

- Corine land cover 2006 inventory provided by the European Environment Agency (<http://www.eea.europa.eu/pt>);
- Level 1 (Artificial surfaces), 4 (Wetlands) and 5 Water bodies) classes were excluded
- 134 million records!



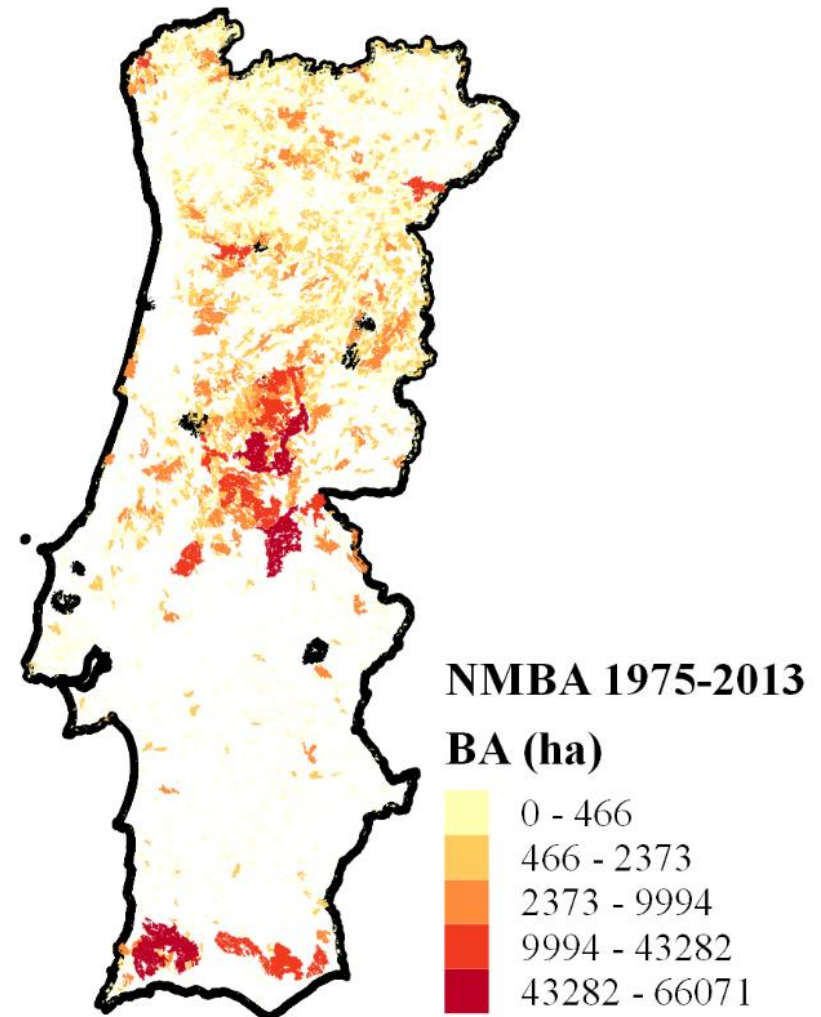
**Corine Land Cover 2006**



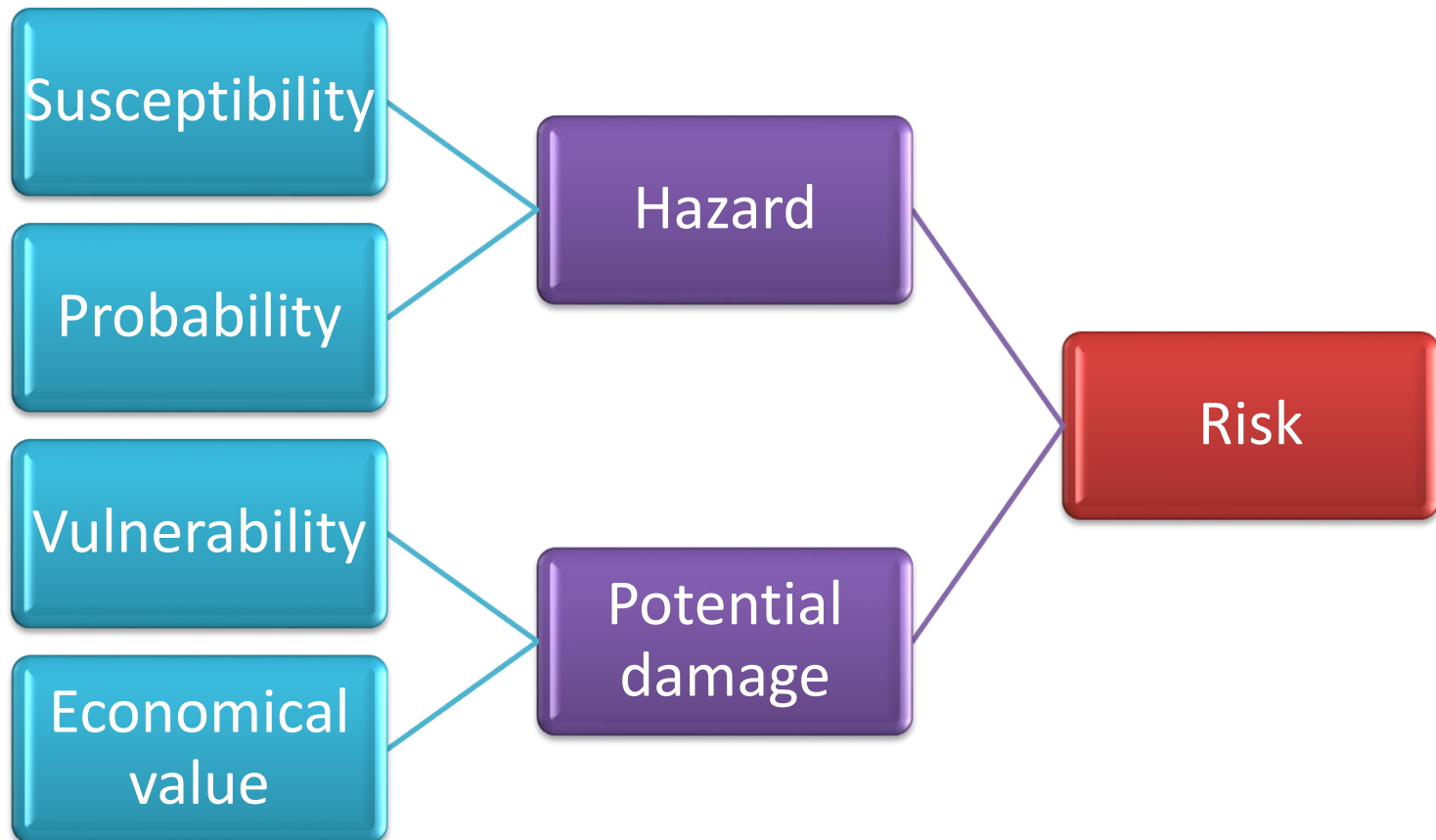


## 3. Materials and Methods: Data

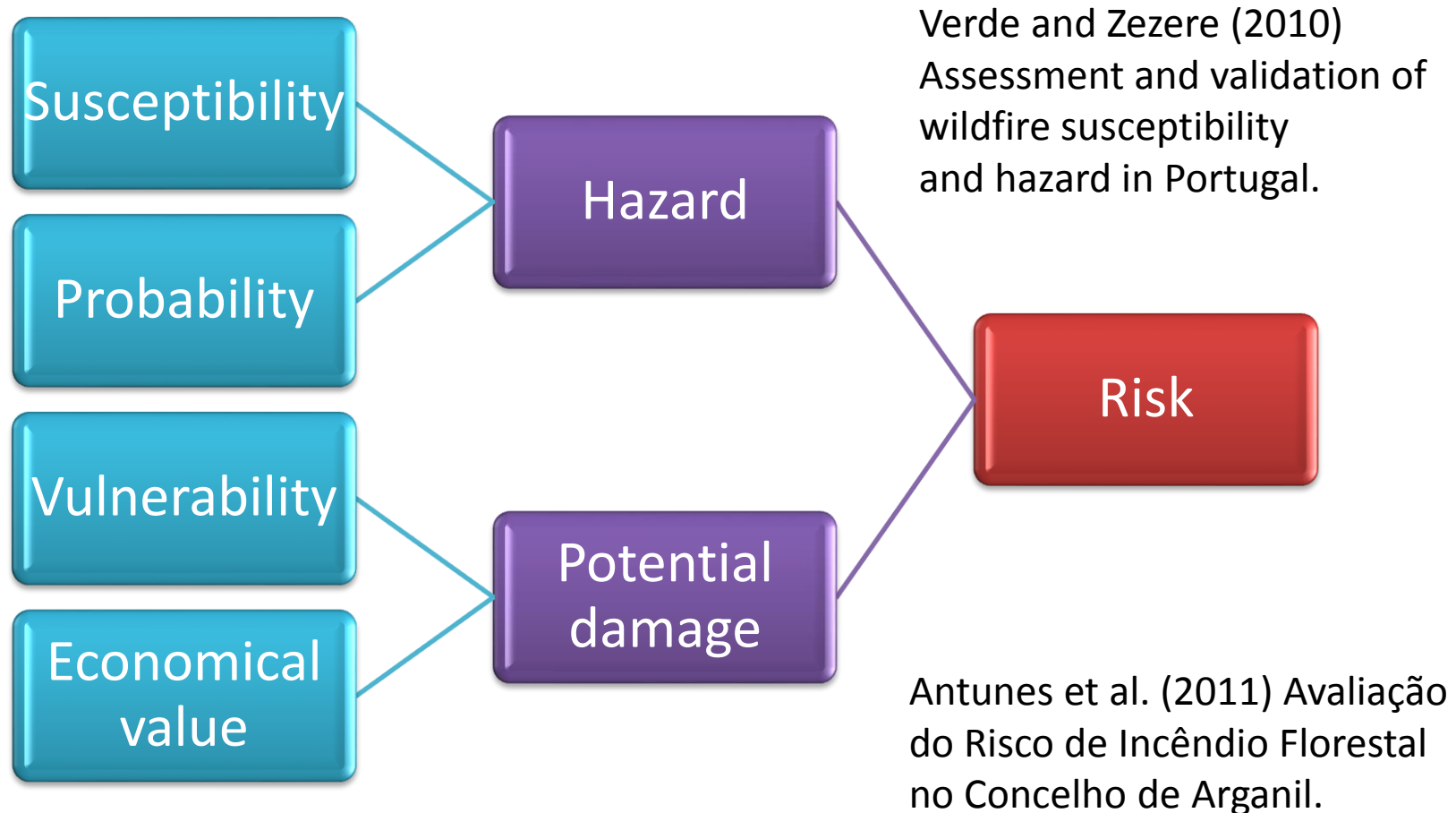
- National Mapping Burnt Areas (NMBA) provided by the Institute for the Conservation of Nature and Forests (ICNF) (<http://www.icnf.pt/portal>).



### 3. Materials and Methods: the framework



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### 3. Materials and Methods: the framework

The susceptibility,

$$UCF = F(pa) \cdot F(Sf1) \cdot F(Sf2) \dots F(Sfn),$$

where,  $pa = \frac{f}{N} \times 100\%$  is the simple (not conditioned) probability,  $f$  the number of times the pixel burns within the  $N$  years of study

$Sfx = \frac{umAx}{\Omega x} \times 100\%$ ,  $umAx$  is the number of burnt pixels in class  $x$  and  $\Omega x$  is the total number of pixels of class  $x$ .

Assuming the Corine-Slope-Probability (CSP) model (Verde and Zêzere, 2010).



### 3. Materials and Methods: the framework

The probability (associated with each susceptibility class  $x$ ),

$$P = 1 - \left(1 - \frac{aaf}{at_x} \cdot vprev_x\right), \text{ where,}$$

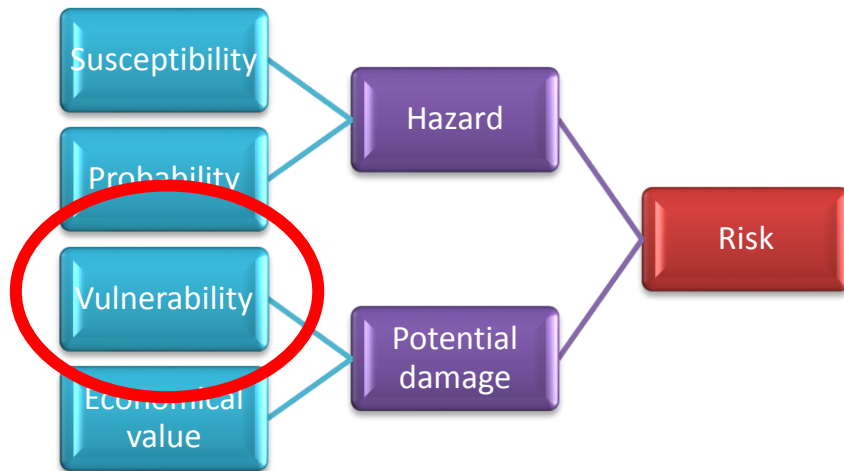
$aaf$  is the total area to be burnt in the considered scenario,

$at_x$  is the total area within the susceptibility class  $x$ ,

$vprev_x$  is the predictive value for the susceptibility class  $x$ .

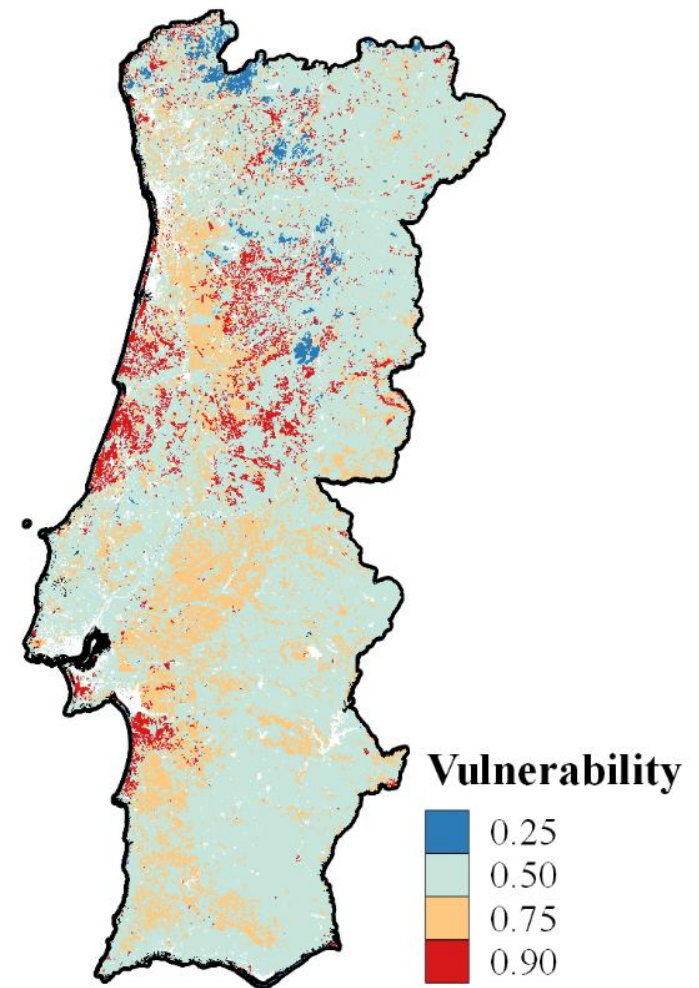


## 3. Materials and Methods: the framework



The vulnerability of the elements are defined according to the level or degree of destruction of the elements caused by fire.

The vulnerability scores for the adopted CLC classes were adapted from Antunes et al. (2011).

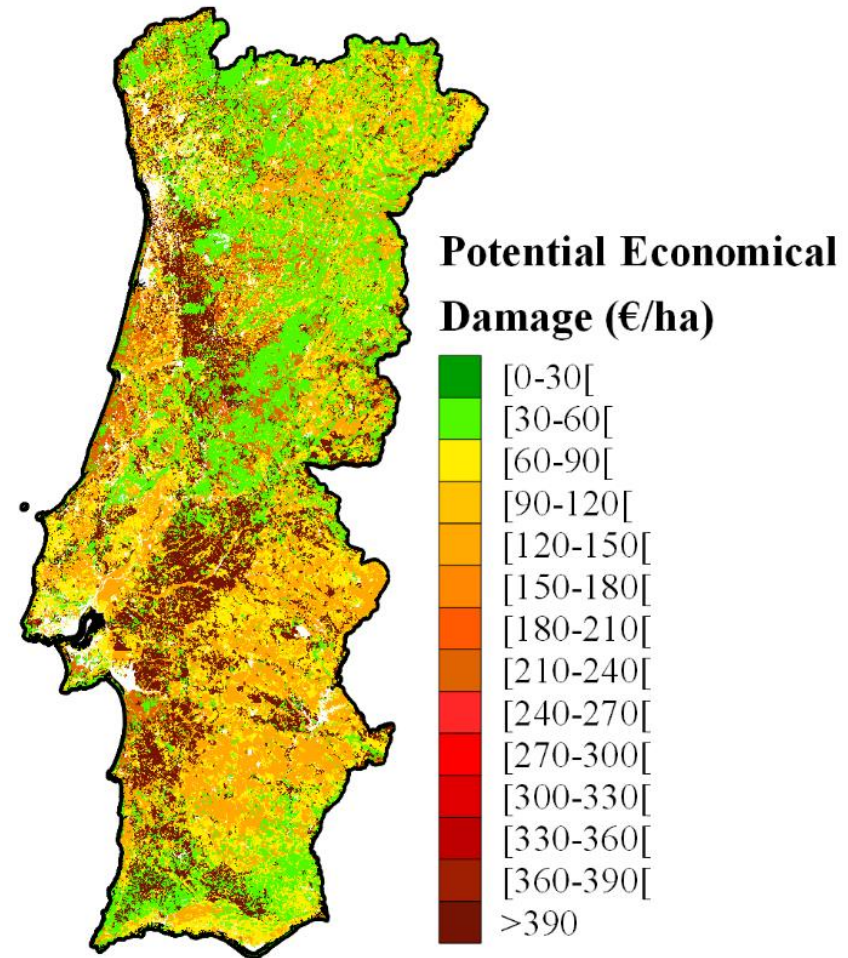




### 3. Materials and Methods: the framework

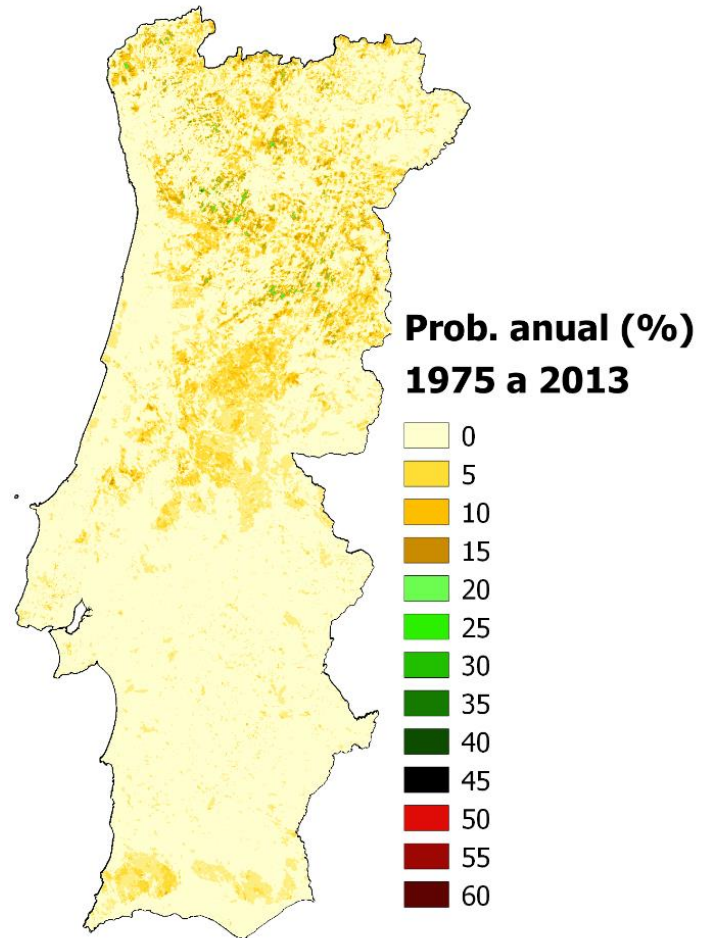
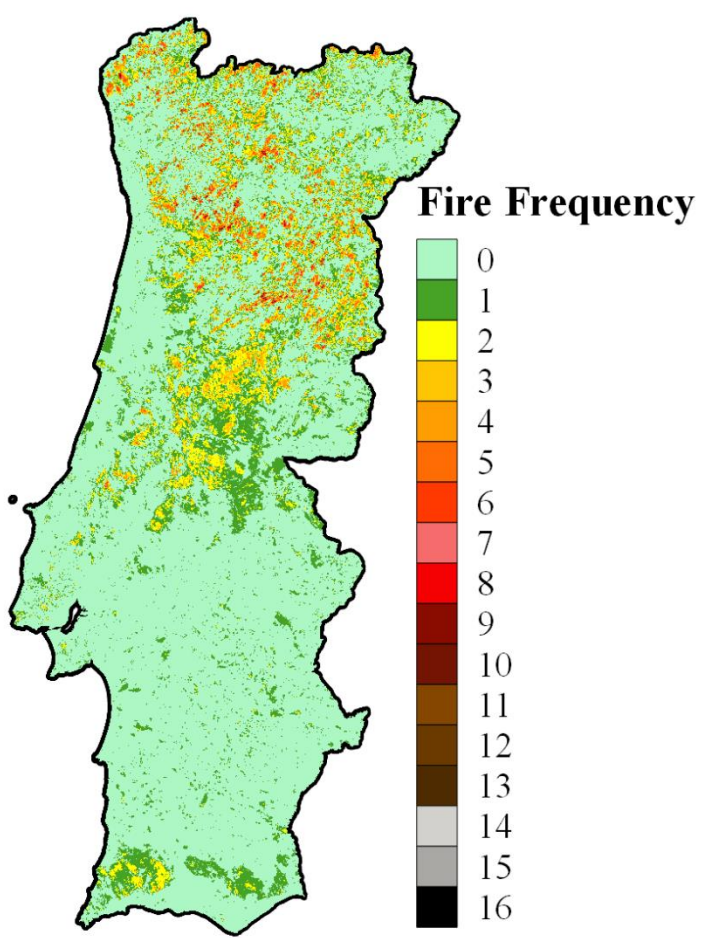


The economical value was assessed from the *Estratégia Nacional para as Florestas*, which is a resolution of the Council of Ministers (Resolução do Conselho de Ministros n.º 114/2006, de 15 de setembro



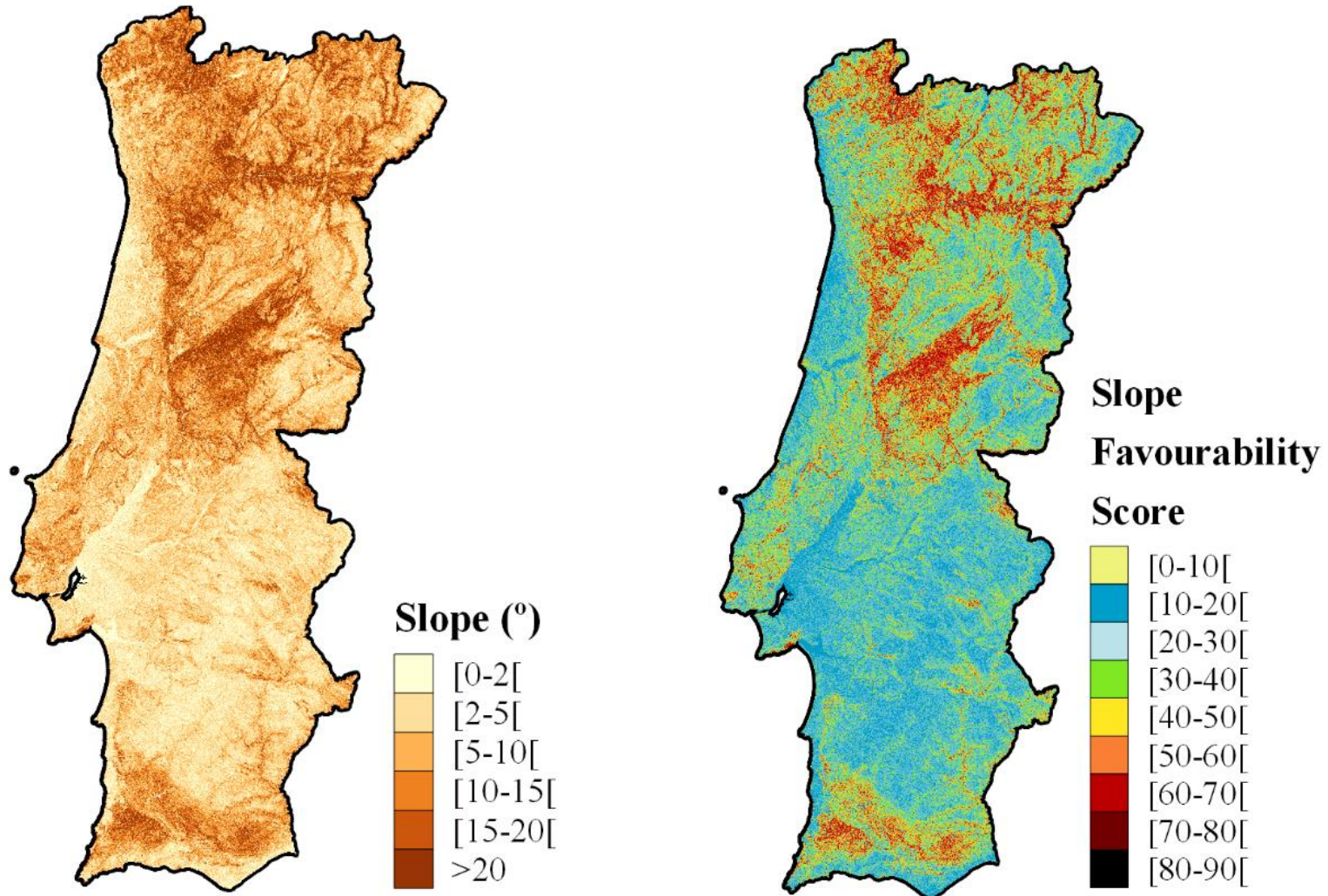


# 4. Results: Annual probability of occurrence

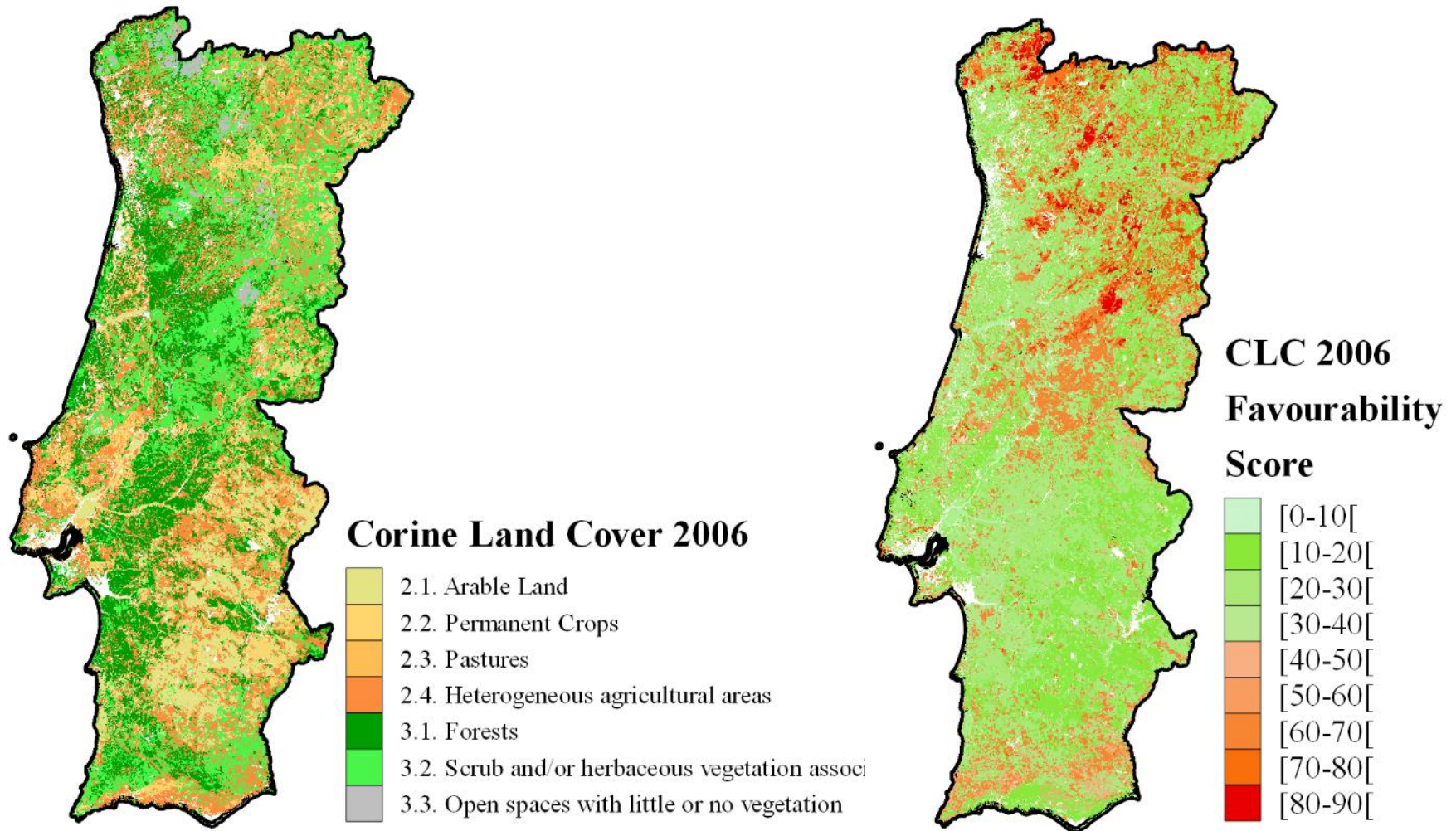




## 4. Results: Slope & Slope favorability score

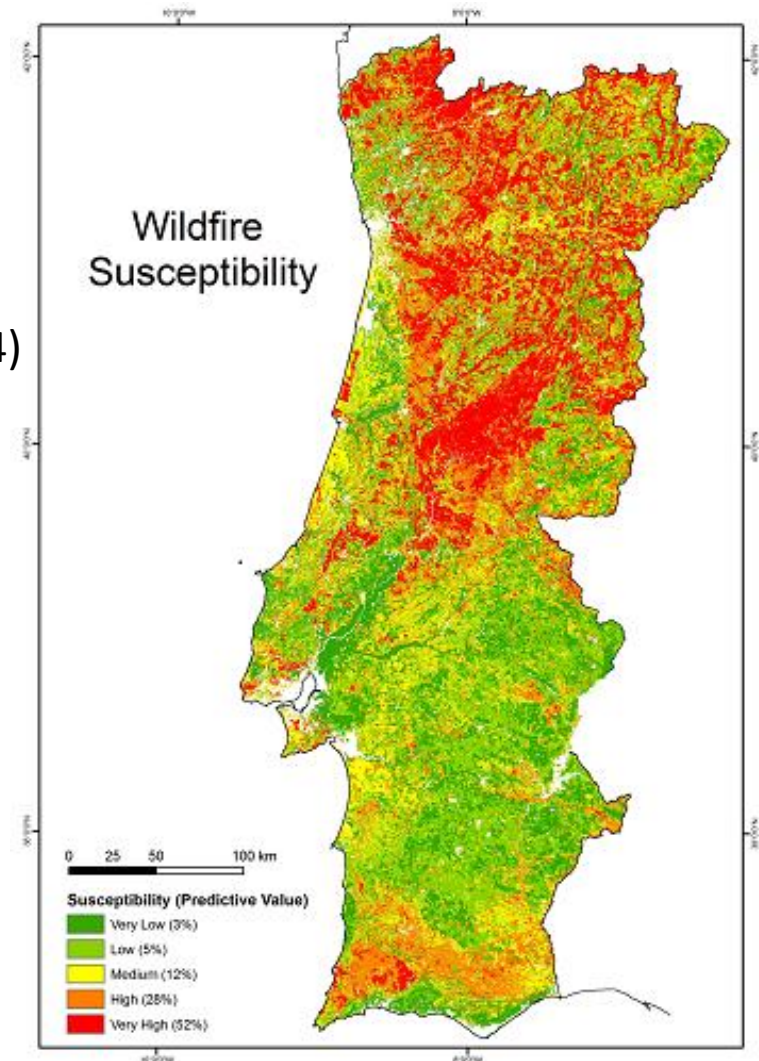
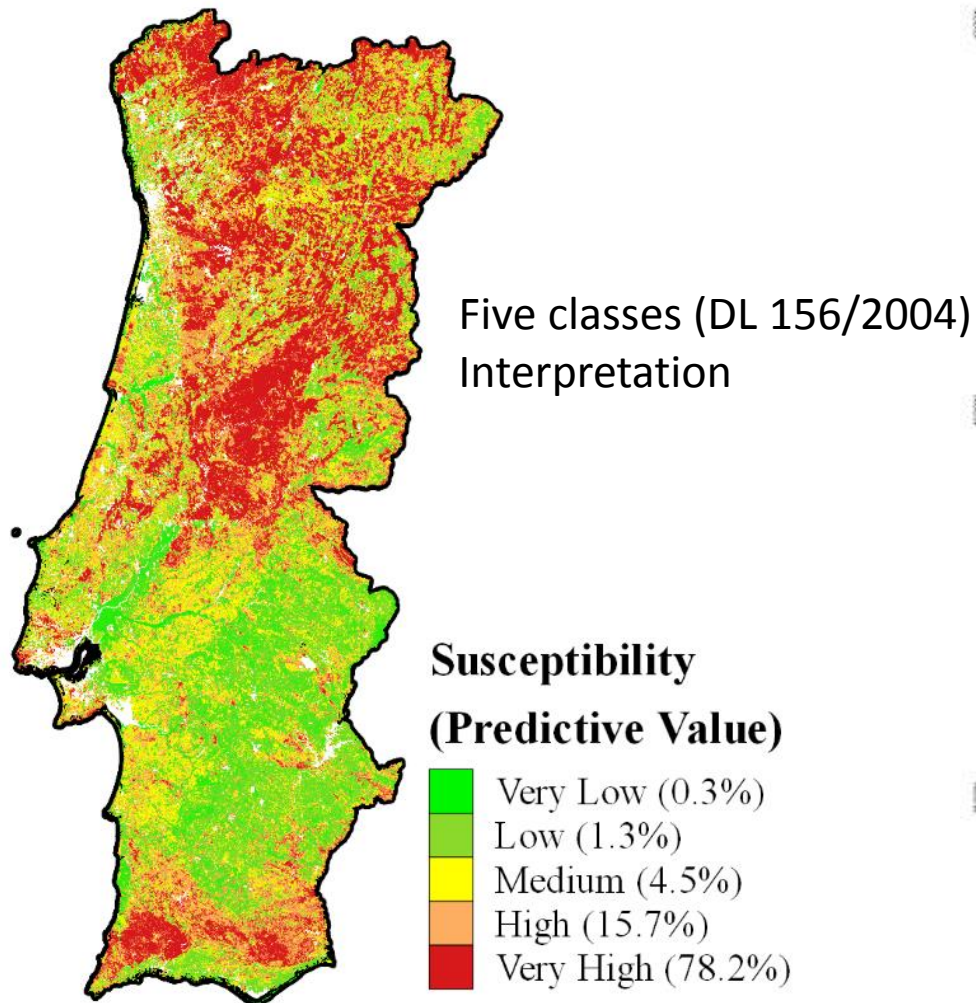


## 4. Results: CLC favorability scores





## 4. Results: Susceptibility



Verde and Zezere (2010)

## 4. Results: Hazard

$$P = 1 - \left( 1 - \frac{aaf}{at_x} \cdot vprev_x \right)$$

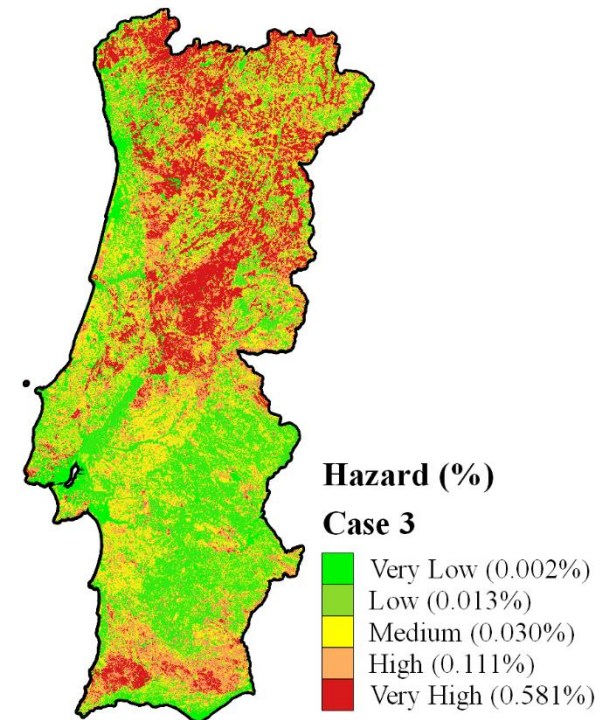
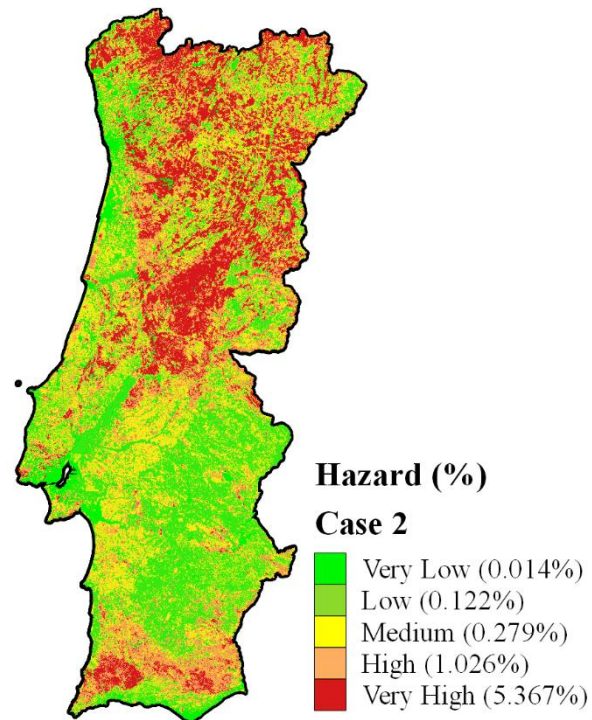
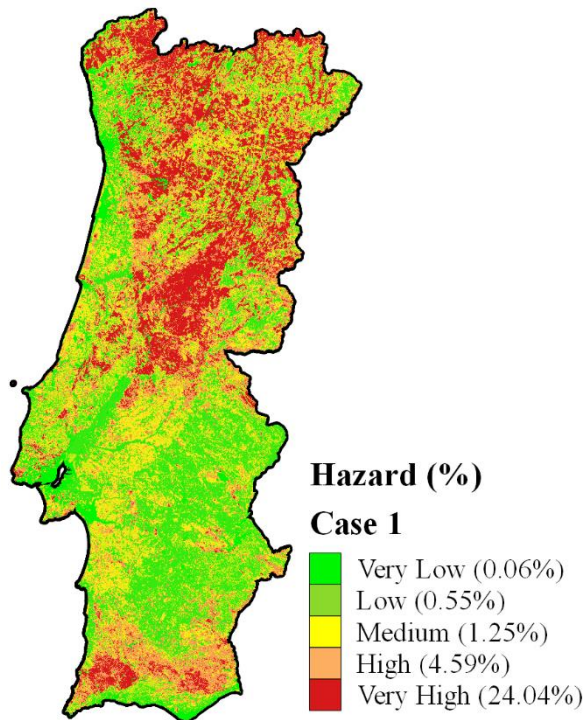
| Susceptibility<br>class | Area                   |       | Predictive<br>value | Probability                | Probability                | Probability               |
|-------------------------|------------------------|-------|---------------------|----------------------------|----------------------------|---------------------------|
|                         | (nr. of 80m<br>pixels) | (%)   |                     | scenario 1<br>(500 000 ha) | scenario 2<br>(112 000 ha) | scenario 3<br>(12 000 ha) |
| Very low                | 33443751               | 24,8% | 0,00                | 0,06%                      | 0,01%                      | 0,00%                     |
| Low                     | 19013965               | 14,1% | 0,01                | 0,55%                      | 0,12%                      | 0,01%                     |
| Medium                  | 28911293               | 21,4% | 0,05                | 1,25%                      | 0,28%                      | 0,03%                     |
| High                    | 27427301               | 20,3% | 0,16                | 4,59%                      | 1,03%                      | 0,11%                     |
| Very high               | 26020791               | 19,3% | 0,78                | 24,04%                     | 5,37%                      | 0,58%                     |
| Soma                    | 134817101              | 100%  | 1,00                |                            |                            |                           |

| Susceptibility<br>class | Area                   |       | Predictive<br>value | Probability                |
|-------------------------|------------------------|-------|---------------------|----------------------------|
|                         | (nr. of 80m<br>pixels) | (%)   |                     | scenario 1<br>(500 000 ha) |
| Very low                | 2783096                | 20,8% | 0,03                | 0,84%                      |
| Low                     | 2780358                | 20,8% | 0,05                | 1,40%                      |
| Medium                  | 2758308                | 20,7% | 0,12                | 3,40%                      |
| High                    | 2634032                | 19,7% | 0,28                | 8,30%                      |
| Very high               | 2401267                | 18,0% | 0,52                | 16,92%                     |
| Sum                     | 13357061               | 100%  | 1,00                |                            |

Verde and Zezere (2010)

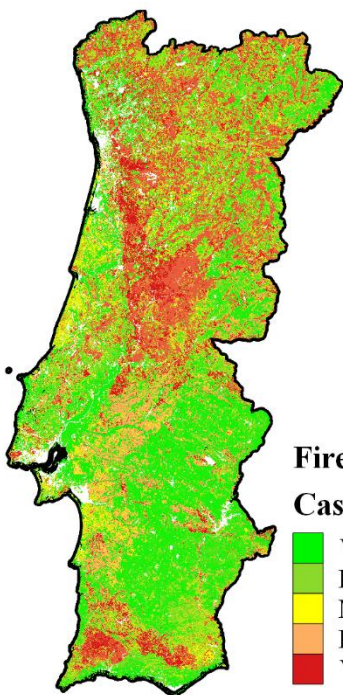


## 4. Results: Hazard

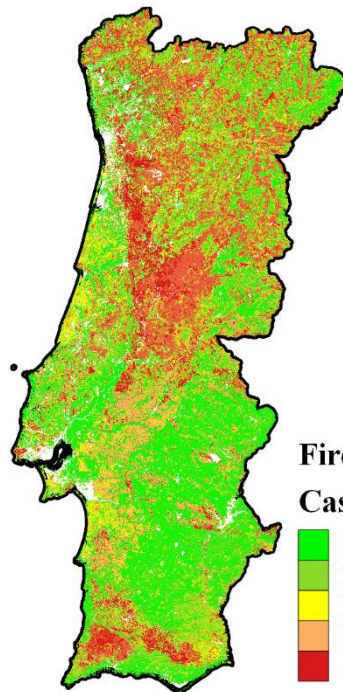
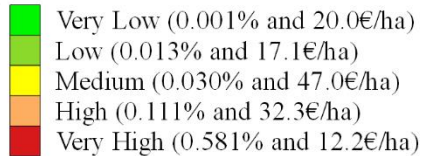




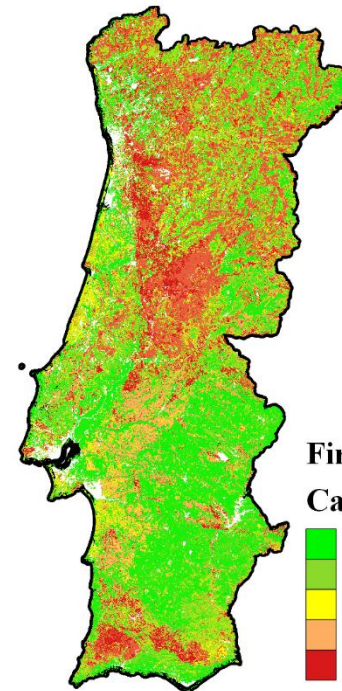
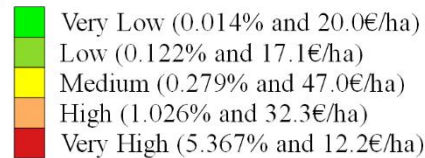
## 4. Results: The fire risk



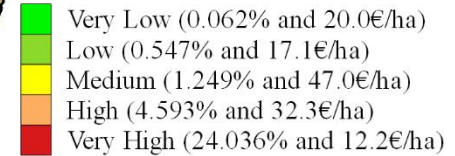
**Fire Risk**  
**Case 3**



**Fire Risk**  
**Case 2**



**Fire Risk**  
**Case 1**



## 5. Conclusions

- Structural forest fire risk map was produced;
- Importance of risk assessment update with greater quantity and quality data;

## 6. Future work

- To assess the usefulness of other variables (e.g., meteorological, socioeconomic) i.e. to refit the susceptibility map;
- Update the vulnerability map;
- To include the dynamical risk factors (e.g., weather conditions);
- To consider human, landscape and ecological potential damage;

# Thank you for your attention

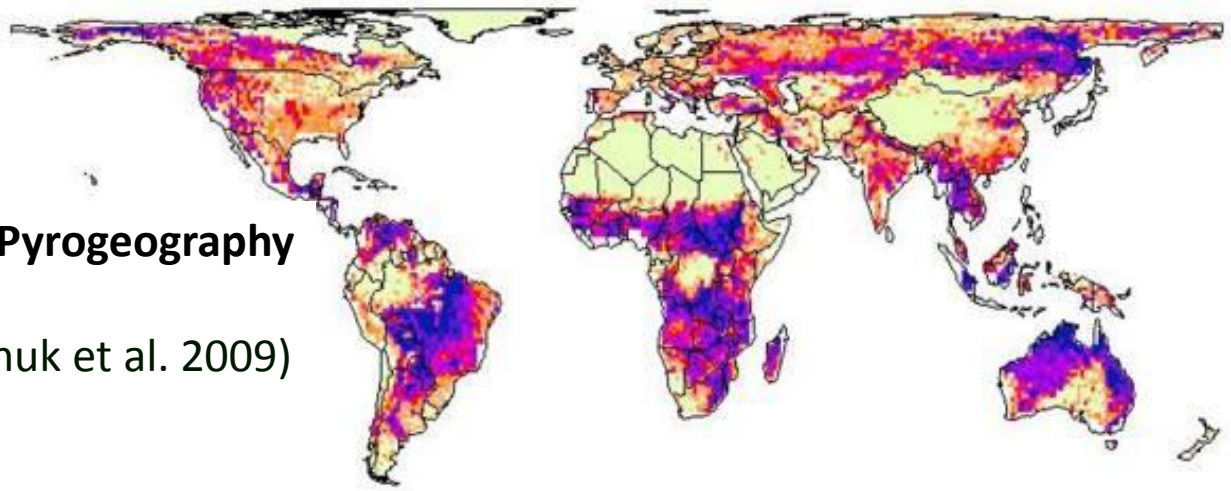






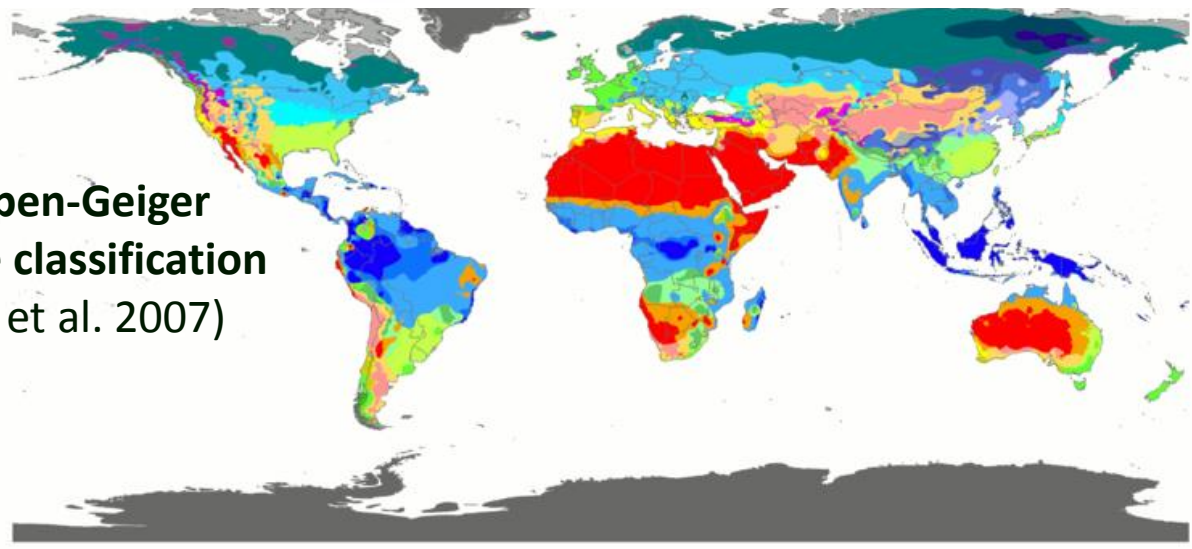
## Global Pyrogeography

(Krawchuk et al. 2009)



## Köppen-Geiger climate classification

(Peel et al. 2007)



Climate defines  
the existence,  
type and life  
cycle of the  
vegetation in  
each site.



|     |     |     |     |     |     |     |     |    |
|-----|-----|-----|-----|-----|-----|-----|-----|----|
| Af  | BWh | Csa | Cwa | Cfa | Dsa | Dwa | Dfa | ET |
| Am  | BWk | Csb | Cwb | Cfb | Dsb | Dwb | Dfb | EF |
| Aw  | BSh | Cwc | Cfc | Dsc | Dwc | Dfc |     |    |
| BSk |     | Dsd | Dwd | Dfd |     |     |     |    |

DATA SOURCE : GHCN v2.0 station data  
Temperature (N = 4,844) and  
Precipitation (N = 12,396)

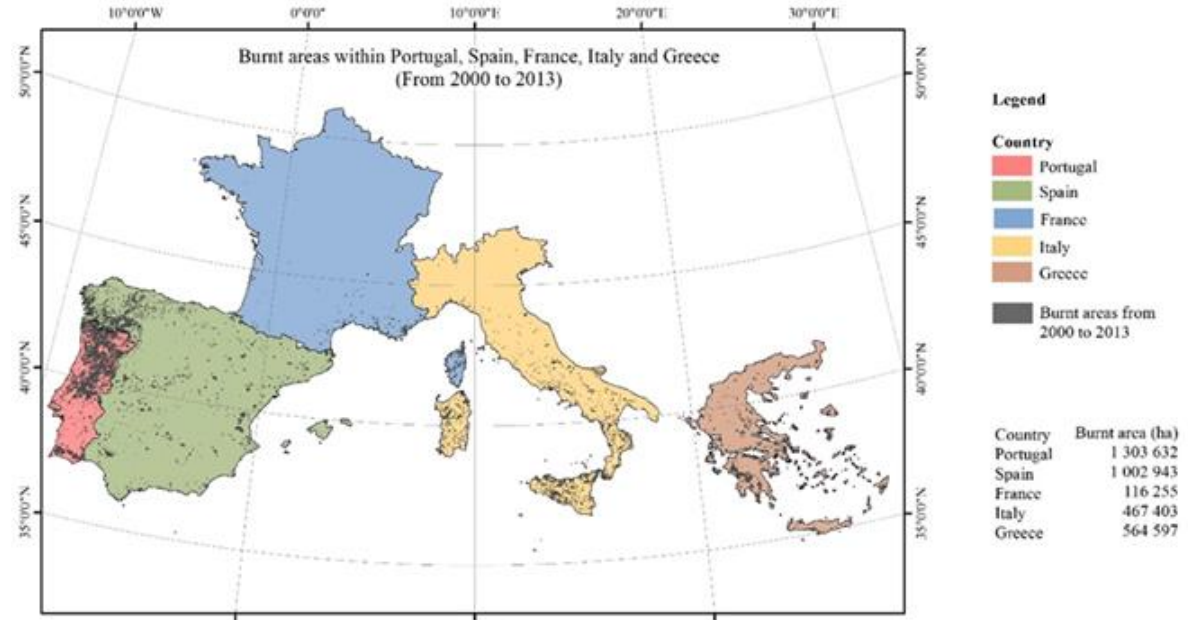
PERIOD OF RECORD : All available

MIN LENGTH : ≥30 for each month.

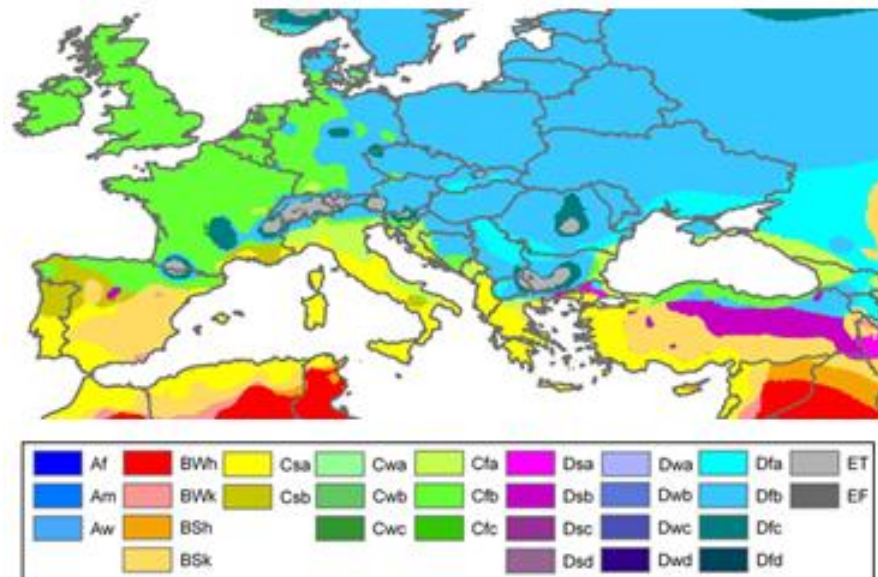
RESOLUTION : 0.1 degree lat/long

Contact : Murray C. Peel (mpeel@unimelb.edu.au) for further information

## Burnt area perimeters in Southern Europe (Pereira et al. 2014)



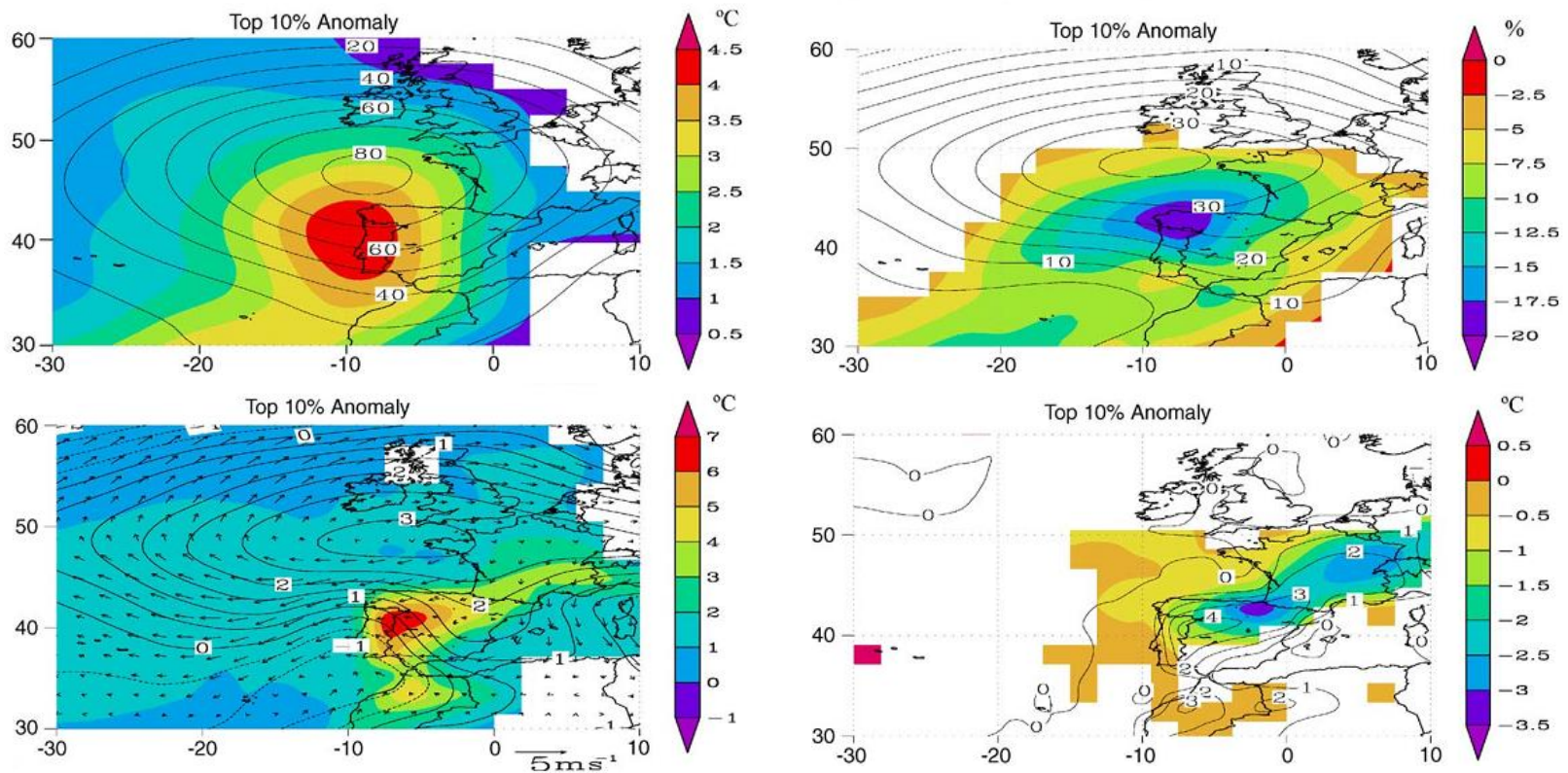
## Köppen-Geiger climate classification (Peel et al. 2007)





## 1. Motivation: How to model?

Extreme fire events are associated to also extreme atmospheric conditions

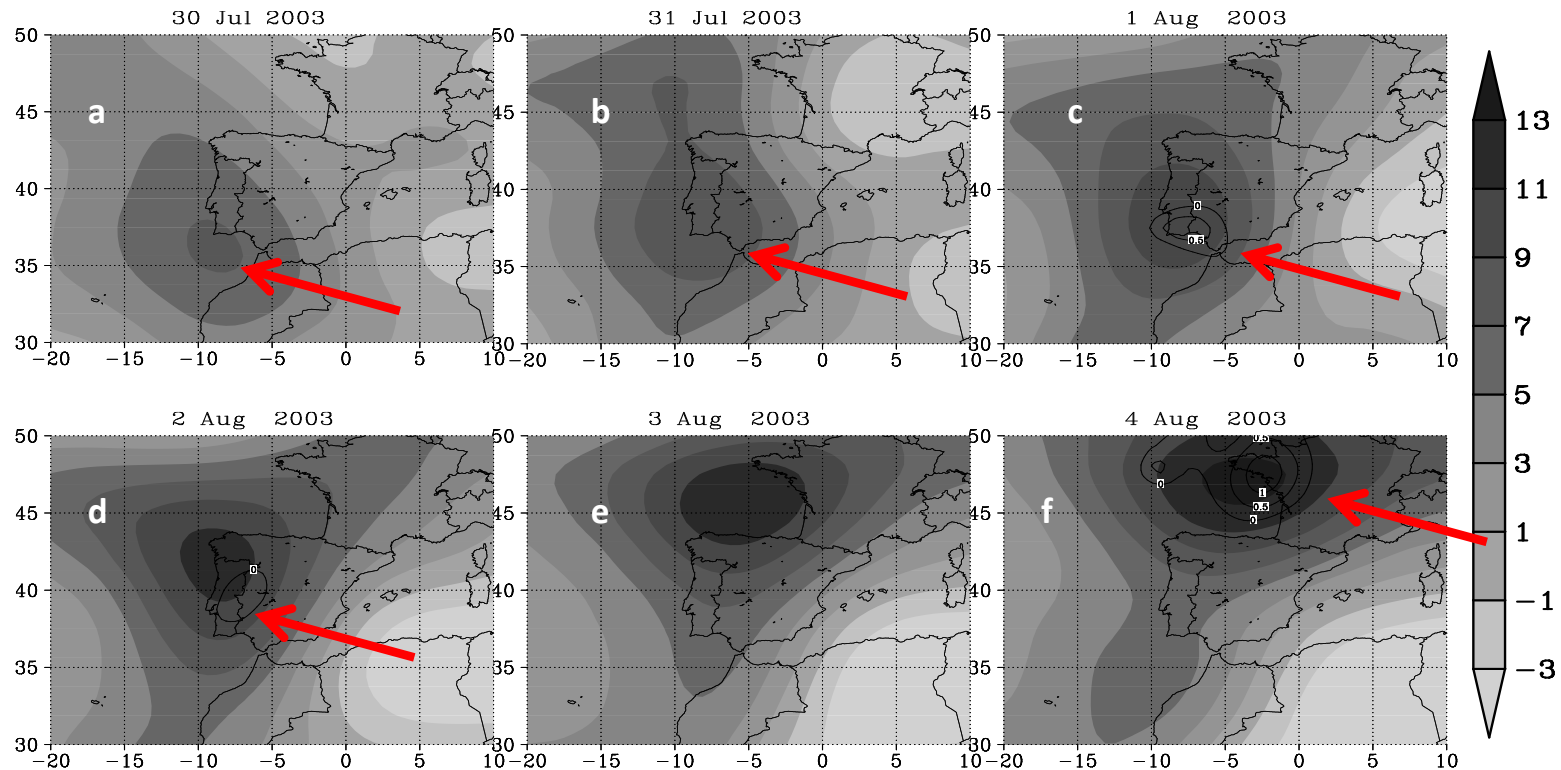


Pereira et al. 2005

Meteorological conditions are able to tell us when fires are more likely to occur.

## 1. Motivation: How to model?

In some cases, atmospheric conditions are also able to tell us where fires are more likely to occur.



**Fig. 4 a-f** - Daily sequence of **850 hPa air temperature anomalies (°C)**. Days are identified on the top of each panel. Regions with **temperature above the historical maximum are delimited by solid contours (°C)**. (Trigo et al. 2006)