

An aerial photograph of a forest fire in a hilly region. The fire is visible as a bright white and yellow area in the center-right of the image, with thick white smoke rising from it. The surrounding landscape consists of green and brown trees, and terraced agricultural fields in the foreground. The text is overlaid on a semi-transparent white box.

***Fire regimes of Portugal:  
pastoral, periurban, wild, and  
agricultural***

***José M.C. Pereira***

***Forest Research Centre, TERRA Associate Lab, School of Agriculture,  
ULisbon***



# Fire regime

There are clear regional variations in predominant "fire syndromes" in Portugal.

- Those variations concern the number of fires, their size and intensity, the time of the year when they occur, the main types of vegetation affected, their relationships with human population and climate, and their main causes.
- We developed a proposal to characterize and map the main "fire syndromes" found in Portugal.

# Fire regime

- Definition of a fire regime addresses where, when, and how fires occur, over a relatively broad area and an extended period of time.
- A fire regime is described by the frequency, size, seasonality, and intensity of the fires (*sensu stricto*, or narrow sense definition).
- The definition of fire regime may also include antecedent variables, i.e. prerequisites for fire ignition and spread (such as land use, population, and climate), as well as immediate consequences of fire, like impacts on vegetation, soil, and water.
- When at least some of these antecedent and consequent variables are considered, we obtain a classification of fire regimes in the broad sense, or *sensu lato*.

# Fire regime mapping

- A fire regime map provides the geographical context for decisions concerning management of fire prevention and suppression resources.
- Such a map will be more useful for mid-to-long term, strategic decision making at the national or regional level than for tactical, short-term, local decisions.
- It will also help distinguish different risk profiles, and identify management priorities and opportunities.
- This research originated to support the regionalization of the National Action Programme (PNA), which operationalizes the strategic options developed under the National Plan for Integrated Management of Rural Fires (SGIFR) .



# Data and variables

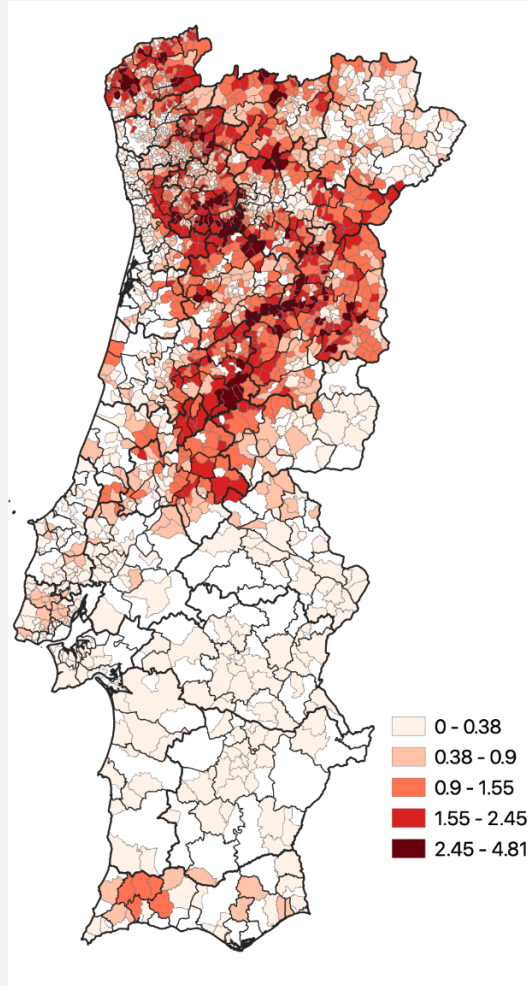
- Official Administrative Map of Portugal (CAOP – DGT), at the parish level.
- Portuguese Rural Fire Database (Pereira et al., 2011), for the period 1980-2017.
- Annual burned area maps for Portugal (CEF/ISA and ICNF), 1980 – 2017.
- MODIS Fire Radiative Power data, 2001 – 2017.



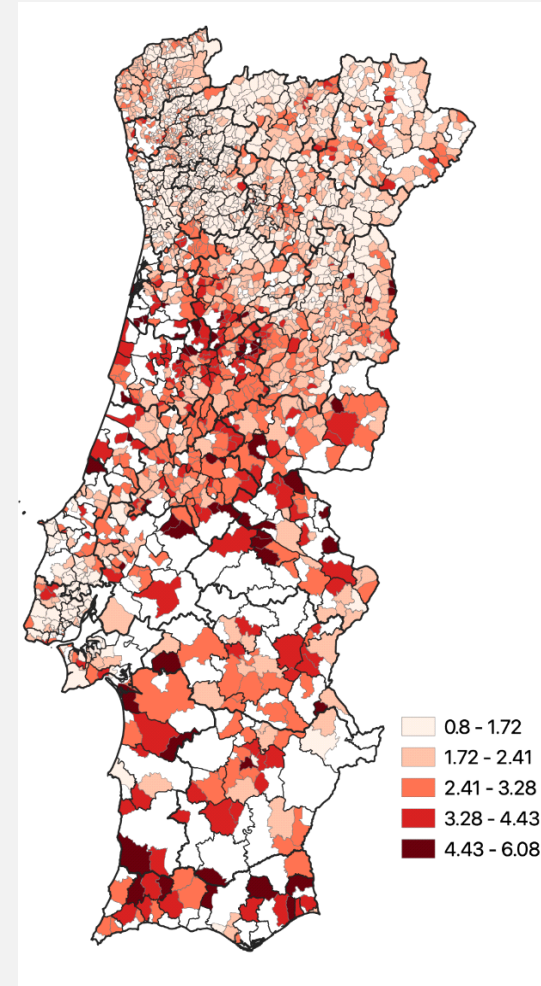
# Data and variables

- Burned area (ha/ha).
- Coefficient of variation of burned area (%).
- Mean size of the 10 largest burned areas (ha/ha).
- Number of fires (#/ha).
- Fire radiative power (90th percentile, MW).
- Fire season duration (days).
- Importance of the (extended, Nov. – Apr.) winter season (% days of total season).

# Maps of the fire variables

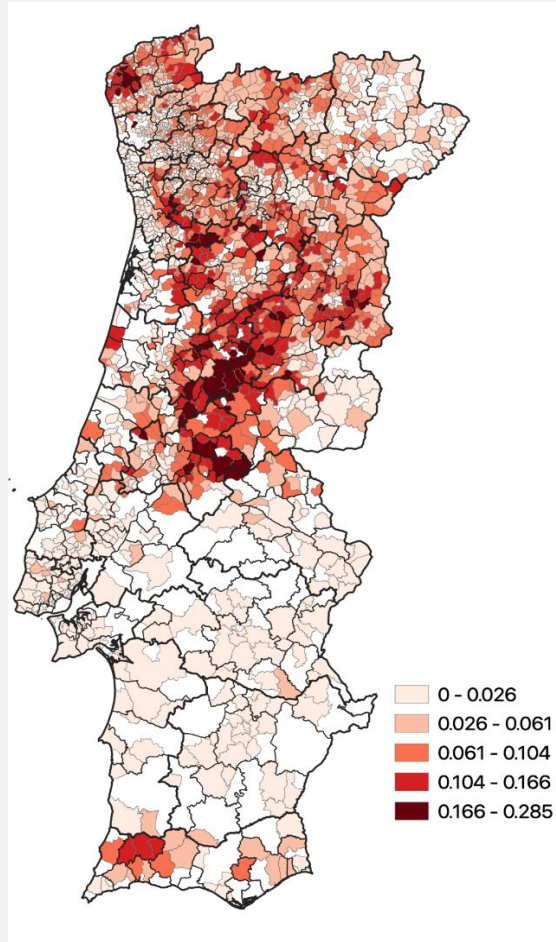


**Figure 1-** Burned area, normalized by the area of the parish (ha/ha).

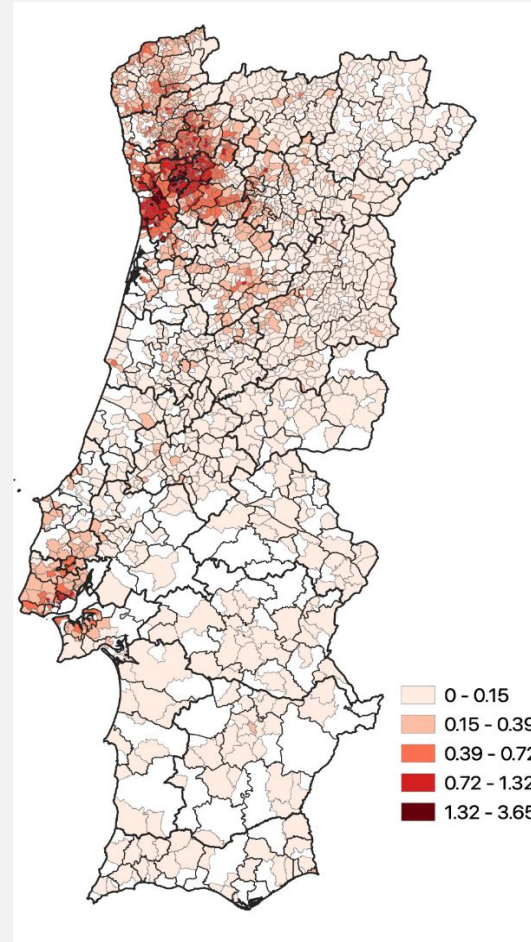


**Figure 2-** Coefficient of variation of the area burned (dimensionless).

# Maps of the fire variables



**Figure 5-** Mean size of the 10 largest fires, normalized by the area of the parish (ha/ha).



**Figure 6-** Number of fires, normalized by the area of the parish (#/ha).



# Maps of the fire variables

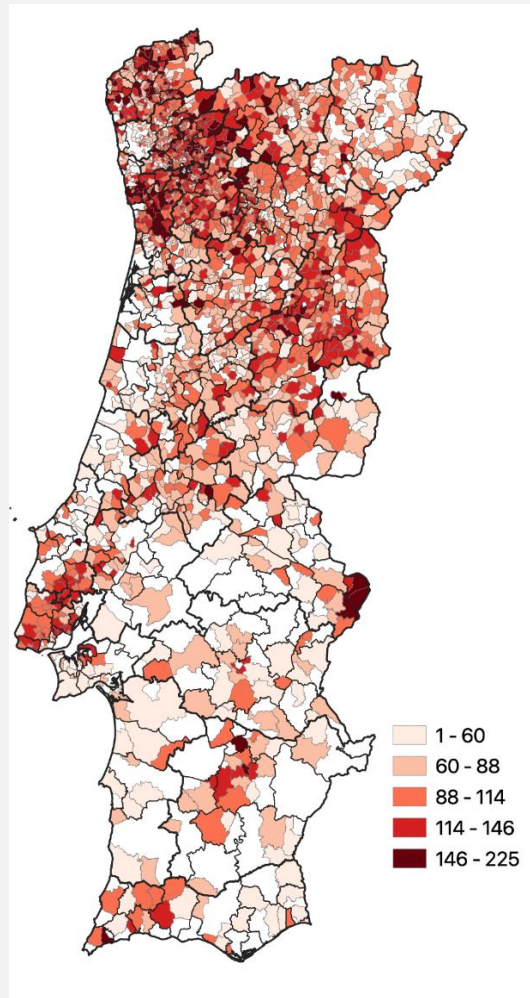


Figure 8 - Duration of the fire season (days)

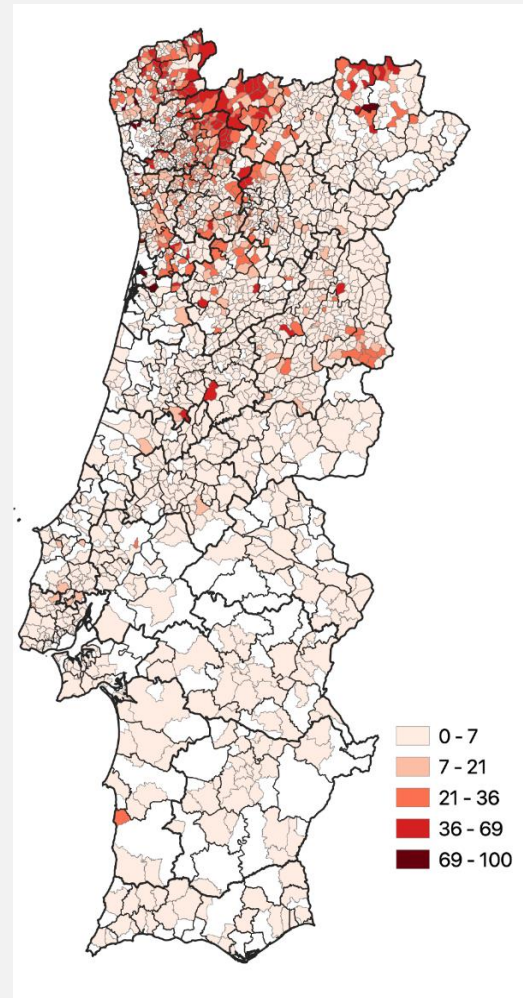
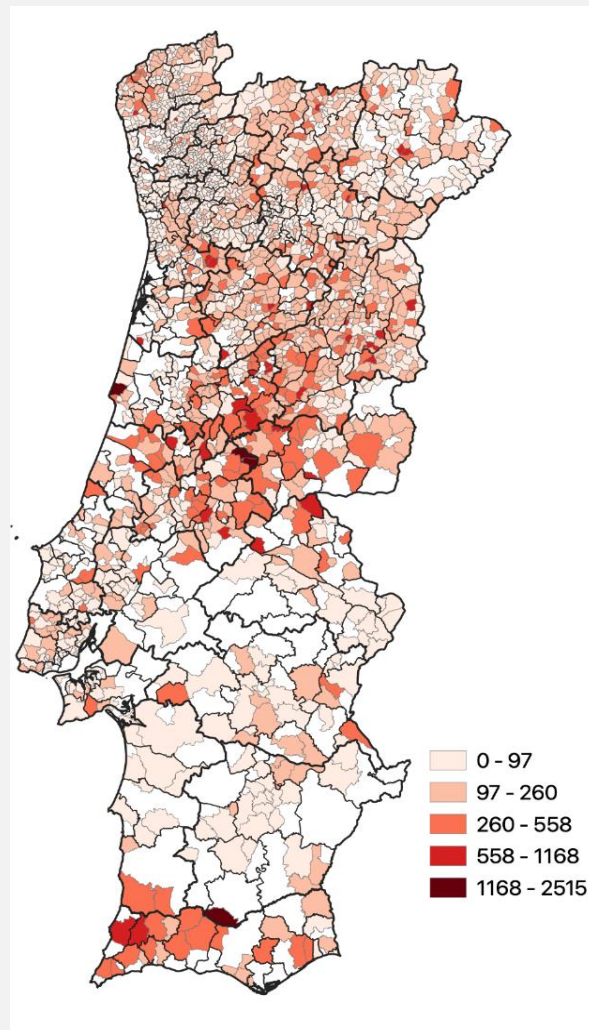


Figure 9 - % fire total fire days occurring during extended winter (1 Nov. – 30 Abr.).

# Maps of the fire variables

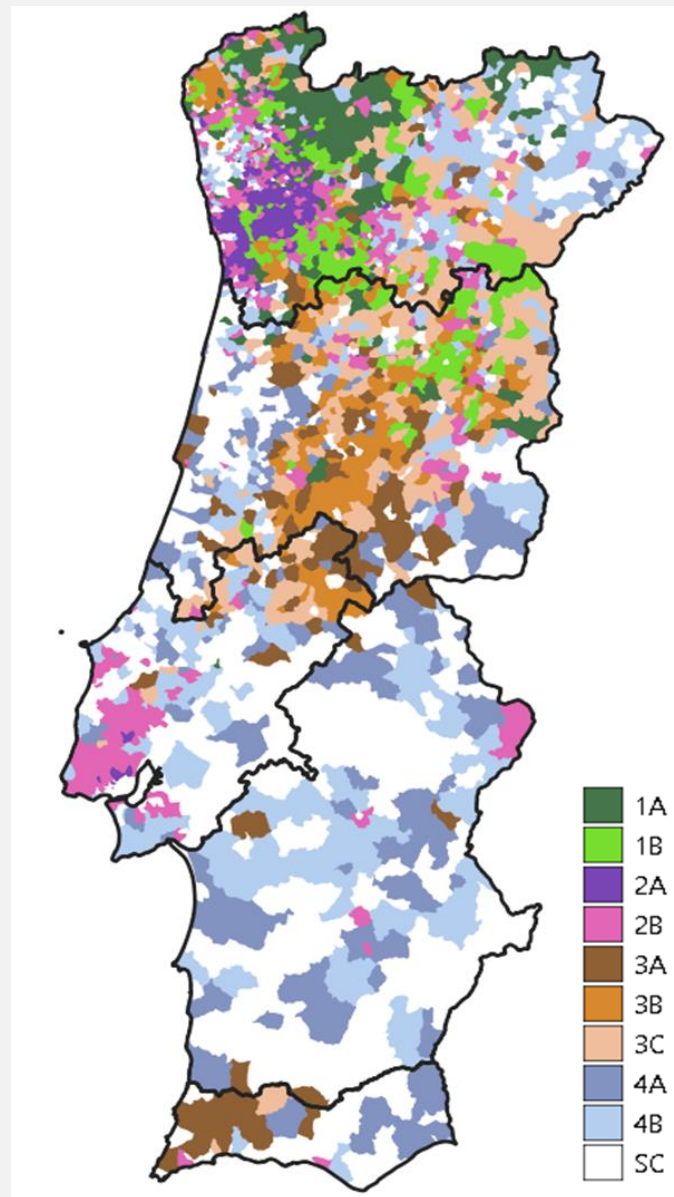


*Figura 7- 90th percentile fire radiative power (MW).*

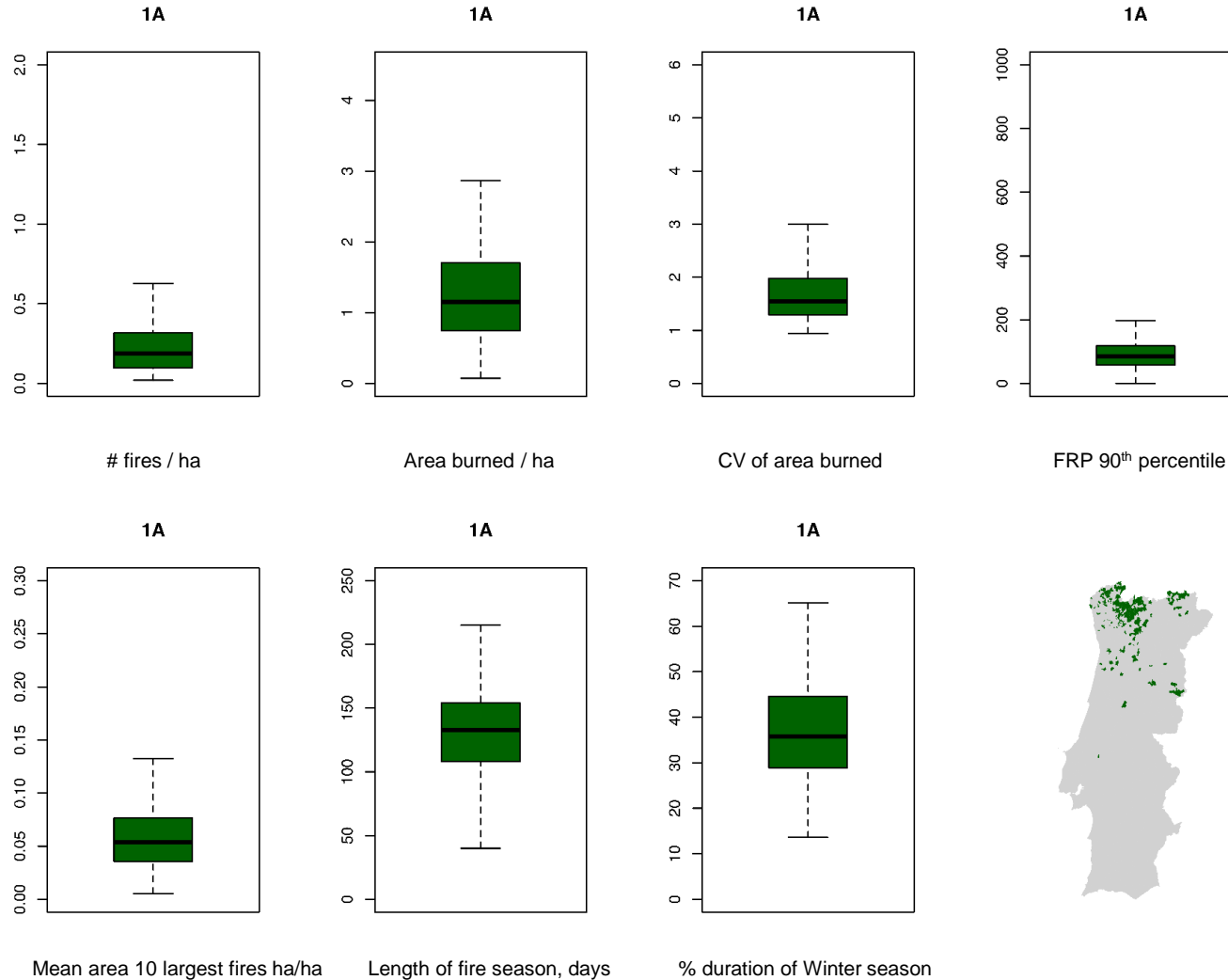
# Fire regime classification

- Principal component analysis, to condense the essential information from the data in a reduced number of variables.
- Cluster analysis, to group parishes according to their similarities and differences in the values of the variables.
- The combination of these procedures yielded a *sensu stricto* classification with nine fire regimes.

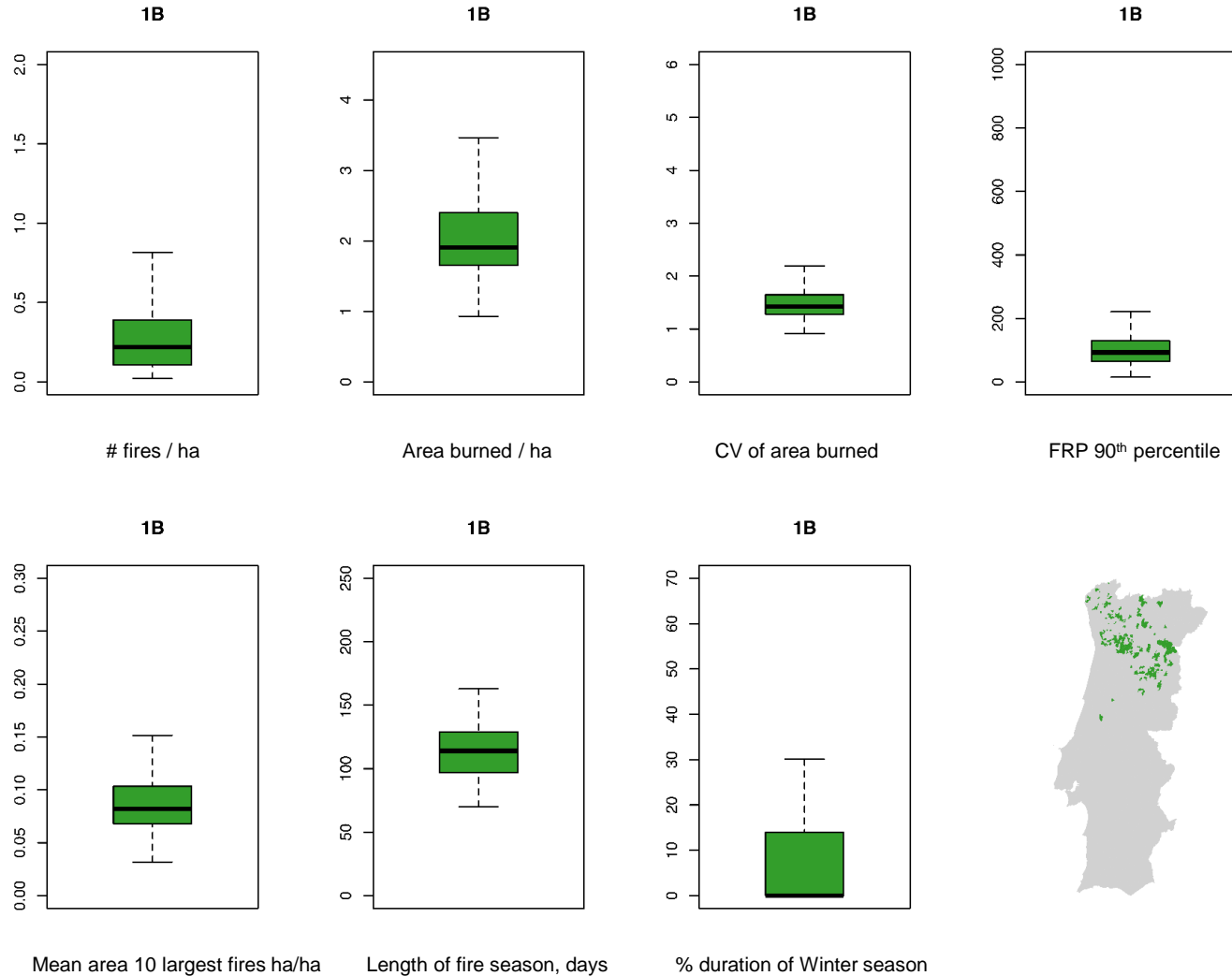
# Fire regime classification



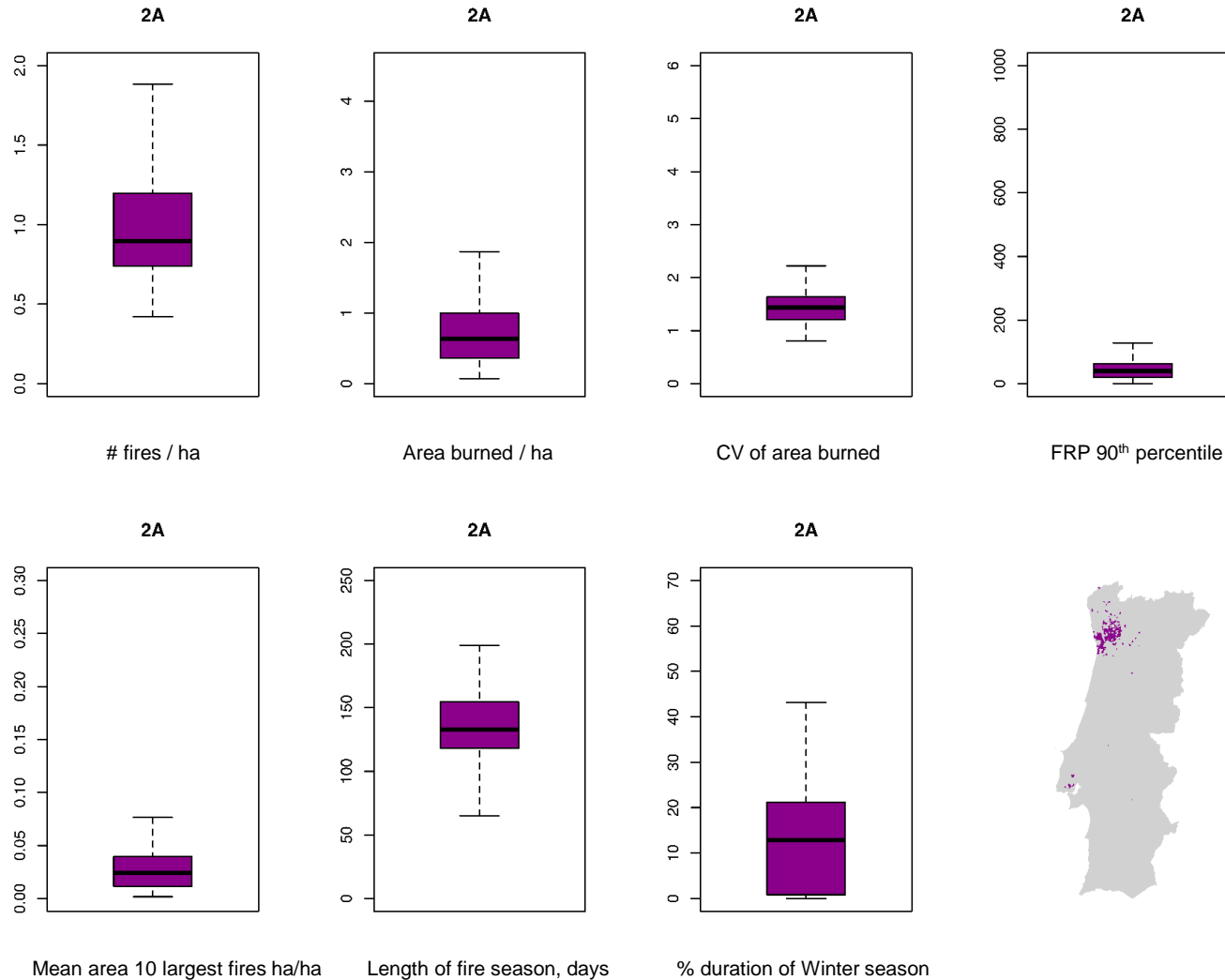
# Fire regime classification



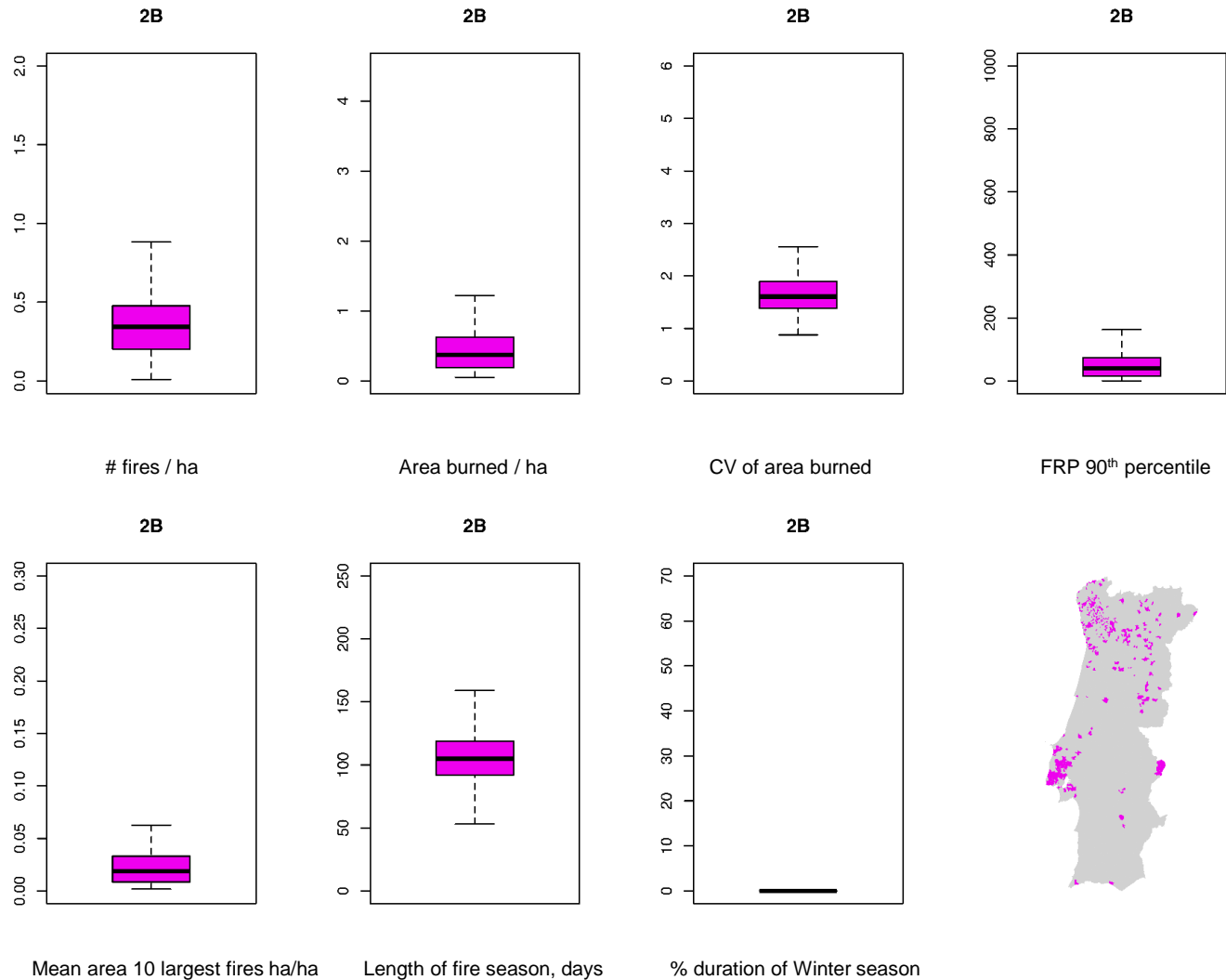
# Fire regime classification



# Fire regime classification

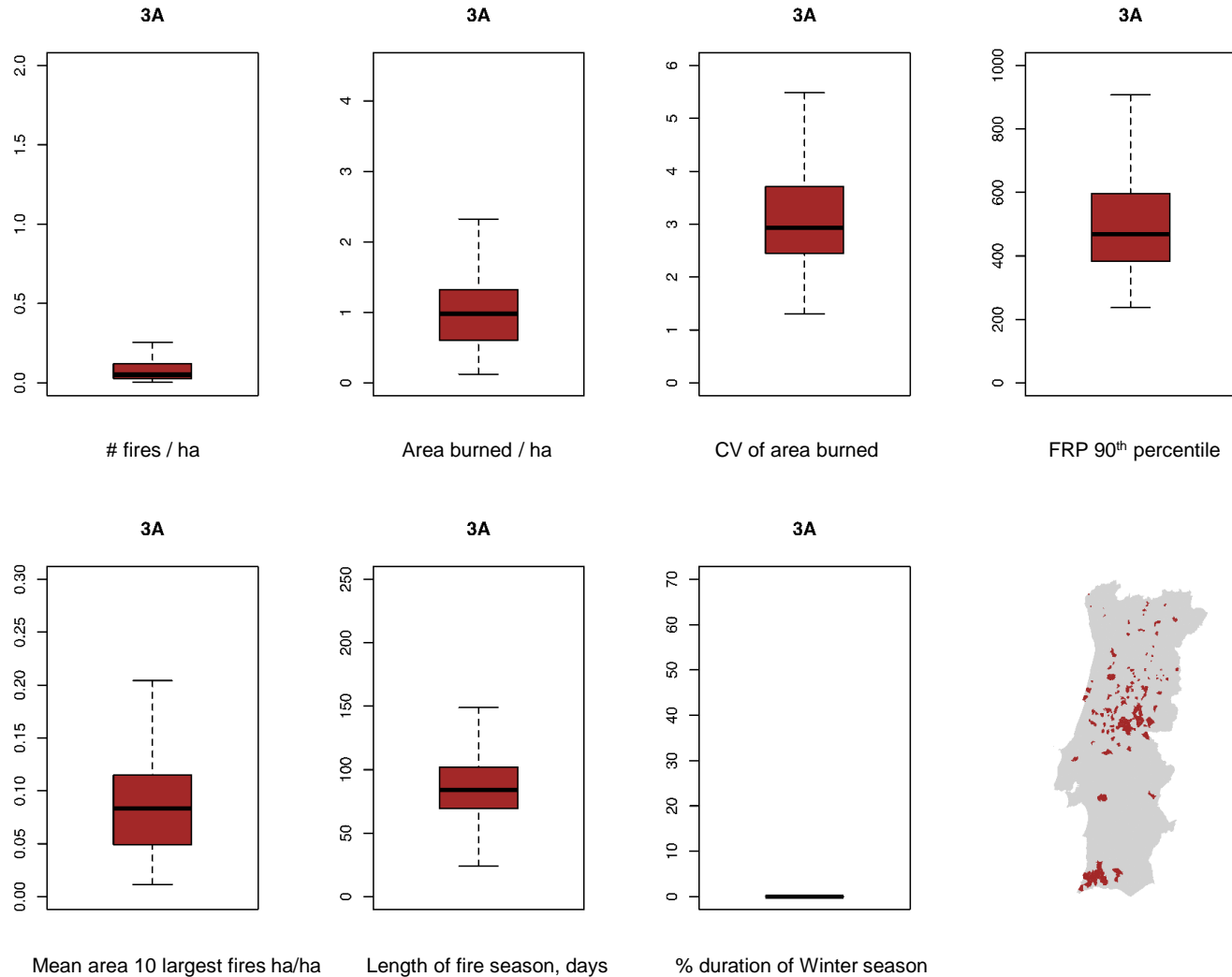


# Fire regime classification

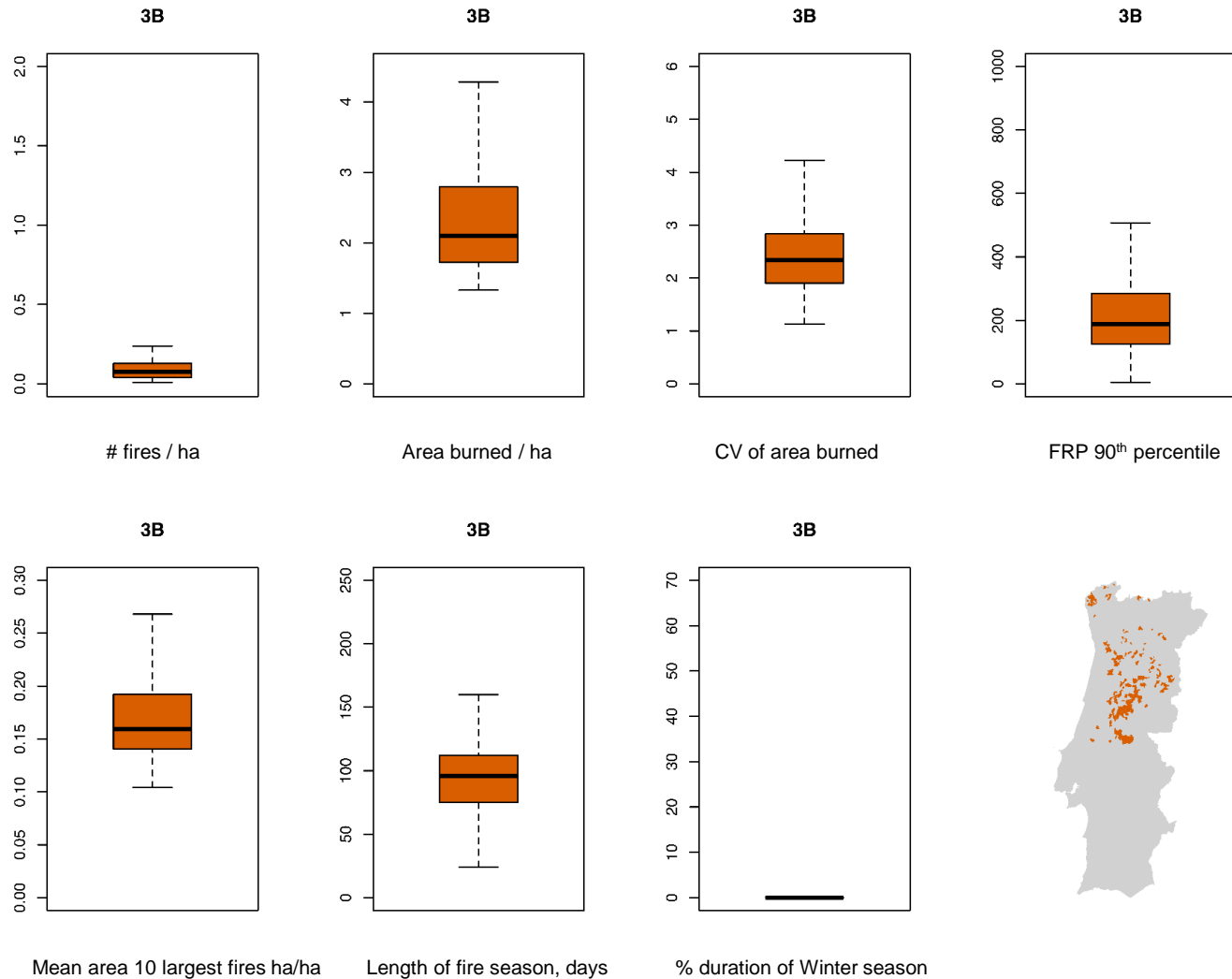




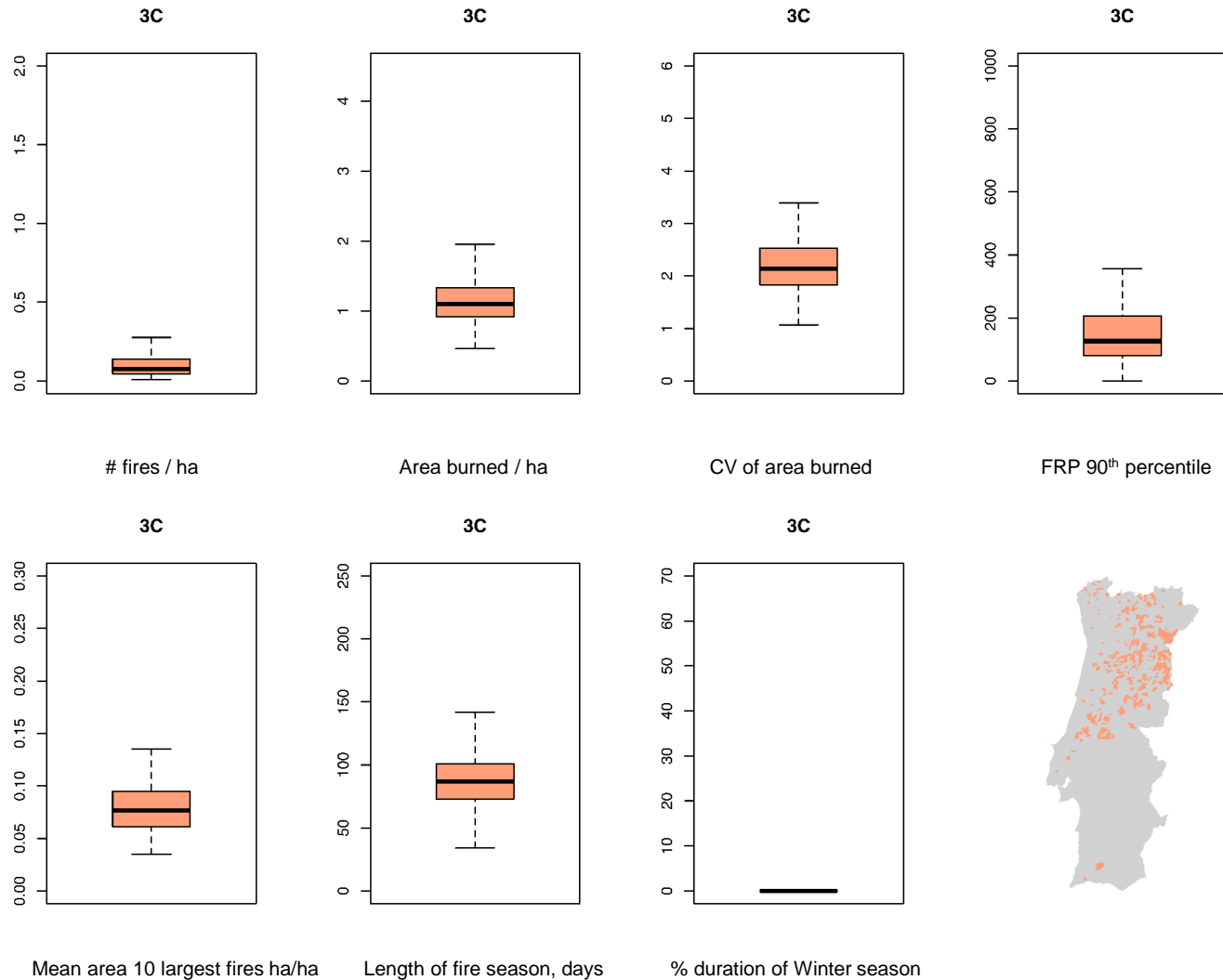
# Fire regime classification



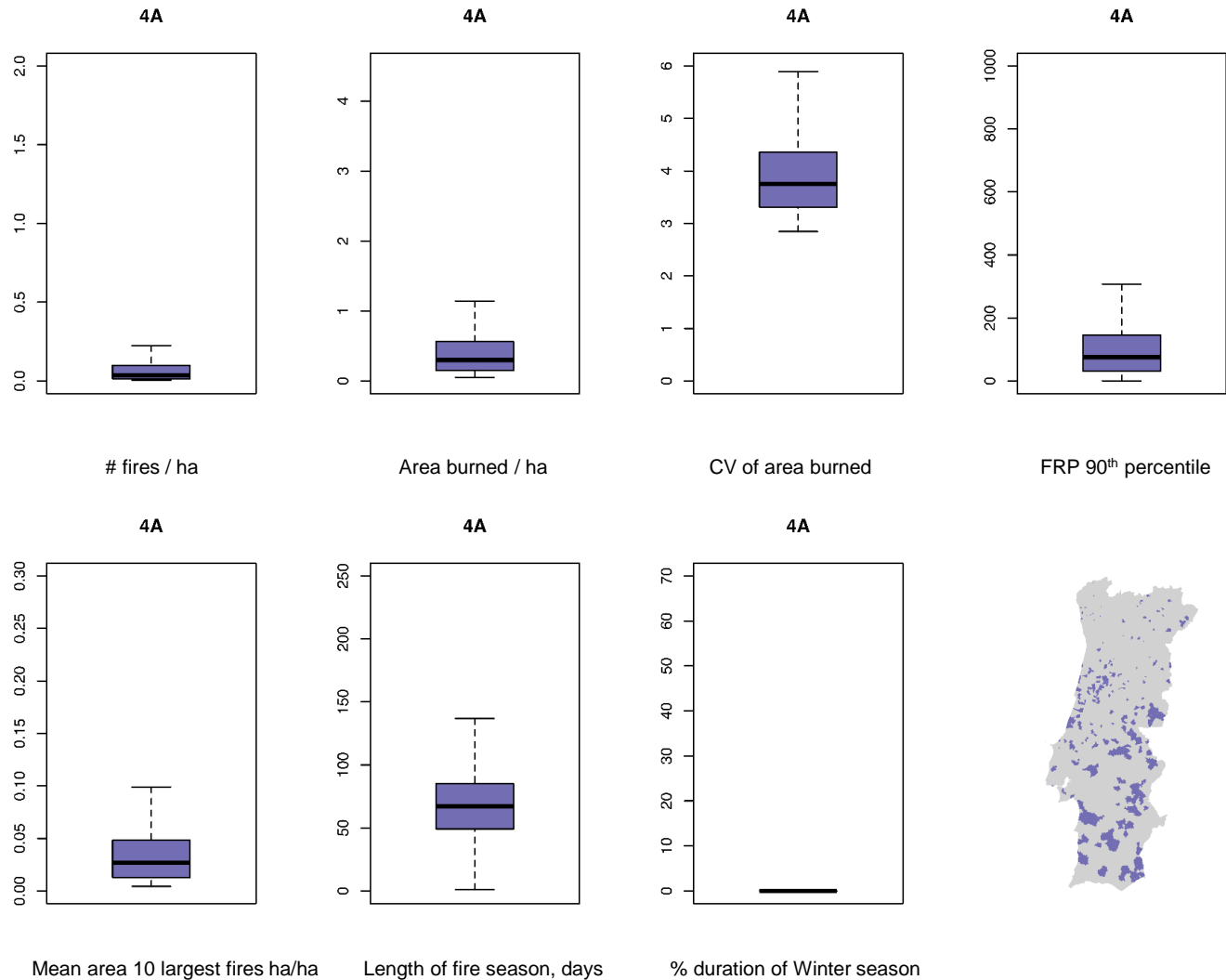
# Fire regime classification



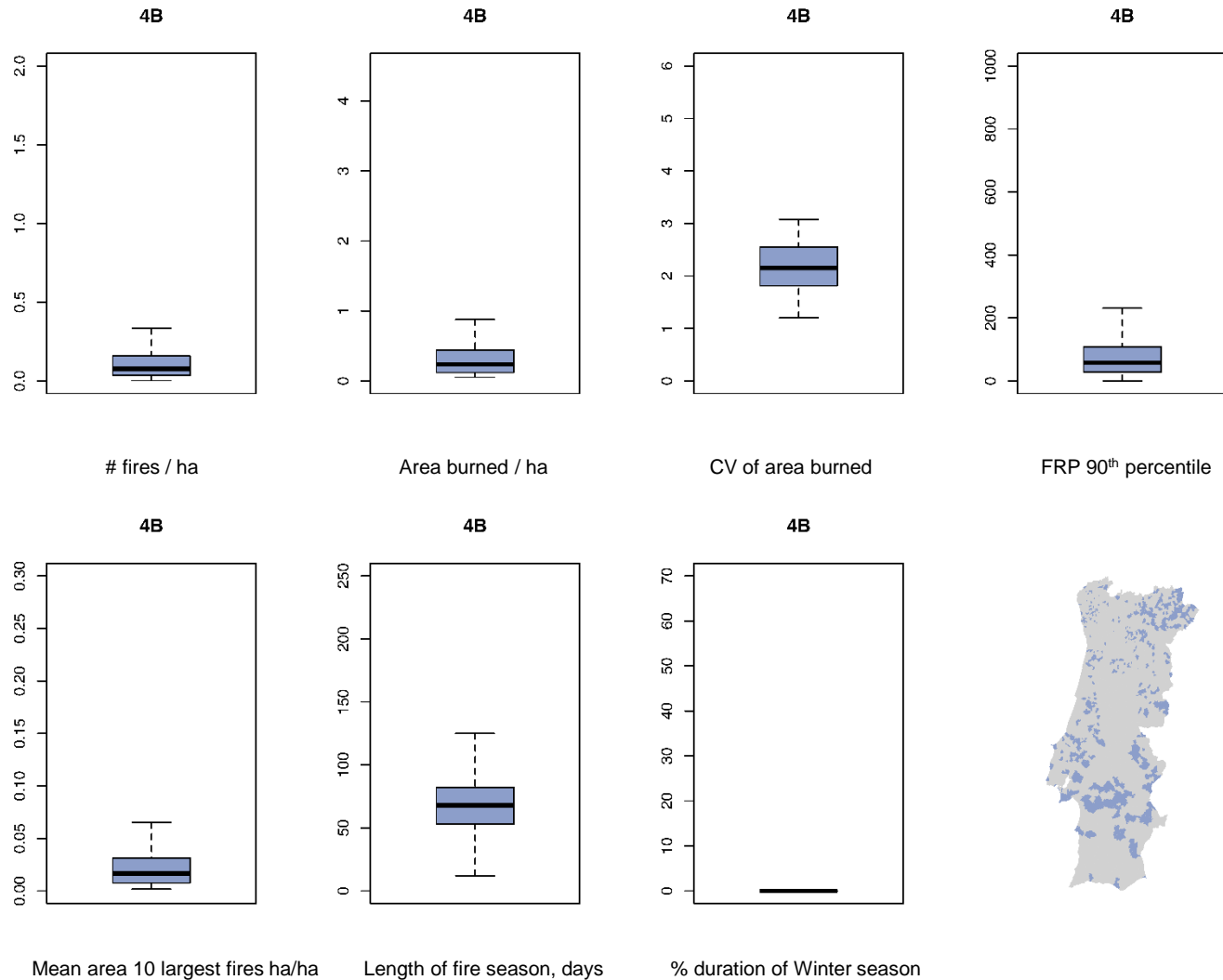
# Fire regime classification



# Fire regime classification



# Fire regime classification



# Fire regime classification

**1A:** Long season, large% of fire days in Winter.

Ex.: Northern mountains: Gerês, Barroso, Cabreira, Montesinho, and Alvão.

**1B:** Extensive burned area, regular burning.

Ex.: Northern and central mountains: Montemuro, Marão, and Marofa, Mondego river headwaters.

**2A:** Many fires, regular burning, and long season.

Ex.: Porto Metropolitan Area, Tâmega and Sousa.

**2B:** Absence of large fires, small area burned, regular burning, and low intensity.

Ex.: Lisbon Metropolitan Area, West, and scattered throughout the whole country.

# Fire regime classification

**3A:** Very intense, sporadic wildfires.

Ex.: Western Algarve and Interior Pinelands.

**3B:** Very large wildfires and extensive area burned.

Ex.: Interior Pinelands, W and NW mountains: Freita, Arada, and Arga.

**3C:** Some large wildfires, but few fires, overall.

Ex.: Guarda district, SE Bragança district, and scattered throughout the Eastern section of Central and Northern Portugal.

**4A:** Very sporadic burning and short season.

Ex.: Alentejo, Beira Baixa and Eastern Algarve.

**4B:** Short season and very little area burned, no large fires.

Ex.: Alentejo, NE Trás-os-Montes and coastal plain.

# Fire regime classification: antecedent variables

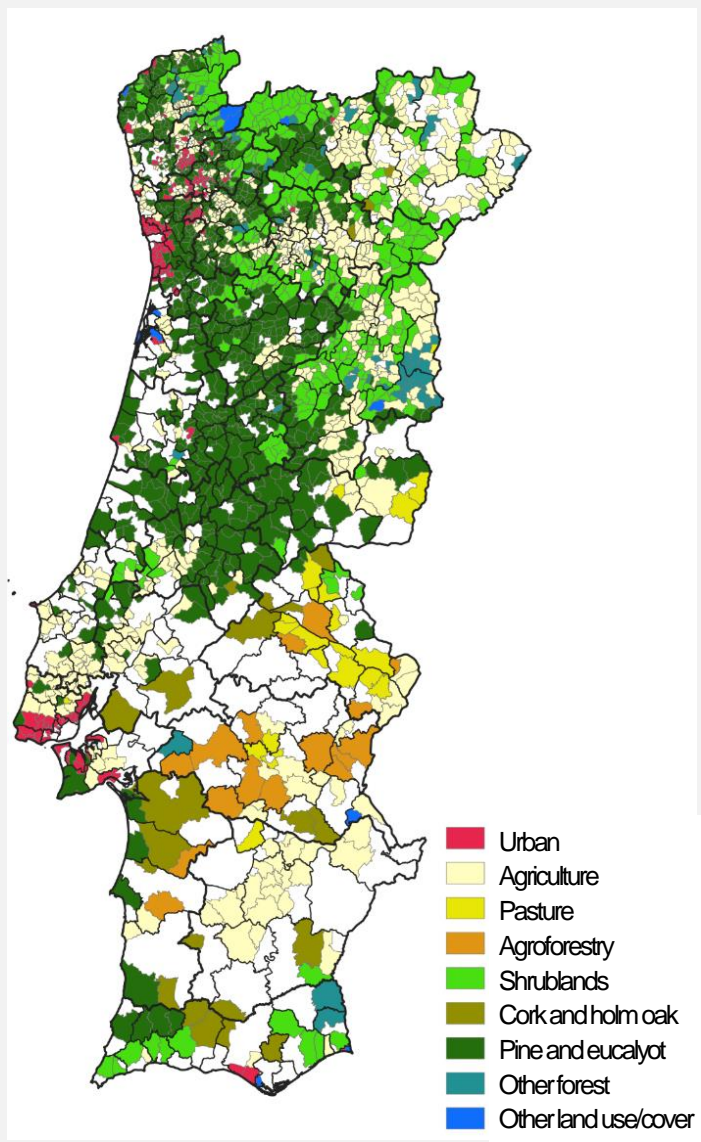


Figura 10- Predominant land use / land cover.



# Fire regime classification: antecedent variables

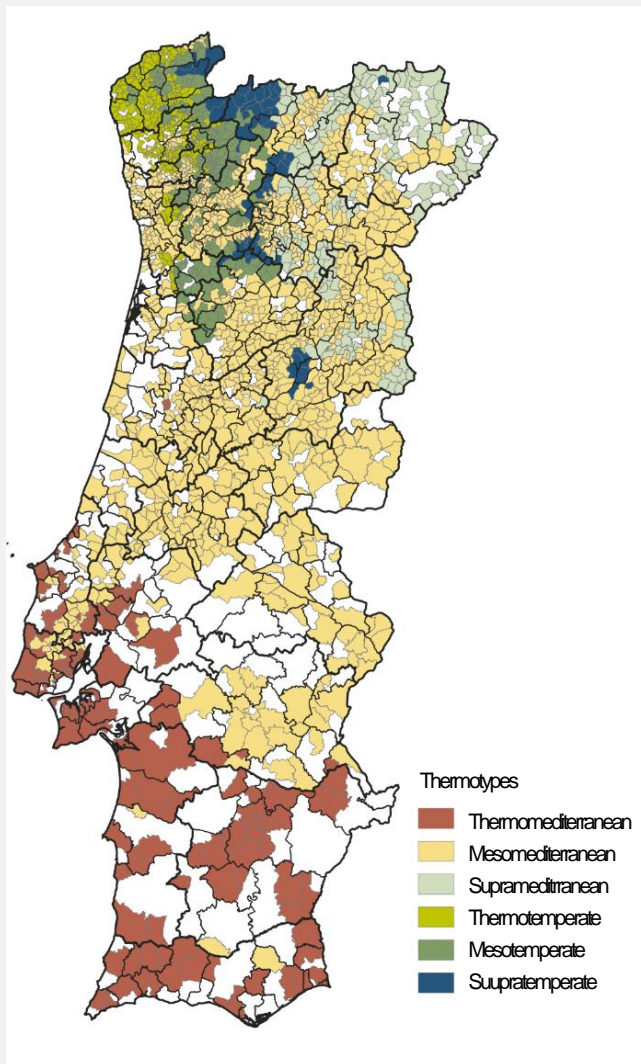


Figura 11- Thermoclimate types.

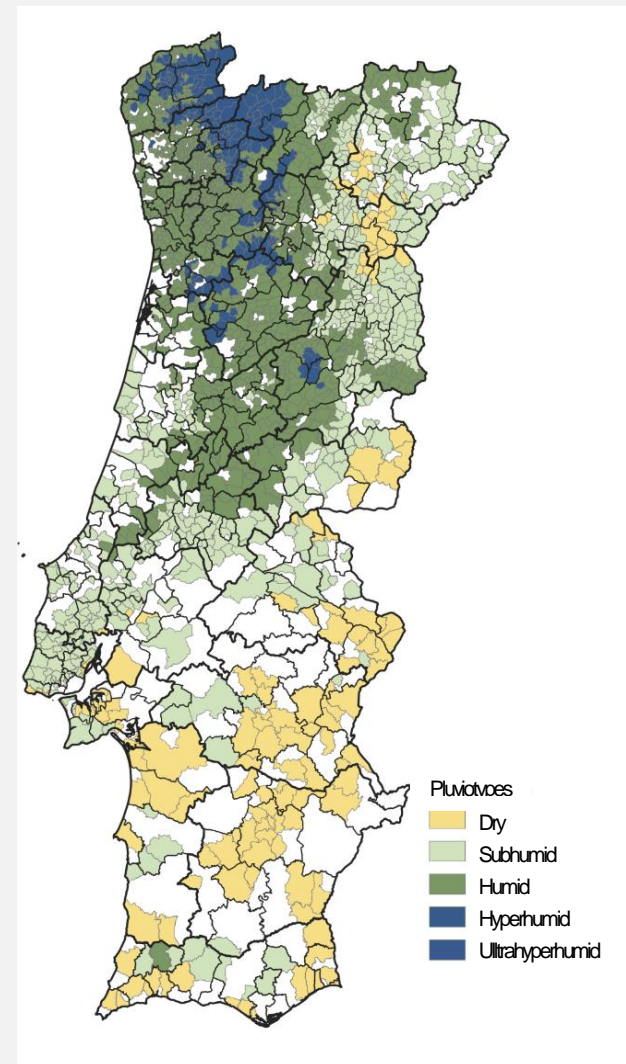


Figura 12- Pluvioclimate types.

# Fire regime classification: antecedent variables

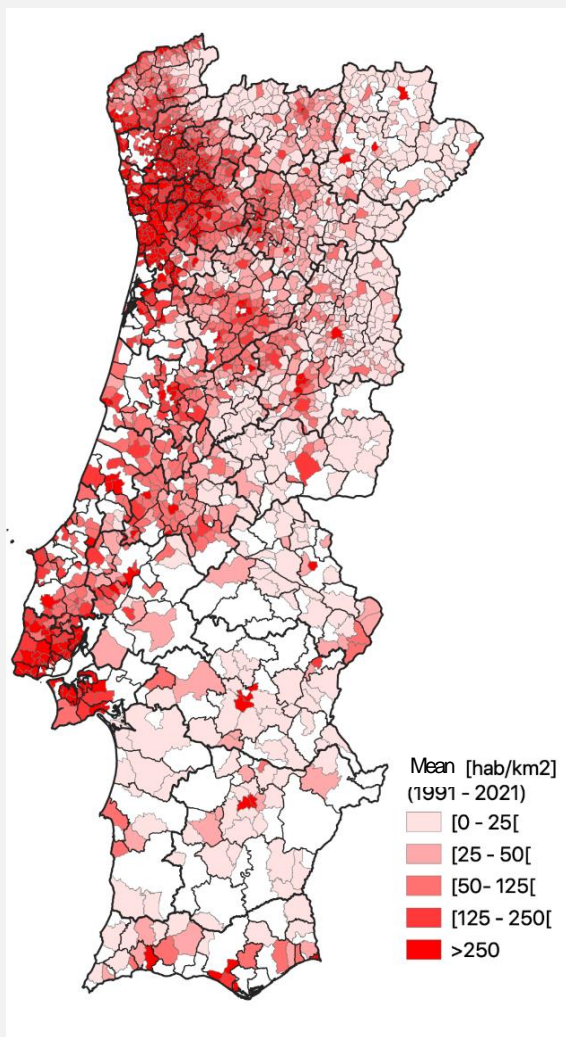


Figura 13- Mean population density.

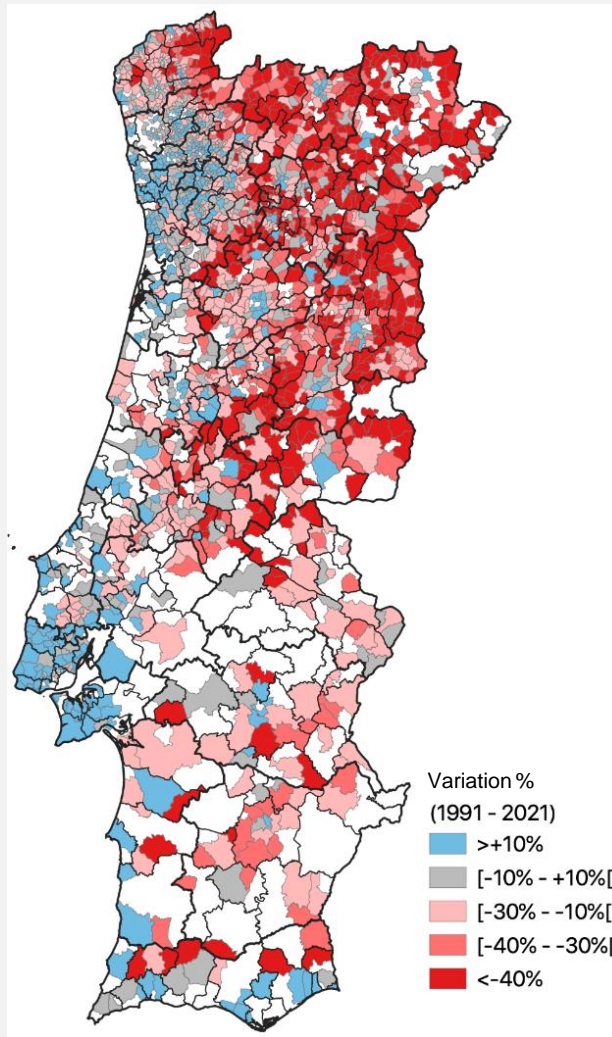


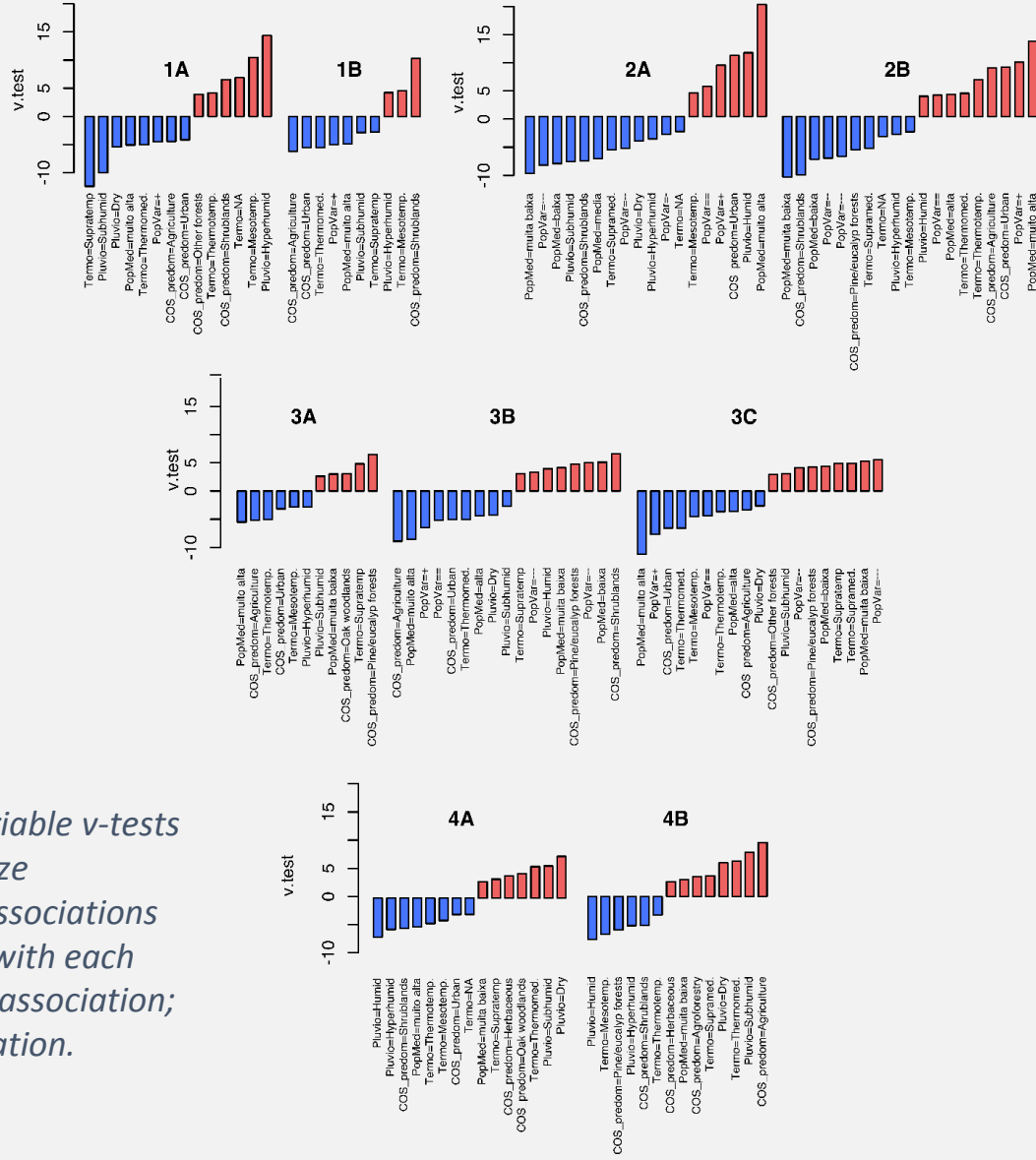
Figura 14- % variation of population density (1991-2021)/1991.

# Fire regime classification: antecedent variables



**Figure 16-** Fire variable v-tests for each fire regime. Bar size represents the degree of associations of each variable category with each regime. **Red bars:** positive association; **Blue bars:** negative association.

# Fire regime classification



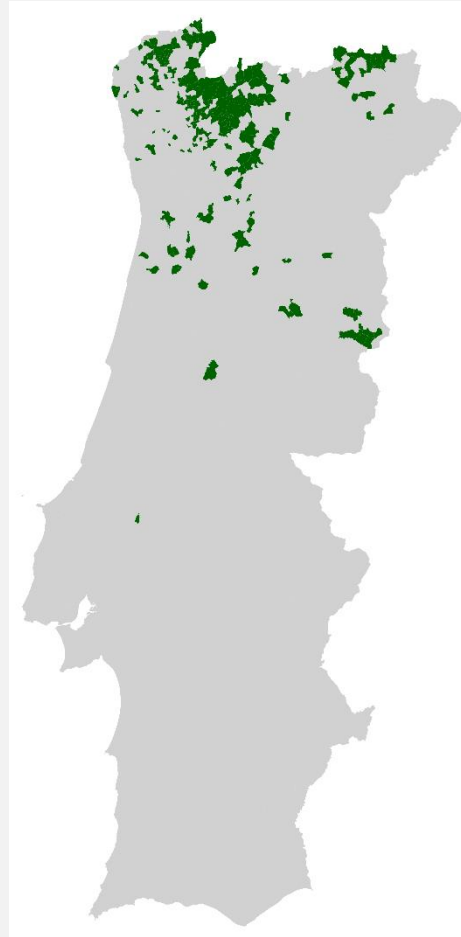
**Figure 17 - Antecedent variable v-tests for each fire regime.** Bar size represents the degree of associations of each variable category with each regime. **Red bars:** positive association; **Blue bars:** negative association.

# Fire regime classification

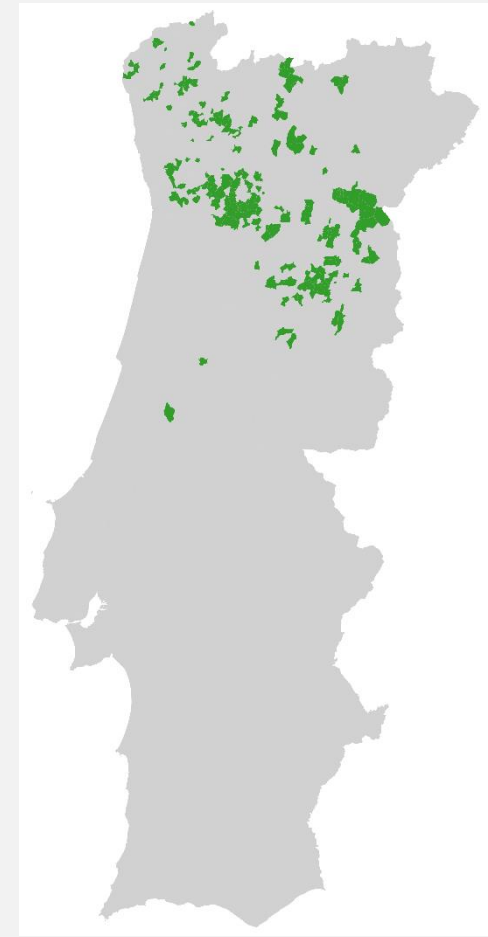
## Pastoral burning

**1A:** Long season, large % Winter fire days; In Shrubland and Other Forest, under Hyperhumid and Mesotemperate climate. Pasture renewal burns.

**1B:** Extensive burned area, occurring regularly; In Shrublands, under Mesotemperate, Hyperhumid climate. Pasture renewal burns and bonfires.



Regime 1A



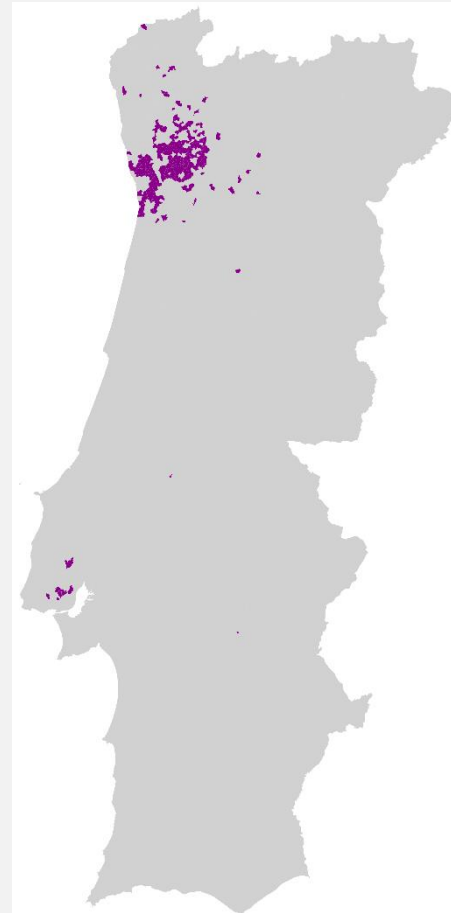
Regime 1B

# Fire regime classification

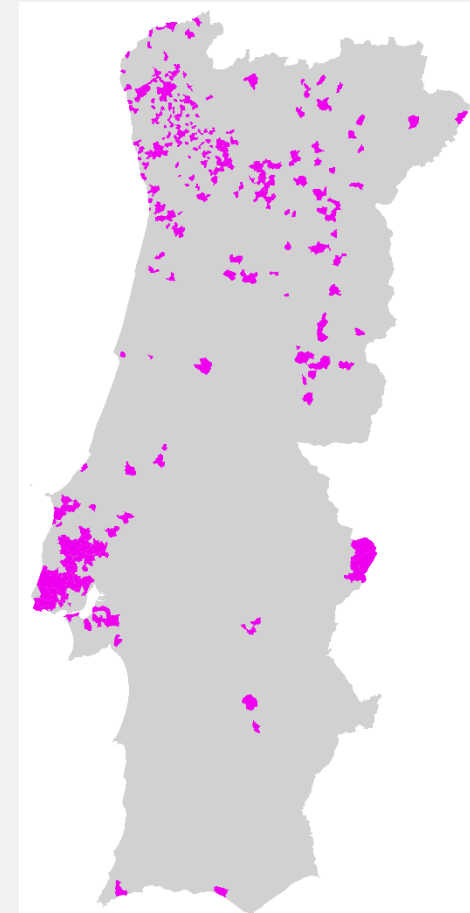
## Small periurban fires

**2A:** Many fires, occurring regularly throughout a long season; In densely populated Urban Areas, with growing or stable population, under Humid climate; Rekindling and bonfires.

**2B:** Absence of large fires, with low area burned, occurring regularly and with low intensity; in densely populated Urban and Agricultural areas, with very high, expanding population density, under Thermotemperate climate. Rekindling.



Regime 2A



Regime 2B

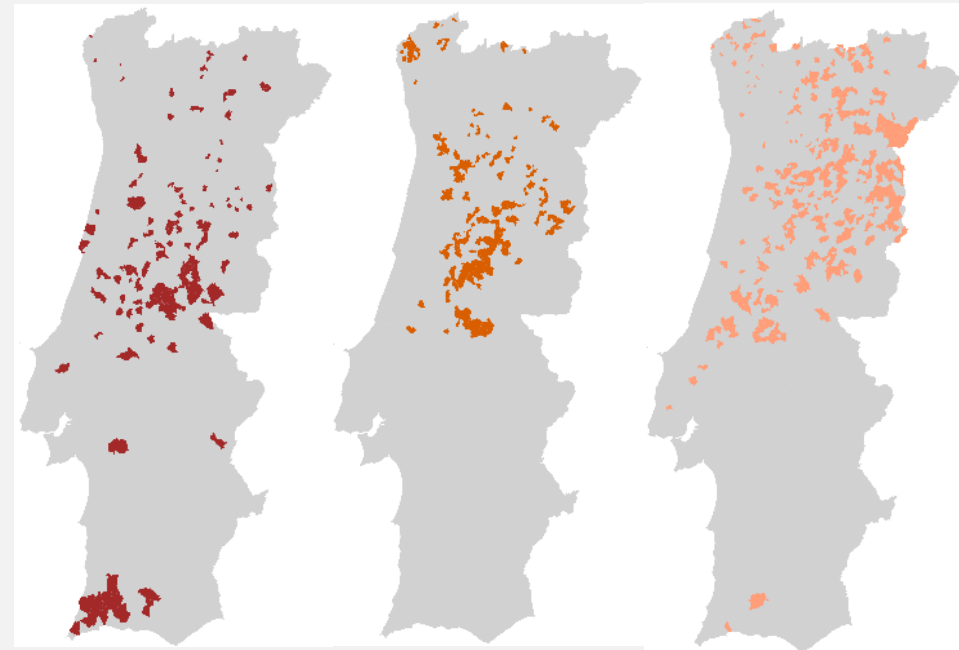
# Fire regime classification

## Forest wildfires

**3A:** Very intense, sporadic wildfires; Pine and Eucalypt forests, under Supratemperate climate. Crop residue burns, powerlines.

**3B:** Extensive burned area and megafires; In Shrublands, Pine forests, and Eucalypt forests of sparsely populated areas that continue to lose population. Vandalism.

**3B:** Some large wildfires, but few fires in total; very low population density, in strong decline; In Pine forests and Eucalypt forests, under Supramediterranean and Supratemperate climates. Vandalism and pasture renewal burns.



Regime 3A

Regime 3B

Regime 3C

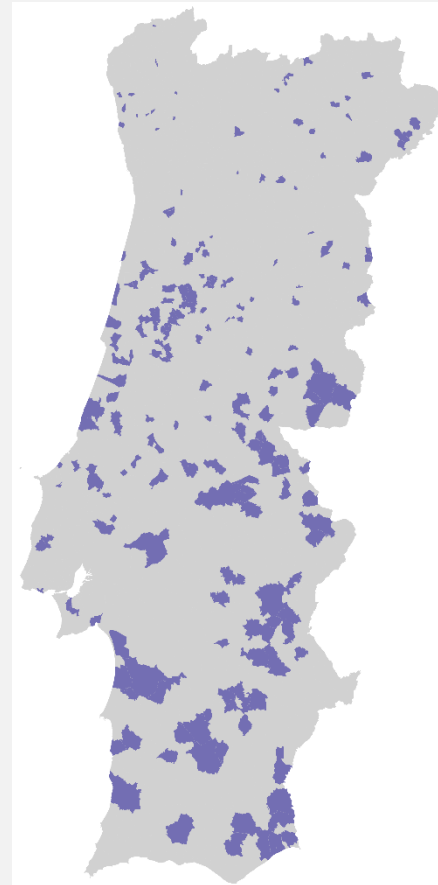
# Fire regime classification

## Agricultural burns

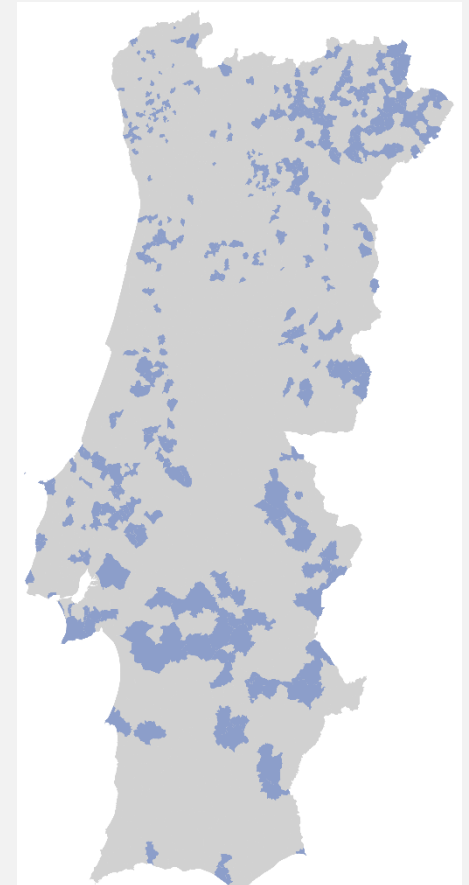
**4A:** Very sporadic burning and short fire season; In Cork Oak and Holm Oak woodlands, and in Pastures, under Dry or Subhumid climates, both Thermomediterranean.

Powelines, crop residue burning, clearing of agricultural soils.

**4B:** Short fire season and very little area burned, no large fires. In Agricultural areas, under Subhumid or Dry or climates, both Thermomediterranean. Clearing of agricultural soil, powerlines, burning of crop harvest residues, cigarette butts discarded by drivers.



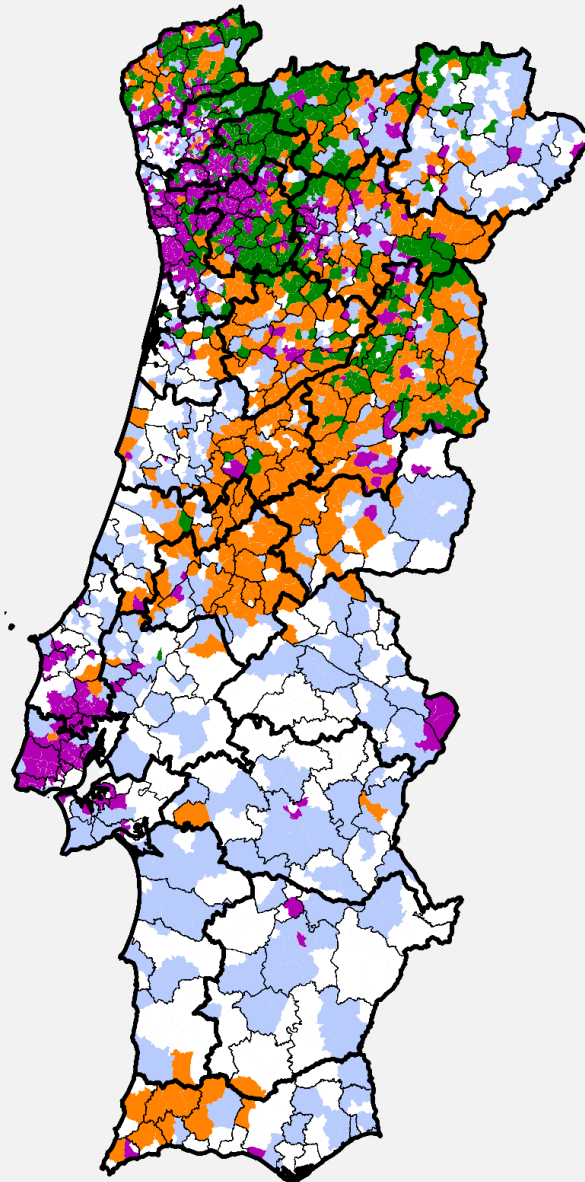
Regime 4A








Regime 4B



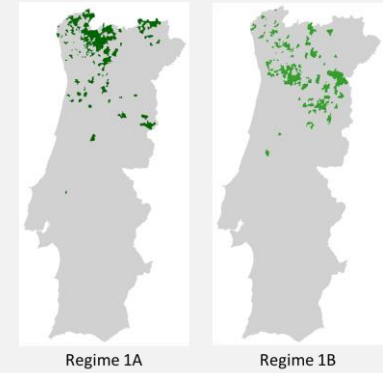
# Fire regime classification



## FIRE MACRO-REGIMES

-  Pastoral burning
-  Small periurban fires
-  Forest wildfires
-  Agricultural burns
-  No data

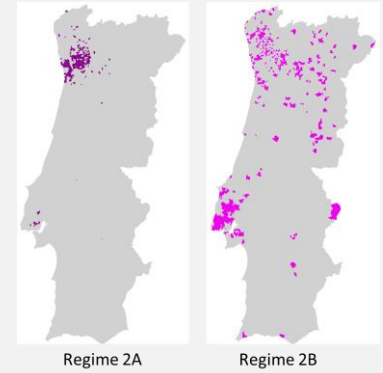
# Fire regime interpretation



## Pastoral burning macro-regime

- The macro-regime where it makes most sense to manage fire along multiple dimensions (“manage the regime”), not just area burned.
- Desirable goals: maintain or expand area burned, with frequent, small, patchy fires of low to medium intensity, outside of the Summer season: manage *where*, *when*, and *how* to burn.
- There are at least 1.000.000 ha (12% of Portugal, 38% of the area burned 1975-2020) in need of this kind of management.
- The most distinctive fire cause is pasture renewal burning.
- It is a pre-industrial fire regime, in the sense of Seijo and Gray (2012), and it is in decline.
- This regime may be *turning feral*, i.e. it may be gradually transitioning to a wildfire regime → less frequent, more intense fires, mostly during Summer.

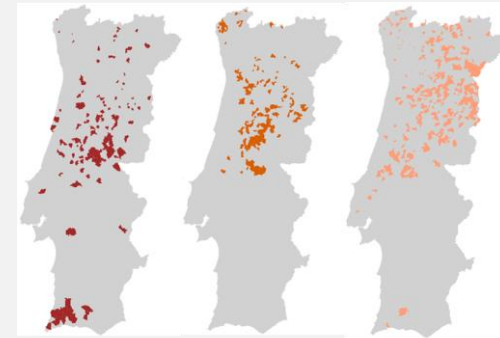
# Fire regime interpretation



## Macro-regime **Small periurban fires**

- Dense population, many ignitions, in a diverse, highly urbanized and fragmented landscape → many fires, mostly small and low intensity, little area burned, long fire season.
- Risk originates more from the value of exposed assets (people, houses, factories, infrastructure) than from fuel hazard. Large wildfires are rare, but even small fires may cause substantial losses and damage in this type of landscape.
- Priority to fuel management around urban areas, scattered settlements and isolated houses → secondary fuelbreak network.
- Most distinctive fire cause is rekindling: response capacity is overwhelmed and fires are not properly mopped-up.
- It is a fire regime characteristic of the rural-urban interface.

# Fire regime interpretation

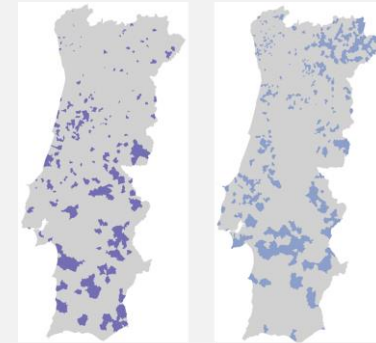


## Forest wildfires macro-regime

- Sporadic events ( $\approx 15$ -25 year intervals), but large and intense.
- Extensive, almost unbroken areas of forest and shrublands with heavy fuel accumulation  $\rightarrow$  need land use/ land cover change and primary fuelbreak network (PFBN).
- Forest management based on preventive silviculture techniques, namely around the PFBN.
- Most distinctive causes are less related to use of fire: accidental (powerlines) and malicious (vandalism).
- Changes in demographics and land use (rural land abandonment and extensive afforestation) over the last century yielded a dangerous, unsustainable fire regime. Climate change increases fire danger.
- “Industrial” fire regimes\*, typical of monofunctional landscapes.

\* Seijo, F., & Gray, R. (2012). Pre-industrial anthropogenic fire regimes in transition: the case of Spain and its implications for fire governance in Mediterranean type biomes. *Human Ecology Review*, 58-69.

# Fire regime interpretation



Regime 4A

Regime 4B

## Agricultural burns macro-regime

- The macro-regime with the lowest fire incidence and the least problematic one.
- Not immune to very sporadic occurrence of wildfires, which may become more frequent with increasing rural depopulation and land abandonment.
- There are precedents, e.g. Nisa and Gavião, 2003, in under-managed cork oak woodlands.
- Occasional large wildfires in cereal croplands (e.g. at Castro Verde).
- Most distinctive causes are clearing of agricultural fields and burned of crop harvest residue piles.
- Need to develop regional calendars of agricultural land management activities involving fire use.



# Work in progress

- Development of a new Fire Atlas of Portugal (1984 – 2022) with monthly dated fire perimeters.
- Uses all Landsat images availables in GEE, so it captures many more winter burns → improved characterization of pastoral burning.
- No need to rely on the PRFD, which is impossible to link to fire perimeters.
- We will replicate this fire regime classification and mapping using the new Fire Atlas of Portugal.