Vegetation fires in Portugal
Context and atmospheric emissions

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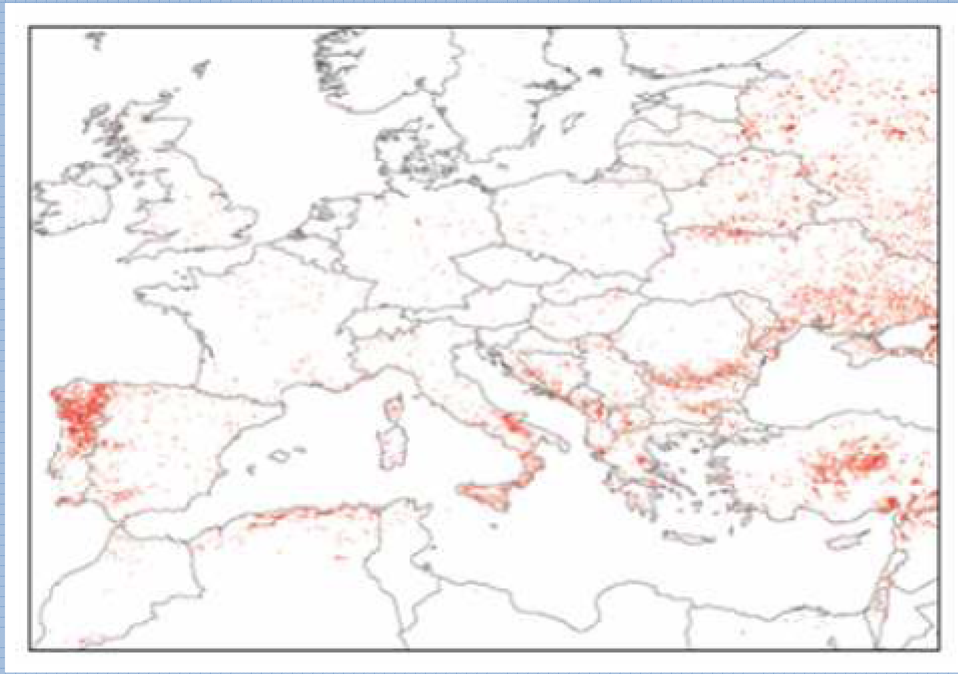
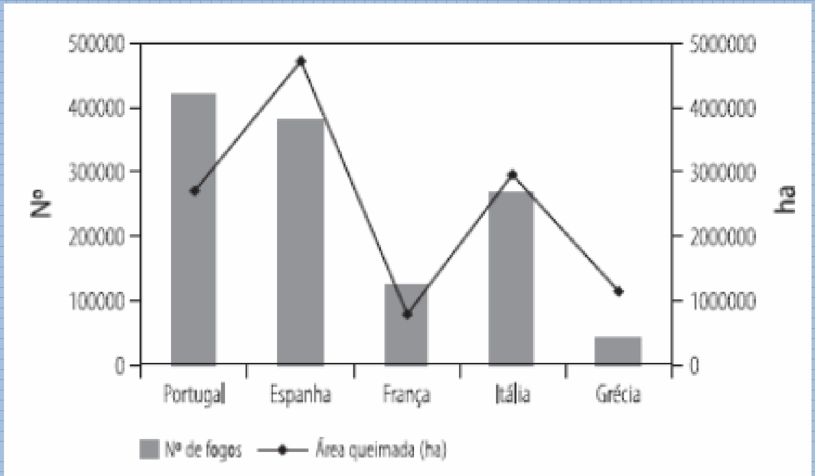
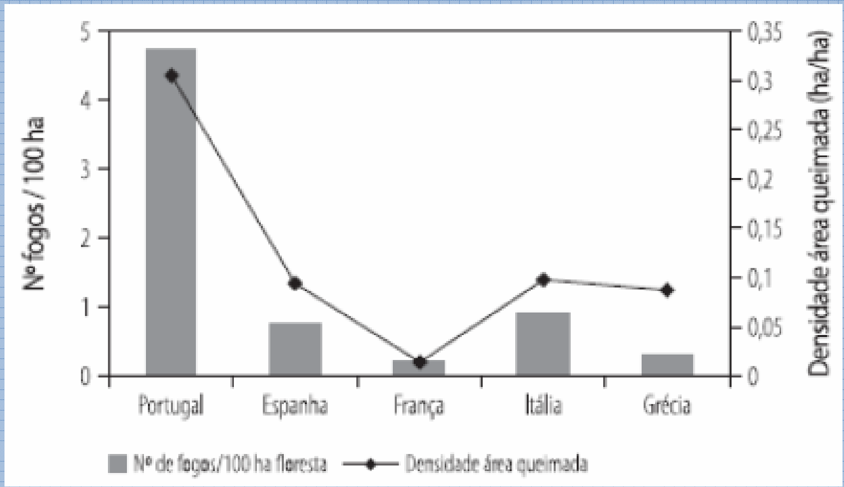
- **Overview**
    - **Fires in Portugal and fire atlas**
    - **Environmental relations of fires**
    - **Estimation of pyrogenic emissions**
    - **What we can contribute**



• **Portugal is the country with the highest fire incidence in southern Europe, considering either numbers of fires or area burned.**



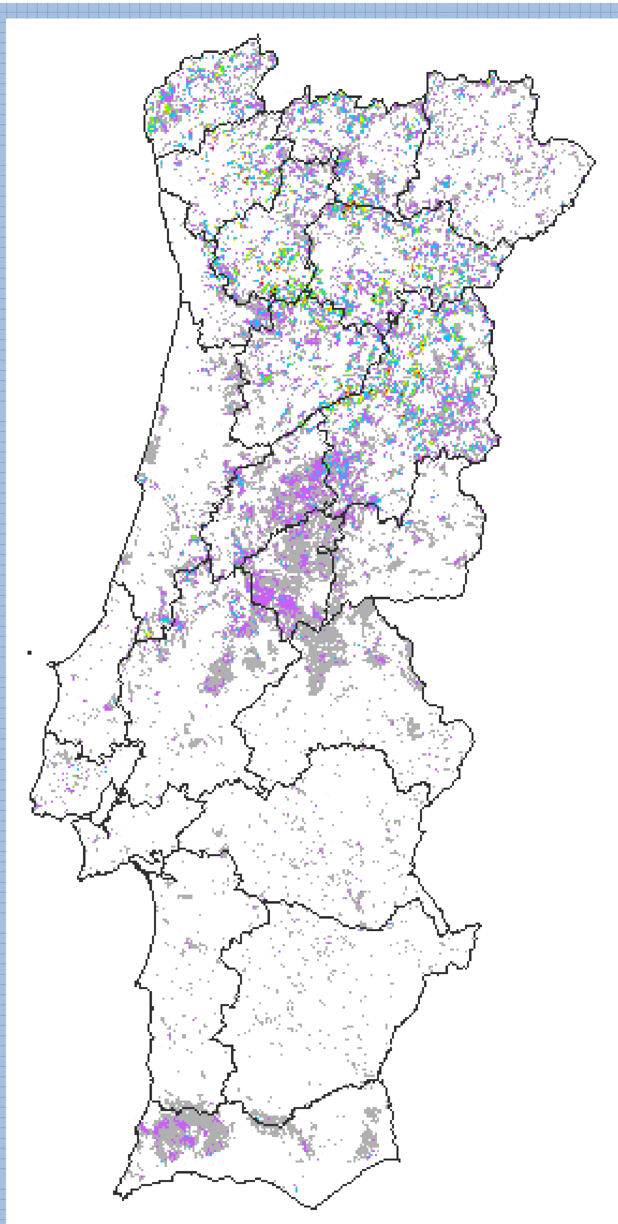


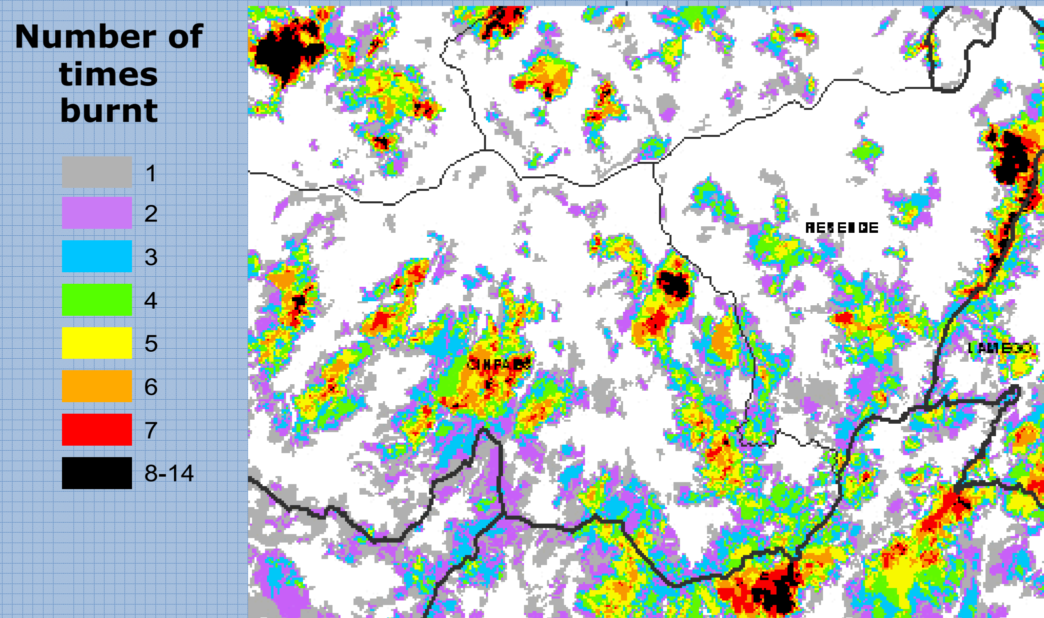
- **In Portugal, wildfires are a major environmental issue, with civil protection, forest protection, and nature conservation implications.**

- **The Pyrogeography Lab, at the School of Agriculture, Technical University of Lisbon, has developed a fire atlas based on the classification of Landsat imagery.**

- **The atlas contains annual burned area maps (1975 – 2008). We've mapped about 40 000 fire scars, corresponding to a total area burned of 3 781 000 ha.**

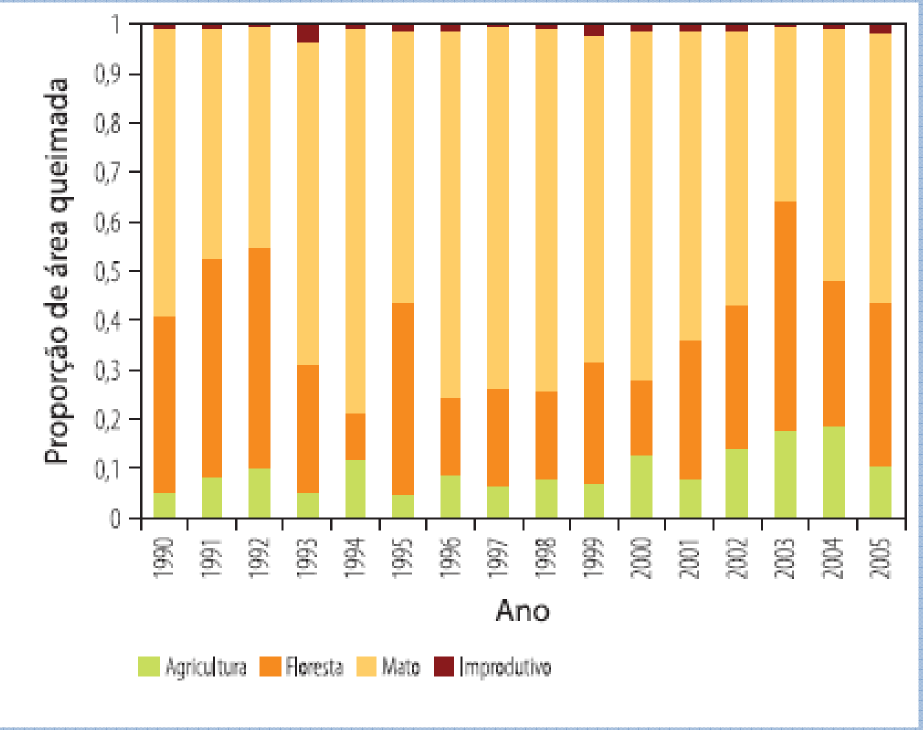
- **These data have been used to:**
    - **map fire risk (including fire firequency analysis)**
    - **support fire supression planning**
    - **develop long-term, regional forest management plans**
    - **prioritise infrastructure (e.g. power lines) reconstruction**
    - **assess pyrogenic emissions**

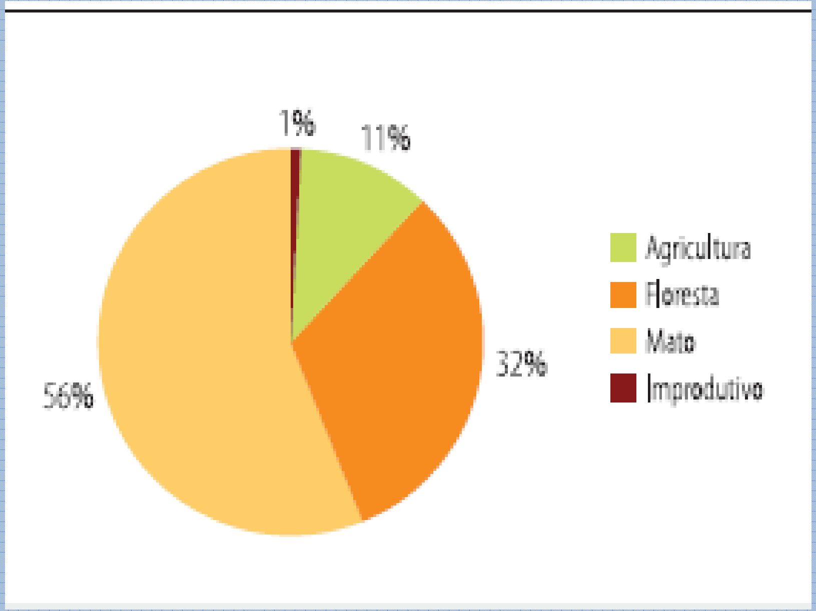


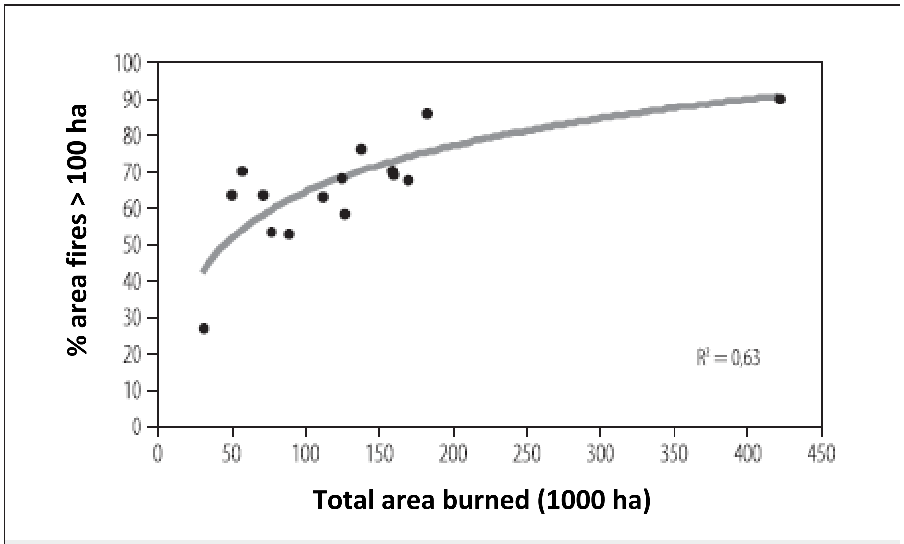


- **Synthesis map of Landsat-based fire atlas, 1975 - 2008**

- These ought to be called “rural fires”, rather than “forest fires” or “wildfires”.
- On average, forest fires represented 1/3 of the area burned.
- The % area burned corresponding to forest lands never reached 50% (1990 – 2005)



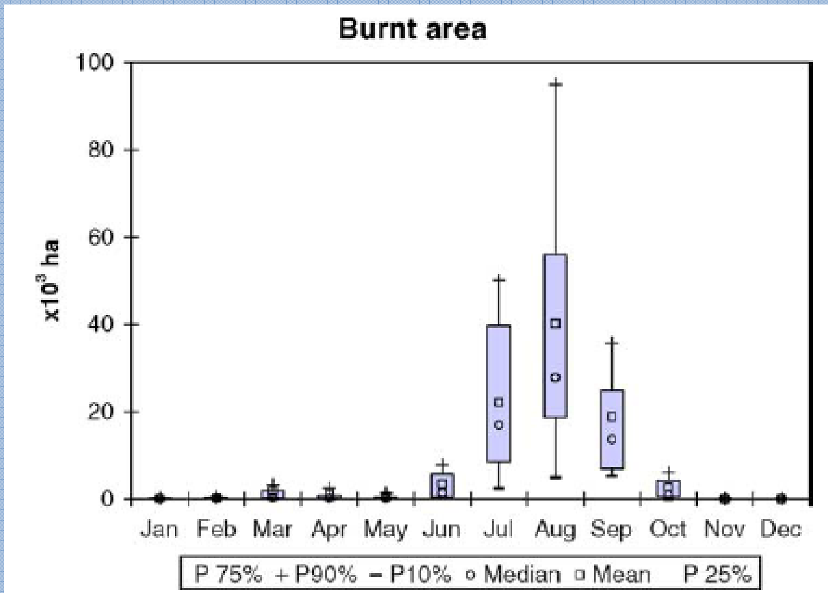




- **Area burned is highly concentrated in space: in 2003 <1% of fires burned >90% of area.**

- **Area burned is also highly concentrated in time: 93% of area burns June-September.**

- **More impressive, 80% of area burns in 10% of summer days (10-15 days).**



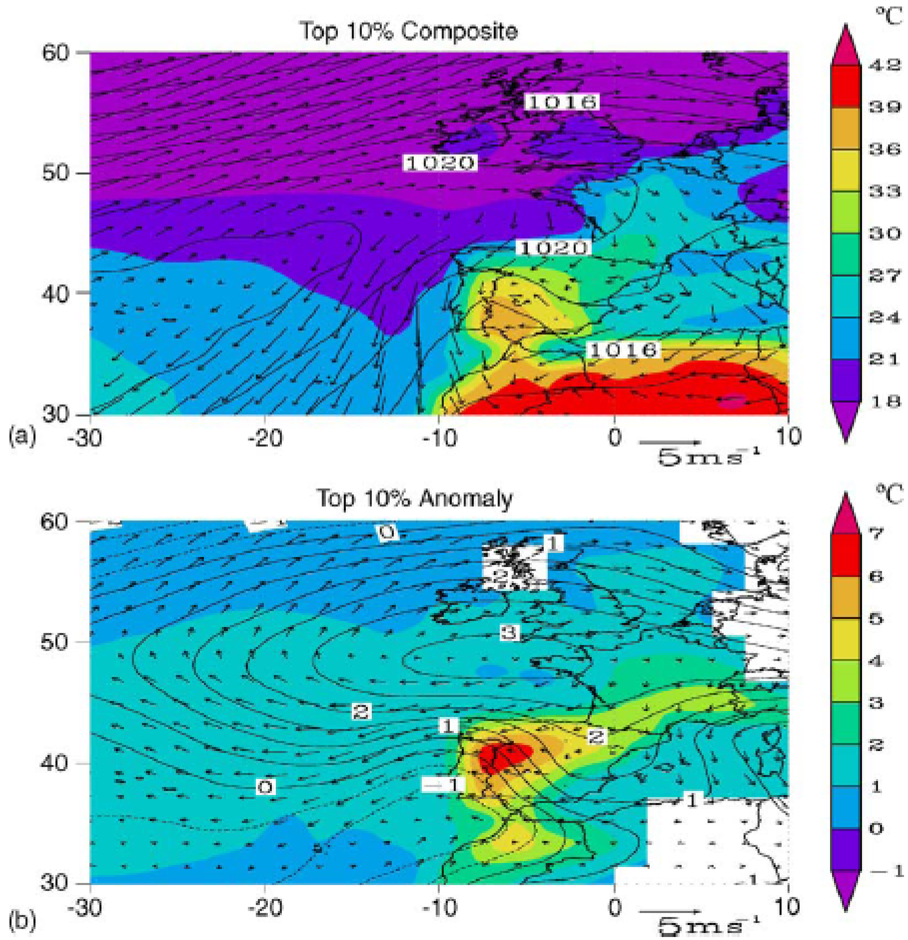


Fig. 6. Maximum temperature (°C), at 2 m height ($T_{x,2}$) for (a) composite for the 10% highest burnt area days in Portugal and (b) the corresponding 10% anomaly. Contour lines and arrows show, respectively, the corresponding sea level pressure (mb) and 10 m height wind fields (m s^{-1}). Climate anomaly field ($T_{x,2}$) is represented only in those areas where such anomaly is significant at the 1% level (or 99% confidence level) computed with a two-tailed t-test.

- **Most of the area burns under quite specific, severe meteorological conditions, which are well characterised.**

Causes of fire in Spain

	Subjective perception (%)	Actual cause (%)
Land use conversion	25,6	0,26
Pyromania	22,7	5,6
Vandalism	14,3	0,93
Timber value speculation	11,9	0,08
Crop residue burning	1,6	17,4
Pasture management	2,7	14,9

- **Fire frequency was characterised quantitatively using a survival analysis approach, based on Weibull distribution.**

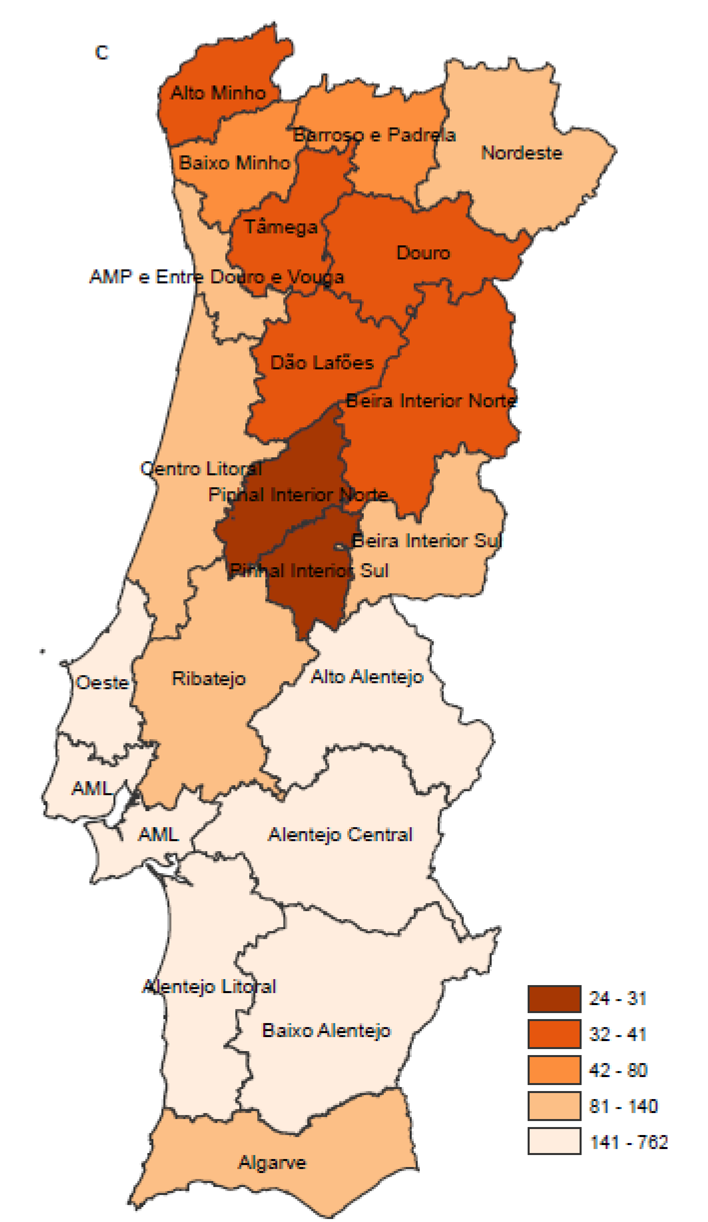
- **Analysis was performed for the 21 forest planning regions of Portugal.**

- **We estimated values for fire frequency descriptors such as the Natural Fire Regime, Fire Interval Distribution, Hazard of Burning, etc.**

- **Some relevant finding are that ,in some regions, fire frequency is too high for maritime pine forest plantations. This has led to expansion to eucalypt plantations.**

- **Another consequence has been land cover conversion to shrub formations, with strong impacts on C sequestration.**

- **Hazard of burning curves reveal that, throughout most of the country, fuel flammability is only weakly dependent on patch age. This indicates strong control of the fire regime by severe meteorological conditions, and limited expectations for fuel reduction (i.e. Prescribed burning) practices.**



Natural fire rotation

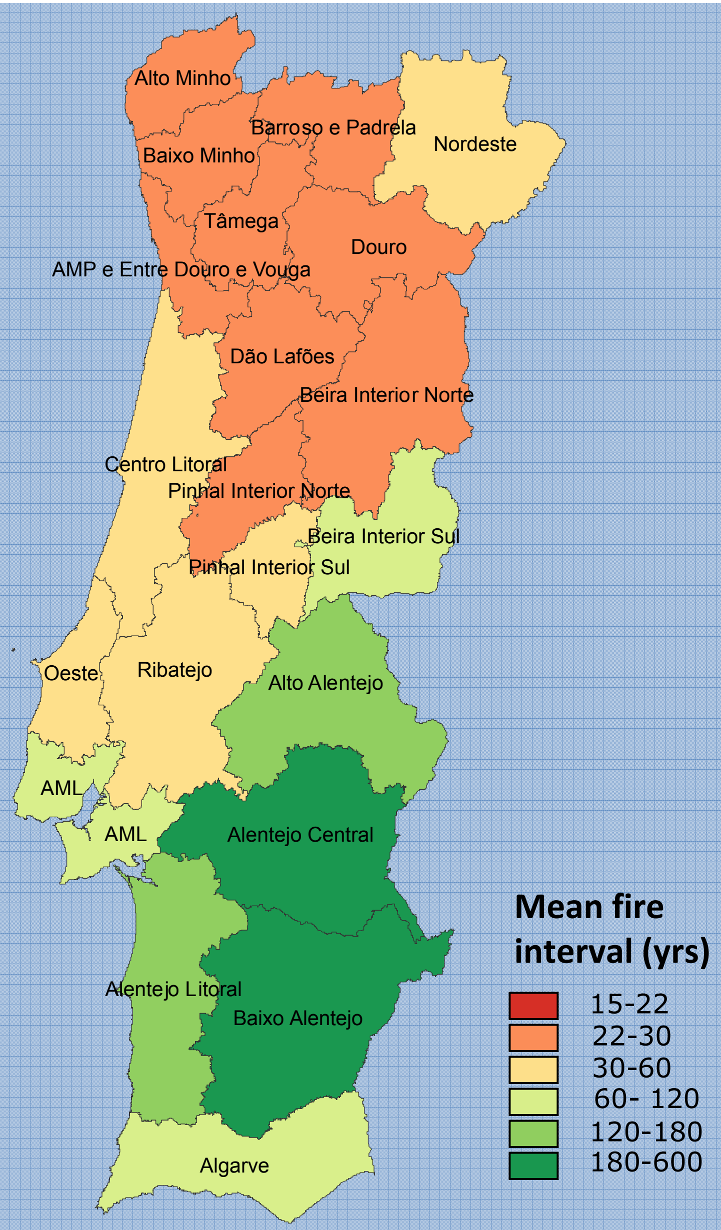
$$NFR = \frac{N}{\frac{A}{S}}$$ where

N – length of study period (yrs)

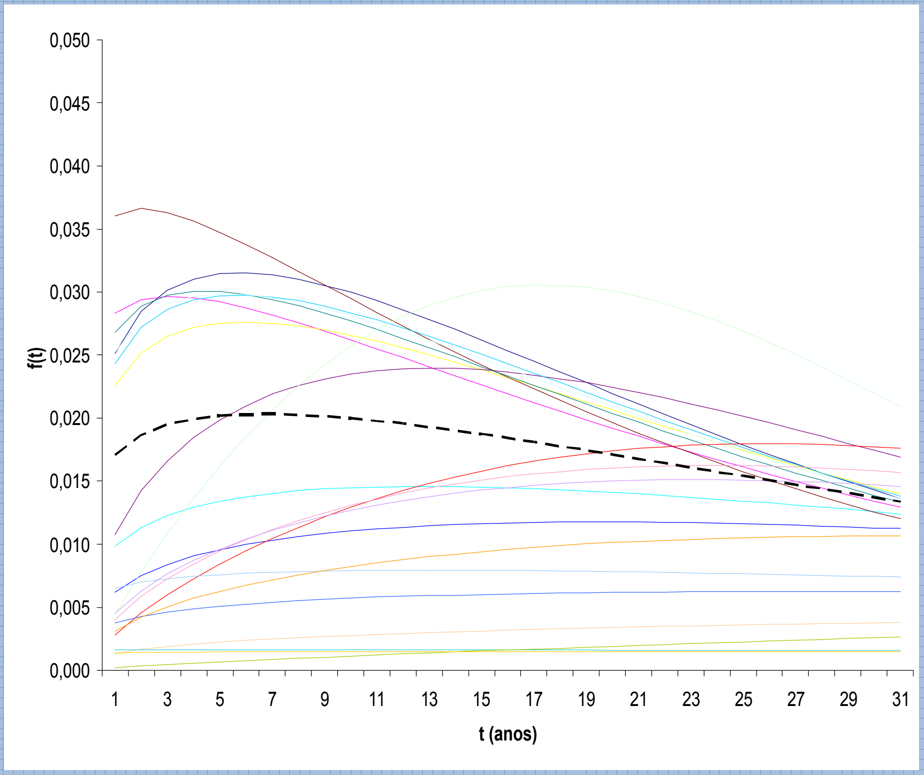
A - extent of area burned

S – extent of study area

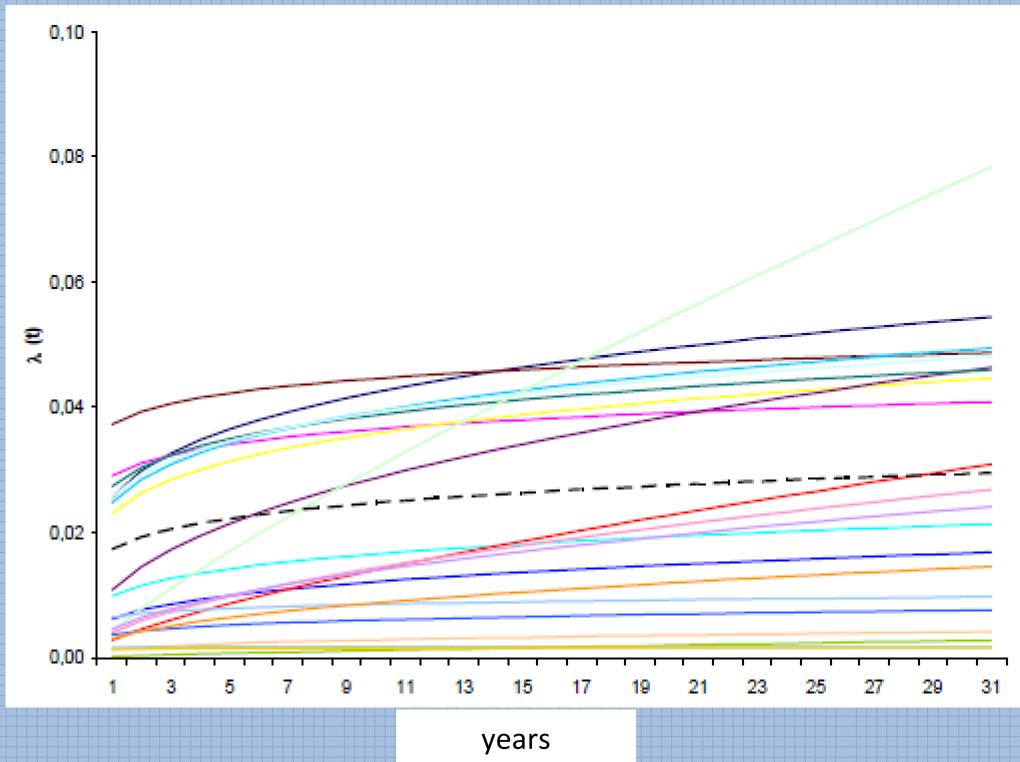
NFR is shortest in densely forested central Portugal. Here, fire frequency is relatively low, but fires tend to be very large.



Fire interval distribution



Fire intervals are shortest in regions with extensive shrublands , frequently burned by sheep/goat herders. Also in regions with high population density.



Hazard of burning

Probability of burning as a function of time (yrs) since last fire.

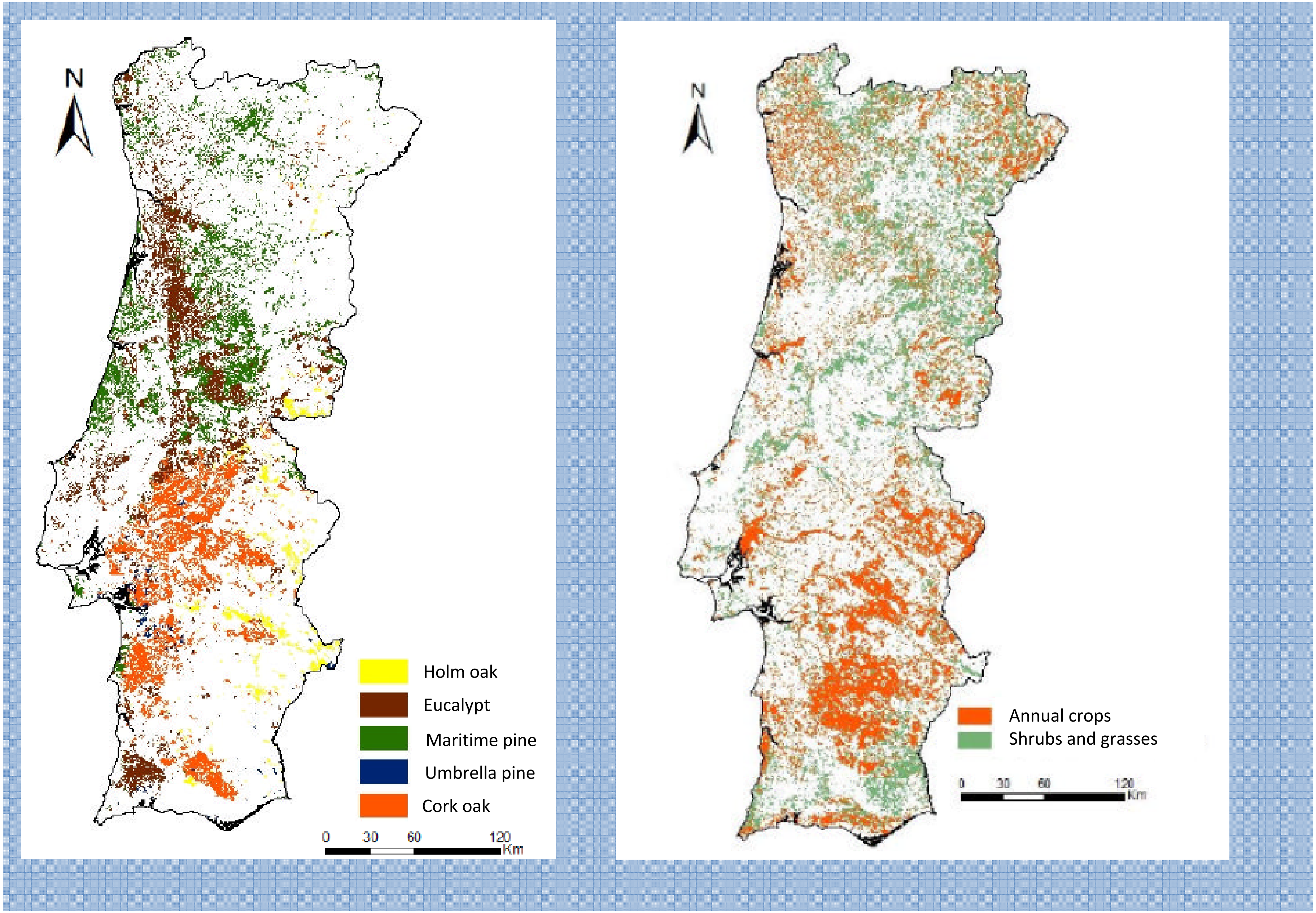
Hazard of burning tends to increase with time.

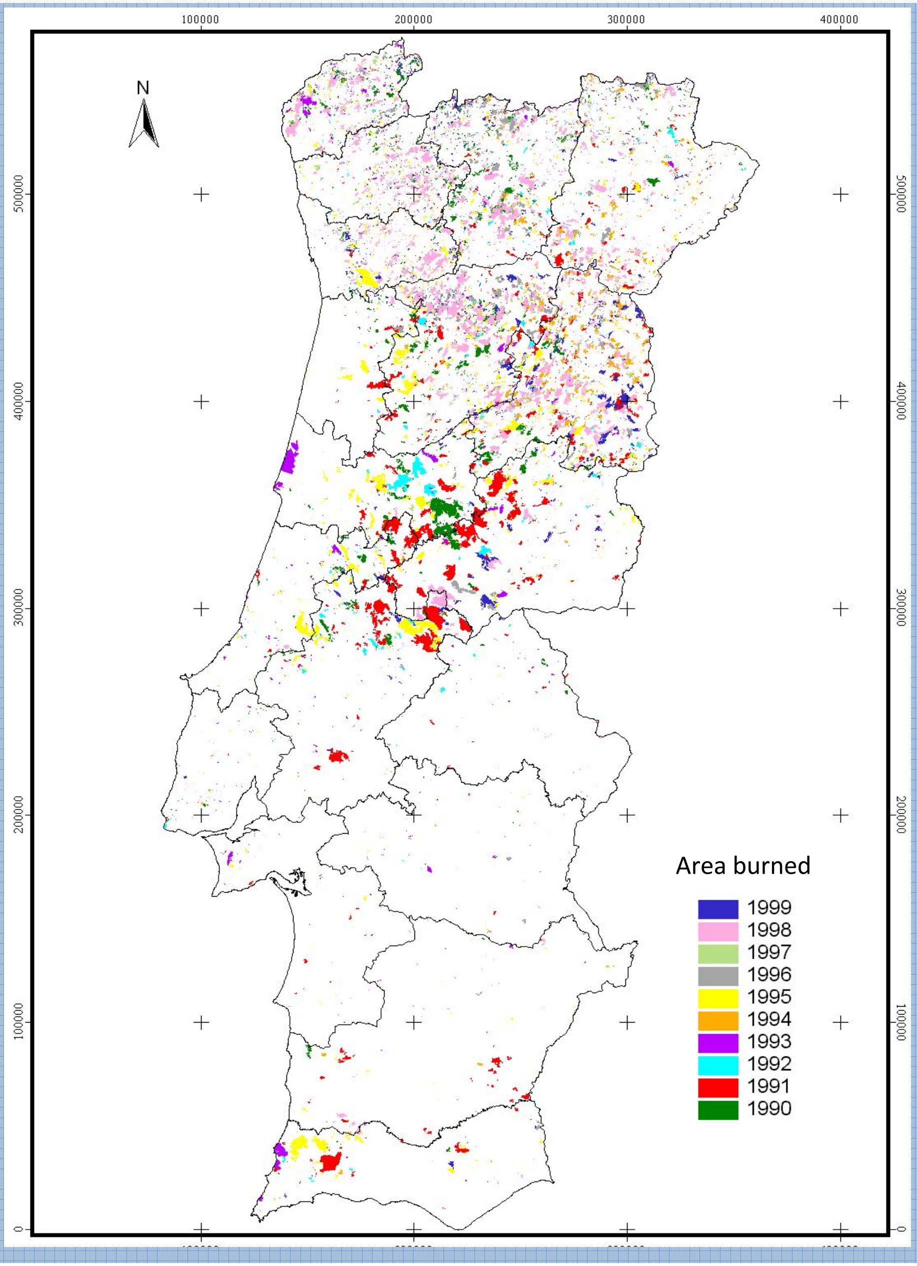
For several regions, it stabilizes after a few years, i.e. vegetation age appears to exert little control over likelihood of fire.

Severe fire weather may be key determinant of fire occurrence.

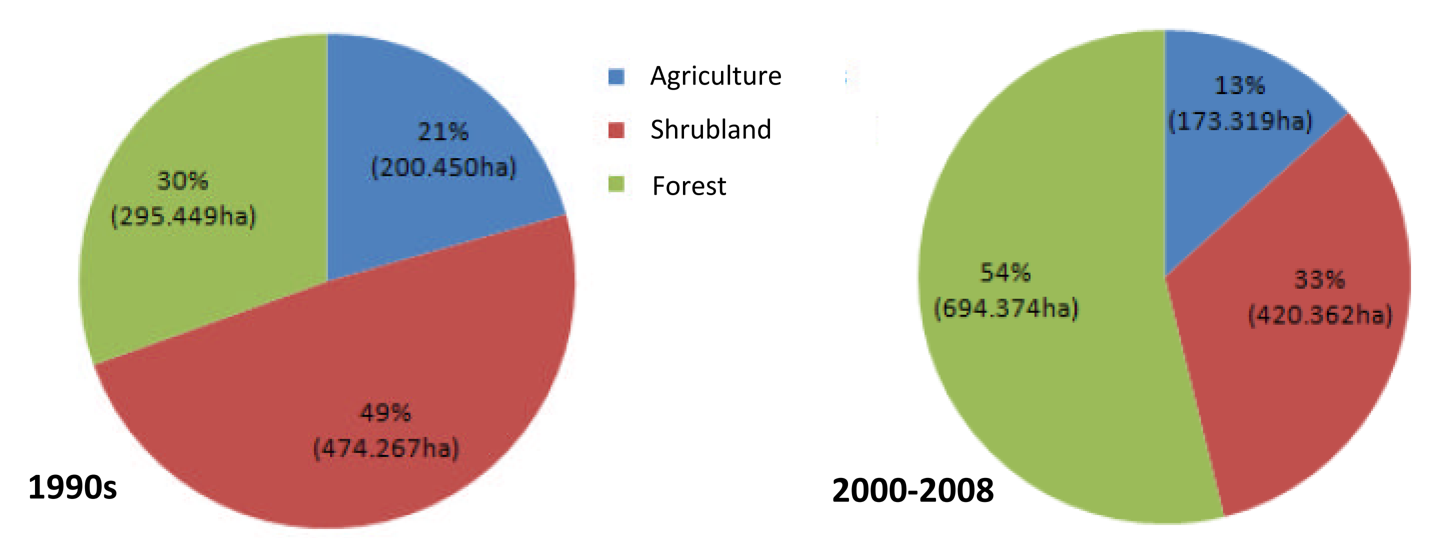
Pyrogenic emissions

- were estimated:
  - for the entire country
  - on an annual basis, 1990 – 2008
  - per major land cover type
  - for several GHG and for particles
- Estimates relied on detailed (scale 1:100.000) land cover (1990 and 2000) and annual fire perimeter maps.
- Used data from thousands of field plots from the National Forest Inventory.
- Used species-specific forest biometry equations and empirical vegetation growth models to estimate biomass loadings.
- Included detailed uncertainty analysis and sensitivity analysis of emissions estimates.


N
Holm oak
Eucalypt
Maritime pine
Umbrella pine
Cork oak
0 30 60 120
Km
N
Annual crops
Shrubs and grasses
0 30 60 120
Km


100000
200000
300000
400000
N
500000
400000
300000
200000
100000
0
Area burned
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990

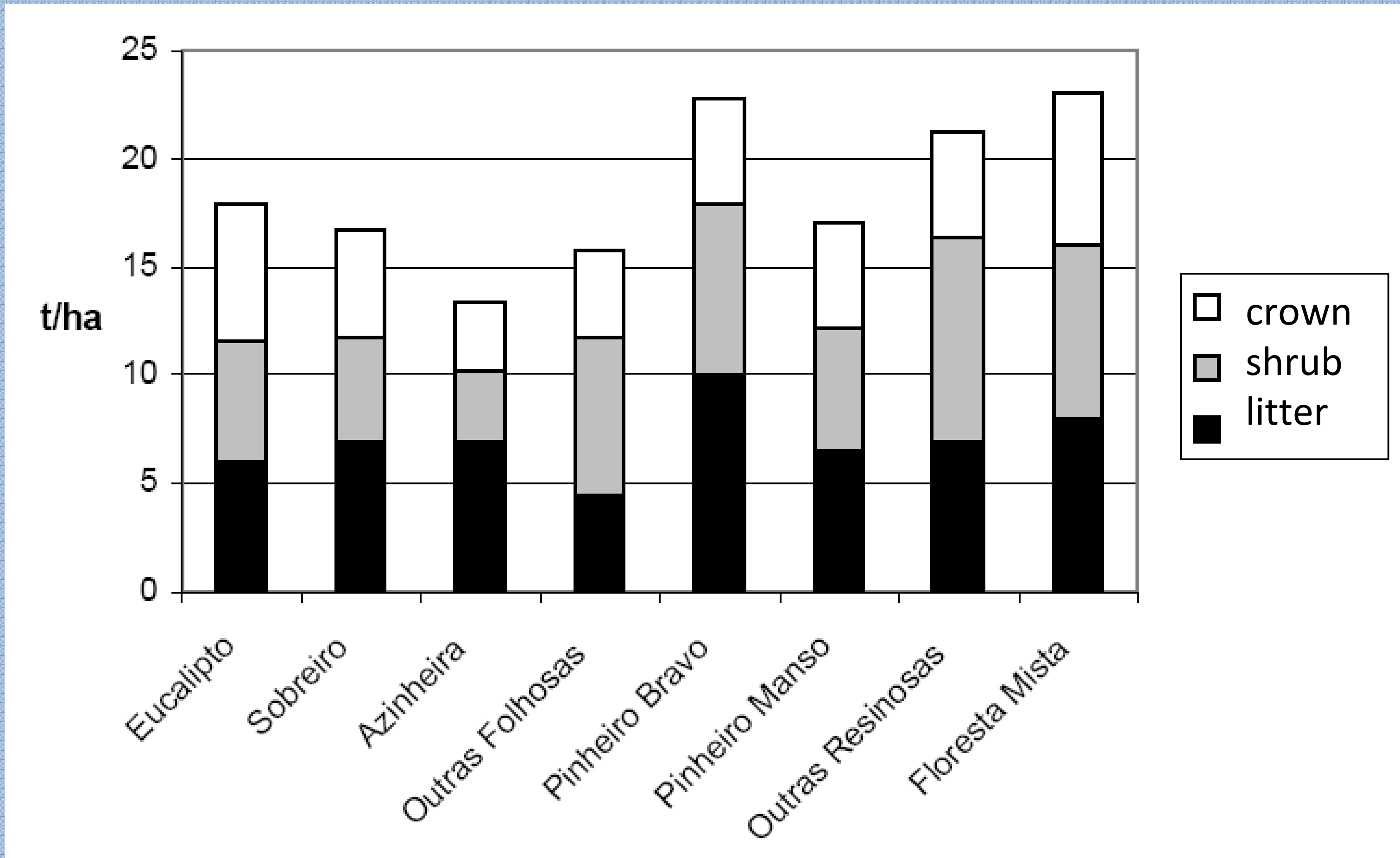
Area burned in major land cover types



Emission = A* B* CC* EF

Data sources

Area burned (A): Landsat-based fire atlas
Biomass (B): CORINE Landcover, Nat' Forest Inventory, field data, models
Combustion completeness (CC): literature
Emissions factors (EF): literature



- **Biomass loadings considered for the three forest fuel strata.**

- **Uncertainty analysis: quantification of overall uncertainty associated with model response, as a result of uncertainties in model input.**

- **Based on Monte Carlo approach, whereby multiple model evaluations are performed, with randomly selected model inputs.**

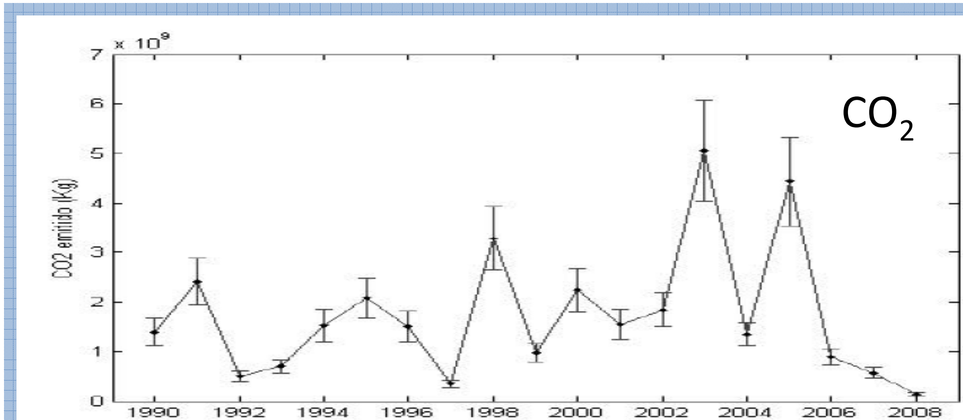
- **Sobol sampling method allows for very uniform (quasi-random) exploration of the input space.**

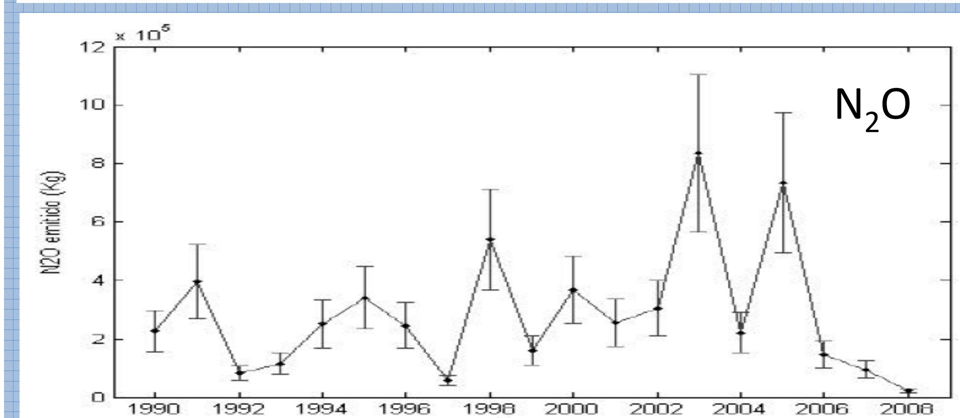
- **4 steps:**

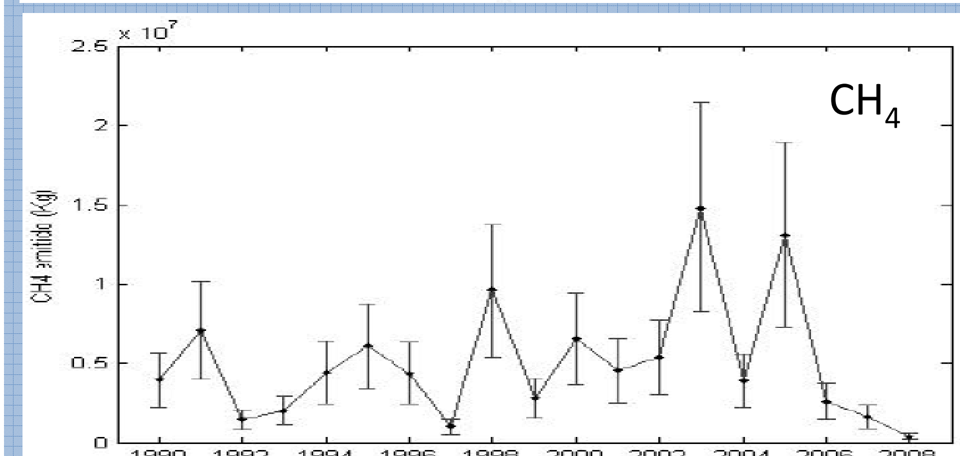
    - **assign statistical distribution (pdf) to each model variable**
    - **generate sample of size N, from pdf, according to Sobol sampling**
    - **evaluate model at each point in input space**
    - **analyse resulting output values**

- **Sensitivity analysis quantifies how variation in model output can be attributed to different sources.**

- **Uncertainty and sensitivity analysis are based on Monte Carlo techniques , as implemented in SimLab (http://simlab.jrc.ec.europa.eu/)**



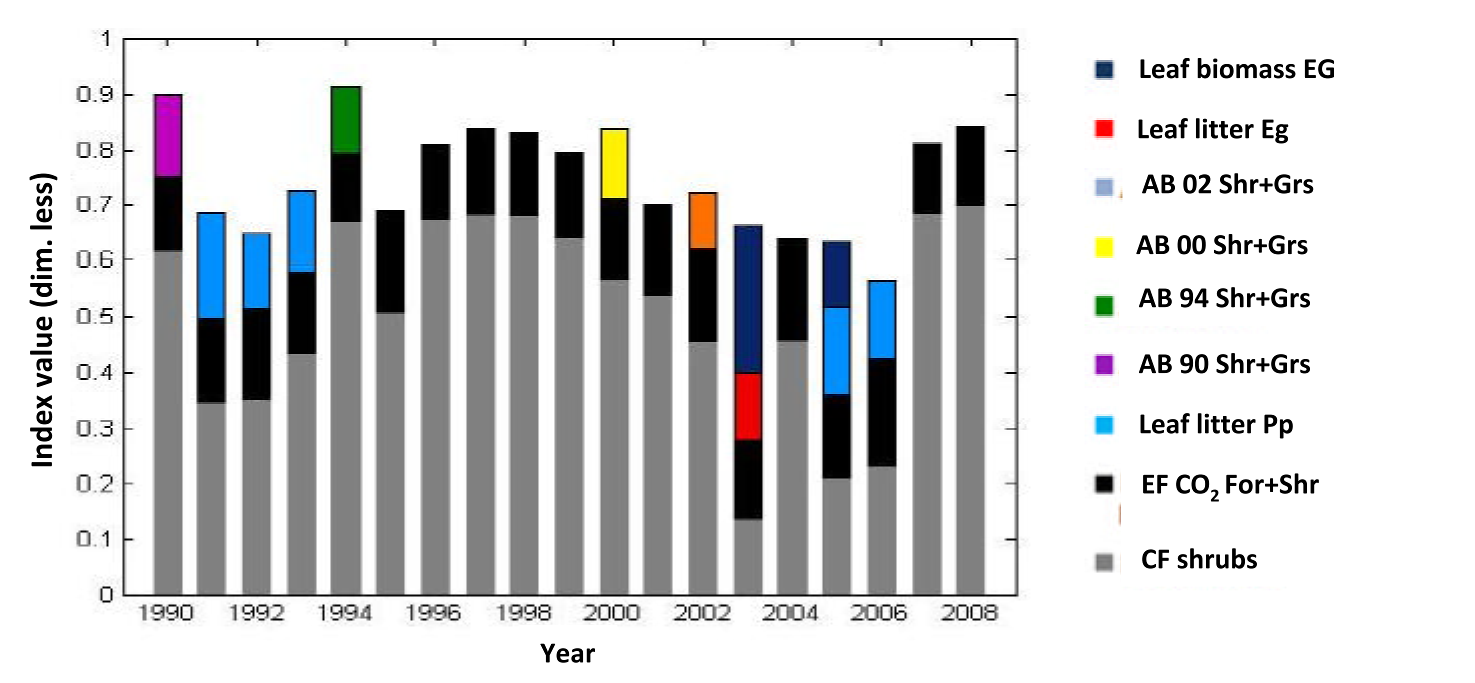




- **Uncertainty in data inputs (area burned, biomass loading, combustion completeness, and emissions factors) was characterised from information contained in our own datasets, and from literature review.**

- **Uncertainty for most model variables was well represented with Gamma or Weibull distributions.**

- **For a few variables , discrete distributions of measured values were used.**



Sensitivity analysis for CO_2 emissions , based on dimensionless output variance reduction index.

- **We estimated a mean biomass consumption of 9 $t.ha^{-1}$ and a mean emissions value (CO_{2eq}) of 16 $t.ha^{-1}$.**

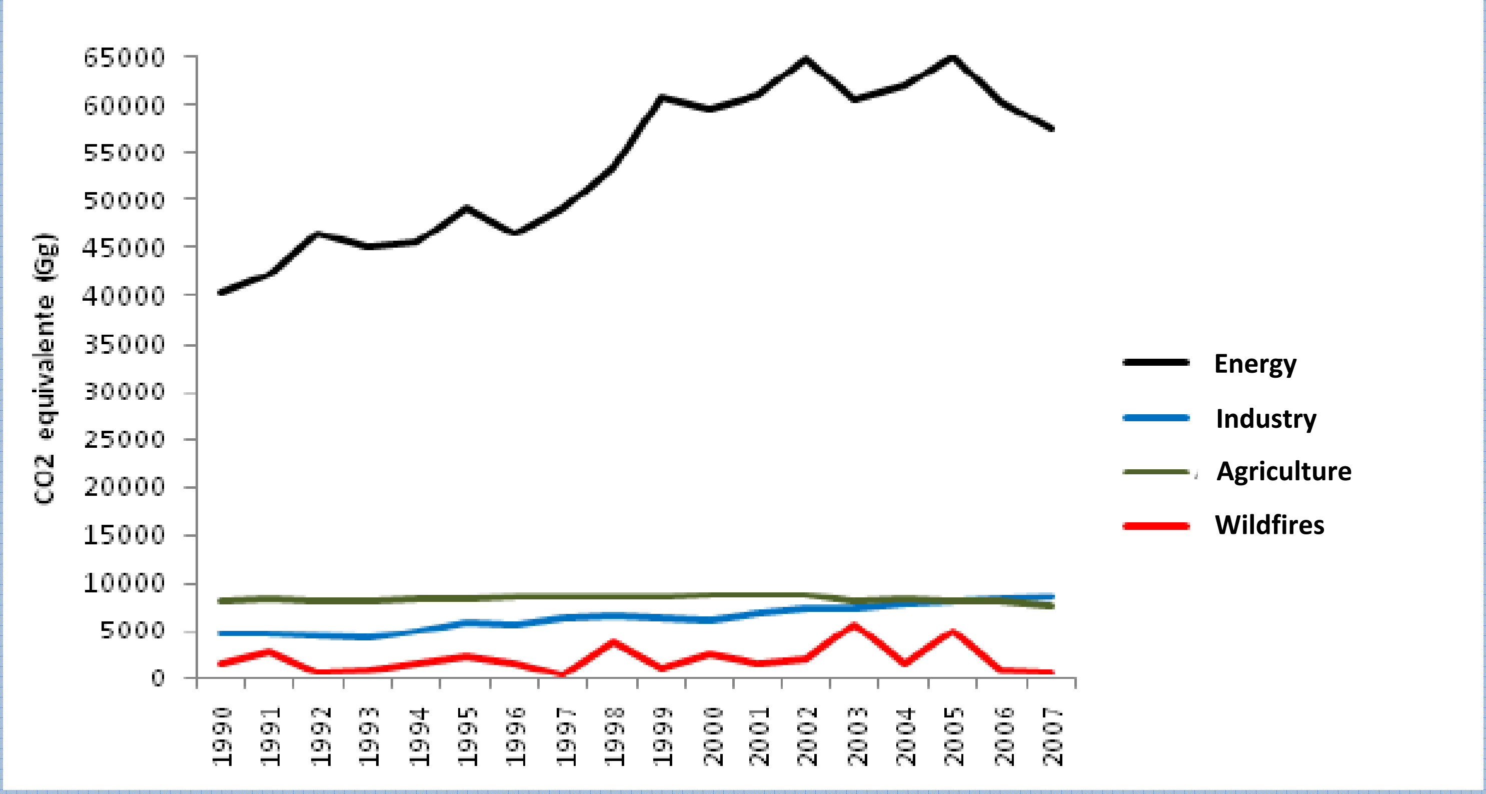
- **During the year 2003, when 440 000 ha burned, 7 Mt CO_{2eq} were emitted.**

- **We obtained a very good correlation between area burned and emissions. The main reason is that, in our assessment, fuel consumption per ha is similar for forests and for shrublands .**

- **In severe fire years, pyrigenic emissions come close to those of agriculture and industry.**

- **However, the latter are spread out through the year, while pyrogenic emissions are strongly concentrated in time.**

- **This has very clear implications for air quality and public health.**



GHG (CO_2, N_20, and CH_4) emissions from various economic sectors and from wildfires, in Portugal.

- **What do we have to offer?**
  - **longest and largest time series of high spatial resolution (1:100.000) fire perimeter maps in Europe.**
  - **abundant field and model data on biomass in portuguese forests and shrublands.**
  - **detailed wildfire statistics, including information on timing and causes of events.**
  - **good capability to extract fire-related information from satellite imagery.**