Heat waves and forest fires: Summer 2003 in Portugal[1]

"We are facing an exceptional situation. It's been brought about by absolutely exceptional weather conditions, so we have to respond with exceptional measures"
Portuguese Prime Minister, Jose Durao Barroso [i]

Introduction: Heat wave hazard

Extreme temperatures are part of nearly every climate on Earth, representing one of the most common natural hazards facing human societies. Portugal's mainland geographic location and climatology makes it especially vulnerable to extremely high summer temperatures, when circulation from the Sahara becomes dominant. Furthermore, Southwest Iberia has recorded the highest temperatures in Europe (47.3ºC was recorded on August 1st 2003 in Amareleja, the second highest temperature ever registered by National Meteorological Authorities across Europe[2]).

Forest ecosystems cover about one third of Portugal and provide a wide range of goods and services. This high economic importance is paralleled by the importance of forests for biological diversity in a diverse landscape mosaic.

Increasing awareness of health-related impacts and complex relations with drought, desertification and forest fires, as well as increasing public concern with climate change and environmental issues, have strengthened the need to manage the risks and mitigate the impacts of heat waves. In 2001, the World Meteorological Organisation (WMO) started to use a Heat Wave Duration Index (HWDI), which defined a heat wave as occuring when maximum daily temperature exceeds by 5ºC or more the average daily maximum of the reference period during a period of at least six consecutive days. This definition is based on the heat wave duration rather than its intensity, suggesting that the use of the HDWI should be complemented with an analysis of temperature anomaly.

Although heat waves in Portugal's mainland may occur anytime throughout the year, their impacts are strongest during summer, the period of highest temperatures, because absolute extreme values may be attained. An analysis conducted by the National Meteorological Authority (IM) reveals that June is the month with the highest frequency of heat waves in Portugal[ii]. It also states that although several heat waves can be identified in records throughout the 20th century, overall heat wave frequency has increased since the 1980s. Due to their intensity, duration and spatial extent, as well as their social and economic impacts, three major events are highlighted: June 1981, July 1991 and July/August 2003.

The 2003 heat wave was the longest recorded since 1941, reaching 17 days in some inland parts of the country, 14 days in the districts of Beja, Évora, Portalegre, Castelo Branco, Vila Real and Bragança, and moe than 10 days in over two thirds of the country (fig. 1). Still, its spatial extent was smaller than in 1981 (fig. 2). Furthermore, the summer of 2003 was preceded by a wet winter and a very dry May, which

[1] This case study has been written by L N Silva, M Bugalho and A Do Ó
[2] After 47.8ºC recorded in July 1976 in Murcia, SE Spain; but all other highest values (above 45ºC) in the Peninsula, as well as in Europe, were registered in the Guadiana and Guadalquivir basins lowlands (Alcoutim, Beja, Mértola, Sevilla, Cordoba), in SW Iberia.

favoured vegetation growth and increased the available fire load. Such climatic conditions added to the role played by the heat wave in July-August and the associated meteorological surface conditions in the propagation of large forest fires[iii].

Risk of heat waves is expected to grow, according to climate change scenarios which point to an increase in the frequency and intensity of heat waves, especially across Mediterranean Europe[iv,v] .

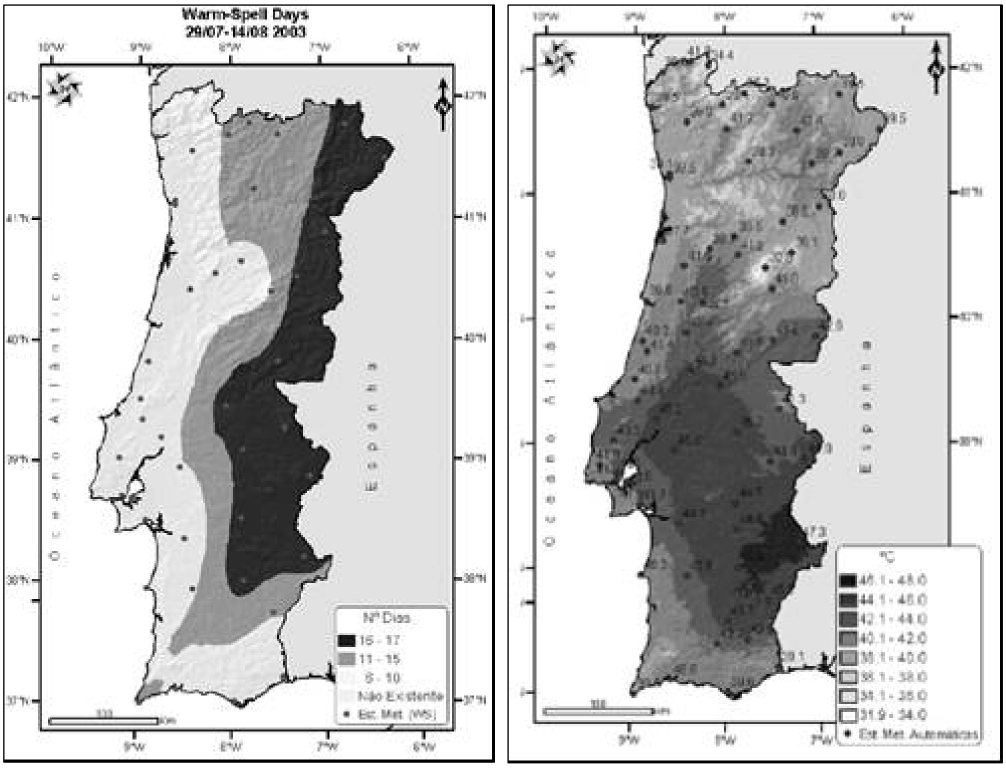

Figure #: **2003 heat wave in Portugal: length in number of days (left) and highest maximum temperatures (right). The darker colours represent the greatest number of days/highest temperature**[vi]

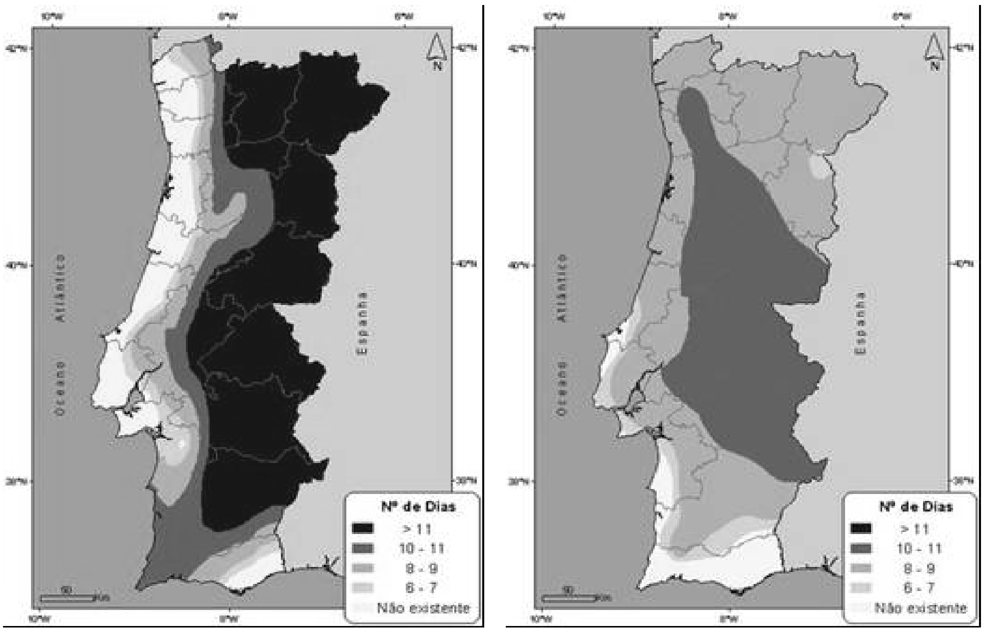

Figure #: **Comparative length (number of days) and spatial extent of heat waves in 2003 (left) and 1981 (right) in Portugal**[vii]

The causes of the disaster: Heat waves and forest fires

Although fire is an important ecological disturbance and regenerative process in Mediterranean ecosystems, the fire regime has been altered over the last few decades and a naturally occurring 25-35 year cycle of fire recurrence in Mediterranean ecosystems has been reduced[viii]. This change in the fire regime has meant that fires have increased in intensity and extension, lost their beneficial ecological role and are becoming catastrophic events[ix].

The relation between heat waves and forest fires in Mediterranean climates has long been studied[x,xi,xii,xiii], and there is little doubt about the important role of heat waves in creating optimal conditions for the propogation of forest fires. Recent data comparing the meteorological Fire Weather Index (FWI, used for monitoring fire risk in Portugal) and total burnt area in Portugal's mainland is quite clear on this relation[xiv], showing how most of the total burnt area is concentrated over a few peaks of high index values.

There are thousands of ignitions every year throughout the country, mainly due to human causes (usually negligence, but also arson). During average weather conditions such fires can be controlled, but during heat waves they easily become out of control and may turn into big wildfires.

The importance of severe heat waves in forest fires is quite evident from the analysis of figure #, depicting the number of days within the official fire season (May 15 – October 15) under each Daily Severity Rating (DSR) class and the corresponding total burnt area for six recent years. A report published in 2006 by the national forest authority (DGRF)[xv] concludes that the relation between DSR and ignitions is quite linear, while the relation of DSR with total burnt area is exponential, with a few high value days causing most of the overall burnt area.

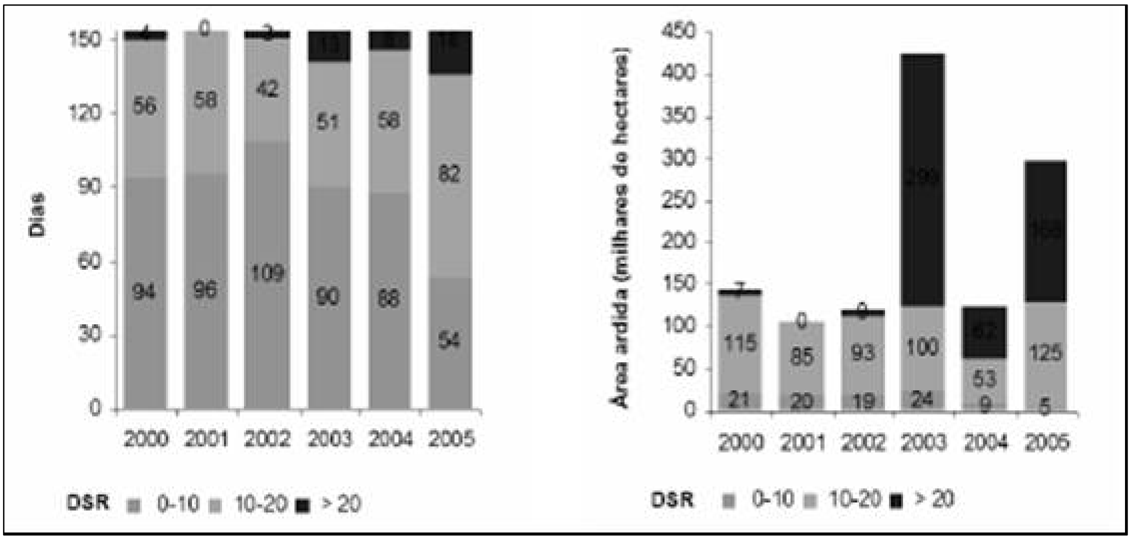

Figure #: **Number of days (left) and total burnt area (right) under three DSR classes for the 2000-2005 respective fire seasons**

2003 was so exceptional that forest fires, usually concentrated in the northern and central regions, also occurred in the south with great intensity. Of the seven districts with over 10,000ha of total burnt area, all except Faro were fully exposed to heat wave conditions. In the remaining 11 districts, which had less than 10,000ha of total burnt area, only three had 100 per cent of their territory under heat wave conditions[xvi] The impacts of this catastrophe were massive: 20 people were killed in fire-related accidents (including four firemen), and damages amounted to almost 2 billion euros[xvii]. There were also impacts reported on air quality across Western Europe[xviii].

Although previous heat waves, such as in 1991, have also caused large forest fires and high values of total burnt area, they can not explain the abrupt increase in the latter, as heat waves themselves have not registered such an exponential trend. Therefore, the cause of such increasing devastation has to be sought in relation to either ignition or combustion conditions, which are mostly dependent on land use.

Pereira *et al*[xix] have shown that in future scenarios of climate change in Portugal (namely those resulting from doubling of CO_2 concentration in atmosphere) the frequency of hot and dry summer days will increase and consequently the number of days of high risk of fire will also increase (fig. 5). In its turn, a higher number of days with a high risk of fire is positively related to total burnt area (fig. 4).

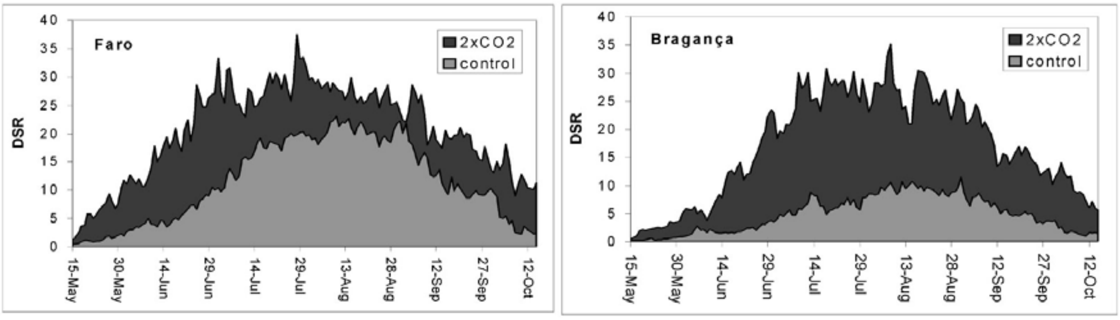

Figure #: **CO_2 doubling scenario and increase in the number of days with high fire risk (DSR index) in Portugal. Changes seem to be larger inland (e.g. Bragança) than in coastland (e.g. Faro) areas. Adapted from Pereira et al[xx]**

Primarily as a result of the European Union Common Agricultural Policy (CAP), several European regions have undergone land abandonment and a subsequent increase in shrublands and/or forested areas. In Portugal, as in other Mediterranean countries, this has been accentuated by migration from rural areas to cities. In Mediterranean ecosystems the diminishing of agricultural activities usually leads to rapid shrub encroachment and invasion of open areas such as grasslands by shrubs. Thus, a reduction of land under agriculture has generally led to dramatic increases of vegetation fuel loads and consequently to larger and more severe fires. Socio-economic factors and related dominant land-uses are thus of crucial importance in partially explaining the increasing fire problem in Mediterranean areas and Portugal in particular[xxi].

Fires and Protected Areas

Most protected areas in Portugal are managed as IUCN Protected Area Management Category V, i.e., areas in which the interaction of people and nature has created significant ecological, cultural and biodiversity values. In addition to the existing protected areas network, Portugal participates in the European Union Natura2000 network (which includes habitat protected under the EU habitat Directive, and areas of special protection for birds). The Natura2000 network covers 21 per cent of the Portuguese territory and is partially coincident with the protected area network.

In Portugal different high conservation value landscapes have been maintained due to agro-silvo-pastoral activities. Most of southern Portugal, for instance, is included in the WWF Mediterranean Ecoregion and is considered a significant biodiversity hotspot particularly due to the presence of evergreen oak savannas, i.e. silvopastoral systems of cork and holm oak. Such systems have considerable within and inter-habitat diversity maintained through centuries of human use. Species such as Iberian Lynx (*Lynx pardinus*), the most endangered felid in the world, or the Imperial Eagle (*Aquila adalberti*) depend on such habitats for survival. Changes in land use, mainly land abandonment, may potentially erode the conservation value of such areas. Risk of fire, in particularly, is increasing due to replacement of extensive agricultural land use (which contributes to create a mosaic landscape) by shrublands.

Protected areas in Portugal are generally following the trend described above, i.e. land abandonment is leading to an increase of shrubland areas and of fuel loads (see table #). Fire management is considered in some protected areas through their Landscape Management Plans, which describe actions at the fire prevention level such as environmental education, creation of fire breaks, monitoring and restoration of recently burned areas[xxii]. However, at present the landscape level changes which are occurring, possibly together with the a lack of implementation of Landscape Management Plans, means that the number of fire ignitions in protected areas, as well as of total burnt area has increased since 1992[xxiii], with an average area of approximately 10,500 ha/year burnt, peaking in 2003 to a total burnt area of 28,273 ha (approximately a quarter of the total burnt area between 1992 and 2005 –table 2).

Table #: **Burnt area in protected areas and overall Portugal in 1991, 2003 and 2005**[xxiv]

Area type	Total area (ha)	Burnt Area (ha) per year					
		1991[1]		2003		2005	
		ha	%	ha	%	ha	%
Protected areas (PA) [2]	1,819,286	31,480	1.7	110,151	6.1	49,409	2.7
Total land area	8,896,882	182,484	2.1	441,429	5.0	269,716	3.0
Total area excluding PA's	7,077,596	151,005	2.1	331,227	4.7	220,307	3.1

[1] Data for 1991 includes some areas classified in later years
[2] Includes the whole protected area network and Natura2000 sites

Land use is of crucial importance for understanding wildfires. In 2005, for instance, another 'heat wave year', shrublands (a land cover which usually results from agricultural abandonment), was the main vegetation cover affected by wildfire in Portuguese protected areas with 11,439 ha (60 per cent of total burnt area) affected. Other land uses affected in 2005 were: forest mixed stands (3,472 ha or 18 per cent of total burnt area), Maritime Pine (*Pinus pinaster*) stands (2,790 ha or 14 per cent of total burnt area) and eucalyptus stands (559 ha or 3 per cent of total burnt area). These data suggest that land use is of crucial importance in understanding the wildfire phenomena, which has , socio-economic roots (agriculture abandonment, lack of people in the countryside managing the land, increase of shrub fuel loads) aggravated by interacting factors such as increase of heat wave frequency. For the Natura2000 areas, approximately 58,000ha (approximately 3 per cent of Natura2000 areas) also burned in 2005.

Whilst the number of wildfires (i.e. ignitions) in protected areas, after an increasing trend, stabilizes after 1998, total burnt area shows a different trend with two peaks during the heat wave years of 2003 and 2005 (Figure 6). There are apparently no significant differences between he burnt area within and outside borders of protected areas. Land-use changes and heat wave factors seem to be interacting in Portuguese protected areas in the same way as in the rest of the country. To date, fire prevention plans in protected areas have yet to make a significant difference. However, awareness of the problem increased following the dramatic fires of 2003 and possibly time will result in proper implementation of plans.

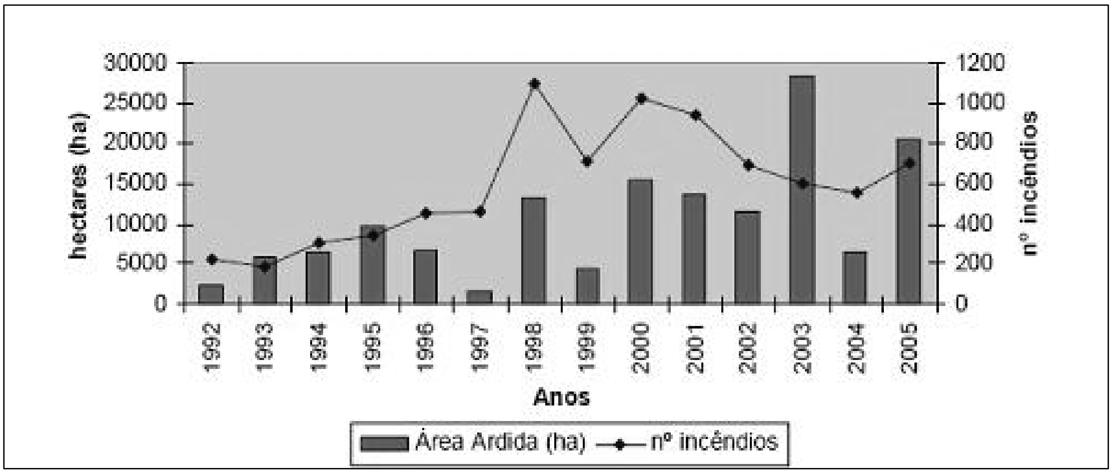

Figure #: **Number of fires and total burnt area in protected areas network between 1992 and 2005**

The Iberian lynx

Conclusions

In conclusion, wildfires, particularly those induced by the heat waves of 2003 and 2005, affected Portuguese protected areas mainly through total burnt areas Main cover affected was shrubland, a land-use resulting from land abandonment, which points to the socioeconomic root of the wildfire problem.

At present, existence of a protected area has not significantly affected the likelihood of fires, either in terms of increasing or decreasing the risks. This suggests that protection as such is not a fire prevention measure. However, the landscape-scale planning inherent in Category V protected areas should allow implementation of more effective fire prevention measures, including fire breaks, encouragement of old-growth (with its attendant fire load) in fire refuge and effective public education campaigns. Such preventive measures can enhance the landscape mosaic and contribute to reducing fuel loads and thus contribute to mitigating wildfires and promoting nature conservation.

This may be achieved, for example, through favouring agri-environment schemes in classified areas, aiming to promote economically viable but responsible and conservation-friendly activities**.** If not possible, than management of protected areas should simulate human disturbance, through processes such as grazing or prescribed fire that may contribute to maintaining low fuel loads and benefit habitat heterogeneity and conservation aims.

Otherwise, the interaction between predicted increasing heat wave frequency through climatic changes and land use changes leading to higher fuel loads on the field will aggravate the fire problem in Portugal.

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