RISCOS NATURAIS ANTRÓPICOS E MISTOS

HOMENAGEM AO PROFESSOR DOUTOR FERNANDO REBELO

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Forest fires in the Ave Region (NW of Portugal): main outputs from the Adaptaclima project

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Abstract:

The project ADAPTACLIMA - Adaptation to the effects from climate change (Interreg Sudoe) was based on the preparation of a series of studies on forecasting and analyzing the vulnerabilities and potentialities in Southwest European territories, related with the ongoing climate changes.

The weather conditions that occur in Portugal, especially during the summer, are favorable to the occurrence of forest fires. However, the ignition and spread of a fire depends on the interaction of several factors besides the weather, namely the presence of fuel and rugged terrain.

There is a wide array of studies and evidence that climate is changing and these changes will manifest themselves very differently in various areas of the planet.

It is expected that fire regimes immediately respond to climate change and may even outweigh the direct effects of global warming in the patterns of the distribution and productivity of species.

In the northwest of Portugal and in particular in the Ave region, one of the main impacts expected from climate change is a substantial increase in the risk of fires. In addition, the period of fire occurrence will extend throughout the year.

Keywords: Climate change. Forest fires. Risk. Ave region (Portugal).

Resumo:

Incêndios florestais no Ave (NW de Portugal): principais resultados do projeto Adaptaclima

O projecto ADAPTACLIMA – Adaptação aos efeitos derivados das alterações climáticas (InterReg Sudoe) parte da elaboração de uma série de estudos de previsão e de análise das vulnerabilidades e potencialidades em territórios do Sudoeste Europeu, relacionados com as mudanças globais em curso.

As condições climáticas que ocorrem em Portugal, especialmente durante o verão, são favoráveis à ocorrência de incêndios florestais. No entanto, a ignição e a propagação de um incêndio dependem da interação de diversos fatores para além do clima, por exemplo, a presença de combustível e do relevo.

Há um vasto conjunto de estudos e de evidências sobre as atuais mudanças climáticas e de como essas mudanças se manifestam de forma muito diferente em diferentes partes do planeta.

É esperado que os regimes de fogo possam responder de imediato às mudanças climáticas e podem até superar os efeitos diretos do aquecimento global nos padrões de distribuição e produtividade das espécies.

No Noroeste de Portugal e em particular no AVE, um dos principais impactes esperados, fruto das alterações climáticas, é o do aumento do risco de incêndio. Para além disso, o período de ocorrência de incêndios irá estender-se ao longo do ano.

Palavras-Chave: Mudanças climáticas. Incêndios florestais. Risco. Ave.

1. Introduction

Fire has been a natural and fundamental factor influencing landscape evolution throughout time (Naveh, 1975; Pyne, 1982; Pausas *et al.*, 2008; Pausas and Keeley, 2009; Bento-Gonçalves *et al.*, 2012). However, recent decades have been marked by a rising concern with the issues related to the ongoing global changes, such as land-use (Meyer and Turner II, 1994; Ippc, 2000; Dolman *et al.*, 2003; Lambin and Meyfroidt, 2011) and climate change (Ippc, 1990; Viner *et al.*, 1995; Hulme *et al.*, 1999; Ippc, 2001; Ippc, 2007a; Hitz and Smith, 2004; Venkata Raman *et al.*, 2012) and its direct and indirect effects on society by inducing abrupt changes in the community (Kazanis and Arianotsou, 2004; Rodrigo *et al.*, 2004; de Luís *et al.*, 2006; Arnan *et al.*, 2007; Shakesby 2011).

Parallel with this tendency, research seeking to identify causes, effects, and mitigation measures has also multiplied (Woodward, 1992; Ippc, 2000; Ippc, 2001; Ippc, 2007b; Ippc, 2007c; Nas, 2001; Hitz and Smith, 2004; Easterbrook, 2011; Holmes, 2011; Humlum *et al.*, 2011; Venkata Raman *et al.*, 2012).

Internationally, this research has been conducted by the Ippc - Intergovernmental Panel on Climate Change (Ippc, 1990; Ippc, 2001; Ippc, 2007a; Ippc, 2007b; Ippc, 2007c), sponsored by the World Meteorological Organization and by the United Nations Program for the Environment. This organization has been active in understanding the mechanisms that affect climate change, its potential impacts on the planet and on human activities, and in defining strategies of adaptation or mitigation of this phenomenon.

It is widely agreed that, based on the data obtained and assessed so far, we have been witnessing a period of global warming and the influence of the anthropogenic factors have helped catalyze this phenomenon (Mitchell, 2001; Venkata Raman *et al.*, 2012). Analysis of climate data and its trends, as well as the influence of human actions are under scrutiny and being modeled (Loehle and LeBlanc, 1996; Solomon *et al.*, 2010), in order to foresee and predict the behavior of the climate system, and to evaluate such climate changes. For this purpose, some physico-mathematical climate models (Global Climate Models - GCM) have been applied to obtain global trend projections of climate change (Ippc, 2007a). These models allow the establishment of different hypothetical socioeconomic scenarios. However, the low spatial resolution of these global models precludes the establishment of detailed regional analyses. Accordingly, methodologies for defining regional scenarios of climate change have been proposed, with a number of examples at the European (van der Linden and Mitchell, 2009) and Iberian level (Santos *et al.*, 2002; Gutiérrez *et al.*, 2010).

A recent European project, the ADAPTACLIMA - Adaptation to the effects from climate change (Interreg Sudoe - http://adaptaclima.eu/) - was based on the preparation of a series of studies on forecasting and analyzing the vulnerabilities and potentialities in the Southwestern European territories, with the aim of creating a collaborative network of stable institutions, permitting both the transmission of knowledge and exchange of experiences among members of the partnership, as well as mutual learning and co-generation of new knowledge.

In the Northwest of Portugal, notably in the Ave region, one of the main impacts expected to result from climate change is an increase in the number and size of fires and their recurrence and, consequently, an increase in the erosion of the top soil layers — where the only nutrients available in most Portuguese soils are located (Bento-Gonçalves *et al.*, 2008).

As part of the ADAPTACLIMA project, an evaluation of the magnitude of climate change in various regions of Southwestern Europe, including the Ave region, was conducted.

PRUDENCE project outcomes (http://prudence.dmi.dk), which present a series of climate change projections for Europe with a horizontal resolution of approximately 50 km, were initially used.

Such projections were made by different institutions utilizing different European regional climate models, based upon the global template HadAM3H, which is one of the global models used in the IPCC and the one that offers the best outcomes for the current climate.

A projection for the period of 2071-2100 was established for each regional model, as well as a control simulation for the period of 1961-1990 which served as a basis for the simulation.

After this preliminary analysis, a more detailed investigation for the AVE region was conducted (MeteoGalicia, 2010b), based on the meteorological stations installed in the Northwest Portuguese territory.

2. Regional Setting

2.1 The Ave Region

The Ave region[1] (Figure 1) reveals a significant demographic growth, which has contributed to the establishment of one of the major settlements in Portugal, as well as one of the oldest. Currently, the Ave region has a demographic density of about 406 hab/km^2. Nevertheless, inter-municipal differences show that there is an inverse correlation between the orography and population density. In effect, the population density increases from the Eastern part of the region Westwards.

The most striking climate feature of the Portuguese Northwest, where the Ave municipalities are located, is unquestionably the high precipitation levels, associated with the frequent passage of frontal surfaces. This feature, coupled with the effects of the mountains located close to the coast, determines an average annual precipitation exceeding 1400 mm.

In fact, the Ave is a region with Mediterranean affinities but with strong Atlantic influence. This results in a climate characterized by mild temperatures, with limited temperature ranges, and heavy average rainfall due to its geographical position close to the Atlantic Ocean. The shape and disposition of the main mountain ranges of the region also contribute to determine this particular climate.

Considering the Climatological Station of Braga located at 41° 33' North latitude, 8° 24' West longitude and at an altitude of 190 meters - it was determined that, in the period 1951-1980, the annual rainfall exceeded 1500 mm (1514.8 mm), distributed over the whole year and counting up to 130.4 days with precipitation. The highest average monthly temperature was recorded in July (20.2°C), while the lowest temperature occurs in January (8.7°C). The average annual temperature is around 14°C and the annual temperature range is 12°C (Figure 2).

[1] Located in Minho, more precisely in the Northwest of Portugal, the Ave region encompasses 10 municipalities (Cabeceiras de Basto - 241,84 Km^2, Fafe - 219,09 Km^2, Guimarães - 241,28 Km^2, Mondim de Basto - 172,09 Km^2, Póvoa de Lanhoso - 132,54 Km^2, Santo Tirso - 136,50 Km^2, Trofa - 71,88 Km^2, Vieira do Minho - 218,48 Km^2, Vila Nova de Famalicão - 201,70 Km^2 e Vizela - 24,70 Km^2), of the NUT III Ave and of the Intermunicipal Community (MIC) of the Ave.

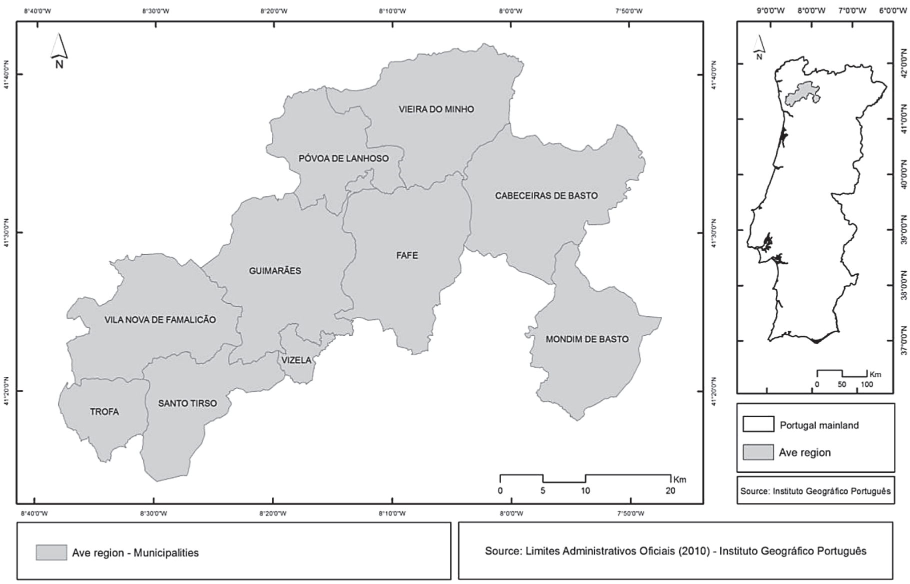

Figure 1
The Ave region: administrative framework.

The Ave region is characterized by the presence of soils with good agricultural capability, high population densities, and high industrial concentration. In terms of land use, the region displays a widespread distribution of the different uses throughout the entire landscape (Bento-Gonçalves and Costa, 2002) (Figure 3).

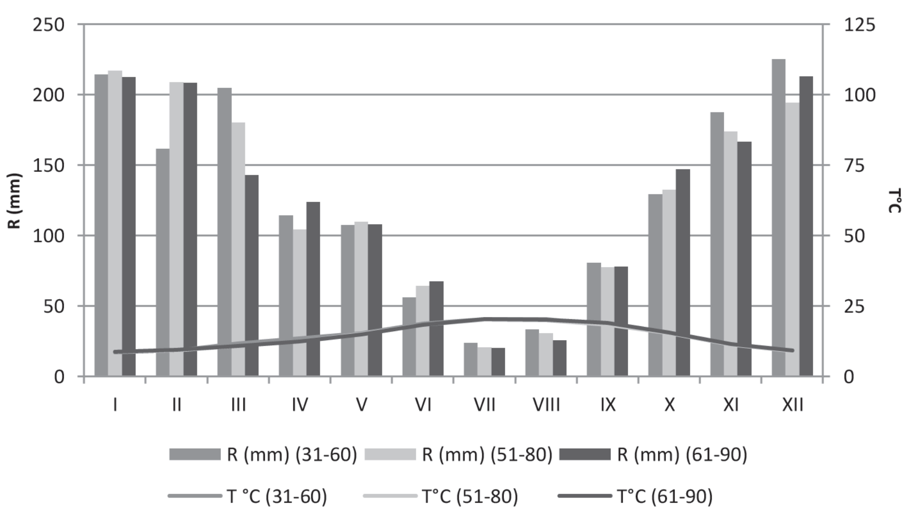

Figure 2
Braga's Temperature-Precipitation Graphic (1931-1960 / 1951-80 / 1961-90).
Source: SMN, 1965; INMG, 1991; IM 2005.

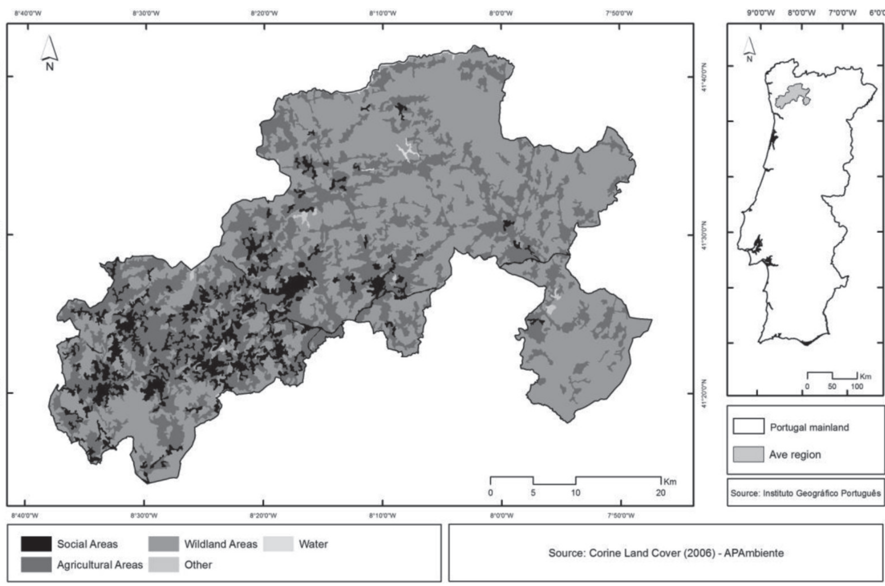

Figure 3
The Ave region: land use (2006).

The forest area in the Ave region is comprised 45.6% of maritime pine, 35.1% eucalyptus, and 9.1% oaks (Figure 4). Due to the fact that the region is heavily humanized, the organization of the landscape presents sharp contrasts. This does not, however, preclude the existence of an ecological unitary system.

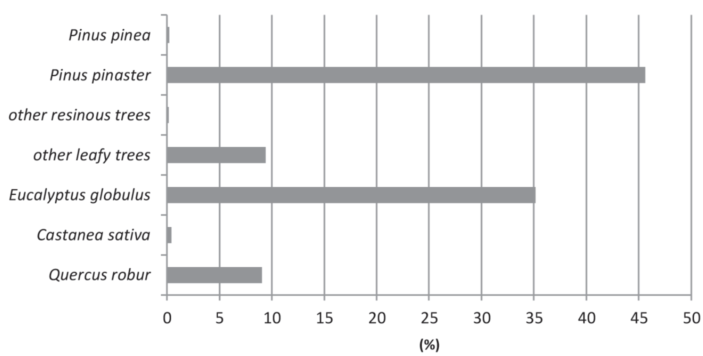

Figure 4
The Ave region: distribution (%) of the forest by forest species.
Source: AFN.

In fact, the region distinguishes itself nationally due to the unique uniformity of its landscape physiognomy, of the set of its inhabitant species, and by its particular adaptive strategies. Thus, the geographical area corresponding to the Ave presents sharply contrasting landscape systems, resulting from a long and intense human occupation, constrained by particular physical conditions, both in terms of topography and climate.

Being a fundamental element of the landscape, the vegetation is an outstanding testament to the soil and climate conditions, as well as to the anthropic action in a particular territory.

In this geographical context, six basic types of land uses can be distinguished based on the basic landscape units (Gomes, 2001):

- plain farming systems, corresponding to the lowland landscape of scattered settlements;
- mountain farming systems, where villages are grouped;
- urbanized systems;
- uncultivated systems, mostly composed of more or less degraded scrublands and areas of skeletal soil and bare rock;
- plantation forests with predominance of maritime pine *(Pinus pinaster)* and eucalyptus *(Eucalyptus globulos)*;
- forests of deciduous species, dominated by two types of oaks - *Quercus robur* and *Quercus pyrenaica*, corresponding to spontaneous or sub-spontaneous areas.

3. Materials and Methods

3.1 Forest Fires in the Ave Region

The evolution of the number of forest fire occurrences and burnt areas in the Ave (considering all 10 municipalities studied), between 1980 and 2009, reveals a large number of deflagrations translated into a total of 56 473 occurrences and a total of 108 836 hectares of burnt area.

The annual change in the number of occurrences within the period considered (1980-2009) reveals that while the 1980s recorded the lowest values, from the end of the decade, more precisely in 1989, there was a rise of about 93% in comparison with the previous year. From that year on, the number of occurrences was always above 1000.

It should be noted that there is a positive correlation between the number of occurrences and the amount of burnt area throughout the time period in analysis (Figure 5), although this correlation is higher in terms of occurrences (R^2=0,5).

In terms of the burnt areas in the Ave region (1980-2009), the 1980s also display the lowest values recorded. In effect, the years 1983, 1986, and 1988 register the lowest values of the series (157, 32, and 354 hectares).The year 1989 stands out as the exception (9150 hectares) and marks the turning point in the evolution of the burnt areas. It is worth noting that the declining trend in the burnt areas for the years 2006, 2007, and 2008, each with values under 5,000 hectares. The year 2009, with a total of 8854 hectares of burnt area, however, counters this trend (Figure 6). Analysing the data on the burnt areas it is possible to verify an uneven spatial distribution. The most striking feature is the stark contrast between the coastal and inland municipalities, which becomes clearly visible when analyzing the cartography of the burnt areas by municipality for the period between 1990 and 2009[2].

[2] Spatial data of the burnt areas are only available from 1990 onwards.

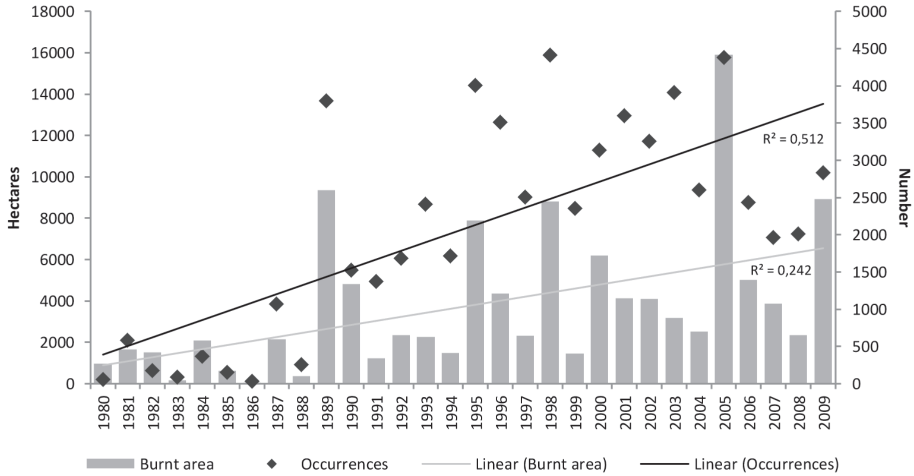

Figure 5
The Ave region: evolution of the number of forest fire occurrences and burnt areas (1980-2009).
Source: AFN.

The municipalities of the interior - hilly, demographically fragile, and characterized by a predominance of wild spaces over the remaining land uses - have more extensive burnt areas, as are the cases of the municipalities of Mondim de Basto, Cabeceiras de Basto, Vieira do Minho, Póvoa Lanhoso, and Fafe (Figure 6).

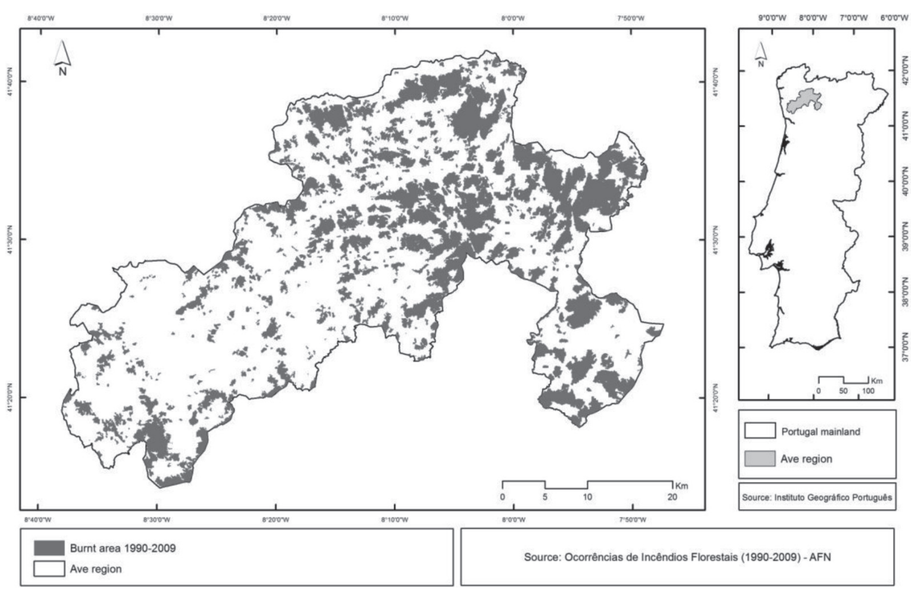

Figure 6
The Ave region: spatial distribution of the burnt areas (1990-2009).

It is also worth noting that in the 19 year period under review, the Ave region displays areas that were repeatedly affected by forest fires (Ferreira-Leite *at al.*, 2011). Some areas in the region registered fires on 8 different occasions during this period (Figure 7). In terms of recurrence of forest fires, this is the maximum value observed nationally when analyzed at a homologous scale and with the same cartographic information.

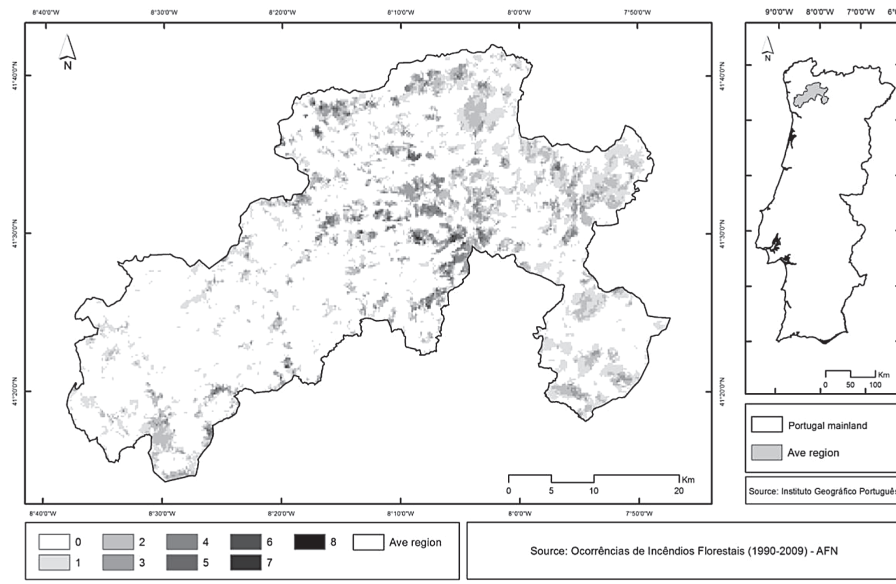

Figure 7
The Ave region: recurrence of forest fires (number of times each place burned, 1990-2009).

3.2 Methodology

The development of predictive scenarios of climate evolution for the Ave region was constructed through the analysis of climatic variables based on regionalization techniques that enabled the projection of the IPCC global models to the regional context. These procedures allow greater accuracy in predicting the specific impacts at the local-regional scale, as well as the implications within the context of climate risks.

In the first stage, an examination of the variability and changes in temperature and precipitation predicted in future climate change scenarios was carried out based on projections of regional climate models. Taking as the starting point the findings of the PRUDENCE project (MeteoGalicia, 2010a), which revealed changes in the projections for the period 2071-2100, two evolution scenarios have been defined: scenarios A2 and B2. These scenarios fall within the typology of evolutionary scenarios defined by the IPCC and take into account the influence of socioeconomic factors on climate change. In a second phase, firmly based upon the scenarios previously defined, a more detailed examination of the Ave region (MeteoGalicia, 2010b), was carried out using data from the meteorological stations in Braga, Pedras Rubras, and Montalegre (Figure 8).

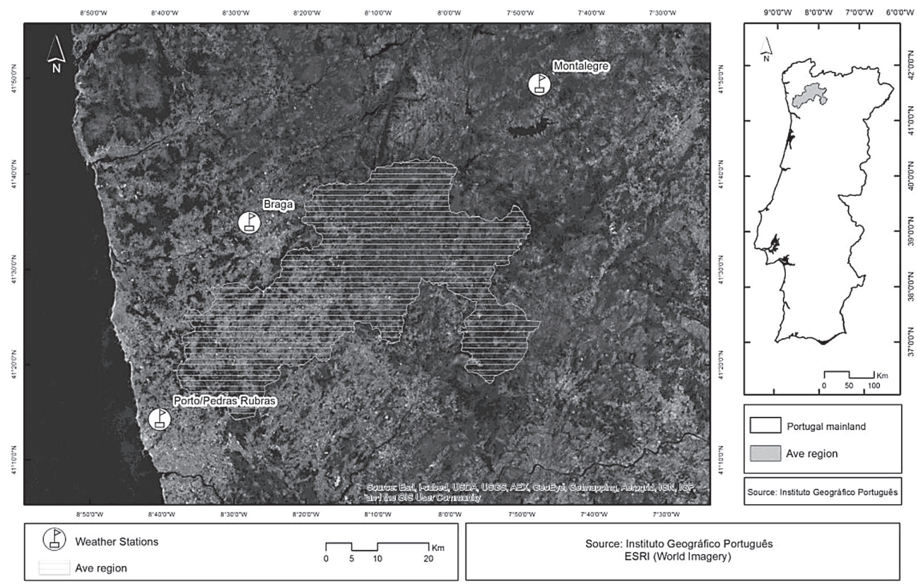

Figure 8
The Ave region: geographic location of the meteorological stations employed.

The variables used in the present study correspond to the series of maximum, average, and minimum temperatures and precipitation.

Using these meteorological stations reveals some problems and raises some methodological issues, which however are not likely to be eliminated. The problems are due to the fact that the stations are all located outside the geographical area of the Ave, putting into question the representativity of the data. However, given the low density of the national network of meteorological stations, these stations are the most reliable for expressing the climatic characteristics of the study area.

Another problem encountered depends on the availability of accurate, complete, and consistent data series. Some of these limitations are related to the changes occurred in the climate registering equipment in all the stations, as well as the change in the location of Braga meteorological station (Table 1). In fact, at different times during the study, the measuring devices available at the stations were upgraded and modernized from manual to automatic systems, with clear implications in terms of the quality of data collected. Moreover, the fact that the upgrades occurred at different times in each station prevents the establishment of correlations between the automated and manual stations.

Accordingly, there is a clear lack of homogeneity in the maximum temperature series registered in Braga, which is not reproduced in terms of average and minimum temperatures.

In addition, problems related with the quality of station data sets were detected, namely: missing data, particularly noticeable regarding precipitation; presence of monthly accumulated precipitation data, when these should be recorded daily; presence of precipitation records with values under 0 liters. For this reason, an extensive data quality control and homogenization process was conducted by MeteoGalicia, the company responsible for processing the data.

Table I
The Ave region: Meteorological stations used for temperature data

Meteorological stations used for temperature data				
List	Station	Initial year	Final year	Station type
1	Braga (Posto Agrário)	1970	2006	Manual
1	Braga (Merelim)	2007	2009	Automatic
2	Montalegre	1970	1999	Manual
2	Montalegre	2000	2009	Automatic
3	Porto/Pedras Rubras	1970	1998	Manual
3	Pedras Rubras	1999	2009	Automatic

Source: MeteoGalicia, 2010b.

4. Results

The analysis based on the PRUDENCE project shows that scenario A2 foresees a major increase in the number of emissions due to the rapid and continued growth of global population and to an economic growth at the regional level, while scenario B2 presupposes a smaller increase in emissions associated with moderate population growth and slower levels of economic and technological development.

The defining process of the AVE scenarios employed series of temperature (maximum, average, and minimum) and precipitation projected for the period 2071-2100. From this data, temperature and precipitation trends were established considering their annual, seasonal, and monthly occurrence, as well as the extreme values.

Therefore, scenario A2 points out that the temperature reveals a positive trend, with a forecast of growth between 1.5°C and 5°C in terms of annual average temperature. These figures indicate an average temperature rise of about 0.56°C per decade for the AVE region in the period 2071-2100. In seasonal terms, positive anomalies between 1.5°C and 8°C are observed, especially in the summer months.

As for precipitation, there is an overall decrease of its occurrence. Seasonally, this reduction is more sensitive in the summer, while registering an increase during the winter months. In accordance with these trends, there is a decrease in the frequency of rainy days, while the number of days of very severe rainfall rises.

Temperature predictions indicate an augment in the number of hot days and nights, translated in scenario A2 in an increase of 100 days per year. Similarly, a slight decrease in the number of days and cold nights is foreseen. For scenario B2, predictions also point to a rise in the average annual temperature between 1.5°C and 4°C, following however a less pronounced trend. The seasonal analysis of temperatures also demonstrates positive anomalies, higher in the summer, but less significant than in scenario A2.

Precipitation forecasts for scenario B2 are similar to those of scenario A2, registering a general annual decline. Seasonally, there is a more significant reduction during the summer, while the winter months record an increase.

Another important dimension is the decrease in the frequency of rainy days and the extension of very intense rainy days, though with levels below scenario A2 for both variables. For extreme temperatures, scenario A2 predicts an increase in the number of hot days and nights (an additional 86 days per year) and a slight decline in the number of cold days and nights, though less pronounced.

Following such analytical procedures, a more detailed study focusing the Ave region was developed. The findings derived from the implementation of regional climate models allow for some conclusions regarding the temperature and precipitation trends.

4.1 Temperature

Through the analysis of the temperature series, the annual, seasonal, and monthly trends for the period of 1970-2009 were identified.

Examining the annual trend, a significant increase in temperature is recorded. For the Braga and Montalegre stations the increase in the maximum, mean, and minimum temperatures is 0.5°C per decade.

Data on the Pedras Rubras station indicates a rise of 0.5°C per decade for the mean and minimum temperatures, but of just 0.2°C per decade for the maximum temperature.

The behavior of the temperature trend is similar in the various stations, whereas such behavior is not homogeneous if the time period filter is applied. In fact, assessing this trend through time, i.e. throughout the reference period for this survey, reveals that the sharp temperature increase dates back just to the mid-1970s.

Regarding the seasonal trend, spring is the season of the year which presents the largest increase in temperature, reaching values of around 0.7°C per decade. This behavior occurs in all the series and temperatures considered, albeit with less intensity.

The monthly temperature trend highlights March as the month with the most significant increase: around 1°C per decade is the increase recorded in the Braga and Montalegre stations, while in Pedras Rubras the numbers are less significant, never exceeding 0.6°C per decade.

Based on daily data of the three temperature series, another relevant aspect concerns the analysis of the extremes[3]. This particular analysis shows a significant decline in the frequency of cold days and cold nights. This trend is more pronounced in the spring and summer and reaches the most significant values in Pedras Rubras during the summer months (a decrease in cold nights of 3.34 nights/decade).

As for the number of hot days, the increase mainly occurs in the spring and summer seasons. This rise is around 1.5 days/decade during the spring (more significant in Braga) and about 2.5 days/decade in the summer (Montalegre and Braga). A rise in the number of hot nights was also identified. In the case of Braga, this increment takes place not only in the spring and summer, but also in the autumn, while in Pedras Rubras it occurs all year long.

[3] For the analysis of temperature extremes, the methodology applied included the calculation of the percentiles p95 and p5 for the maximum and minimum temperatures in each series and for each season. Hot days designate those in which the maximum temperature exceeded the 95 percentile and hot nigths those in which the minimum temperature exceeded the 95 percentile. Similarly, cold days are those in which the maximum temperature was below the 5 percentile and cold nights the ones registering a minimum temperature below the 5 percentile.

4.2 Precipitation

A homologous procedure to the one performed for temperature allowed for the identification of annual, seasonal, and monthly precipitation trends for the period 1970-2009, for the Braga, Montalegre, and Pedras Rubras stations (Table II).

Table II
The Ave region: meteorological stations used for precipitation

Meteorological stations used for precipitation data				
List	Station	Initial year	Final year	Station type
1	Braga (Posto Agrário)	1970	2006	Manual
1	Braga (Merelim)	2007	2009	Automatic
2	Montalegre	1970	2009	Manual
3	Porto/Pedras Rubras	1970	2009	Manual

Source: MeteoGalicia, 2010b.

Concerning the accumulated annual precipitation, no significant trend in any of the three series is observable. As for the seasonal behavior of precipitation, a slight significant positive trend, corresponding to a likely increase of 1.58% per decade, is recorded during the autumn season in Braga. The same pattern occurs in Montalegre where a slight significant positive trend associated to a likely increase of 1.97% per decade emerges in the autumn seasons.

Shifting to a monthly scale, a precipitation decrease in February and an increase in October is forecasted. These results are consistent with those obtained in the study conducted by Cruz *et al.* (2009) on the trends for Galicia, for the period of 1960-2006.

Finally, regarding the rainfall extremes, no detectable annual trend is drawn from the examination of the frequency of rainy days in which certain limits are overcome.

5. Discussion

Once the major trends in terms of climate change for the Ave region were surveyed, the following step consisted in identifying the primary and secondary impacts to the forest (Table III).

As a consequence of the rise of 0.2 to 0.5°C per decade of the maximum, average, and minimum temperatures, an increase in forest fire risk is estimated, as well as an extension of the “fire season”. This new scenario will be characterized by a larger number of occurrences, higher recurrence of fires, and the occurrence of more and larger “big forest fires”.

Conditions for the increase of burnt areas are created with implications that will result in a devaluation of the landscape and a loss of its touristic attraction, as well as increased erosion, changes in land use, loss of biodiversity (spread of invasive non-native species), and decreased productivity.

The expected increase of the average temperature of 0.6°C to 1°C in the month of March, combined with the decrease of precipitation in February, will be reflected in a rise of the forest fire risk during the month of March. Accordingly, a significant increase of the recurrence of forest fires during this month is expected. Consequently, an enlargement of the burnt areas, erosion, and forest-grazing conflicts will take place. The report prepared by MeteoGalicia (2010b) points to an increase of hot days in the spring (1.5 days/decade) and during the summer months (2.5 days/decade), as well as an increase of hot nights in the autumn, which will catalyse conditions favorable to an increase in the number of heatwaves.

Table III
Climate Change and its impacts on the Ave forest

Climate Changes	Primary Impacts	Secondary Impacts
Temperatures Maximum, average, and minimum temp. rise of 0.2 to 0.5°C/decade	- increased risk of forest fires - forest fire season extends over more months - more forest fires - higher recurrence of forest fires - more “large forest fires”	- increase of burnt areas - devaluation of the landscape - loss of touristic attraction - increased erosion - change in land use - loss of biodiversity - decrease in productivity
Average temperature significant increase in the spring March – rises 0.6 to 1°C Precipitation decline in February	- more forest fires in March - higher recurrence of forest fires	- increase of the burnt areas - increased erosion - increased forest-grazing conflicts
Hot days significant increase in Spring and Summer 1.5 days/decade in Spring 2.5 days/decade in Summer	- increase of heatwaves - increased risk of forest fires - more forest fires - higher recurrence of forest fires - more “large forest fires”	- increase of the burnt areas - devaluation of the landscape - loss of touristic attraction - increased erosion - change in land use - loss of biodiversity - decrease in productivity
Hot nights significant increase Braga – in the Autumn Pedras Rubras - in all seasons	- increase of heatwaves - increased risk of forest fires - more forest fires - higher recurrence of forest fires - more “large forest fires” - large forest fires extend over into autumn	- increase of burnt areas - devaluation of the landscape - loss of touristic attraction - increased erosion - change in land use - loss of biodiversity - decrease in productivity
Precipitation nearly significant increase in Autumn Braga – 1.58%/decade Montalegre - 1.97%/decade increase in October	- impoverishment of soils	- change in land use - loss of biodiversity -decrease in productivity

This phenomenon will ultimately entail an increased risk of forest fires, increasing the number of occurrences, higher recurrence of fires, and the occurrence of more and larger “big forest fires”. Within this predictive framework, the autumn will present favorable conditions for the occurrence of “large forest fires”.

These conditions will generate a rise of the burnt areas, which can imply a devaluation of the landscape and the loss of its touristic attraction, increased erosion (with the impoverishment of the soil), and change in land use with loss of biodiversity (spread of invasive non-native species), and decreased productivity.

Finally, a predictable increase in precipitation in the autumn, especially during the month of October, should be noted. This is the season when soils are often unprotected by vegetation as a result of forest fires. This situation can lead to an impoverishment of soil nutrients, involving changes in land use, loss of biodiversity, and decreased productivity.

6. Conclusions

Results obtained throughout the Adaptaclima project are consistent with those presented by several authors, both at the national (Santos et al., 2002) and Iberian level (Gutierrez *et al.*, 2010), which indicate a rise in the annual temperature trend and an increase in hot days and nights. Regarding precipitation, significant trends can only be detectable at the seasonal and monthly level, highlighting a decline in February and an increase in October.

Therefore, we identified the major trends in terms of climate change, as well as the primary and secondary impacts on the forest spaces of the Ave.

In conclusion, the Ave region appears to be territory highly prone to forest fires. This fact, coupled with the expected climate change scenarios might lead to a significant increase in the risk of forest fires and the extension of the fire season, as well as an increase in the size, intensity, and severity of forest fires.

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