Wildfires in the Alpine region: first results from the ALP FFIRS project

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Abstract

Starting in September 2009, the Alpine Space Interreg-project Alp-FFIRS (Alpine Forest Fire waRning System) was launched with the aim of monitoring and reducing forest fire hazard in the Alpine environment through prevention and mitigation actions. In the framework of the project, a harmonised forest fire data base was build making for the first time possible characterizing the forest fire regime in the Alpine region and to highlight the main differences with respect to fires in the Mediterranean area.

For the whole Alpine Space, basic statistics are applied in order to quantify the link between fire frequency and burned area at a global scale. A more detailed analysis has been carried out for some European Alpine regions, depending basically on the amount of features and spatial attributes available. In this way spatial and temporal variability of the Alpine fire regime is identified.

The analysis of the forest fire data confirms the presence of a mixed fire regime with a winter season displaying mostly quick spreading human-induced surface fires at low altitudes with a concentration in March-April and a summer season with a peak of lightning-induced fires in July-August. Annual fire frequency differs from region to region and especially from the northern to the southern slope of the Alps. Nevertheless, a general increase in lightning-induced fires during the mid-summer may be detected. Among fires of known cause, most events and burnt areas may be linked to negligence and premeditated human actions. Depending on the region and the season up to 30% of the fires are induced by lightning, especially on the southern slopes of the Alps.

The main differences in respect to the Mediterranean fire regime are therefore, the existence of a peak in fire frequency and burned areas in spring and a consistent portion of light-induced fires in the high summer season.

Keywords: Forest fires regime, Alpine environment, statistical data

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Introduction

A new awareness among scientists and managers has been rising about the ecological role of fire and the necessity to understand its past natural and cultural dynamics in different ecosystems, in order to preserve present ecosystem functionality and minimize management costs and negative impacts (Fries et al. 1997; Swetnam et al. 1999; Bengtsson et al. 2000; Whitlock and Larsen 2001; Kalabokidis et al. 2002; Bergeron et al. 2002). As a consequence we assisted in the last decades to a general shift from the fire control to the fire management approach (Conedera 2009), where fire prevention, fire danger rating, fire ecology, fire pre-suppression and suppression strategies are fully integrated in the landscape management (Sulli 1993; Leone 1988; Bovio 2001; Castellnou et al. 2002; Velez & Merida 2002; Neff et al. 2004). In this respect the Alpine region do not represent an exception although research on forest fire management has been initiated quite recently as for example in Switzerland (Berli 1996; Conedera et al. 1996; Gimmi et al. 2004; Weibel et al. 2009), France (Gatheron 1950), Italy (Tiller 1988; Bovio 1996), Germany (Goldammer et al. 1997) and Austria (Gossow et al. 2009; Vacik et al. 2011). Nevertheless, transnational fire investigations are still lacking in this region and an overall picture of the fire regime in the Alps is still to be performed. Following this need, the Alpine Space project Alp-FFIRS (Alpine Forest Fire waRning System, http://www.alpffirs.eu) was launched in September 2009 with the aim of monitoring and reducing forest fire hazard in the Alpine environment by setting a shared fire danger warning system (Valese et al. 2010). In the framework of the project, it is for the first time possible to share forest fire data among countries and regions of the Alpine Space what allows characterizing the forest fire regime in the Alpine region intended as number of fires, burnt area, fire seasonality and main ignition sources (anthropogenic vs. natural) in the last decade.

At present time, an overall characterization of wildfires in the Alpine region is not available, probably due to the higher impact of other forest disturbances, mostly related with storms, debris flows and infestations. This paper aims at filling this gap by providing a first comprehensive picture of the region, helpful for comparisons at global scale, as for a better understanding of wildfires impact during the last decade, to be employed for future scenarios hypothesis as for reducing fire hazard.

Study area

The Alpine Space as defined in the frame of the Alpine Space Programme under INTERREG IIIB covers the entire mountainous area of the Western, Eastern, Northern and Southern Alps, including the surrounding foothills and lowlands, as well as a small part of the Mediterranean coastal area including the Adriatic and parts of the great river valleys of Danube, Po, Adige, Rhône and Rhine (Figure 1A). In the study area the anthropogenic influence on the wildfire regime is very relevant both in terms of fuel composition and distribution (land use changes and rural abandonment especially) and ignition sources (tourism-related activities, social conflicts).

The key factors of fire propagation (weather, fuel and terrain) are extremely uneven in the Alpine region. The geography of the Alpine region, crossroads between the Mediterranean, the Atlantic and the Eurasian zone, affects landscape structure and forest composition, leading to a tremendous unevenness of both ecological and demographic issues. Two important gradients determine local climate, associated to the distance from the sea and to altitude levels. The analysis carried out by ZAMG (Central Institute for Meteorology and Geodynamics of Vienna) well draw this differentiation inside the so-called Greater Alpine Region GAR (Figure 1B). Longest GAR temperature and air pressure series extend back to 1760, precipitation to 1800, cloudiness until the 1840s and sunshine into the 1880s (Ingeborg et al. 2007). Two important sectors can be defined in this frame: the Northern sector, where most of Germany, Austria and Switzerland territories lies; the Southern sector, including Italy, France, Slovenia, part of Austria (Carinthia) and part of Switzerland (Canton Ticino and minor parts of the Cantons Valais and Grisons). The southern sector is warmer and more affected by drying fall winds. An additional differentiation regards eastern and western areas, but it is not so clear-cut. In this sense, Slovenia, Friuli Venezia Giulia and Veneto can be isolated as the regions more influenced by proximity to the Adriatic sea, while, on the western side, France is much affected by Mediterranean shades. In general, climatic diagrams show a concentration of rainfall during summer and autumn (Figure 2). In the northern Alpine region the precipitation series show a distinct maximum during the warm season, whereas in the Mediterranean the autumn amounts exceed those of the summer season. On the other hand, a great number of vegetation types result from the combination of climate and topography, going from pseudo-Mediterranean and Mediterranean forests (nearby seas and lakes) to boreal-like conifer stands (for example in Austria). Furthermore, there is a marked difference associated to aspect between southern and northern slopes: in the same valley, Scot Pine stands or grasslands generally cover the southern xeric slope while Norway Spruce or broadleaves stands are placed on the northern mesic side.

The time window we are going to analyse is certainly very short (one decade) and we are able to capture only a recent fragment of fire history in the Alpine region. Fortunately, the studies carried out by the University of Bern in collaboration with the Swiss Federal Research Institute enable a valuable, even if partial, look at the millenary fire regime in the Alps, starting from the last post-glacial age. In particular, the pollen-charcoal particles of lake sediments profiles (Origlio lake and Muzzano lake, southern Switzerland) have been analysed.

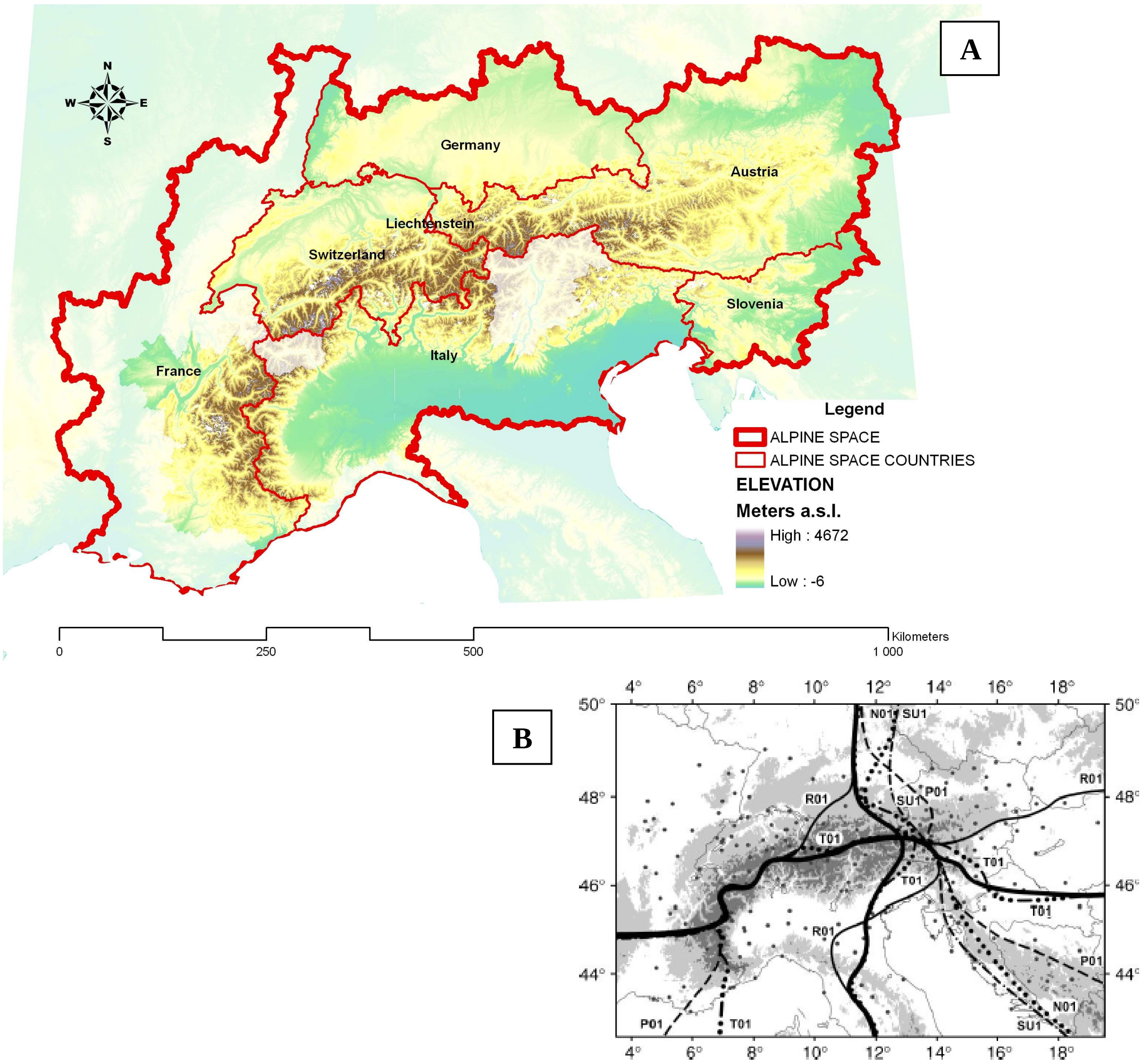


Figure 1— A) The Alpine Space geography and the Alp-FFIRS domain (non-participating regions are displayed in transparency). B) Leading horizontal climatological subregions of the GAR, based on monthly anomalies for air pressure, P01; air temperature, T01; precipitation, R01; sunshine, SU1; cloudiness, N01. Bold lines: the coarse resolution compromise allowing for intra-elemental comparisons based on equal subregions for each climate element. Source: Ingeborg et al. 2007.

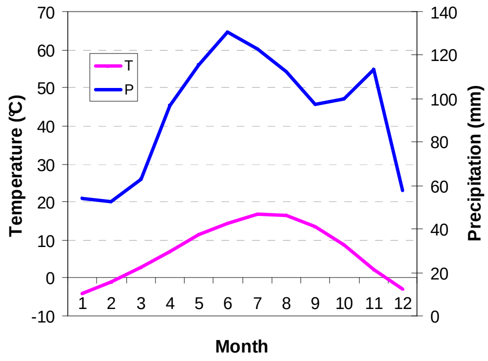


Figure 2—An example of alpine climatic diagram: weather station of Auronzo, Dolomites (Italy), 864 m a.s.l. (average values for the period 1961-1990).

The level of the charcoal influx rose suddenly around 8300 BP cal. during a continental temperate climate phase. At this stage, the major role was still exerted by natural fires (Tinner et al. 1999; Conedera and Tinner 2000a) and a low intensity fire regime was prevailing. Starting from 5500 BP cal., with the transition to the Neolithic, fire frequency increased due to human action. During late Bronze and Iron Ages (800-15 BP cal.) the absolute highest charcoal levels in the fire history of Canton Ticino were reached, due to slash and burn practices for opening agricultural and grazing lands. Charcoal values dropped from 0 to 100 AD in coincidence with the introduction of chestnut cultivation by the Romans (Tinner and Conedera 1995, Conedera et al. 2004). Afterwards, fire regimes have been dominated by social, legal and commercial factors that can be only partially generalized to the rest of study area. From the Middle Age to the modern times intensive land management and reduced use of fire occurred (Conedera and Tinner 2000b). Other proxies document the illicit use of fire to clear pasture land and eliminate trees and brushwood from beginning of the 19th century, consequently to the need for timber to feed Lombardy's industry. This trend lasted till the second half of the 19^{th} century. In the last 100 years an increase of anthropogenic fire frequency occurred in the late 1950s, due to the rapid socio-economic development after the Second World War as to the general abandonment of rural and forest activities, while the decrease of fire frequency and burnt area (from 1980–1990) are much likely the result of fire prevention and fire fighting organization improvement. This short journey inside charcoals shows how actual fuel types, as well as actual fire regimes, depend essentially on human action exerted for centuries on land management, and are then susceptible to change quickly. On the other hand a component of this regime has been determined by lightning-induced fires. Monitoring the complex interactions and weight of both natural and anthropogenic components of fire regime is crucial, since demographic pressure is not going to diminish and a temperature increase has been detected in the Alps (Böhm et al. 2001), so that future developments are difficult to assess.

The harmonised Alpine Fire dataset

The harmonized Alpine fire dataset is one the first outputs of the Alp-FFIRS project. It covers the countries of the Alpine Space participating to the project, with the exception of some regions of the northern sector, as shown in Table 1 and Table 2. Collecting fire-related data is challenging for the following reasons: 1) some authorities are still adding fire data from archives; 2) the information available about forest fires is patchy and expressed in different languages; 3) there are different national or regional definitions of "wildland fire" and "forest"; 4) there are different minimum thresholds of burnt area and "fire ignition" definitions. These limits need time to be overcome and will be part of next Alp-FFIRS phase. A synergy with Manfred (http://www.manfredproject.eu/) Alpine Space project is likely to be found for realizing this objective.

Table 1—*Number of fires and burnt area in the Alp-FFIRS domain by regions and sectors during the period 2000-2009* .

Region (sector)	Number of fires and frequency		Burnt area (ha) and frequency	
Burgenland (NE)	10	0.12%	26.4	0.04%
Carinthia (SE)	14	0.18%	50.95	0.07%
Lower Austria (NE)	68	0.89%	127.7	0.19%
Upper Austria (NE)	12	0.16%	6.725	0.01%
Salzburg (NE)	11	0.14%	16.67	0.02%
Styria (NE)	16	0.21%	30.4	0.04%
Tyrol (NE)	18	0.24%	58.65	0.09%
Vorarlberg (NE)	5	0.07%	4.5	0.01%
Austria	***154***	***2.01%***	***321.995***	***0.47%***
Alpes de Haute Provence (SW)	307	4.02%	6015.061	8.74%
Alpes Maritimes (SW)	429	5.61%	5525.827	8.03%
Hautes Alpes (SW)	52	0.68%	540.354	0.78%
Isere (SW)	15	0.20%	29.57	0.04%
Savoie (SW)	4	0.05%	59.15	0.09%
France	***807***	***10.55%***	***12169.96***	***17.68%***
Mittelfranken (NW)	28	0.37%	20.6	0.03%
Niederbayen (NW)	7	0.09%	33.8	0.05%
Oberbayern (NW)	13	0.17%	14.43	0.02%
Oberfranken (NW)	7	0.09%	3.51	0.01%
Oberpfalz (NW)	4	0.05%	2.101	0.00%
Schwaben (NW)	6	0.08%	3.57	0.01%
Unterfranken (NW)	4	0.05%	4.75	0.01%
Germany	***69***	***0.90%***	***82.761***	***0.12%***
Fruili Venezia Guilia (SE)	728	9.52%	4677.586	6.80%
Lombardia (SW)	2081	27.22%	17319.69	25.16%
Piemonte (SW)	2435	31.85%	25148.31	36.53%
Veneto (SE)	476	6.23%	2250.328	3.27%
Italy	***5720***	***74.81%***	***49395.91***	***71.76%***
Slovenia (SE)	***705***	***9.22%***	***5004.62***	***7.27%***
Canton Ticino (SW)	170	2.22%	1494.56	2.17%
Canton Valais (SW – NW)	21	0.27%	365.37	0.53%
Switzerland	***191***	***2.50%***	***1859.93***	***2.70%***
Alp-FFIRS domain	***7646***	***100.00%***	***68835.18***	***100.00%***

Table 2—*Fires frequency and burnt area in the alpine climatic sectors during the period 2000-2009.*

Sector	Country (Region)	Number of fires	Freq (%)	Burnt area (ha)	Freq (%)
NE	Austria,	154	2.01	321.99	0.47
NW	Germany	69	0.90	82.76	0.12
Northern		223	2.91	404.75	0.59
SE	Slovenia, Italy (Friuli V.G., Veneto)	1909	24.97	11932.53	17.33
SW	Francia, Italy (Piemonte, Lombardia)	5323	69.62	54637.95	79.38
Southern		7232	94.59	66570.49	96.71
SW-NW	Switzerland (Canton Ticino and Valais)	191	2.50	1859.93	2.70
Total		7646	100.00	68835.17	100.00

The dataset consists of a ten years historical series (2000-2009) of fire frequencies and burnt area on a daily basis. Other interesting information, such as fire cause and localization are only partially available. In order to harmonize the dataset, we have set the minimum threshold of burnt area equal to 0.1 hectares, passing from more than 11000 to 7646 of the original records. This choice has been necessary since the range of recorded smallest fires was very different between countries, suggesting a different way of including fire events.

Considering the limits, we do not expect to provide a full and comprehensive result, but provide a first insight on the Alpine fires order of magnitude along the last decade. Form a first look, it shows up that the highest frequency of so far recorded fires occurred in Italy (74,81% of the records and 71,76% of the total burnt area), France (respectively 10,55% and 17,68%) and Slovenia (9,22% and 7,27%). This territory is placed in the southern sector and covers about 42% of the Alp-FFIRS domain. As regards Switzerland, only Canton Ticino and Canton Valais have been analyzed. As they represent the most fire prone districts of Switzerland, they have been chosen for the analysis. Both districts lie in the Southern sector (Canton Ticino and the smallest part of Canton Valais) and in the Northern sector (the largest part of Canton Valais) and correspond to 2,5% of fires: a relevant rate if we consider that they cover only 2,7% of the Alp-FFIRS domain. On the contrary, wildfires are much less in number in those countries lying on the northern sector (Austria, Germany and the rest of Switzerland), where only 12% of the recorded fires occur (8% of the total burnt area). Furthermore, it is important to underline that Germany and Austria fire datasets are still being completed and additional records might be included in the future.

Wildfires characterization

A simple characterization of wildfires is described in the next sections. We will try to answer some basic questions: 1) what is the description of fire frequency and burnt area along the last ten years? 2) considering fire frequency and the average/maximum size of the Alpine fires, what is the difference respect to other climatic areas? 3) what is the difference between climatic sectors in terms of large fires definition? 4) what about seasonality in the northern versus southern sector? 5) what is the weight of natural fires when we make local widenings on fire origin?

Fire frequency and burnt area (2000-2009)

During the period 2000-2009, the Alpine region has been affected by an average of 765 fires and 6890 ha per year. As shown in Figure 3, fire frequency and burnt area decreased after 2003, considered the worst year of the decade, with the exception of 2007, when fire severity was influenced by fuel accumulation deriving from storm damages (for example in Austria).

The total burnt area (68835 ha) has been classified by ten size classes (Fig. 4-5) in order to get a clue about fire intensity during each year, under the hypothesis that burnt area is a proxy of fire intensity. Fires larger than 1000 ha occurred only during the summer 2003 in France, where the maximum value was reached (2013 ha), in Slovenia and in Italy. During 2004 and 2009 fires larger than 250 ha have not been represented at all. The frequency of large fires decreased from 2000 to 2009. There is a wide difference between climatic sectors: in the northern countries (Germany and Austria) fires larger than 50 ha did not occur during last decade, while, in the southern sector fire size is on another order of magnitude. The countries can be ordered by decreasing fire size as follows: France, Italy, Slovenia, Switzerland (Canton Ticino and Valais), Austria, Germany.

However, it needs to be stated that the number of forest fires throughout the years needs to be looked at carefully since the number of forest fires recorded varies throughout the years. Years where only a very low number of forest fires have been recorded, should be seen critical and the results should not be overestimated. As the data sources for the development of the forest fire database are quite heterogeneous with a wide range in data quality and quantity it can be hypothesized that the total number of forest fires might change in relation to the invested time for studying the archives and building up the database.

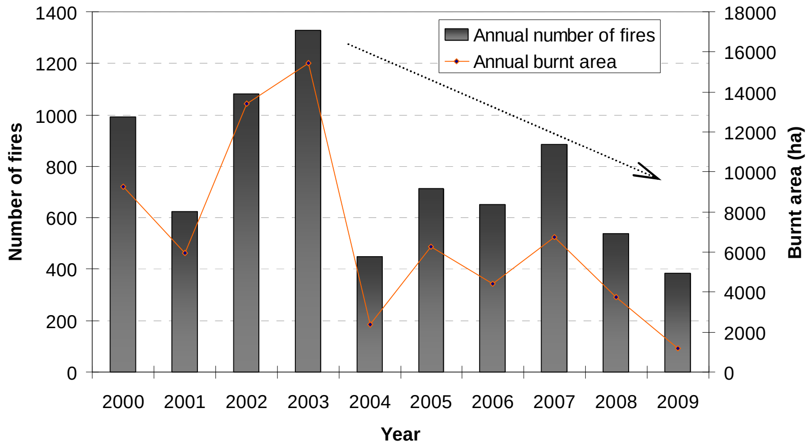


Figure 3—Annual number of fires and annual burnt area during the period 2000-2009.

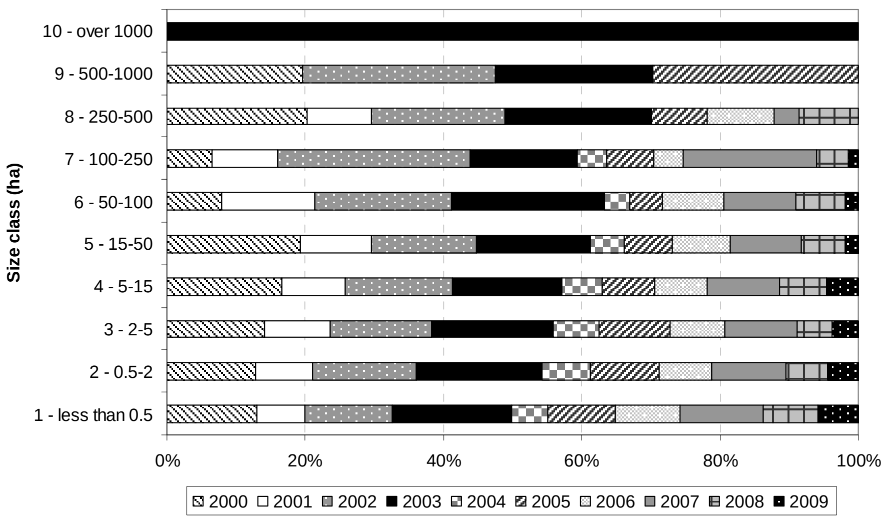
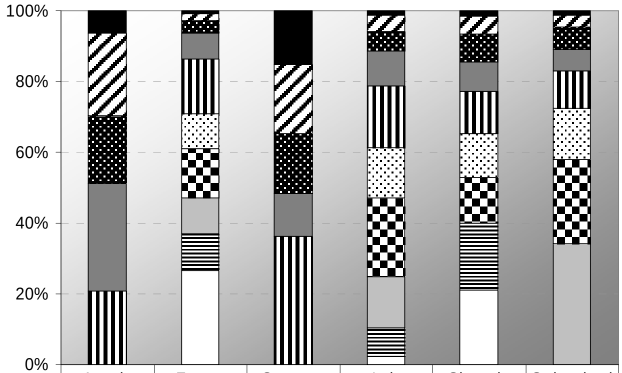


Figure 4—Percentage of burnt area by size class and year during 2000-2009.



	Austria	France	Germany	Italy	Slovenia	Switzerland
1 - less than 0.5 ha	20.375	79.9553	12.541	569.14103	80.28	24.47
2 - 0.5-2 ha	74.62	269.7143	16.22	2262.4465	253.68	62.51
3 - 2-5 ha	62	409.7616	14	2741.0666	391.85	117.51
4 - 5-15 ha	98	909.2963	10	4918.4196	417.18	110.49
5 - 15-50 ha	67	1872.6517	30	8621.5606	596.81	196.45
6 - 50-100 ha	0	1217.503	0	7001.9912	615.75	271.5
7 - 100-250 ha	0	1687.5	0	10976.46	650.5	442
8 - 250-500 ha	0	1220.15	0	7124.6258	0	635
9 - 500-1000 ha	0	1265	0	4104.2	950	0
10 - over 1000 ha	0	3238.43	0	1076	1048.57	0

Figure 5—Percentage of burnt area by size class and country during 2000-2009. For Switzerland only Canton Ticino and Valais have been considered.

Average fire size

In Table 3 basic statistics (mean values, range of variation, standard deviation) are shown for the whole Alpine region as for the countries. Alpine wildfires are characterized by an average value of 9 ha, with a peak of 15 ha in the southern sector (France) and a minimum mean value of 1.2 ha in the northern sector (Germany).

Differently from the Alpine region, where vegetation is generally considered sensitive to fire, other environments are shaped by nature for resisting to fire or even need fire for regeneration. These regions include the humid grasslands and savannas of South America and Africa, the prairies of North America, the Asiatic savannas, the Mediterranean shrublands and the boreal forests (Conedera 2009). In Table 4 a comparison is set between the Alpine region and three fire adapted environments: the boreal forest (Alberta, Canada), the Rocky Mountains forest (British Columbia, Canada) and the Mediterranean forest (Spain). We have chosen to compare these environments with the Alpine one because they are closer to some vegetation types we find in the Alps: in Austria a large part of conifer stands have characteristics in common with the boreal forest; in France and in the Karst Plateau of Slovenia and Friuli Venezia Giulia (eastern sector) many Mediterranean species are present. Fire statistics for Canada and Spain have been derived by the corresponding national statistics (http://nfdp.ccfm.org/fires/national_e.php, http://www.fire.uni-freiburg.de/inventory/stat/es/fire_stat_es.htm) published on the Global Fire Monitoring Center website (http://www.fire.uni-freiburg.de/inventory/database/statistic.html). The average size of a fire has been calculated respect to the total national area. In Canada (British Columbia and Alberta provinces) this value is quite high (respectively 45 and 86 ha) respect to the other countries, and might be interpreted as a large fires dominated regime. In fact, although Canadian surveillance system is extremely rigorous, time for reaching a fire can be higher than in other countries. What's more, all fires occurring in wilderness are natural and are left burning. This choice, also justified by the need of fire for regeneration, is not feasible in the Alps, where concentration of people is tremendously high (most of fires are human-caused) and fire is still perceived as a natural disaster. As regards Spain, the value of average fire size is even lower than the alpine one: a surprising result. On the other hand the impact of area burnt in the 2000-2009 decade on the Spanish territory is the highest: 0.4 fires occurred per squared kilometre and 2.46% of the national land has been threatened by fire. These values are very high respect to the Alpine region, probably due to the environment susceptibility to fire (flammable species, extreme weather conditions). Actually, in Spain the number of fires larger than 500 ha, recorded in ten years, is equal to 302 records, while in the Alpine region a number of just 13 record is reached. This difference is not explained by the larger national area of Spain, that is only twice the area analysed in the Alp-FFIRS domain.

Table 3—*Basic fire statistics for the Alp-FFIRS countries: number of fires (N), total area burnt (Area), mean values (Mean), standard deviation (SD) and maximum values of fire size (Max).*

Area	N	Area (ha)	Mean (ha)	SD	Max
Austria	154	321.99	2.09	3.55	24.85
France	807	12169.96	15.08	94.07	2013
Germany	69	82.76	1.19	3.78	29.88
Italy	5720	49395.96	8.63	38.97	1076
Slovenia	705	5004.62	7.09	54.87	1048
Switzerland (TI and VS)	191	1859.93	9.73	38.11	324.88
Alp-FFIRS domain	**7646**	**68835.23**	**9.00**	**48.87**	**2013.00**

Table 4—*Comparison between the Alp-FFIRS countries and British Columbia, Alberta, Spain by national area, number of fires (N), area burnt during the period 2000-2009, ratio between burnt area and national area, mean number of fires per squared kilometer and average size of fires.*

Country	National area (km^2)	N	Burnt area (km^2)	Area burnt over national area in ten years (%)	Mean number of fires per km^2 (in ten years)	Average size of fires (ha)
Austria (N)	84311	154	3	0.00	0.00	2,1
Germany (N)	46063	69	1	0.00	0.00	1,2
France (S)	31153	807	122	0.39	0.03	15,1
Italy (S)	75074	5720	494	0.66	0.08	8,6
Slovenia (S)	20314	705	50	0.25	0.03	7,1
Switzerland (TI and VS) (S)	8038	191	19	0.23	0.02	9,7
Alp-FFIRS domain	**264953**	**7646**	**688**	**0.26**	**0.03**	**9,0**
British Columbia	944735	21639	9861	1.04	0.02	45,5
Alberta	661848	15611	13486	2.04	0.02	86,4
Spagna	504030	201683	12409	2.46	0.40	6,1

Large fires classification

The definition of large fire, used in forest fire data gathering, is different for each country joining the Alpine sector. The definition could vary also from one region to another (e.g. Italy) depending on the aim or the institutions involved. To overcome this problem, *a priori* threshold corresponding to the 95th percentile was selected in order to harmonize the data and analyze the phenomenon.

At “ALP FFIRS countries” level, the threshold value corresponds to 31 ha (Table 5). Although forest fires that burned over more than 31 ha represent only 5% of the total events occurred during the period 2000-2009, they accounted for the 75% of the total burned area (Figure 6). This fact highlight the importance of this issue.

Results showed also remarkable differences between countries. Switzerland showed the highest value (47.5 ha) followed by France and Italy (42 and 33 ha respectively). The lowest values were recorded for Austria (5 ha) and Germany (2 ha) where, with respect to the regions involved in this study, no fires higher than 30 ha occurred in the analyzed period.

The threshold value seems to follow a different geographical trend where regions located in the southern side of the Alps show higher values with respect to the northern ones. This fact is clearly associated to the different meteorological, topographical, social characteristics of the considered areas. Wind effects or scarce precipitation during spring or summer seasons may influence fuel moisture content much more in the South of the Alps than in the North. Nevertheless, these findings point to the need for a more in-depth analysis on the diverse issues based on a geographically-based approach. Forest fire prevision, prevention and fighting organization play also an important role in preventing that a small fire becomes a large fire. In this sense the Alp-FFIRS project aims at creating a network reflecting common policies on forest fire, harmonizing mitigation and management procedures.

Table 5—*Large fire and other quantiles threshold values for the Alp-FFIRS countries. For Switzerland only Canton Ticino and Valais have been considered.*

	Burnt area (ha)						
Quantile	**Alp-FFIRS countries**	**Austria**	**France**	**Germany**	**Italy**	**Slovenia**	**Switzerland**
100% Max	2013	25	2013	30	1076	1048.57	325
99%	154.69	25	240	30	155.24	81.75	310
95%	**30.68**	**8**	**42**	**3.5**	**33.035**	**17.15**	**47.5**
90%	12	5	19.9	2	12	6.5	12
75% Q3	3.25	2	5.7	0.75	3.2	2.6	3.2
50% Median	1.00	1	1.5	0.35	1	0.95	0.9
25% Q1	0.40	0.50	0.5	0.2	0.4	0.32	0.3
10%	0.20	0.20	0.2	0.15	0.2	0.2	0.2
5%	0.15	0.20	0.15	0.15	0.15	0.15	0.15
1%	0.12	0.15	0.15	0.12	0.12	0.12	0.12
0% Min	0.10	0.15	0.12	0.12	0.1	0.11	0.12

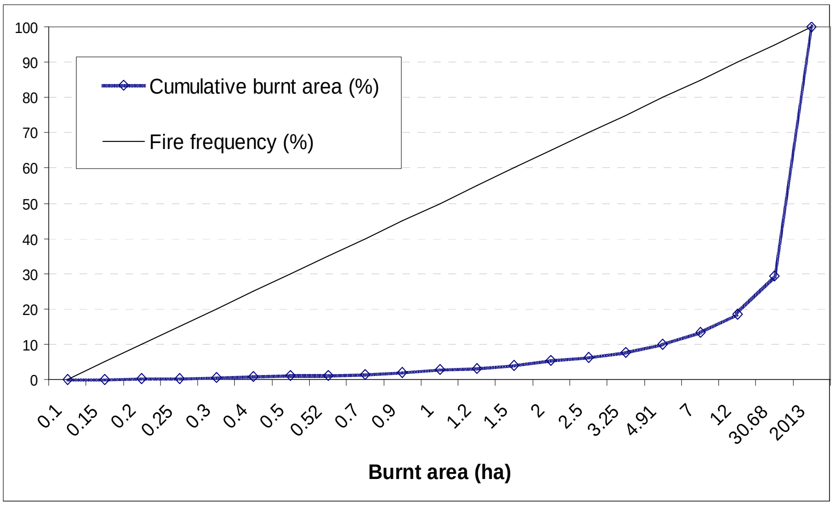


Figure 6—Cumulative burnt area and fire frequency for the definition of large fires.

Seasonality and origin: winter and summer fires, nature and man

Another important factor affecting fire size is the season (winter versus summer) when fires occur. In the Alpine region, the higher percentage of burnt area is generated during winter (from November to April), mainly by those fires classified as small or mean (Figure 7). On the contrary, fires larger than 1000 ha just occur in summer (from May to October), when temperatures are higher. Nevertheless, in France and in Slovenia the percentage of burnt area is much higher in summer (almost 70%), probably due to the Mediterranean climatic component (Figure 8), resulting in dry conditions, and to the Karsic substratum, characterized by a low capacity of water storage. In Austria the percentage of area burnt in summer is also relevant (about 45%). In fact (Figure 8), the fire season is concentrated during late spring and summer, quite differently from the rest of the studied area, where two peak are evident: the first during winter (from January to April) with a maximum value of 27% in March; the second during summer (July and August) with lower values (less than 10% per month). In the winter season mainly surface and fine fuels-driven fires have been observed in the Alpine region, especially under 1000 m a.s.l., while underground and crown fires are more likely to occur in summer, in reaction to long lasting, and exceptional, drought periods (as in summer 2003).

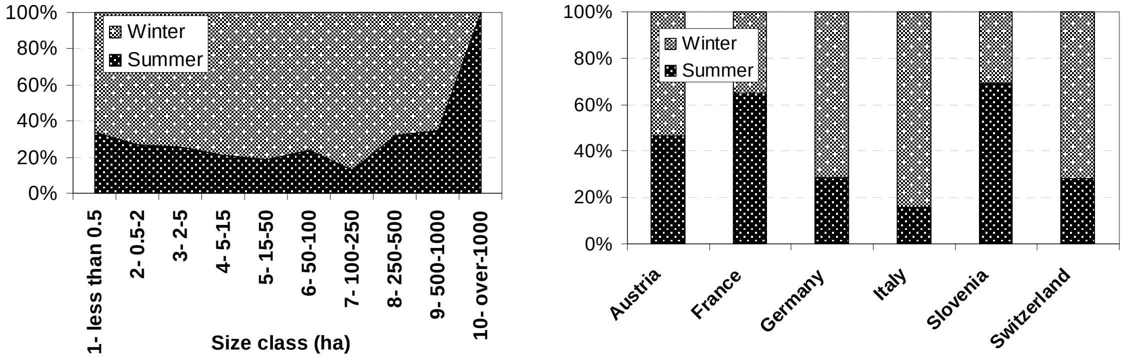


Figure 7—Percentage of burnt area by season and fire size (on the left); percentage of burnt area by season and country (on the right).

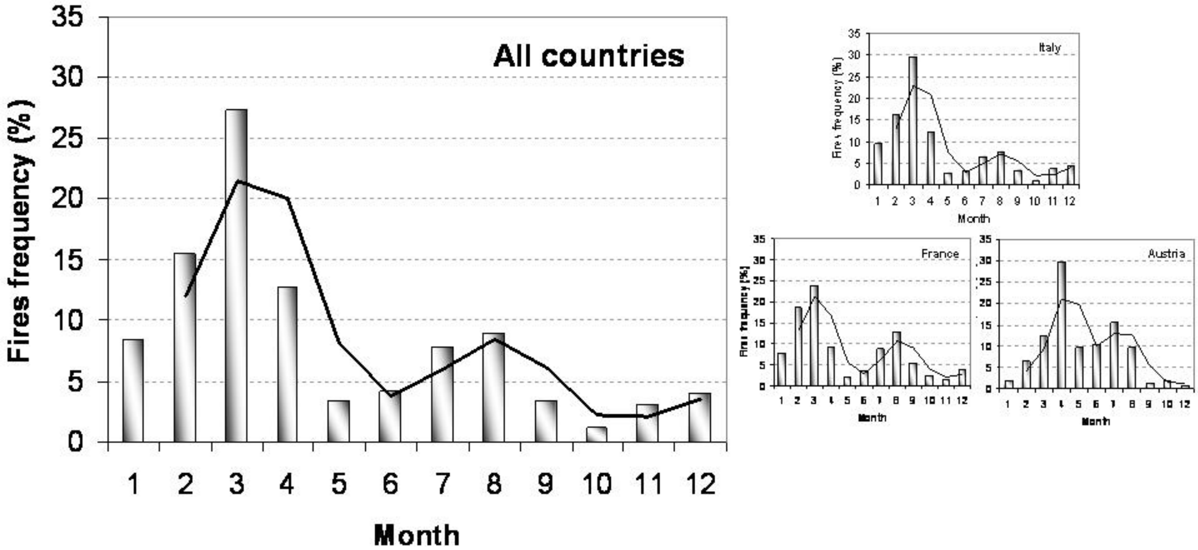


Figure 8—Fire frequency by month for all Alp-FFIRS countries (on the left) and examples of monthly fire frequence for some of them: Italy, Austria and France.

The origin of fire is shown in Figure 9 as local zoom in three neighboring regions: Lombardia (Italy), Canton Ticino and Canton Valais (Switzerland), Austria. Most of the human-induced fires occur between March and April, corresponding to the higher peak in Figure 8. As regards lightning-induced events, there is a marked difference between Lombardy, where the number of natural fires is very low (or even non-significant) and the other regions. In Switzerland and Austria natural fires are concentrated during summer (from June to August), with a minor percentage in May and April, and a major occurrence in July – August. In Canton Ticino and Valais up to 30% of the fires are induced by lightning. Natural fires has been observed at high altitudes, where lightning induce underground and long-lasting fires.

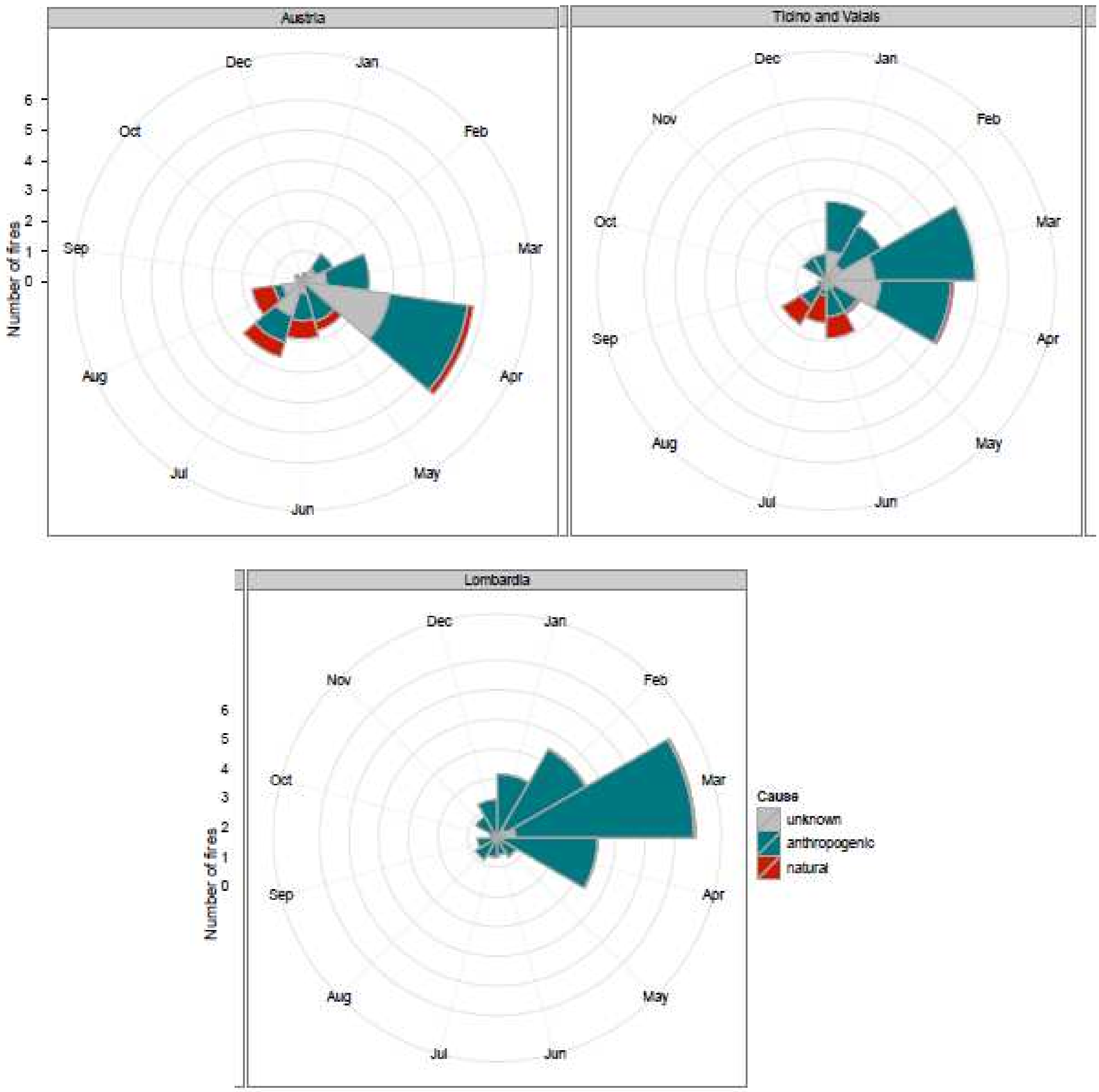


Figure 9—Number of fires by origin (unknown, anthropogenic, natural) and month in Austria (top left), Lombardia (bottom) and Switzerland (Canton Ticino and Canton Valais) (top right).

Conclusions

The analysis of the forest fire data confirms the presence of a mixed fire regime with a winter season displaying mostly quick spreading human-induced surface fires at low altitudes with a concentration in March-April and a summer season with a peak of lightning-induced fires in July-August. Annual fire frequency differs from region to region and especially from the northern to the southern slope of the Alps. Nevertheless, a general increase in lightning-induced fires during the mid-summer may be detected. Among fires of known cause, most events and burnt areas may be linked to negligence and premeditated human actions. Depending on the region and the season up to 30% of the fires are induced by lightning, especially on the southern slopes of the Alps.

The main differences in respect to the Mediterranean fire regime are, therefore, the existence of a peak in fire frequency and burned areas in spring and a consistent portion of lightning-induced fires in the high summer season, especially at high altitudes. The size of fires is much lower with respect to boreal and Mediterranean fires, where fire prone ecosystems are more extended and continuous.

Through basic statistics the first picture of wildfires in the Alpine region has been drawn. Without doubts, this preliminary characterization shall be enhanced by improving the dataset. Some areas not participating to Alp-FFIRS are missing; it is worth to include them by finding a synergy with other projects of the Alpine Space. Essential parameters such as the severity related to fire danger weather indices and to the pyric potential of fuel types shall be included as well. It is also wished to set a permanent platform for monitoring the fire trend after the end of Alp-FFIRS. This vision is likely to be part of the recently born Euro-Alpine Sub-Regional Network activities.

Acknowledgements

For problems of space not all the ALP FFIRS participants have been listed as authors. Our acknowledgement is to all of them, partners, observers and local partners, as well as to the Alpine Space II programme, funding the largest part of the project.

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