Forest Fires and Wildland-Urban Interface in Spain: Types and Risk Distribution

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Abstract

This paper presents the main results and conclusions of a two-year study funded by the Spanish Ministry of Environment, Directorate General for Biodiversity, for the identification, characterisation and mapping of wildland-urban interface patterns in Spain, and their associated risk distribution in each province due to forest fires. The methodology applied is based in the results of the WARM project, funded by the European Commission from 2001 to 2004, for which this group was co-ordinator. The results are presented in the form of a catalogue of 17 representative wildland-urban interface situations, with the associated risks according to their vulnerability, an atlas showing their distribution in Spain and a guide for the elaboration of prevention and emergency plans according to the described vulnerability criteria. These results are of direct application in or country, but also are a good baseline for its application in other countries in the Mediterranean Basin. The results also contrast with the hypothesis followed in USA, Australia and Canada, which mainly point to the sustained burning of houses, while in Spain the houses rarely burn from outside and that may even be considered as fire shelters in extreme entrapment situations. Some practical examples are also presented.

Introduction

In the last 10 years, Spain has experienced a noticeable increment in the territorial development in areas touching or mixing with forested lands and, at the same time, a change in the use and occupation of rural houses. These changes have entailed a real challenge for the management of forest fires. However, this development has been unequal in the different Autonomies of Spain and in some cases is dramatically different among provinces. A number of factors, such as geomorphology, vegetation, urban areas aggregation, tourism patterns and people movement, have entailed a differential distribution of a number of Wildland-Urban Interface (W-UI) situations or typologies, each one with an associated level of risk.

Objective

This paper presents the methods and results of a two-year study funded by the Spanish Ministry of Environment, Directorate General for Biodiversity, for the preliminary identification, characterization and mapping of W-UI patterns in Spain, and their associated risk distribution in each province due to forest fires.

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Background

The methodology followed and presented in this paper is based on the previous experience acquired in other Mediterranean countries affected by fires, and also on the specific research programs funded by the European Commission under the Research Framework Programmes. In particular, the research projects SPREAD, FIRESTAR and more specifically WARM (Caballero, 2004), have rendered approaches, findings, methods and conclusions that are precursors of the present work.

The general objective of WARM project (Wildland-urban Area fire Risk Management[2]) is to characterize direct and indirect risks associated to forest fires affecting the W-UI in Europe. Second, to provide a methodology and an information system to assess in the minimization of losses and impacts in houses, socio-economy and environment. Six European countries participated in this project providing study cases out of which identify commonalities and differences among them and with same situations in other countries, such as USA.

Methodology

Classification criteria

To develop the present work, two scales of criteria have been considered: the individual house scenario and the W-UI scenario.

While traditionally in the publications the concept of W-UI has been associated frequently to the specific situation of vegetation, topography and building type of individual houses (the first mentioned scale), this concept has been extended here to the idea that implies different groups of houses which are sitting in areas with common potential conditions of forest fire propagation and exposure to such danger.

For the identification of the different situations of W-UI, and its associated level of risk in Spain, a number of aspects have been considered, namely:

- The potential progress of the fire in the vicinity, in the border and inside the settlement
- The existing options for fire defense and civil protection operations
- The exposure of houses to the potential fire within the interface
- The level of vulnerability of houses

The potential progress of the fire depends in a large extent of the structure and typology of forest fuel, but also the ornamental vegetation, the accumulation of vegetal remainings, such as those resulting from the gardening and other maintenance operations, the accumulation of wood for fireplaces and the presence of fuel tanks and other flammable substances. Also, the slope and special topographic situations, such as shafts, saddles and canyons, have been considered.

The options for the fire defense operations and civil protection are directly and strongly affected by the accessibility, that is, the road and street network and the

[2] Contract no. EVG1-CT-2001-00044

escape and mobility opportunities. Also by the existing infrastructure for defense, such as hydrants network, water take points, the presence of safe and defensible areas, the presence and adequacy of signals and, lastly, the presence of buildings or other structures that can serve as refuges in case of entrapment.

The estimation of the exposure to the potential fire is obtained according to the clustering of houses and the pattern formed with the existing vegetation, computing the *specific interface length index* (Caballero & Beltran, 2003) which measures the accumulated length of houses façades exposed to vegetation or other sources of heat in relationship of the total developed area. This index provides a comparison value of the potential number of houses that could be visited by fire at the distance of flame contact, radiation or flying embers. This exposure has also been considered for the escape routes, in the estimation of successful and safe evacuation operations.

Estimation of vulnerability of houses, that is, the calculation of the potential damage when exposed to a certain level of danger, focuses on the factors that entails the survival, partial affection or destruction of a house. This is characterized trough the study of the individual house situation.

Vulnerability of house situations

Vulnerability of houses is understood as the unwanted effects of fire in the buildings, that is, the degree of destruction expected when exposed to a certain level of danger (fire). Each typified house situation is studied in detail, according to the criteria given below:

- Potential sources of heat and distances to the building elements
- Elements suitable to be affected or destroyed, or that allow the entrance of fire
- Elements of active or passive defense present around the house

It is important to note that the selection and development of these criteria is based in the hypothesis that best explains the reality in Spain: the destruction of houses is normally a consequence of the fire entering the house, and not a sustained ignition.

Sources of heat

Three levels of fire effect importance are considered, to which a specific form of heat transfer is mainly associated (contact, radiation, convection or firebrand-contact) and, also, a distance of action within which the source of heat has an effective effect on the elements of the house is considered. The distances are:

- Direct contact of flames or embers (0-2 m.)
- Radiation and convection (2 to 10 m.)
- Production of firebrands (10 to 30 m.)

In the assessment of distances to the sources of heat, it is necessary to consider the 3-dimensional spatial distance. It is also required to perform a crosscheck of all potential sources of heat and the potentially affected elements as, according to our

experience, only one of these combinations can entail the total destruction of the house.

Vulnerable elements in the house

A building, from the point of view of its vulnerability to an external fire, can be considered as a set of elements that separately or simultaneously bring an ignition in the outside and drive the fire inside the house, frequently causing its destruction. Among all of the possible elements, a set of the most significant have been selected:

- Roof
- Windows
- Horizontal elements, balcony, platforms
- External walls
- Gutters
- Eaves

Vulnerability assessment procedure

The procedure for vulnerability evaluation is based in the convolution (product) of the singular vulnerability of each of the existing elements and their exposure to the expected level of danged (fire) in the surroundings. The danger levels are characterized by the factors governing the behavior of the potential fire and the mode of heat transfer (contact, radiation, convection and firebrands).

The convolution is applied using tables in which the different vegetation units (potential sources of fire) and the distances are presented, one table per vulnerable element. For each vulnerable element three vulnerability levels are considered, from low to high. Thus, each cell in the table has a value of 0 (not-applies), 1 (it affects slightly), 2 (it affects noticeably) or 3 (affects considerably and with high probability), reflecting the possible degree of affection when exposed to each type of heat transfer. Each combination of elements and sources of heat results in a scoring. The final scoring integrates the total vulnerability, providing a measure of the probability of destruction or affection of such vulnerable element.

The procedure is repeated with all the elements of a particular house, and then an assessment is done for the expected degree of destruction of the whole house. This procedure has been applied to each typified house situation, thus having a first approximation of the expected vulnerability for each catalogue entry.

Overview of the potential interface zoning

At W-UI scale, the first analytical step has been to study the overall potential distribution, type and density of the urban settlements and housing areas in the forested areas of Spain. To achieve this goal, a set of digital maps have been selected and adapted, referring them to the same co-ordinate system (UTM Zone 30) and to a common spatial resolution of 250 meters.

A map containing the forestlands, shrublands and wildland grasslands areas has been composed combining the information of the simplified CORINE Land Cover (CLC2000) and the Spanish Forestry Map (MFE200). Some of the agro-forestry patterns have also been considered due to their importance, particularly the *dehesas*.

For the study of the overall distribution and types of urban areas, a thematic coverage of the main settlements (year 2000) in Spain has been used. Besides, this has been complemented with the CORINE classes for urban areas and also the satellite image of the artificial light in the night.

For the identification of settlements aggregation and patterns in each province, data from EUROSTAT has been also used, in particular the size and clustering of settlements and urban areas, the housing rate (of the last 10 years), the average distance between urban settlements and the relationship between urban and rural areas.

Special attention has been paid to the topography and geo-morphology, because these factors affect the type and distribution of both, forested areas and urban settlements. It has been observed an important correlation between hilly or mountainous regions with forested areas and dense territorial development of first and second residence housing areas.

A first approximation of the type and distribution of interface areas in Spain has been obtained by overlaying the mentioned maps in a GIS platform, which ended up in a first coarse zoning of the main W-UI areas in the country.

First review of interface types in Spain

After this, a more detailed analysis, province-by-province focusing on the identified W-UI areas, has been done, integrating more specific information given by Autonomic and local Authorities. The first zoning has rendered a first set of observations, which have further driven the detailed analysis. These are:

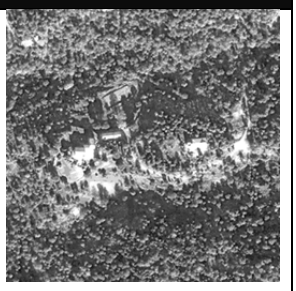
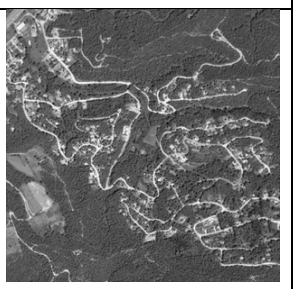
- It has been observed a very important presence of wildland-urban interface around metropolitan areas in the vicinity of forested lands, which is frequently affected by the presence of mountainous and coastal zones. The conjunction of these factors is very prominent in the provinces of Madrid, Girona, Barcelona, Málaga, Pontevedra, Coruña, Balearic Islands and some areas of Valencia, Castellón, Cádiz, Granada, Asturias and Cantabria.
- The territorial development of settlements in the Mediterranean coastline meets and mixes with forested areas in the places where mountainous areas are close to or coincide with the coastal zone. This fact is noticeable in Málaga, Castellón, Barcelona, Girona and Balearic Islands, as well as in some points of the Canary Islands.
- There are a large percentage of settlements and housing areas sitting in the vicinity of shrublands with sparse or no tree coverage at all. This fact is more evident in the Mediterranean part of Spain and in some inner provinces of the north, such as Orense.
- Rural areas show a large number of small towns and settlements dispersed across forested or agro-forested areas, especially in the base of mountains (piedemonte). The inner provinces of southern Spain and Extremadrura, alternate the presence of interface in the shrublands, the agro-forest mosaic, the *dehesa* and, less frequently, in the middle of important forest stands (for example in Sierra de Cazorla, Jaen)

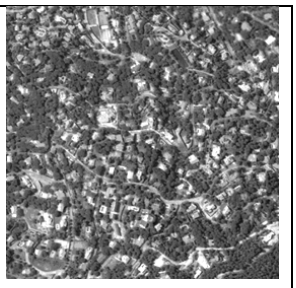
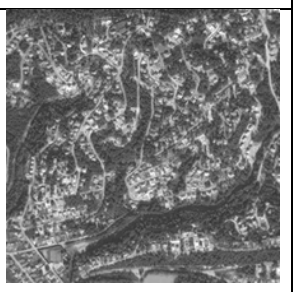
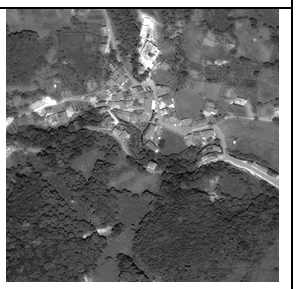
- In some provinces it is observed a conjunction of all the previously mentioned factors, such as in Girona or Barcelona (Catalonia), while in others a good number of different interface situations are found, such as in Madrid.
- In the Northwest quadrant of Spain, it is frequent to observe small towns surrounded by grazing pasture or other green agricultural exploitation that keeps them isolated from the nearby forests.

Catalogue of interface situations

This set of typified interface situations is the synthesis of what has been found in the Spanish geography, offering a simple but meaningful interpretation of reality. Although a rather complete and comprehensive set of cases is provided, it is expected that should be improved or even extended in the future with other cases and sub cases, according to what researchers and forest fire managers provide with their experiences.

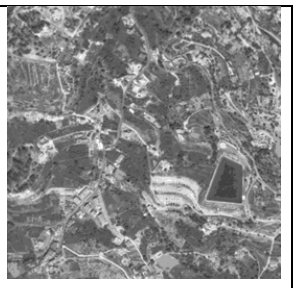
The main objective of this catalogue is to help to the quick but accurate identification of the most frequent situations by applying an intuitive key, and to assimilate any real interface with one of the typified classes, hence estimating the associated risk. The catalogue of interface situations is tightly related to the catalogue of house situations, from which the average vulnerability is estimated (see next point). In light of what is exposed above, most of the interface situations found in the Spanish geography can be assimilated to one of the following typified catalogue entries:

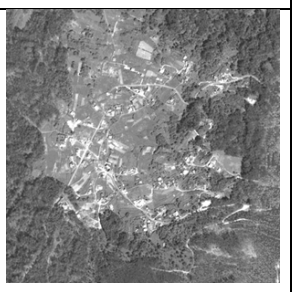
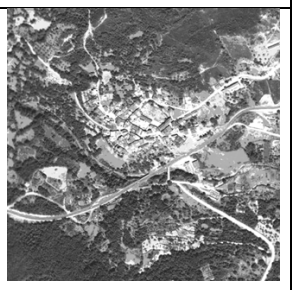
A - INTERFACE MODELS WITH DENSE FOREST	
A1. Isolated house amid a densely forested area. Isolated buildings or houses sitting amid a dense forest stand. Both, houses and access roads are potentially exposed to the fire, and no defense infrastructure is found common with other houses, as in the case of settlements. A self-protection plan is needed, the access routes and evacuation operations must be pre-planned in advance and ideally the house should also serve as effective fire shelter in case of entrapment. Risk: HIGH	
A2. Dispersed housing area in a forested area. Houses are placed separately, or forming small clusters or linear groupings, leaving large areas of forested land. Frequently an intricate network of streets and roads is present, with dead-end and cul-de-sac situations. From above, the streets draw a worm nest-like pattern, especially in abrupt topography. These settlements are frequently found mid-slope or in the crest, in the areas near to the coastline in order to have a good sightseeing. Risk: VERY HIGH	

A.3 Dense and uniform intermix in a forested area. A continuous mixing of forest vegetation and houses. Houses are distributed one close to the other, but providing enough space for the forest and ornamental vegetation. Common defense infrastructures are present. Settlement borders are frequently undefined. Accessibility is complicated, as in A2. Potentially, all houses are exposed to fire, as fire progresses without difficulty in this pattern. Firebrands and spotting creates dangerous situations. Self-protection plans are important; evacuation has to be planed in advance, giving the large number of people present. Risk: VERY HIGH	
A4. Intermix with straps of forest vegetation. Dense mix of houses and vegetation, with forested areas or corridors inside the settlement. High number of houses, forming linear or clustered patterns, mixed with vegetation straps that create many interface situations. The straps, frequently, are associated to canyons where gardening remains are disposed. Fire progresses in a discontinuous pattern, jumping from lot to lot, frequently through hedges and other ornamental. The fire is locally intense; spotting is also frequent, creating entrapment situations. Common defense infrastructures, and common maintenance is required. The houses placed immediately to the straps are more exposed to fire and destruction. Risk: VERY HIGH	
A.5 Forest interface with a compact settlement. Clustered and compact settlement, with little or no vegetation inside, with well-defined border with the forested area, frequently with a road or service street. Fire will in the exterior of the settlement, but firebrands can affect some houses inside. The defense is concentrated in the border of the settlement, where fire defense installations are present. Evacuation not always is required; many of the houses may serve as refuge. In this case, the smoke affecting people may be more important than fire front itself. Risk: HIGH	
A.6 Forest interface with small rural town. Houses of a rural town which are in contact or mix with the forested land, closely associated with an agricultural mosaic. The houses in the border are more exposed to fire, but firebrands falling in the roof frequently affect the ones placed inside. Houses are, mainly, built with stone, bricks or other resistant material. A surface or crown fire will approach the town; usually the fire runs also on the shrubs in the fringe with lots and the river margins. The fire rarely progresses inside the town, which may serve as refuge in case of entrapment. Evacuation is most recommendable if there is enough time, otherwise confinement and defense is possible in most of cases. Risk: HIGH	

A.7 Forest interface with a large urban area or city. A clear border of the city and the forested area is defined, thus the majority of houses are safe to the flames. Smoke can create some problems. The houses located immediately to the forest area and the second row can be directly affected. Rarely, falling firebrands can affect some houses. A fuel-less strap surrounding the city in the areas of contact with forest should be enough to facilitate fire attack and suppression. It is also frequent that fires are started in the border towards the forest, something that has to be contemplated in the defense plans. Risk: HIGH	
A.8 Forest interface with an industrial area. Area of industrial activity with buildings, warehouses and people. There exists the possibility of accumulation of toxic or dangerous materials, or flammable elements. The activity o the installation can produce, in turn, fires towards the forested area. The fire approaching to the border can progress inside the installations depending on the existing flammable components, creating sometimes a new emergency scenario. A low-density vegetation strap around the installation is required. Dangerous substances may be located a minimum of 30 m. inside from the forested area. Risk: HIGH	
A.9 Occluded forest interface in a large urban area or city. Large forested areas inside cities forming interface with the houses placed in the ring border. This situation rarely develops large or intense fires, but a low-vegetation strap must protect the houses placed immediately to the border. Accessibility normally is very good, and the fire, in the worst cases, should self-extinguish against the fringe with the city. Smoke can cause some problems and, normally, evacuation is not required. Risk: MODERATE	

B - INTERFACE MODELS WITH SHRUBLAND	
B.1 Isolated house amid a shrubland. A moderate to high intensity fire can be developed affecting the house and the access routes. A self-protection plan must be prepared, and forest fuel management is frequently economically and technically more feasible. Ideally the house should serve as fire refuge in case of extreme entrapment. Risk: MODERATE	

B.2 Disperse housing area in a shrubland. Small clusters of houses or linear patterns of grouped buildings, with a noticeable amount of shrubland and ornamental vegetation. Access roads and streets are intricate and frequently of poor quality, especially in the complex topography. Fire normally progresses inside the housing area, increasing intensity in canyons or saddles. Roads and streets sometimes are effective as fire barriers or as anchor for indirect attack. These settlements, frequently, are developed with illegal constructions, or with houses of poor quality, and are located near the coast in the south and east Mediterranean Spain. Risk: HIGH	
B.3 Intermix with shrubland and ornamental vegetation. Dense developments of housing forming a continuous mix with shrubland and ornamental vegetation, particularly drought-resistant hedges. Borders of settlements are not well defined, and fire progresses through the lots jumping and thanks to the production of flying embers. Accessibility is normally poor, and situations of cul-de-sac are frequent. The self-protection plan of the settlement is required, and some first-attack of trained inhabitants of the settlement can be effective for incipient fires. Risk: HIGH	
B.4 Compact settlement interface with shrubland. Clustered settlement with little or no vegetation inside, typical situation of a recently developed housing area with a high-value of land. A well-defined border with the shrubland is frequently in direct contact with the immediate row of houses. The fire progresses in the exterior of the settlement, and flames and firebrands affect sometimes houses, although normally buildings are fire-resistant. Evacuation not always is necessary, as ideally the houses should serve as refuges to the fire. Risk: MODERATE	
B.5 Interface of shrubland with a large urban area or city. A clear border of the city and the shrubland area is defined, thus the majority of houses are safe to the flames of a surface fore of moderate to high intensity. Smoke can create some problems. A fuel-less strap surrounding the city in the areas of contact with forest should be enough to facilitate fire attack and suppression. Evacuation is rarely needed, although smoke can create some problems if the developed fire is large or persistent. Risk: MODERATE	

C - INTERFACE MODELS ON AGRO-FOREST MOSAIC	
C.1 Isolated houses or small clusters of houses in areas of dehesa. Houses and access roads are potentially exposed to fire, although it is expected that a low to moderate fire front is developed due to the low density of trees. Houses normally brick or stone-built are resistant to the fire and offer good protection in case of entrapment. Rarely it has been observed the destruction of houses when fire or firebrands enter the house and this starts a fire inside. Isolated houses are encouraged to have a self-protection plan and planned routes for evacuation. Defensible areas and adequation of passive measures for fire fighting is also recommended. Risk: LOW	
C.2 Disseminated housing area or small rural towns surrounded by pasture or other green agricultural area amid the forest (Galician model). This is a very frequent pattern found in North and Northwest Spain, and also in Portugal. The irrigated agricultural or green pasture area serves as a natural defense to the housing area from the fire developed in the forest. However, smoke and firebrand production may constitute a problem, as the type of forest is basically *Eucalyptus* and *Pinus*. In abandoned areas, the pasture evolves to dense and high shrubland, which develop intense surface fires. Houses are normally fire-resistant and offer good protection from fire. However, a self-protection plan is recommended, including the maintenance of the green strap around the houses. Risk: LOW	
C.3 Town or settlement in agro-forestry mosaic. A very common situation in Spain in which a mosaic of dry agricultural areas mixes with forested areas and housing plots or rural towns. The borders of the interface are not well defined, as some of the houses or agricultural installations may fall outside the boundaries of the town. Houses are, in general, fire-resistant, but are in close contact with the agro-forestry mosaic, offering less exposure to intense fires than in the cases of fully forested areas. The fire is of a variable intensity, depending on which fuel is affecting, agriculture lands, shrubland or forested land. Normally the fire does not affect the main town and it serves as refuge. Evacuation is not required in all cases, although smoke can create problems. Risk: MODERATE	

Catalogue of house situations

To identify the situation in which the houses are within a specific interface scenario, two main criteria have been applied:

- Position of the house in the settlement or housing area, in regards to the sources of heat, and measured through the **exposition** criteria presented previously (for example, the specific interface length index)
- Type of building, according to the **vulnerability** criteria presented previously, mainly based in the type of house and its elements

In light of this, and looking into the interface situation classes, the house situations are typified by crossing the following criteria:

I. Position of the building

- Isolated house
- Small cluster of houses
- House placed in a intermix area
- House placed in a compact settlement
- House of rural town
- House in a large city
- Industrial installation in an industrial area interface

II. Type of the building

- New house of stone, concrete or steel building, fire-resistant
- Solid building most of it fire resistant, with burnable elements in the exterior
- Industrial building, warehouse, presence of flammable materials
- Rural house, with old wood structure and clay stone or tile roofing
- House of average quality with noticeable presence of plastic, wood and other burnable material
- Poor-construction house, temporary warehouse with abundance of flammable and burnable elements

Frequency of interface types

As said, a second review of each province has been performed, in which a first estimation of the frequency and importance of each of the catalogue entries has been obtained. The results are presented in the Table 1. Out of this coarse accounting of interface types, a distribution map has also been obtained for each class, which has been the base of the estimation of risk distribution. These configure the interface risk atlas of Spain.

Análisis I-UF España	A1	A2	A3	A4	A5	A6	A7	A8	A9	B1	B2	B3	B4	B5	C1	C2	C3	Riesgo			
Provincia	3	4	4	4	3	3	3	3	2	2	3	3	2	2	1	1	2	Total	Arbolado	Matorral	Mosaico
. Álava	2					2	2	2	1							3	1	31	26	0	5
. Albacete	1	1				1				1			2	2			3	26	10	10	6
. Alicante	1	2	1		1	2				2	2	3	2	2			2	55	24	27	4
x Almería	2	1				1					2						1	21	13	6	2
. Asturias	2					3	2	1								1		25	24	0	1
. Ávila	2	3	2	1	1	2	2			1	2		1				1	57	45	10	2
. Badajoz	1					1				1					2		2	14	6	2	6
. Barcelona	2	3	2	3	2	2	2	2	2								1	68	66	0	2
. Burgos	1	1				3	2			1	1						3	33	22	5	6
. Cáceres	2	1				2	1			1					3		1	26	19	2	5
x Cádiz	2	1			1	1	2			1	2	1	1	1			2	41	22	15	4
. Cantabria	2	2				2	2	1								1	2	34	29	0	5
. Castellón	1	2	2	2	2	2	2	1		2	1	1	2	2			2	70	48	18	4
Ceuta																		0	0	0	0
. Ciudad Real	1	1				1				2			2	2			2	26	10	12	4
x Córdoba	2	2				1	1			1	2	2			1		2	39	20	14	5
. Cuenca	2	2	2		2	2	2										2	44	40	0	4
. Gerona	3	3	3	3	3	2	2	2	2								2	80	76	0	4
x Granada	2					2			1	2	2		2	2			2	36	14	18	4
. Guadalajara	2	2	2		1	2											3	37	31	0	6
. Guipúzcoa	2					2	2	2	1							3	1	31	26	0	5
x Huelva	2	1				2				2	1	1			1		2	31	16	10	5
. Huesca	2	1				3											2	23	19	0	4
. Islas Baleares	2	2	2	1	2	1	2			1	1	1	1	1			2	57	41	12	4
x Jaén	1	2				2				1	2						2	29	17	8	4
x La Coruña	2	2			2	2	2	2		1	1					3		46	38	5	3
. La Rioja	1					1				1	2			2			2	22	6	12	4
. Las Palmas	1	1	1							2	2	2	1	2			2	37	11	22	4
. León	2					3	2				2			2			3	37	21	10	6
. Lérida	2	2				3											2	27	23	0	4
. Lugo	2	2				3	1	1								3	1	34	29	0	5
. Madrid	2	2	2	3	3	2	2	1	1	1	2	2	2	2	1		1	85	60	22	3
x Málaga	1	2	2		2		1		1	2	2	2	2	1				52	30	22	0
Melilla																		0	0	0	0
. Murcia						1	1	1		2	2	2	2	2			2	37	9	24	4
. Navarra	2	2				3	2										2	33	29	0	4
. Orense	2	1			2	2	2			2	2		1	2		2		46	28	16	2
. Palencia	2					2	2			1				1			2	26	18	4	4
. Pontevedra	2	2			1	2	2	2		1	1					3	2	47	35	5	7
. Salamanca	2	1				2				1	1			1	3		2	30	16	7	7
. Santa Cruz de Tenerife	1	1	1	1	1	1	1			2	2	2	2	2			2	52	24	24	4
. Segovia	2	2				2	2			1	1			1			2	37	26	7	4
x Sevilla	1									2	2	1			1		1	19	3	13	3
. Soria	2					3				1	1						3	26	15	5	6
x Tarragona	2	2	1	1	2	2	1	1				2		1			2	52	40	8	4
. Teruel	1	1				1	1			1				1			2	21	13	4	4
. Toledo	1	2	1							1	2	2	2	2			2	41	15	22	4
. Valencia	1	2	2	2	2	1	1			1	2			2			2	55	39	12	4
. Valladolid		1	1			1											2	15	11	0	4
. Vizcaya	2					2	2	2	1							3	1	31	26	0	5
. Zamora	2	1				3				2	2			2			2	37	19	14	4
. Zaragoza	2	1				1				1				1			3	23	13	4	6
	82	63	27	17	30	87	51	21	10	45	47	24	25	39	12	22	88				
	A1	A2	A3	A4	A5	A6	A7	A8	A9	B1	B2	B3	B4	B5	C1	C2	C3				
									388					180			122				

A - MODELOS SOBRE ARBOLADO DENSO

A.1. Casa aislada en entorno forestal arbolado
A.2. Urbanización dispersa en el arbolado
A.3. Intermix uniforme y denso en arbolado
A.4. Intermix denso con fajas de vegetación
A.5. Interfaz de urbanización compacta y arbolado
A.6. Interfaz de pequeña población con arbolado
A.7. Borde de gran población con área forestal arbolada
A.8. Interfaz Industrial-Forestal
A.9. Interfaz ocluida en núcleo urbano

B - MODELOS SOBRE MATORRAL

B.1. Casa aislada en el matorral
B.2. Urbanización dispersa en el matorral
B.3. Intermix en el matorral y vegetación ornamental
B.4. Interfaz de urbanización compacta y matorral
B.5. Borde de gran población con matorral

C - MODELOS SOBRE MOSAICO AGRO-FORESTAL

C.1. Pequeños núcleos y edificios aislados en zonas de dehesa
C.2. Diseminado en área forestal con faja de agricultura (modelo "gallego")
C.3. Población en mosaico agro-forestal

0 No presente o muy infrecuente
1 Algunos casos
2 Significativo
3 Muy frecuente o dominante

Table 1 — Frequency of W-UI types in Spain in each province (1= some cases; 2= significant; 3= very frequent or dominant), with the associated total risk, and the partial in the forestland (arbolado), shrubland (matorral) and agro-forestry mosaic

Measurement of risk

Each of the interface types found in the W-UI catalogue has an associated risk due to forest fire. The risk has been estimated according to the criteria presented previously, both, in regards to the interface and the house situations.

The final risk accounting for each province has been obtained then by simply convolving the importance (frequency) of each type by the associated risk as mentioned above. The resulting synthetic map of all provinces provides a first view of the risk due to forest fires in the W-UI in Spain (see Figure 1)

Together, a set of maps regarding the partial accounting of the risk in the interface types dominated by forested lands, shrublands or agro-forest mosaic has been obtained. All the maps constitute the atlas of the W-UI forest fire risk in Spain.

Results

Distribution of W-UI fire risk in Spain

After the analysis of each province, and looking into the resulting risk map, the following main results were obtained:

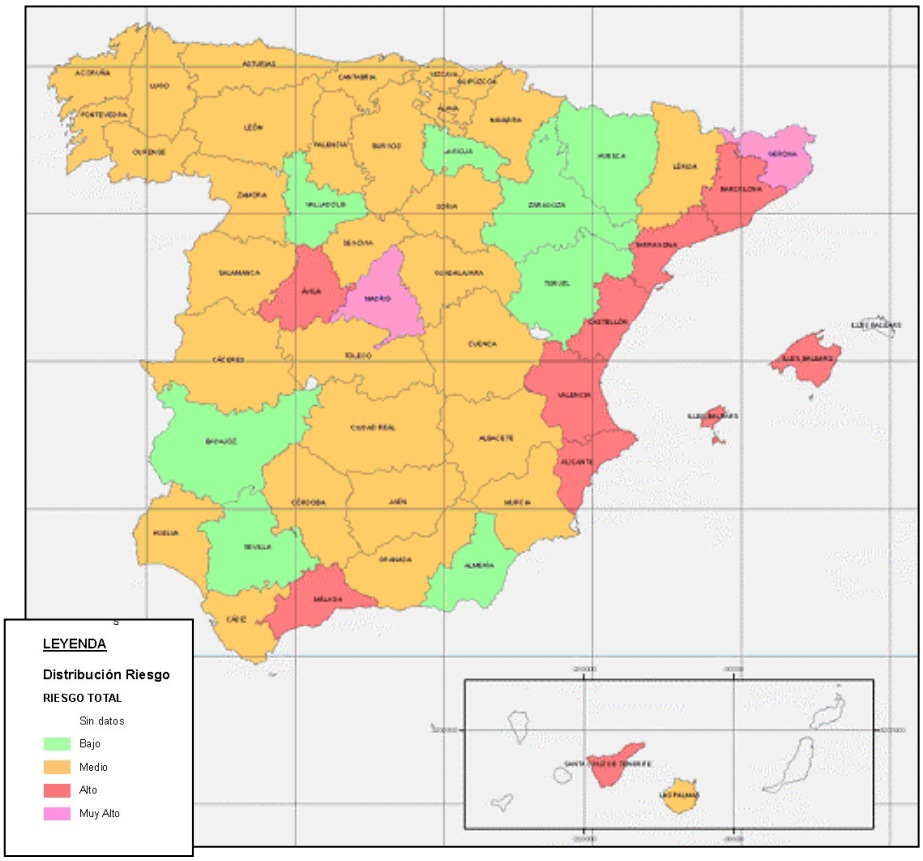


Figure 1—Risk distribution of the wildland-urban interface in Spain, presented in four levels: low (green), moderate (orange), high (red) and very high (magenta)

The most affected provinces are Madrid and Girona, closely followed by Barcelona which in the threshold of extreme risk. Madrid has a high density of settlements and urban areas, covering almost all types of interface situations, many of them of a very high risk. Besides, Madrid is a mega-cephalic province dominated by a metropolitan area of more than 4 million people, causing a noticeable pressure on the surrounding forested land. Girona also holds a vast number of settlements in several interface situations, many of them of the most dangerous types (specially the intermix) in the forested lands. In Barcelona the impact of the forest-urban interface is more noticeable in the surroundings of the main city, due to the aggressive territorial development. The Mediterranean coastline, from Girona to Castellón to Málaga presents a high risk level due to the typology and dense number of interface situations which are more risky, being less frequent in the rest of coastal zones in Spain. In the province of Avila a large number of interface situations in the forested lands, of the most dangerous types, are present, particularly along the valley of Tiétar river, thus entailing a continuum of the risk with the province of Madrid. The provinces less affected (in green) are those in which the number of interface situations is noticeably less important, or because the situations created are of a lower risk. Also the frequency and type of forest fires is taken into account.

Conclusions

A two-year study on the wildland-urban interface in Spain has been conducted and concluded, with some preliminary results that may serve as baseline for a more detailed study in each Autonomy, at municipality level. A set of criteria and a procedure for vulnerability and risk estimation has been applied for the typifying of house and interface situations, gathered in catalogues of practical application. Future improvements and extensions of these catalogues are expected after other experiences. An atlas of potential risk map has been obtained. This map set should serve as baseline for discussion and design of action planning on the interface problem, particularly in those provinces in which the risk has scored high and very high. Taking into account the criteria and the situations found in the reality of Spain, a number of recommendations and preventive actions have been presented to the Ministry of Agriculture, together with some comments for the review, improvement and development of specific legislation on this matter. It is the aim of this work to raise the consciousness of all implied actors, homeowners and stakeholders as well as the Administrations that there exists a high potential of disastrous fire episodes in the wildland-urban interface in Spain, and that actions must be done to prevent them.

References

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