Management Adaptation to Fires in the Wildland-Urban Risk Areas in Spain[1]

Gema Herrero-Corral[2]

Abstract

Forest fires not only cause damage to ecosystems but also result in major socio-economic losses and in the worst cases loss of human life. Specifically, the incidence of fires in the overlapping areas between building structures and forest vegetation (wildland-urban interface, WUI) generates highly-complex emergencies due to the presence of people and goods. During the last decade in Spain, the occurrence of such fire events has led to the concept of wildland-urban interface which has been included, at least implicitly, in all regional forest fire management policies and which, in certain cases, has had a specific policy development.

This paper advocates establishing a WUI typology based on the elements and processes that make up these areas with the aim of adapting a fire management strategy tailored to the specific characteristics and needs of each one. On the other hand, it recognizes the need for an integrated response to this problem that encompasses different fields (forest and fire policy, civil protection, spatial planning) and different fire management phases (forecasting, prevention, suppression).

Keywords: adaptation, forest fire, planning tools, wildland-urban interface, management, legislation, Madrid, risk.

Introduction

During the last several decades in Spain, there has been a significant growth in urban areas, first occupying farmland zones near population settlements and later on more distant forest areas. This process has enhanced the emergence of WUI areas. From 1987 to 2000, WUI areas increased by an estimated 6.8% and by 2.16% between 2000 and 2006, reaching 412,687 hectares of WUI[3] (Herrero 2011).

---

[1] An abbreviated version of this paper was presented at the Fourth International Symposium on Fire Economics, Planning, and Policy: Climate Change and Wildfires, 5-11 November 2012, Mexico City, Mexico.

[2] Research Engineer. INRA. Department of Forest Ecology, Meadows and Aquatic Environments URFM. Domaine Saint Paul, Site Agroparc F-84914 Avignon, France. Email: gema.herrero-corral@avignon.inra.fr.

[3] From the land cover cartography of the project: CORINE Land Cover 2006 (National Geographic Institute).

Its configuration has occurred coincidently with a series of socioeconomic and political changes that have aggravated the forest fire problem. Processes of rural depopulation, land abandonment or reduction of traditional forest use have led to forest ecosystems becoming more dangerous structures with high combustibility, increasing the associated fire hazard. Additionally, increased recreational use of forest areas and the lack of adequate policies governing fire use in forest environments have helped create areas with a high wildfire risk (Vélez 2009). In this context, the rapid expansion of urbanization on forest vegetation spaces has contributed to generating new conflict scenarios where wildfires become true civil protection emergencies (Montiel and Smith 2010).

The historical incidence of forest fires in Spain is a recurring fact every summer (MARM 2009). However, the incidence and severity vary in each area and as such should receive special treatment. Similarly, the influence of the WUI distribution pattern on forest fire risk is not the same in all areas. Certain territory characteristics, related to forest cover and settlement system, influence not only the space occupied by the interface area, but also their evolutionary dynamics and characteristics associated with the forest fires risk.

The possibility of programming a true management adaptation of the WUI spaces to physical and social conditions that create the problem in each regional context requires a thorough knowledge of these areas to previously assess the situation and management needs. Assuming that the fire risk depends not only on the WUI presence, but also on its type and the characteristics of the territory in which it is located, this paper focuses on characterizing and establishing WUI situations as a useful tool for wildfire risk management planning adapted to the specific needs of each WUI type.

In this work, the specific objectives to be achieved are: (i) assess the degree of integration of the WUI concept as a forest fire risk area in the legislation and planning instruments in the Spanish context, (ii) define, delineate and characterize wildland-urban areas, addressing the territorial specificities that the phenomenon acquires to establish a typology and characterization that allows better forest fire management planning.

Study area and method

The study area is located in the western area of the Madrid community[4]. Its features make it an area of great interest for WUI studies as wildfire risk territories. On one hand, it concentrates a large area of forest areas that border heavily-urbanized areas on the city's boundaries.

[4] 40° 50' 00'' N, 3° 51' 15'' W; 40° 30' 00'' N, 4° 11' 15'' W

In addition, the dynamics of urban growth on forest areas and the abandonment of farming activities have promoted the formation of WUI areas (a 37% increase from 1987-2000). By 2005, 23% of the Madrid WUI areas were concentrated in just over 9% of the total regional area (Herrero 2011). Furthermore, the area had an increase in its number of fires between 1989 and 2007, with humans in 99% of the cases being the ignition cause. Lastly, 22.3% of the fires occurred near built-up areas and, on several occasions, there were civil protection incidents (evacuations, damage to structures, power outages and road obstructions, personal injury).

During the last few decades, European research on forest fires and, specifically, population risk, has been very active, forming a well-structured research group highly experienced in the subject (Birot 2009). The ability to use this research as a basis for future strategies and policies on the subject has encouraged the scientific community to recognize the importance of considering political aspects, and to incorporate them as objectives within their research lines in order to produce useful scientific results to support political decision making (Agudo and Montiel 2009).

This approach to WUI areas in the forest fire context through the diagnosis and assessment of legal and policy instruments is a first step towards proposing new management approaches. In this analysis, there is a combination of qualitative and quantitative methodologies to study WUI areas spaces relative to forest fire risk in the Spanish context.

First, the regulatory and planning context of forest fires in Spain is presented, in order to place the management of WUI areas relative to this type of risk, from the collection of policy and planning documents related to forest fire management and its subsequent critical analysis. To do this, the management of WUI areas in relation to forest fires depends to a large extent on the legal, institutional and political framework in which it is supported (Simorangkir and others 2003).

In Spain, political and administrative decentralization establishes the separation of powers between the State and the Autonomous Communities (CCAA), leaving forest fire management and policy development responsibilities at the autonomous level and the responsibility to approve basic legislation at the state level (Fernández-Espinar 1991). Therefore, the diagnosis of the regulatory situation starts from documents approved at the national and regional levels.

Another aspect that determines fire risk management in WUI areas is related to the multisectoriality of the topic addressed by the various policies involved in forest fire management. Civil protection policy aims to protect life and property in emergencies, with fires being a type of risk that requires the development of special plans. In Forest Policy, fires are considered a threat to forest systems; their respective planning and legislation usually include a chapter devoted to wildfires with general measures. In a complementary way, in most cases, a legal and specific wildfire

planning framework, which sets out concrete prevention and suppression actions, has been developed, and delves into the risk management associated with buildings in the forest environment.

Along with fire sectoral policies, it is necessary to consider other spatial policies with a great influence on the issue. Specifically, spatial and urban planning policies have the ability to influence land-use organization and regulate their occupation conditions. Thus, by adopting the "precautionary principle" in spatial planning, it is possible to minimize the potential consequences of forest fires on civilians (Buxton and others 2011).

The next step is establishing *WUI situations* from the study of the structural elements that make up the territory and identifying the dynamics that determine their evolution under the Regional Geographic Analysis approach (Herrero and others 2012). For this purpose, the spatial analysis method for the delineation and characterization of WUI areas using Geographic Information Systems (GIS) has been applied. The process begins with mapping the WUI areas and subsequently characterizing them from the integration of different WUI types in the territorial context in which they are located. Thus, useful information is obtained for forest fire management planning (Fig. 1).

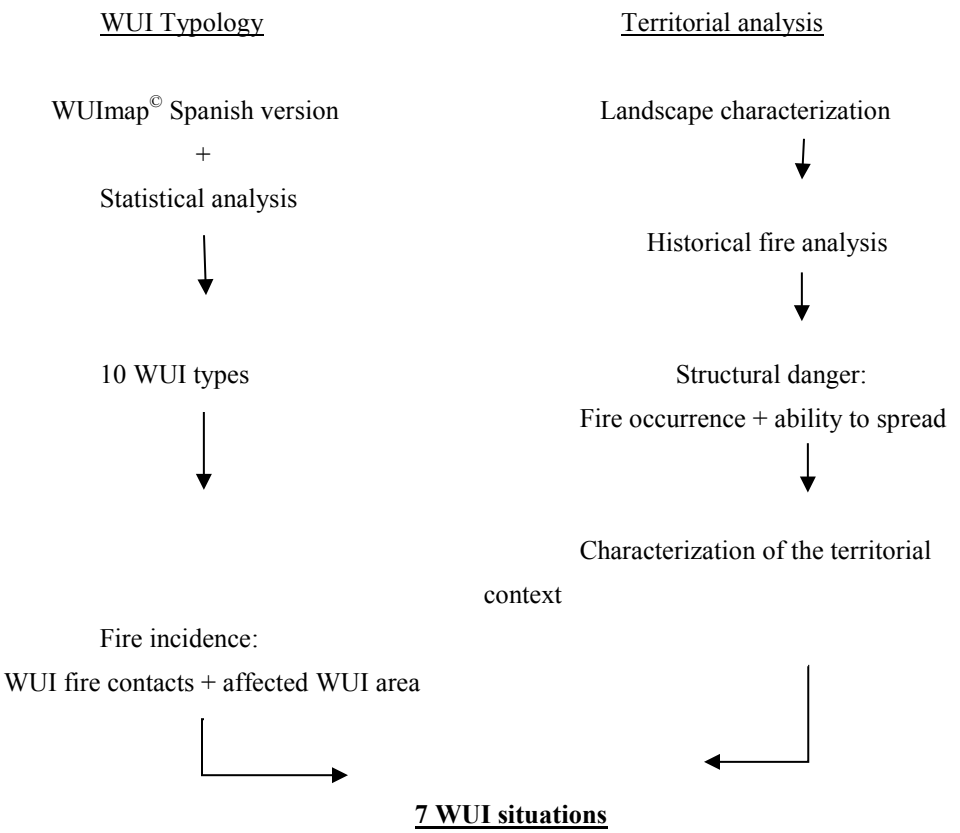

Figure 1—Process for WUI classification and characterization

Cartography of wildland-urban interface types

WUI areas have been mapped and classified based on the configuration of the buildings and the structure of the adjacent vegetation (Lampin-Maillet and others 2010). Spatial calculations were made with WUImap© software (Lampin-Maillet and Bouillon 2011) developed by Cemagref/Irstea Research Institute. To use WUImap© in the Spanish territorial context, it was necessary to make a number of changes to the software that have resulted in WUImap© Spanish (2010).

For calculation purposes, WUI is considered the area corresponding to a 100-m buffer around all those buildings located in a forest area or inside the forest influence area. This influence area is set at 400m from forest stands (Herrero 2011). The WUI areas are classified by integrating the information on the settlement type (isolated buildings, group of buildings, developments and cities) and the horizontal structure of forest vegetation from the aggregation index[5] (*high*= structure with a strong aggregation degree and high vegetation continuity; *medium*= shows certain forest vegetation dispersion; *low*= no forest vegetation or no aggregation).

By using K-means cluster analysis. it was possible to classify each of the WUI entities into ten types[6]. Subsequently, the incidence of forest fires during the 2002-2008 period in WUIs is studied from the number of fire contacts and the burnt interface area, enabling the identification of the WUI types most affected by fire.

Territory characterization according to fire risk

The *regional context*[7] in which WUIs are located plays a key role in managing fire risk. In many cases, forest fire occurrence and fire behavior depend on the structure of the landscape that results in a particular organization of land covers and uses (Mermoz and others 2005; Lloret and others 2002; Turner and Romme 1994). Furthermore, landscape arrangements have a big influence on residential settlement patterns because of the structure of the rural parcel which underlies this process, resulting in mixed urban/ agricultural parcels that evolve into WUIs. Moreover, the landscape character in which they are inserted provides information on the foreseeable dynamics in land use and vegetation evolution (especially natural regeneration processes) that is of great interest in evaluating the change in risk levels

5 The vegetation aggregation index was calculated with FRAGSTATS software © (McGarigal, 2002).

6 Type 1. Dispersed habitat with high vegetation continuity; Type 2. Dispersed habitat with medium vegetation continuity; Type 3. Dispersed habitat with large dispersion or without forest vegetation presence; Type 4. Group of buildings with high vegetation continuity; Type 5. Grouping of buildings with medium vegetation continuity; Type 6. Group of buildings with large dispersion or without forest vegetation presence; Type 7. Developments with high vegetation continuity; Type 8. Developments with medium vegetation continuity; Type 9. Developments with large dispersion or without forest vegetation presence; Type 10. Urban core in contact or proximity to forest vegetation.

7 From Zipperer (2005), the regional context refers to the WUI location in the landscape and its immediate environment.

(Galiana and others 2007). Thus, the study of landscape structure and composition is useful for analyzing land use and resulting changes in the landscape with impact on fire occurrence and its ability to spread (Romero-Calcerrada and Martínez 2004).

The Landscape Character Assessment Methodology of the Countryside Agency and Scottish Natural Heritage (2002) consists of the establishment of a hierarchical typology of units and landscape type in order to identify regions with homogeneous characteristics related to relief, forest vegetation, land uses and dynamics of the territories where WUIs are located. This information is critical for the adoption of prevention and suppression strategies based on forest fire risk (Galiana-Martin, Herrero and Solana 2011).

The landscape characterization in terms of fire risk that this work develops comes from the general definition of *Risk = Hazard x Vulnerability* (Camia and others 2006). It focuses on the danger, which is defined as the probability of a fire being produced (occurrence) and spreading over the territory (intensity) (Blanchi and others 2002). Its calculation is based on variables that can be considered static in the long term, such as topography or vegetation type (San-Miguel-Ayanz and others 2003).

The characterization of different types of landscapes based on the wildfire structural danger (fig. 2) correlates the fuel and slope characteristics with the landscape type to assess its ability to spread; and, on the other hand, it links forest fire occurrence to certain landscapes with specific characteristics. Thus, WUI typologies defined above are contextualized in a particular landscape that has an associated fire hazard degree.

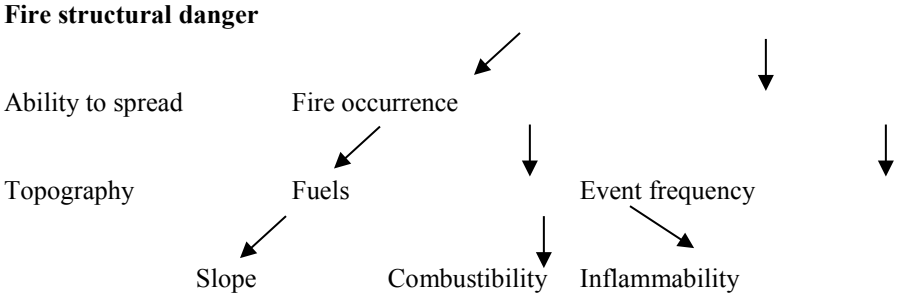

Figure 1—Components for the fire structural hazard calculation

WUI situations for forest fire management planning

This last stage contextualizes the different WUI types in the landscape where they are located in order to identify WUI situations. The term *"situation"* derives from the

scenario concept but does not refer to a prediction or a forecast (Hernández & Wider, 2006). This study defines "situation" as a theoretical description of reality, based on what is observed, to anticipate management needs (Caballero and others 2007, Castellnou and others 2009). Thus, this classification is a useful tool in forest fire prevention and suppression planning.

In this case, the seven most representative WUI *situations* in the study area have been identified from the inclusion of a specific interface type – set from the building model and adjacent vegetation structure – in a specific spatial context, shaped by landscape, structural and dynamic elements. From the in-depth analysis of the seven examples, management strategies and action proposals adapted to each *situation* are proposed.

Political and legal context

The first legal reference on record where the presence of buildings in a forest environment is recognized as a big fire risk is the specific national forest fire legislation (Act 81/1968 and its regulations 1972) which includes "preventive rules to be observed in (...) homes, buildings and industrial facilities located in the forest area". Later on, from Civil Protection policy, the *"Basic Guideline for Emergency Civil Protection Planning for Wildfires"* (1993) was approved; this document is a planning tool targeted specifically to the defense of "businesses, isolated villages, housing developments, campsites, *etc*., that are located in fire risk areas". From this point, CCAAs began to develop general regulations for forest fire management that collect specific prevention and protection measures for WUI areas. More recently, state Forest Law 43/2003 also encourages the WUI concept in its forest fire management chapter.

Incorporation of WUI areas by political instruments for forest fire management is proposed for two reasons: as a vulnerable area where it is necessary to develop measures for the protection of people and assets through actions aimed at fuel reduction and the building of defense infrastructure; but also, as potential fire-generating territories where it is necessary to adopt measures to prevent ignition and possible fire spread towards nearby forests by regulating activities and fire use.

Fire hazard management of WUI areas develops preferentially from specific fire regulations and Civil Protection planning while forest law, in most cases, acts only as an auxiliary. There are different models for the organization of autonomous forest fire planning. The regions that keep a separation between the specific forest fire policy that addresses prevention and self-protection measures for the population, and the Civil Protection that focuses on the establishment of response protocols and functional organization at the time of emergency. On the other hand, there are the

autonomous communities, the CCAAs, where prevention and emergency management in WUI areas are included in the same planning document.

The articulation and development of regulatory and planning instruments may be (i) *hierarchical,* with the approval of regulations or plans at different levels subject to a hierarchically higher regulation and following a "cascade" organization, as in civil protection, or (ii) *Horizontal Sectorial*, where specific legislation influences the approval of regulations in others; for example, autonomous forest fire legislation recognizes the need to adopt self-protection plans that are set in the context of Civil Protection.

Integrated forest fire risk management associated with WUI areas requires an approach towards spatial planning policies. This connection occurs, on one hand, with the incorporation of criteria developed in the field of urban planning by forest fire regulations; for example, the design and material conditions for public protection and safety that are incorporated in the Building Code (2006) for buildings on forest land. On the other hand, urban planning includes preventive measures established by the sectorial regulations to reduce the risk of forest fires and the damage that might result in the interface areas (for example, the obligation to draft protection plans or the implementation of preventive measures in newly constructed buildings). Some urban regulations already integrate these precepts but it is still difficult to determine if they comprise a purely indicative function or will have truly binding effects.

In general, treatment of forest fires and, specifically, the interface areas are not developed in the spatial planning policies, where land use and urban planning are included, with all the potential that sectoral policies demand. The main opportunity for urban planning resides in avoiding the development of land with high wildfire risk. The existence of this risk must be established prior to the adoption of urban plans by mapping or writing reports by the pertinent sectoral agency. However, there is a lack of adequate zoning and forest fire risk mapping because in their preparation spatial planning is not considered as an end user.

In general, all autonomous wildfire regulations include the fire risk associated with the presence of urbanized areas located next to the forest environment and the need to address its management. However, advances in this area have followed a different pace depending on the importance given to this issue in each CCAA (Herrero 2009). Only in some CCAAs does the identification of WUI areas and their forest fire management attempt to adapt to the problematic and territorial specificities of the region[8]; this indicates the need to typify WUIs to adapt their management.

[8] Cataluña focuses on developments without immediate continuity with the urban and located within 500 m of forest land, while Extremadura prioritizes villages' environments.

WUI situations

Seven WUI situations were identified in the study area (Figure 3): (I) exempt developments in the foothill meadows, (II) the foothill escarpment developments, (iii) developments on forest hills and slopes, (IV) urban edge in contact with forest vegetation; (V) scattered habitat in the foothill meadows; (VI) dispersed habitat in mountain forest; (VII) group of buildings in the foothills.

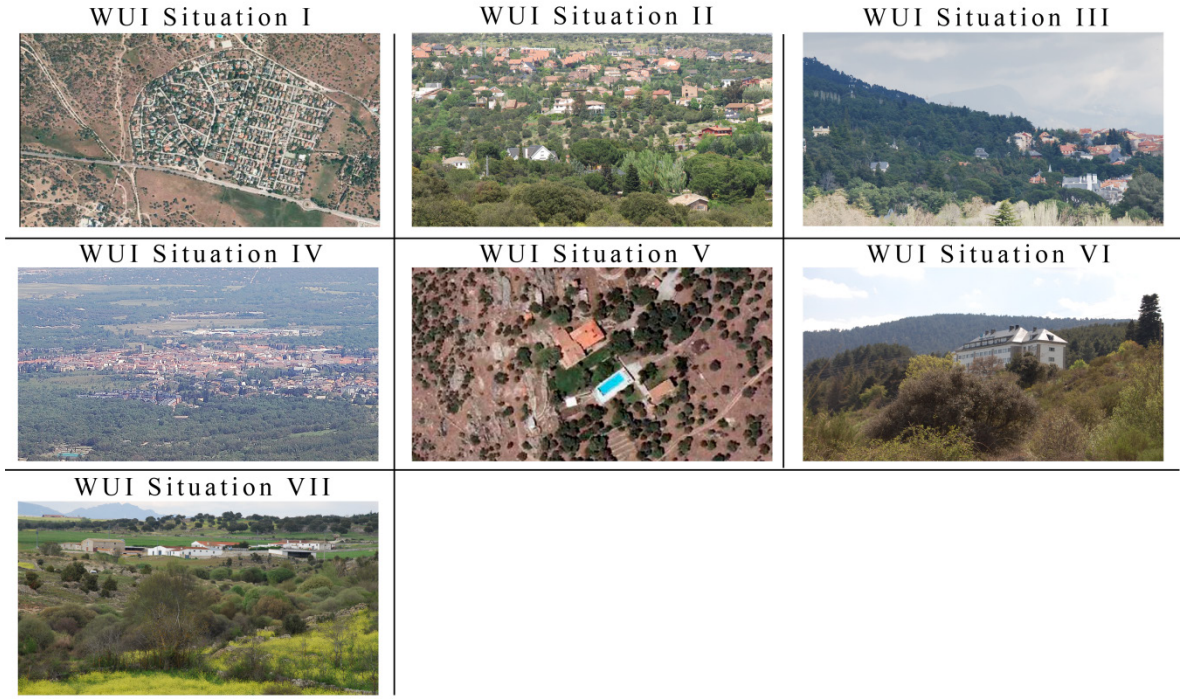

Figure 3—WUI situations in the study area

For each situation there is a card with the information gathered about: settlement name and municipality, aerial photograph, distribution area of equivalent situations, WUI type, morphological characteristics (building distribution, roads and perimeter), topography and vegetation, considerations in relation to wildfire risk based on physical variables and fire occurrence in the past. It also includes information on urban planning (where the new growth will occur, on what kind of ground cover and of what building type) to infer its evolution in the future. Furthermore, the legislation on protected natural areas that could affect buildings located in natural surroundings is taken into account. Also, the existence of forest fire prevention and emergency plans are collected. Lastly, the degree of adoption of specific fire management measures grouped into fuel reduction actions, information to the residents and the existence of other defense infrastructures is evaluated. All the information is embodied in proposed recommendations for their forest fire management approach.

The availability of regulations that govern basic measures to minimize the fire risk in interface areas is essential as a basis for effective management. However, the implementation of actions that have been approved generically is not always useful or feasible in some cases. For example, management needs in a development located in a mountain forest are often different from those of an isolated house in a foothill meadow. Not only because of the structural differences of both settlement types, but also because of the situation that they occupy in the territory and the characteristics of their environment.

In this regard, it is appropriate to have common guidelines, notwithstanding the need to assess the specific characteristics and needs of each territory in order to adapt and establish suitable measures in each case. The classification of WUI areas in Situations provides managers with information on the spatial organization of the territory, given that the interfaces grouped under the same Situation share similar characteristics and that common actions can be implemented to manage fire risk.

Conclusions

The approach to forest fire management should be based on a global and territorial approach to the problem where there is a link between fire and territorial policies, with the main objective of incorporating the structural causes of the fires with a population condition. In addition, complementary to the specific treatment that WUIs receive from the various policies involved, this type of area should be incorporated as a transversal element that is taken into account in the adoption of strategies that have an impact on the territory to facilitate the necessary coordination between the various sectors. This is to ensure consistency between the different policy objectives aimed at avoiding negative impacts; in this case, they materialize in a higher incidence of forest fires and increased loss and damage in habited areas.

Managing forest fire risk in WUI areas requires a comprehensive approach consisting of proper planning based on three stages: forecasting, prevention and suppression. Zoning and urban planning policies play a key role in preventing the proliferation of new interface areas, or at least minimizing their vulnerability. Its main contribution is the ability to predict and warn about the formation of possible risk situations. Through proper land-use zoning aimed at avoiding urban developments in high risk areas and the adoption of a safe settlement model can mitigate wildfire risk. Overall forest and specific forest fire policies address prevention actions aimed at preventing fire occurrence in existing buildings that are located close to forest environments. Additionally, the development of regulations and planning tools with objectives focused on suppression and emergency management is addressed by civil protection policy that establishes protocols for

action and self-protection at the time of the fire.

Shortcomings have been identified regarding policy instruments aimed at avoiding these risk situations. Such aspects must be addressed by territorial policies with influence on urban development and forest management. As earlier indicated, the possibility of integrating the issues associated with WUI areas in these policies requires, on one hand, having a joint vision of the area to be managed, considering the different uses to make them compatible and, on the other hand, to achieve greater integration with fire sectoral policies. In any case, it is important to distinguish between the existence of regulations on the subject, their development through planning instruments and their effective implementation through concrete actions that ultimately enable forest fire management in WUI areas.

Regarding the planning of forest fire management in interface areas, the use of WUI Situations is proposed as a useful tool, based on the theoretical description of reality, which enables anticipating management needs. As for the consideration of WUI area characteristics in isolation, the analysis of the WUI Situations also integrates relevant territorial information in order to propose a wildfire risk management approach adapted to specific conditions and applicable to similar scenarios. Drafting of planning instruments for fire risk management should take into account the existence of this variability in order to propose a different treatment that responds to the characteristics and needs of each situation.

Acknowledgements

The results presented here are from the doctoral thesis "Wildland-urban interfaces as fire risk areas: analysis and regional characterization in Spain" defended in the Department of Geography at the Autonomous University of Madrid. We are grateful to FIRE PARADOX project FP6-018505. Document available at: www.interfazurbanoforestal.com.

References

Agudo, J.; Montiel, C. 2009. Basis to start the process for a proposal of a new legislation at EU level. [Unpublished] Integrated project Fire Paradox, D7.1-1.3. 45p.

Birot, Y. 2009. Living with wildfires: what science can tell us. EFI Discussion Paper 15. Finland: European Forest Institute. 82 p.

Blanchi, R., Jappiot, M., Alexandrian, D. 2002. Forest fire risk assessment and cartography. A methodological approach. In D. X. Viegas (Ed.), IV International conference on forest fire research and wildland fire safety. Coimbra, Portugal, 16-20 November 2002.

Buxton, M.; Haynes, R.; Mercer, D.; Butt, A. 2011. Vulnerability to Bushfire Risk at Melbourne's Urban Fringe: The Failure of Regulatory Land Use Planning. Geographical Research (49). Pp. 1-12.

Caballero, D., Beltrán, I., Velasco, A. 2007. Forest fires and wildland-urban interface in Spain: types and risk distribution. En: IV Conferencia Internacional sobre Incendios Forestales. Sevilla: 13-17 Mayo, 2007.

Camia, A., Guglielmet, E., Bovio, G., Deshayes, M., Lampin, C., Salas, J., Martínez J; Molina D; Carrega, P; Fox, D; Berolo, W; Sabaté, S; Vayreda, J; Martín, P; Martínez, J; Conese, C; Bonora, L; Karteris, M; Mallinis, G; Sergiopoulos, I; Gitas, I. 2006. Wildland fire danger and hazards: A state of the art (80 pp.) Unpublished report. EUFIRELAB project. [On line]. www.eufirelab.org.

Castellnou, M., Pagés, J., Miralles, M., Piqué, M. 2009. Tipificación de los incendios forestales de Cataluña. Elaboración del mapa de incendios de diseño como herramienta para la gestión forestal. Paper presented at the 5° Congreso Forestal Español, Ávila, 21-25 Septiembre.

Countryside Agency and Scottish Natural Heritage. 2002. Landscape Character Assessment. Wetherby: Countryside Agency and Scottish Natural Heritage; 96 p.

Fernández-Espinar, L. 1991. La legislación forestal en el Estado de las Autonomías. Revista de estudios Agro-Sociales (158). Pp. 107-129.

Galiana, L.; Herrero, G.; Solana, J. 2007. Caracterización y clasificación de Interfaces Urbano- Forestales mediante análisis paisajístico. El ejemplo de Sierra Calderona (Comunidad Valenciana, España). En: IV Conferencia Internacional sobre Incendios Forestales. Sevilla: 13-17 Mayo, 2007.

Galiana-Martin, L., Herrero, G., Solana, J. 2011. A wildland-urban interface typology for forest fire risk management in Mediterranean areas. Landscape Research, 36, 151-171.

Hernández-Jimenez, V.; Wider, N. 2006. Running experiments with the Madrid Simulation Model. [Informe inédito] Time-Geographical approaches to Emergence and Sustainable Societies (TiGrESS) project. 24 p.

Herrero, G. 2009. Assessment of the Growing Importance of Wildland-Urban Interfaces in Fire Risk Management: WUI Regional Patterns in Spain. En: González, A. (coord). Proceedings of the III International Symposium on Fire Economics, Planning and Policy: Common Problems and Approaches.Puerto Rico: 29 Abril- 2 Mayo, 2008. Pp. 238-248.

Herrero, G. 2011. Wildland-urban interfaces as fire prone areas in Spain: Regional analysis and characterization (p. 546). Director: Galiana, L. Universidad Autónoma de Madrid. Dep. Geografía www.interfazurbanoforestal.com

Herrero-Corral, G., Jappiot, M.; Bouillon, C.; Long-Fournel, M. 2012. Application of a geographical assessment method for the characterization of wildland–urban interfaces in the context of wildfire prevention: A case study in western Madrid. Applied Geography (35). Pp. 60-70

Lampin-Maillet, C., Bouillon, C. 2011. WUImap: a software tool for mapping wildlandeurban interfaces in Mediterranean European context. Journal of Environmental Science and Engineering, 5, 631-642

Lampin-Maillet, C., Jappiot, M., Long, M., Bouillon, C., Morge, D., Ferrier, J. P. 2010. Mapping wildland-urban interfaces at large scales integrating housing density and vegetation aggregation for fire prevention in the South of France. Journal of Environmental Management, 91, 732-741

Lloret, F., Calvo, E., Pons, X., Díaz-Delgado, R. 2002. Wildfires and landscape patterns in the eastern Iberian Peninsula. Landscape Ecology, 17, 745-759.

Mermoz, M., Kitzberger, T., Veblen, T. T. 2005. Landscape influences on occurrence and spread of wildfires in Patagonian forests and shrublands. Ecology, 86 (10), 2705-2715.

Ministerio de Medio Ambiente y Medio Rural y Marino. 2009. Los incendios forestales en España. 156p.

Montiel, C.; Herrero, G. 2010. An overview of policies and practices related to fire ignitions at the European Union level. En: Sande, J.; Rego, F.; Fernandes, P.; Rigolot, E. (eds). Towards Integrated Fire Management. Outcomes of the European Project Fire Paradox. Finland: European Forest Institute. Pp. 35-46.

Romero-Calcerrada, R.; Martínez, J. 2004. Nuevas técnicas para el estudio de los cambios en la ocupación del territorio: aplicación en la ZEPA Encinares de los ríos Alberche y Cofio (Comunidad de Madrid)". En: Conesa et al (ed). Territorio y Medio Ambiente: Métodos cuantitativos y técnicas de información geográfica. Murcia: Universidad de Murcia. Pp.329-342.

San-Miguel-Ayanz, J., Carlson, J. D., Alexander, M., Tolhurst, K., Morgan, G., Sneeuwjagt, R., Dudfield, M. 2003. Current methods to assess fire danger potential. En: E. Chuvieco (Ed.), Wildland fire danger estimation and mapping: The role of remote sensing data. Singapore: World Scientific Publishing. Pp. 24-34.

Simorangkir, D.; Moore, P.; Haase, N.; Moore, P. (Ed). **2003.** Fires, laws and regulations – Towards best practices for legal aspects of fire. Project Fire Fight South East Asia (IUCN and WWF). 68p.

Turner, M.; Romme, W. 1994. Landscape dynamics in crown fire ecosystems. Landscape ecology (9). Pp. 59-77.

Vélez, R. 2009. Los factores causantes: las fuerzas y cambios sociales y económicos. En: Birot, Y. (ed.). Convivir con los incendios forestales: lo que nos revela la ciencia. Finland: EFI Discussion Paper (15). Pp. 23–27.

Zipperer, W. C. 2005. Ecological assessment and planning in the wildland-urban interface: a landscape perspective. In S. W. Vince, M. L. Duryea, E. A. Macie, & L. A. Hermansen (Eds.), Forests at the wildland-urban interface: Conservation and management. Boca Raton: CRC Press. Pp. 161-174.