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Socio-geographic analysis of wildland fires: causes of the 2006's wildfires in Galicia (Spain)

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Abstract

Aim of study: To propose a methodology to establish motivations underlying wildland fire episodes by analyzing both the socioeconomics of the affected territory and the geographical distribution of the wildfire.

Area of study: The wildfires occurred during 2006 in Galicia, in the NW of Spain, were analyzed and compared regard to the previous years.

Material and methods: The proposed methodology in this study is divided into four steps: (a) definition of the forest context, (b) fire episode and socioeconomic data collection, (c) geospatial representation through map production, and (d) joint analysis and data interpretation. A combined analysis of the spatial and temporal coincidence of wildfire and the socioeconomic activities is performed.

Main results: A combined analysis of the spatial and temporal coincidence of wildfire dynamics and the socioeconomic activities allow us to assess and to interpret wildfire causes and motivations of socioeconomic groups. In our area study, a broad analysis indicates that wildfire recurrence within this region is related to an accelerated rural flight process which exacerbates the conflict between rural and urban models.

Research highlights: The socio-geographical analysis of a territory's wildfire dynamics enables us to establish possible causes and motivations of their origins. Providing the specific contextual and socioeconomic information, this methodology has potential applicability across varied study locations.

Key words: forest; wildfires' causes; geographical distribution; socioeconomic analysis.

Introduction

Fire is a landscape-shaping natural disturbance. In the last half-century human activities have changed characteristics and dynamics of wildfires, causing them to acquire abnormal levels of intensity, severity, and return frequency. In addition to constituting an environmental problem during the last decades of 20th century, wildfires have become a social issue with major impacts on affected areas (Goldammer, 1998).

Recently, several regions in southern Europe (*e.g.,* Portugal, 2005; Spain, 2005 and 2006; Greece, 2007 to present) have been affected by wildfires (European Commission, 2001). Many broad forest management plans can be found at the national level. In this sense, Hyytiäinen and Haight (2010) evaluate various forest management systems under risk of wildfire. Bassi and Kettunen (2008) analyze main causes of wildfire in countries commonly affected. More exhaustive studies were proposed, where Marques *et al.* (2011) and Moreira *et al.* (2010) characterized long temporal series of wildfires in Portugal by typology and spatial pattern. Similar analyses have been performed in Spain that considered both spatial and temporal incidence of fire (Martín *et al*., 1998; Prieto, 1989; Bardaji and Molina, 1999). In Spain, the wildfires that occurred in the summer of 2006 were small in quantity yet they exhibited exceptional severity in Galicia, traditionally one of Spain's most fire-affected regions. In only 12 days, 80,000 ha of forest were burned, representing 4% of the Galician forest extent (Consellería de Medio Rural, 2007; González-Alonso and Merino-de-Miguel, 2009).

Galician wildfires in 2006 showed the highest recent severity however they also exhibited characteristics

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Abbreviations: FAA (Forest Affected Area); IFN (*Inventario Forestal Nacional*); GIS (Geographical Information Systems); IGE (*Instituto Galego de Estadística*); IGN (*Instituto Nacional de Estadística*); MVMC (*Montes Vecinales en Mano Común*).

previously unrecorded. These included a variation in spatial distribution and a change in location of occurrence from the southern to the western zones, particularly in the provinces of Pontevedra and A Coruña. Although there was a notable increase in burned forest area, wildfire occurrence frequency was lower than an average year. During 2006, the number of major fires[1] reported in Galicia increased substantially in relation to the rest of Spain (Ministerio de Medio Ambiente, 2006). Although the wildfires are usually perceived to occur in southern Europe to Mediterranean forests (Moreno, 1989; Carrega, 1991), the region of Galicia is located at the northwest of the Iberian Peninsula, and it has an Atlantic habitat. This is the region of Spain conventionally more affected by wildfires, containing 50% of the forest affected area (FAA) and 35% of wildfires at the national level (Bardaji and Molina, 1999; Baamonde, 2005).

Many studies analyzing wildfire incidence in this region have been performed (Pérez and Delgado, 1995; Baamonde, 2005; Díaz-Fierros and Baamonde, 2005; Fernández-Couto, 2006). However most of them consider vast temporal series and are not focused on the idiosyncrasies of exceptional fire campaigns and their causes. In addition, many of these works are systematic enumerations of the possible motivations (Chas and Touza, 2009), and few studies (Costafreda-Aumedes *et al.*, 2013) consider wildfire spatial incidence or specific socioeconomic causes related to the fires. This paper aims therefore to establish a methodology to analyze and determine the causes and motivations of specific wildfire episodes. It will jointly study wildfires' spatiotemporal geographical distributions and the socioeconomic context in a given territory. This methodology is applied to comprehensively study the fires occurred in Galicia in 2006.

Material and methods

Methodology

The proposed methodology is divided into four steps: (a) definition of the forest context, (b) fire episode and socioeconomic data collection, (c) geospatial representation, and (d) joint analysis and data interpretation (Fig. 1). The forest context is provided by describing the local particularities and the forest management model of the study area, considering forest typology, dominant species, property regime, productivity level and historical evolution. Two kinds of data are required. The first one is related to the spatiotemporal component of the wildfires (*i.e.,* geographical and historical datasets). This is achieved by compiling official statistics about wildfires, species and affected area. These data must be of a spatial resolution suitable for the scale of study. The second kind of data describes the socioeconomic situation of the study area. Data related to any of the wildfire phases are of particular significance, considering the spatiotemporal context of fire occurrence. Map production of the most important wildfire indicators allows for geospatial visualizations of wildfires. Finally, combined analysis of the spatial and temporal coincidence of wildfire and the socioeconomic activities is performed. Here, wildfire causes and motivations of socioeconomic groups are assessed and interpreted.

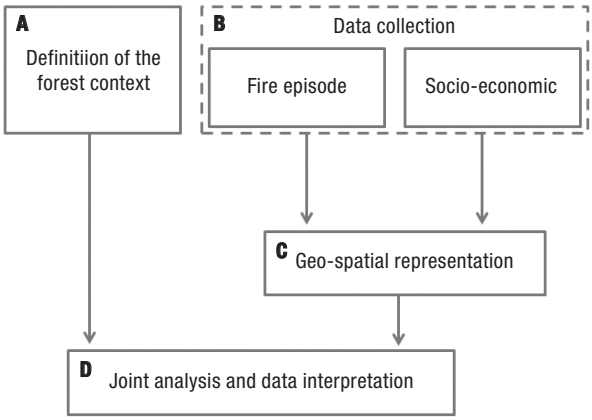

Figure 1. Components of the proposed methodology.

Study area and forest regime contextualization

The Autonomous Community of Galicia is located in the northwest Iberian Peninsula. Galicia has a surface area of 29,574 km^2 (5.8% of Spain) and a population of 2,795,422 (5.9% of the Spanish population). This entails a population density of 93.78 people/km^2, similar to the mean population density of Spain (93.51 people/km^2) (INE, 2011). Galicia is divided into four administrative provinces, three coastal and one landlocked: A Coruña, Lugo, Pontevedra, and Ourense, respectively (Fig. 2a). For forest management purposes, in 2008 Galicia was divided into 19 forest districts to improve forest management (Ley 43/2003, Decreto 43/2008) (see Fig. 2b).

[1] Major fires are denoted those wildfires affecting an extend larger than 500 ha.

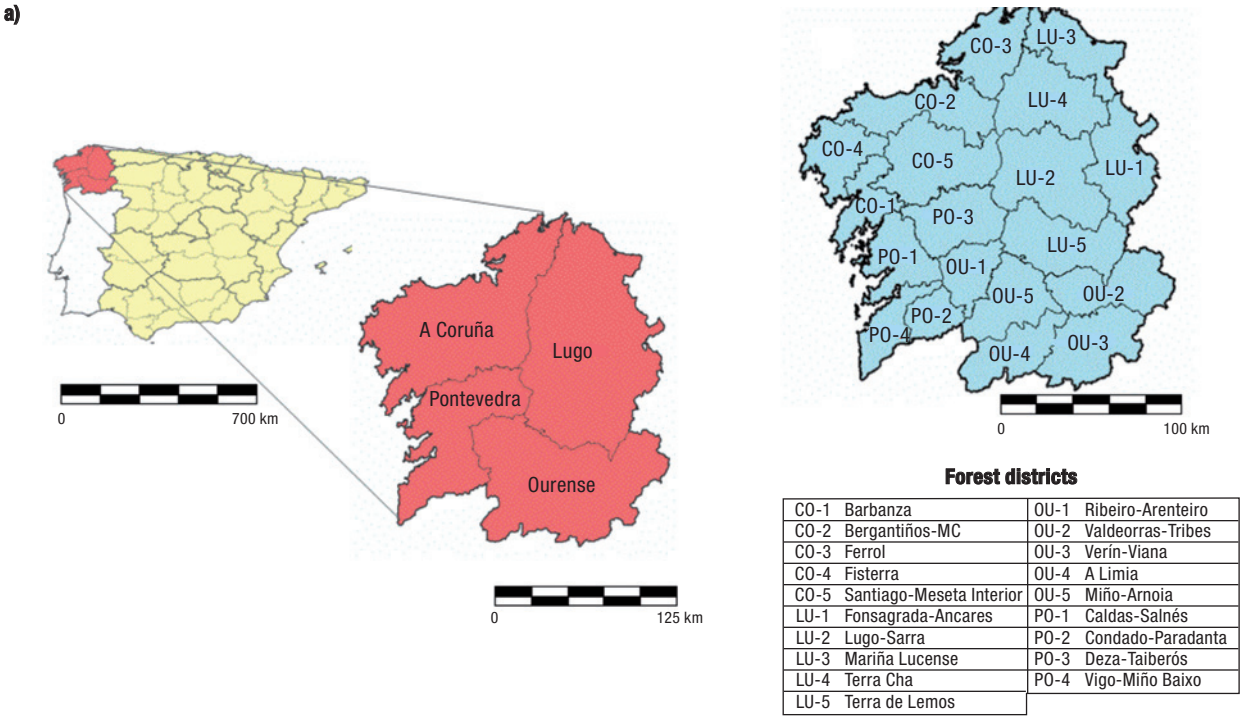

Figure 2. (a) Location of Galicia within Spain and province division. (b) Forest districts division.

Galicia has the sixth greatest absolute forest area among Autonomous Communities, with more than 2,000,000 ha of forest representing 68.9% of Galician land cover (7.4% of forest cover in Spain). Ratio of the forest surface is notably higher than the national average (55.2%) (IFN3, 1997-2007). Forests in Galicia are mainly closed with a generally even distribution among the three groups: conifers (506,026 ha), hardwood (562,417 ha), and mixed (337,008 ha) (IFN3, 1997-2007). Galician forests are largely autochthonous hardwoods (*e.g.,* oak or chestnut) with an average canopy height, and a dense understory comprising ferns, broom, and gorse. Introduction of rapid-growing species, such as *Eucalyptus globulus,* influenced a change in the traditional physiognomy of Galician forests (FAO, 1981; Elorza, 1965). The most representative reforestation species in the Atlantic and Cantabrian areas are the eucalyptus and the pine, due to their low frost tolerance, common in inland areas (Díaz-Balteiro *et al.*, 2009; Sánchez and Rodríguez, 2002; Villegas, 1953). Proportionally, Galicia's two southern provinces, Ourense and Pontevedra, have forest extents considerably larger than in the northern provinces (Ourense: 81.1%; Pontevedra: 75.5%; see Fig. 3a). Closed forest is an important factor in the coastal provinces, particularly in A Coruña (forest area is 81.6% closed forest).

Regarding the property regime of the land, most Galician forest is private (97.2%), and this percentage is noted as being much higher than the national average at 67.7% (Balboa, 2005; Artiaga and Balboa, 1992). Private forest ownership is subdivided into either particular ownership or communal ownership in collective woodlands (*Montes Vecinales en Mano Común,* MVMC), an ownership typology almost exclusive to Galicia. Particular ownership forests are 67.9% of the forest extent and almost a fourth of Galicia's population owns forest land (672,000 registered owners according to the Cadastre). This necessitates an atomization of the forest, the average per capita extent being approximately 2 ha. This extent may be further subdivided into several plots, mostly with a surface lower than 0.5 ha (Picos, 2009). The MVMC are generally owned by the lowest population entity levels (parroquia, aldea, etc.) and the exploitation rights belong to their residents. Almost a third of the forest (29.8%) is ruled by 2,800 MVMC owners' communities (IFN3, 1997-2007), in Germanic regimes (Artiaga and Balboa, 1992; Mangas, 1984) and without quota assignations (Fernández-Couto, 2006; Marey *et al.*, 2010). Major communal properties are held in the provinces of Ourense and Pontevedra (Prada, 1991).

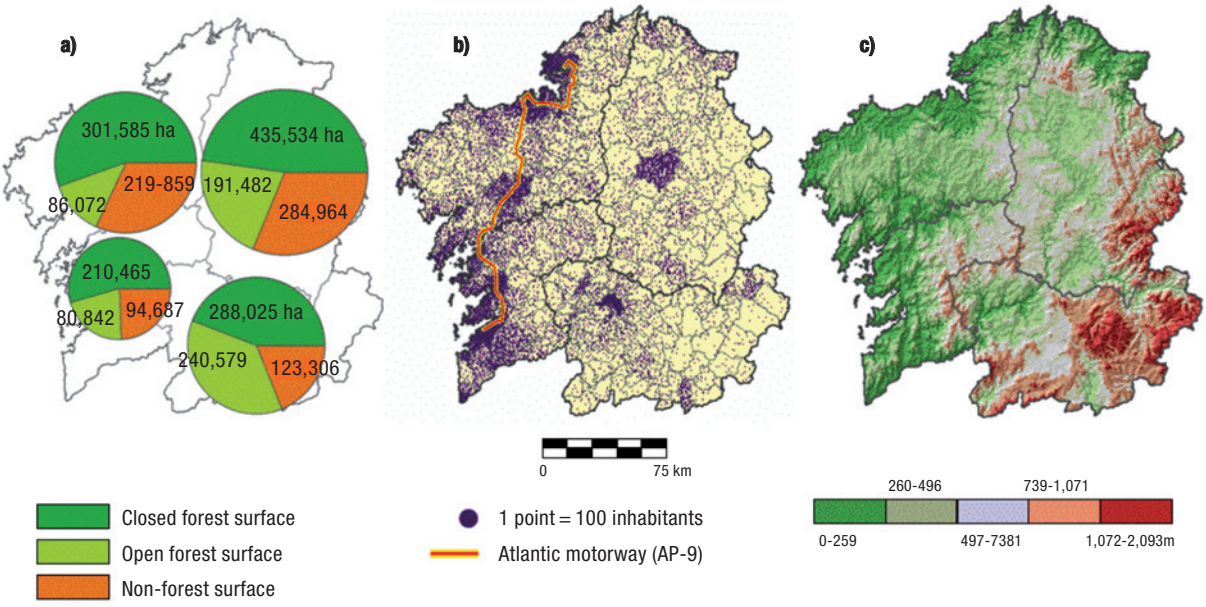

Figure 3. (a) Forest typologies surface distribution in the provinces of Galicia. The chart surface is proportional to each province surface. (b) Population distribution map, including the route of the AP-9 motorway. (c) Orographic map of Galicia. *Source:* (a) Consellería de Medio Rural, 2007. (b) Instituto Nacional de Estadística, 2007.

From a commercial point of view, the main use of the Galician forest is related to logging activities (Lage, 2003). Galicia is currently the leading timber forest products producer in Spain and the ninth in Europe (AITIM, 2009) with production levels (95 m^3/ha of timber volume) comparable to some European countries with a long tradition of forestry such as Sweden or Finland (IFN3, 1997-2007; Eurostat, 2009). The timber industry thus has significant economic importance, with annual revenues of 2,259,000,000 €, or 3.5% of the regional GDP (IGE, 2008).

Results

In this section we apply the proposed methodology to analyze the causes and motivations of the fires produced in Galicia, Spain in 2006. The section is divided into (a) data collection, (b) spatial analysis, and (c) socioeconomic analysis.

Data collection

In order to achieve a fine spatial resolution we work, whenever possible, at municipality level. Most of the wildfire data is published by the Regional Government (*Consellería de Medio Rural* from the *Xunta de Galicia*), whereas socioeconomic data have been supplied by Spanish National Statistical Institute (*Instituto Nacional de Estadística*) and Galician Statistical Institute (*Instituto Galego de Estatística*). The socio-geographic information is represented in Fig. 3b, showing the spatial distribution of the population together with the route followed by the AP-9 motorway, which connects many major cities and represents the wide range of socioeconomic conditions in Galicia. Fig. 3c shows the topography of the region.

To provide a large temporal and spatial context, we collected the number of wildfires and the affected area in Galicia and the rest of Spain between 2003 and 2010 (Fig. 4). The burned forest area is mapped in Fig. 5, where the five preceding years are compared with 2006. For a more detailed analysis, these data also are numerically presented for each forest district in Table 1. The specific information of the surface of forest affected per province and forest typology is presented in Figs. 6 and 7. A detailed background of the relationships between economic activities and wildfires was provided by gathering information of the most frequent motivations for arson (Fig. 8) and by jointly analyzing the spatial distribution of fires with the real estate activity of each municipality (Fig. 9).

Spatial analysis of the wildfire distribution

Wildfires in Galicia are a recurrent problem and are showing increasing levels of severity. The analysis of

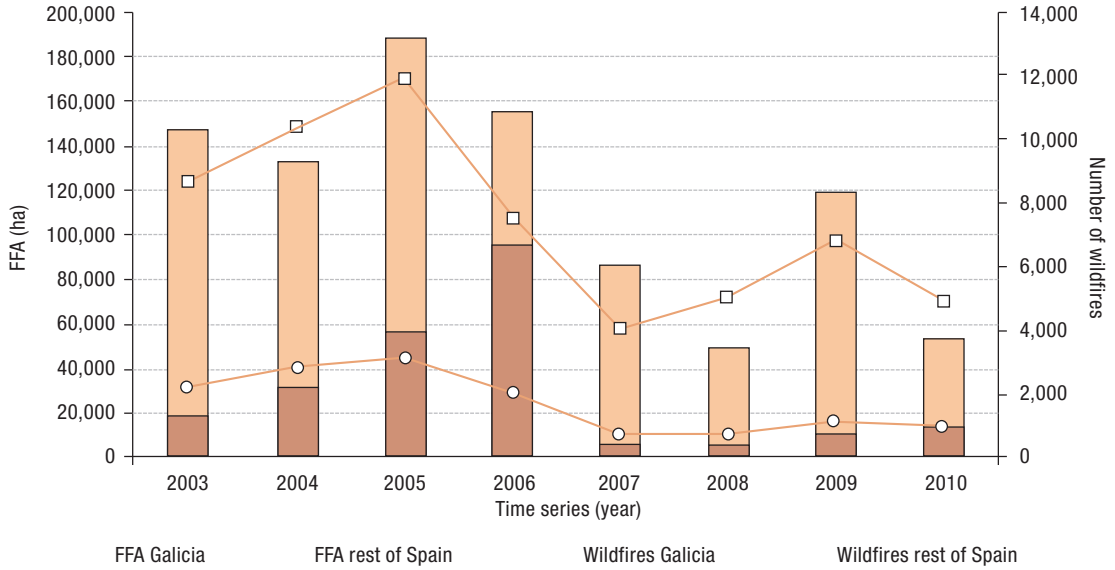

Figure 4. Wildfire activity in Galicia and Spain between 2003 and 2010. FFA: Forest affected area. *Source:* Instituto Nacional de Estadística, 2010.

the data, however, shows irregularities in the wildfire dynamics between years. Fires in 2006 affected the largest area, although the number of fires was less than in preceding years (Fig. 4). Wildfires in 2006 marked changes in regional and spatial distribution in comparison with preceding years (Figs. 5 and 7a). Wildfires mainly affect smaller rural municipalities located in the south of the region having low population den-

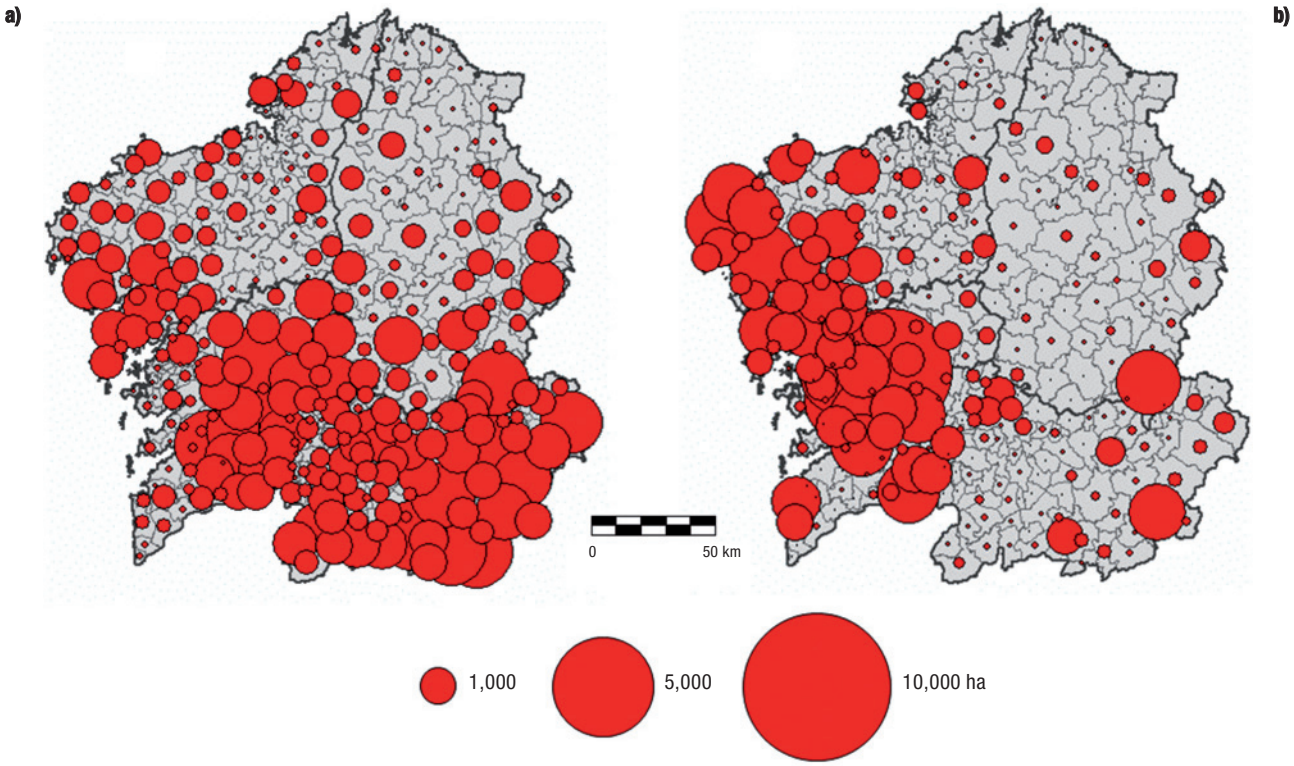

Figure 5. (a) Per-municipality burned forest surface between 2001 and 2005 and (b) in 2006. *Source:* Consellería de Medio Rural, 2007.

Table 1. Comparison of forest affected area (FAA) between 2001 and 2005, and FAA in 2006 at forest district level

	Forest districts	Municipalities	Province	Forest surface (ha)	FAA 2001-2005 (%)	FAA 2006 (%)
CO-1	Barbanza	13	A Coruña	63.381	12.3	19.7
CO-2	Bergantiños-MC	27	A Coruña	105.353	4.4	4.7
CO-3	Ferrol	20	A Coruña	104.573	3	0.8
CO-4	Fisterra	12	A Coruña	75.260	8.2	17.3
CO-5	Santiago-Meseta Interior	22	A Coruña	119.089	4.2	4.6
LU-1	Fonsagrada-Ancares	9	Lugo	131.243	4	1.2
LU-2	Lugo-Sarria	18	Lugo	133.993	4.4	0.5
LU-3	Mariña Lucense	15	Lugo	104.879	0.5	0.1
LU-4	Terra Cha	13	Lugo	126.256	1.8	0.8
LU-5	Terra de Lemos	12	Lugo	130.651	6.3	2.1
OU-1	Ribeiro-Arenteiro	19	Ourense	74.143	16.8	5.1
OU-2	Valdeorras-Trives	17	Ourense	129.385	10.8	1.2
OU-3	Verín-Viana	12	Ourense	130.194	16.6	2.9
OU-4	A Limia	16	Ourense	89.538	13.6	0.7
OU-5	Miño-Arnoia	28	Ourense	105.339	13.2	2.3
PO-1	Caldas-Salnés	28	Pontevedra	87.087	6.9	22.2
PO-2	Condado-Paradanta	9	Pontevedra	50.532	16.2	10.2
PO-3	Deza-Tabeirós	9	Pontevedra	98.147	9.9	10.5
PO-4	Vigo-Miño Baixo	16	Pontevedra	55.539	12.9	11.2

Source: Consellería de Medio Rural, 2007.

sities and regressive demographic dynamics due to both low birth rates and an ageing population. These municipalities have also been unaffected by recent foreign immigration patterns, which, combined with the rural flight of the last century, has led to strong declines in population. Additionally, economic structures are based on primary sectors, making these municipalities unattractive from a socioeconomic point of view.

Regressive demographic trends explain the abandonment of farmlands by both particular and communal owners, producing an important organizational disinte-

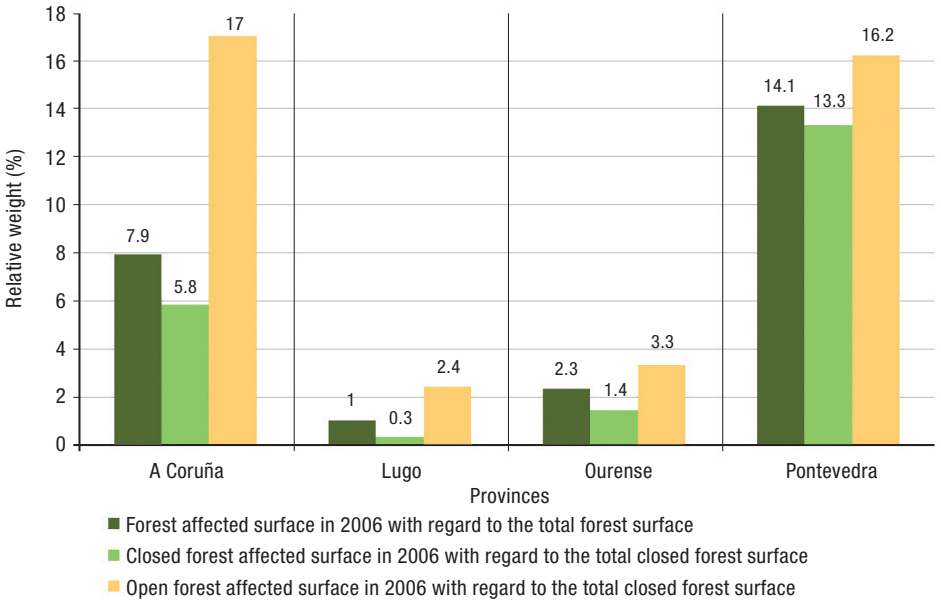

Figure 6. Relative surface of forest affected by the 2006's wildfires per province. *Source:* Consellería de Medio Rural, 2007.

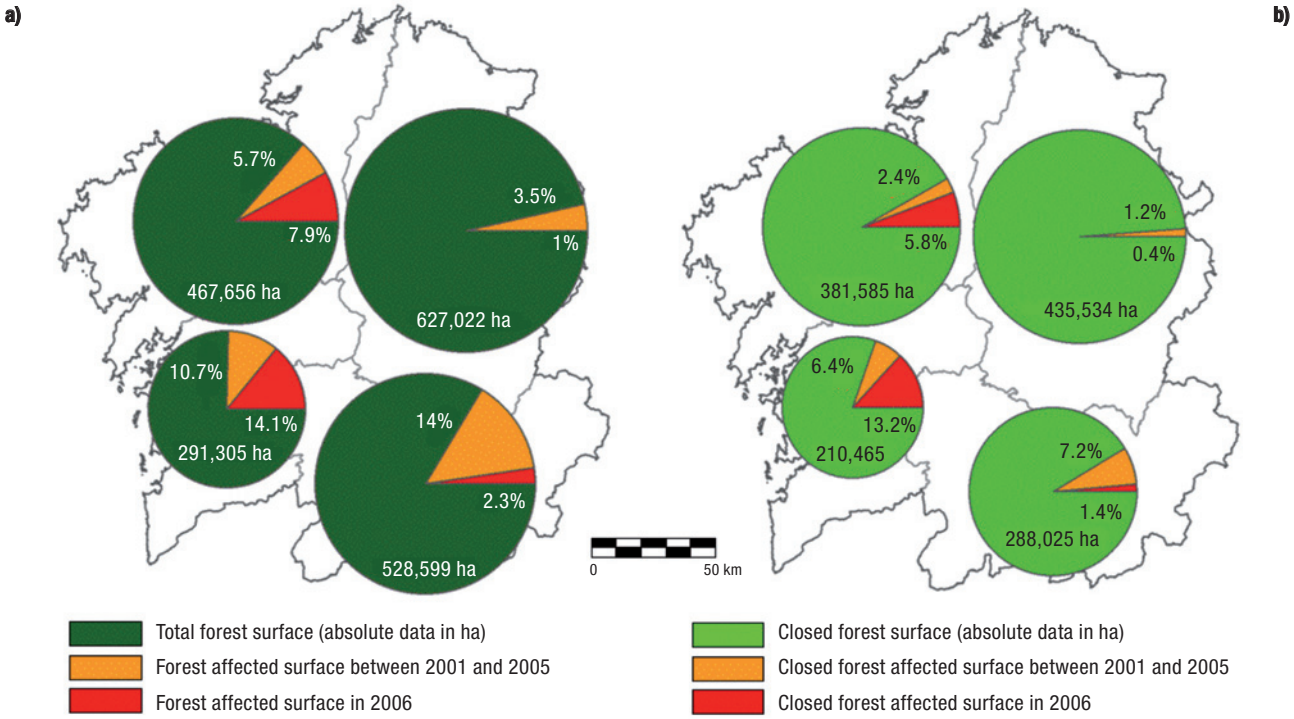

Figure 7. (a) Percentage of burned forest surface, and (b) burned closed forest surface between 2001 and 2005 and during 2006. The chart area is proportional to forest surface and closed forest surface, respectively, for each province. *Source:* Consellería de Medio Rural, 2007.

gration process. This is mainly given in municipalities located in east/southeast Ourense and along the border between Ourense and Pontevedra. This pattern of land abandonment may be viewed as economically predictable, as little profit was to be made from a degraded agriculture land base and thus encouraged relocation as an adaptation strategy. In the period between 2001 and 2005, mountainous terrain and low forest-related demographic pressure were strong indicators of fire incidence (Fig. 5a). Most abandoned farmlands have become shrublands or open forest where silviculture is not practiced (Lage, 2003). Molinero *et al*. (2008) state that traditionally wildfires are likely attributable to conflict between public administrations and rural populations. Thus, whereas rural populations view forests as profitable natural capital, public administrations primarily perceive forests as main supports of urban areas (Lage, 2003).

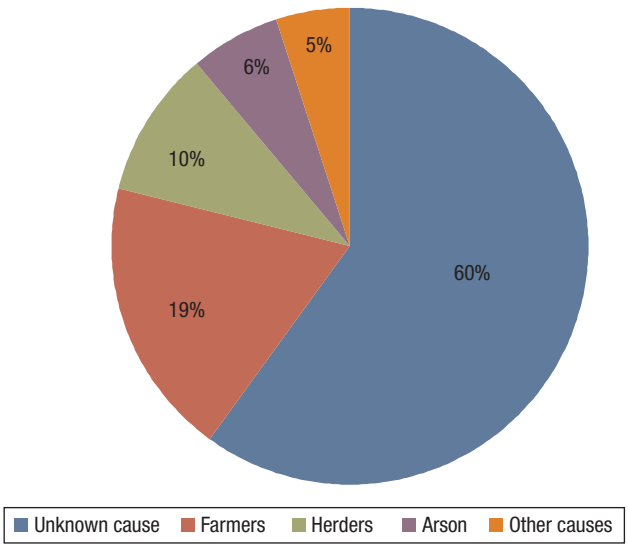

Figure 8. Pauses of the intentionally caused fires between 1988 and 2006. *Source*: Chas and Touza, 2009.

In 2006, however, wildfires occurred in distinctly urban areas (Fig. 5b). That year, 80.5% of burned area was located in the provinces of Pontevedra and A Coruña, which together contain 39.5% of the Galician forests. Pontevedra lost 3.6% of its forest area, with A Coruña losing 7.7%. In Lugo and Ourense, only 1% and 2.3% of the forests were burned, respectively.

Spatial distributions of the wildfires were unbalanced, both within and between provinces. A Coruña and Pontevedra saw fires concentrated in the *Atlantic Axis* and in *A Costa da Morte* in A Coruña (Balsa-Barreiro, 2012b). Table 1 shows the percentage of forest affected surface in 2006 (FAA2006) compared with the forest

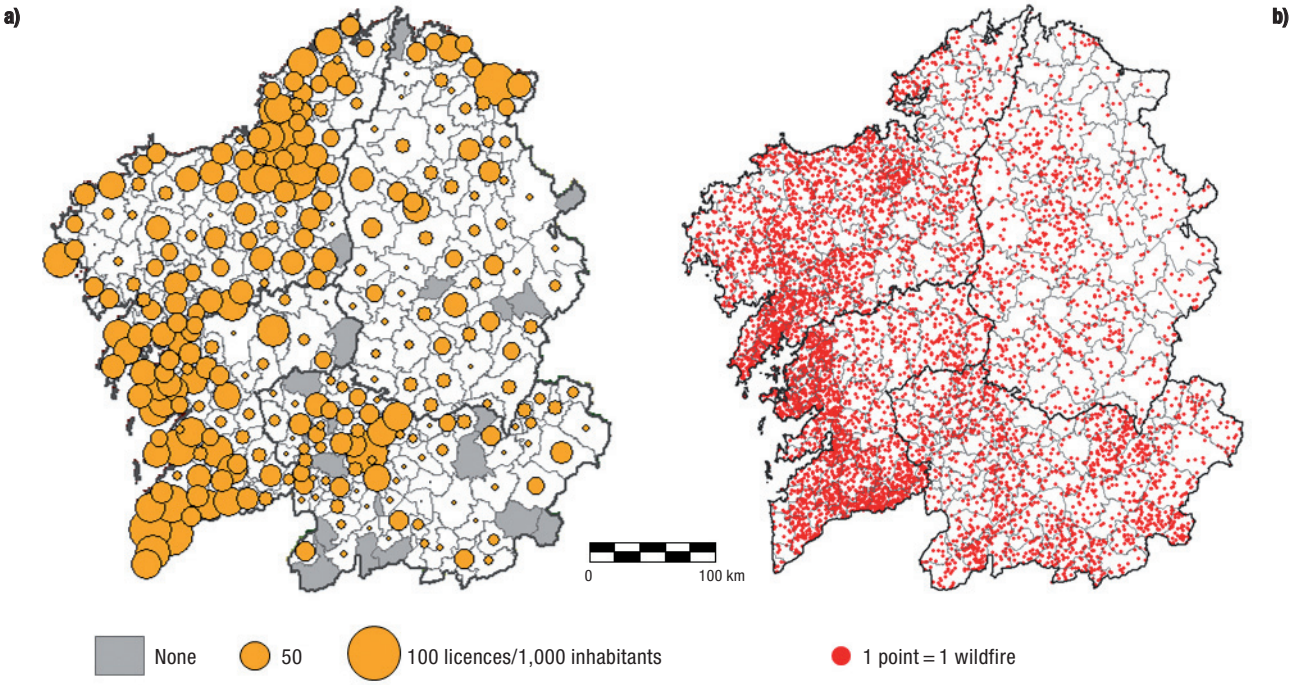

Figure 9. (a) Number of construction licenses per 1,000 inhabitants between 2001 and 2006. (b) Spatial distribution of Galician wildfires in 2006. *Source:* (a) Instituto Nacional de Estadística, 2006. (b) Consellería de Medio Rural, 2007.

affected surface from the previous five years (FAA2001-2005) in the different forest districts. It is notable that, in 2006, greater amounts of forest were burned in six of the forest districts from Pontevedra and A Coruña than in the five previous years.

The area influenced by the AP-9 motorway contains the highest population concentration and the majority of economic activities in Galicia (Fig. 3b). Municipalities in this area are largely urban or peri-urban, with high population density rates and stable or positive demographic growth rates (Hernández, 2005). Population density rates are additionally influenced by proximity to major Galician cities and to main civil infrastructures. Foreign immigration dynamics recorded during recent years had a beneficial effect by balancing the negative vegetative growth. Main economic activities in the *Atlantic axis* belong to the tertiary sector. Here, forest areas are under continuous pressure by both economic and residential activity. Wildfire occurrences may therefore have been caused by the subsidiarity of the forest to other economic sectors, but were likely also affected by the lack of proper and consistent management practices following owners' initial investments.

Galician wildfires in 2006 also affected forests in *A Costa da Morte* (A Coruña), an area with high environmental and landscape value. Most of the municipalities in this area have stable or slightly negative demographic dynamics (Balsa-Barreiro and Landsperger, 2013).

Variation of the wildfires' spatial distribution in 2006 greatly increased the vulnerability and level of risk compared to previous years. Authorities' response potential (*e.g.,* extinguishing mechanisms) was limited due to the dispersed nature of settlements in Galicia, and thus efforts were focused more on preventative measures (*e.g.,* evacuations) than in the direct fire extinction, producing a high social alarm (Balsa-Barreiro, 2012a; Rábade and Aragoneses, 2004).

Analysis of socioeconomical motivations of the wildfires

Galicia has the highest rate of fire intentionality at national level with estimates between 73.6% (Consellería de Medio Rural, 2007) and 81% (Hernández, 2006). "Unknown cause" is frequently reported because determining the true cause of many wildfires is a difficult task (Chas and Touza, 2009) (Fig. 8).

The concentration of wildfires in Pontevedra and A Coruña in 2006 reflects a change in certain groups' interests. Analysis of the spatial distribution and typology of wildfires may help to reveal which social

collectives and economic sectors are linked to the fire events.

The urban and peri-urban character of the affected municipalities and the increase of population during the summer time, combined with the scattered population of Galicia (Balsa-Barreiro, 2011) elevated the fire risk (Pérez and Delgado, 1995; Badía *et al*., 2010). Although the official investigation does not account for the existence of organized plots (Molano *et al*., 2007), it seems evident that the intention of the fire perpetrators, whether organized or not, was to cause panic by setting fire to forests close to urban areas and in areas with environmental and landscape value. In many cases, this forced the evacuation of citizens, which increased media coverage and the social perception of emergency situation.

The construction and real estate sectors were suspected to be involved in Galician wildfires in 2006, due to the tourist potential of the Galician coast framed in the economic boom context of mid-2000s. The vegetative growth of coastal municipalities and the population concentration entailed an urban sprawl process, which was accelerated by increasing tourism, which is a significant factor in several coastal municipalities' economies. Traditionally, forest burning as perpetrated by the real estate sector aimed to create new areas for development, simultaneously causing a decrease in land prices resultant from an increase in land supply. The spatial distribution of Galician wildfires in 2006 highlights the strong correlation between urban development activities and fire density, especially in the municipalities of Rías Baixas in Pontevedra, which gather most of the construction activity linked to the tourism boom (Figs. 9a and 9b).

The timber sector has also fallen under suspicion of arson. Pyrophytic reforestation species, such as the eucalyptus, close to the Atlantic coastline (Elorza, 1965) was another factor that aided the rapid spread of wildfires. The fire concentration in this area may incriminate also fundamentalism activists (Cancio, 2003). These environmentalist groups have some importance in Galician society and reject the notion of reforestation with exotic species. The construction boom greatly increased wood demand. Wildfires on the Galician coast would diminish wood prices, thus forcing owners to sell at minimum prices and increasing the supply in a sector where reforestation species are demanded by the timber industry (Díaz-Maroto and Vila, 2002).

Public administrations have developed laws to minimize rezoning in forests affected by wildfires. Such laws include the national-level *Ley de Montes* (43/2003) and the Galician *Lei de ordenación urbanística e protección do medio rural* (9/2002). Both laws deal with rezoning procedures following wildfire events to avoid involvement of vested interests. The National Law specifically prohibits land-use change for burned locations within at least 30 years of a fire event. The Galician Law prevents rezoning of all forest and rural land without specific permission of the Galician Government. In addition this law specifies that all burned forest becomes protected rural forest land (*suelo rústico de protección forestal*). Although the National Law prevents land-use change of burned forests for at least 30 years, loopholes and implementation difficulties work in favor of speculator interests. In fact, this law is only applied to closed forests and excludes shrublands or open forests. Therefore as 42.1% of burned areas in 2006 were open forest, the national law does not preclude rezoning.

Analyzing the burned forest surface at the provincial level, it is noted that open forests are less protected by the laws and as such are always most affected at the relative level (Fig. 6). A Coruña and Pontevedra are the provinces with less open forest surface (Fig. 3a), and this forest typology was significantly affected by wildfires in 2006, the relative values being higher than 16% in both provinces. However, the ratio between closed forest area burned and the overall closed forest area is lower than the shrublands and open forest ratio in the four provinces, with a notable relative difference in A Coruña (Fig. 6). It remains unclear why the province of Lugo was not the most affected, as it has the largest closed forest extent (33% of Galicia) and a significant presence of reforestation species at the coastal sector. In fact, only 12.8% of the wildfires occurred in Lugo, affecting 2.7% of the burned closed forest (Fig. 7b). A possible answer may lie in the specific natural and environmental conditions of the coastal area of this province. Besides the relative population density, higher rates of humidity and rainfall create less favorable conditions for the spread of wildfires.

The practice of recreational hunting may have also influenced occurrence of wildfires in 2006. These activities, at their extreme, are a denigration of the post-materialist dimension of the forest (Lage, 2002). The intentional burning of forest located near urban areas by certain related groups would influence the expansion of hunting areas by increasing visibility, stimulating habitats for small game species, and/or merely

protesting against the limitations and restrictions of hunting areas (Fernández-Couto, 2006).

Some agricultural and livestock activities have different motivations for fire usage. For example, stubble burning is a frequently practiced activity that aims to expand agricultural lands, remove crop-damaging wildlife, facilitate the movement of people or vehicles to private plots, and increase the visibility of plots affected by land consolidation or expropriation processes. Livestock activities, especially in areas with extensive agricultural systems, use fire to enlarge and renew the pastures, eliminate predatory wildlife and increase cattle visibility to improve control and management.

The spatial distribution of Galician wildfires show that these occurred largely in municipalities where the communal ownership regime was involved (south-eastern A Coruña and in much of Pontevedra). This would confirm, under certain circumstances, the communal ownership regime as a primary risk factor in 2006 (Pérez and Delgado, 1995). This regime occasionally produces a management model where many forest owners live in urban areas and, consequently, neglect their forest management responsibilities. A lack of rural landowners' understanding of tasks and responsibilities leads to poor forest management in many of the MVMCs. Proximity of these areas to main cities increases the number of stakeholder groups involved and the complexity of interactions between these groups' interests regarding the areas' exploitation. The absence of agreements between landowners causes mismanagement as well, and thus in light of conflicting interests, fire may be used as a pressure instrument.

Discussion

This paper presents a methodology to analyze the causes and motivations underlying the occurrence of wildland fires. We have applied this methodology to fire episodes in Galicia in 2006, analyzing both the change in spatial distributions and possible involvement, motivations, and interests of particular social collectives and economic sectors. The events of that year require a broad framework, wherein the forest management model presents serious structural deficiencies (Balsa-Barreiro, 2012a). The methodology proposed enables analysis of the connection between spatial coincidence and distribution of socioeconomic data and registered fire dynamics. Data are collected at the municipality level, the lowest administrative level. Spatial representation is achieved by means of Geographical Information Systems (GIS) which allow for the spatial relation of socioeconomic and geographic data.

During the 20th century Galicia has gone from a predominantly rural region, with an economy based on subsistence agriculture and livestock, to an urban society with relatively high specialization in the tertiary sector. There is a considerable demographic and socioeconomic imbalance between the Atlantic coast and the inland sections, the latter being a direct consequence of the former. While the inland sector of the region has experienced strong population declines, the *Atlantic Axis* comprises most of the population and also has positive demographic rates.

This population dynamics model has influenced the management and exploitation of forest area. In the traditional agrarian model of early 20th century, the forest was perceived as a multipurpose space with multiple uses and functions complementing the economy of rural societies of that time (Bouhier, 1979; Marey *et al*., 2004). This forest management model was sustainable and balanced, adapted to both transitory demographic needs and existing technology (Marey, 2003). A breakdown of the balance between population and resources occurred when resources diminished and/or when the migration flows greatly increased. The massive rural flight of the second half of the 20th century that began with the migration to Central Europe led to a series of socioeconomic changes that altered the agricultural model in use (Marey *et al*., 2004). The rural flight mainly affected the working-age rural population, causing regressions at both demographic (depopulation, declining birth rate, population aging) and economic levels (workforce and competitiveness loss, unviability of the farms, lack of generational replacement).

Expanded urbanization in the mid-20th century augmented the contrast between rural and urban areas, especially after the 1960s with the development policies promoted by the Franco regime (1939-1975). Rural areas became a declining environment with an increasing average age, implying less competitive economic activities. This resulted in a cessation of farming activities and, eventually, in the abandonment of many agricultural plots (López, 2000; Crecente *et al*., 2002; Corbelle and Crecente, 2008).

The demographic imbalance and the intensified conflict between rural and urban areas forced a conver-

sion of forests, which adopted a complementary role for the family economy, mostly unrelated to agricultural activities. Thus, the Government decided to reforest shrublands and open forest by introducing foreign species (*e.g.,* pine and eucalyptus) which have high levels of productivity and profitability, making it a clearly lucrative measure (Rico, 1995).

Government reforestation actions continued until the mid-1960s and then were imitated by private owners, who possessed most of the forested lands. Coupled with the lack of owners' professionalism, most being completely unfamiliar with the rural reality, forests were oftentimes perceived as "investment funds". There are major demographic and socioeconomic differences between urban and rural models. Both models have a different perception of the forest, but both agree on its dependency to other productive sectors. There is a conflict between the rural and urban models, the former having historically been used to manage the forest, and the latter having arbitrarily imposed laws and practices on the rural world. This conflict is clear at multiple scales: between provinces (inter-provincial level), within provinces (intra-provincial level), and between different lower administrative and territorial divisions (*e.g.,* comarcas, municipalities).

While Galician wildfires in 2006 contrasted in several different ways with previous years' fires, the fundamental problem was the same. The enormous scale of fires was unexpected by both fire extinguishers and authorities due to changes in several characteristics of the wildfires, including spatial distribution, spatio-temporal concentrations, proximity to populated areas, and closeness to tourist settings during high season. These factors explain the failure of firefighting systems, which were clearly overwhelmed due to the proximity of roads and inhabited areas. As a consequence, a feedback phenomenon occurred with grave consequences.

Galician wildfires in 2006 are exemplary of a constant and recurring problem. Inefficiency of the forest areas, the dependency in regards to other productive sectors, low levels of owner professionalism, and the conflict between rural and urban worlds are some of the problems explaining the dysfunctional forest management model and its limited adaptation to the current reality of Galicia (Ambrosio *et al*., 2001).

Although this methodology proposed in this paper has been applied to a singular and unique challenge, it also can be consistently used to analyze the causes and motivations of wildfires in other regions at national and international levels. This methodology enables an overall view of the greatly nuanced issue of wildfires by providing a framework with which we may analyze fire dynamics. Research outcomes may be used to design novel, or improve current, fire prevention and planning policies.

Conclusions

The socio-geographical analysis of a territory's wildfire dynamics enables us to establish possible causes and motivations of their origins. This is achieved by performing a holistic study of the fire spatial distribution, forest conditions and management, and important socioeconomic indicators. We have applied this methodology to Galicia, which is traditionally one of Spain's most fire-affected regions. Results indicate that wildfire recurrence within this region is related to an accelerated rural flight process which exacerbates the conflict between rural and urban models. Providing the specific contextual and socioeconomic information, this methodology has potential applicability across varied study locations.

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