Spatial modelling of the influence of human activity on wildfire ignition risk in a Mediterranean landscape

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Introduction

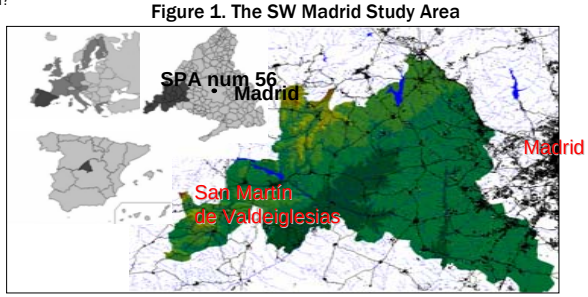
In countries where more than 95% of wildfires are caused by direct or indirect human activity, such as those in the Iberian Peninsula, ignition risk estimation must consider anthropic influences. However, the importance of human factors has been given scant regard when compared to biophysical factors (topography, vegetation and meteorology) in quantitative analyses of risk.

The reasons for this are diverse, but one of the most important is the difficulty in spatially evaluating and modelling the human component of fire ignitions.

Objective

This paper focuses on the spatial characteristics of ignition and ignition risk in the SW of Madrid (Figure 1) between 2000 and 2003. First, we illustrate the spatial patterns of ignition. Second, we determine what socioeconomics characteristics best help us to understand the causes of ignition and delineate areas of high ignition probabilities. We propose a novel approach to analyze fire ignition patterns in relation to independent variables modelling. The proposed approach intends to give answers to the question: are models of spatial wildfire ignition risk affected by how data for human activity are classified?

Figure 1. The SW Madrid Study Area



Methods and Dataset

We used weights-of-evidence based GIS modelling (Romero-Calcerrada, *et al.* 2008) to examine the relative influence of socio-economic variables on the spatial distribution of wildfire ignition risk for a six year time series of 508 fires in the SW of Madrid.

In our study we used 11 independent variables (Table 1), comprised of five socio-economic variables and six spatial variables or spatial attributes of socio-economic variables (e.g. distance to urban areas), for a multi-use landscape in the SW of Madrid, Spain. The spatial variables were defined to represent human access across the study area and the spatial pattern of human land use. National and regional statistics were examined to find the main socio-economic aspects that might be used to characterize ignition risk. All variables were selected because of their influence on wildfire ignition risk.

From these groups of variables we derived four datasets of independent variables using different techniques: socio-economic variables alone (sev) and socio-economic variables using dasymetric methods (sev-dm); and spatial variables using equal interval classes (sv-ei) and spatial variables using cost analysis (sv-ca) (friction maps or cost of human movements). The dependent variable was an ignition point dataset for the years 2000-2003. These data were grouped into four- (Model 1) and two- month (Model 2) fire seasons. Ignition points for 2004 and 2005 were used for model testing.

Eight predictive maps of wildfire risk were produced: 1) four for the two-month fire season combining the four datasets of independents variables (Group 1. sev-dm and sv-ca; Group 2. sev and sv-ca; Group 3. sev-dm and sv-ei; Group 4. sev and sv-ei) and 2) another four for the four-month fire season using the same dataset combinations.

Table 1. Input Layers

Group	Description (Units)
Socioeconomic Data	Density of Population (Inhab / ha of Urban areas)
Socioeconomic Data	Density of secondary housing (secondary housing/ ha of urban areas)
Socioeconomic Data	Density of Cattle (Cattle/ ha of Pastures)
Socioeconomic Data	Density of Sheep (Sheep/ ha of Pastures)
Socioeconomic Data	Density of Goats (Goats/ ha of Pastures)
Socioeconomic Data: Spatial Relationship	*Distance from Recreational Areas (m)*
Socioeconomic Data: Spatial Relationship	*Distance from Housing Areas, Shopping Areas, etc. (m)*
Socioeconomic Data: Spatial Relationship	*Distance from Industrial Areas (m)*
Socioeconomic Data: Spatial Relationship	*Distance from Roads (Motorways etc. (using car)) (m)*
Socioeconomic Data: Spatial Relationship	*Distance from Tracks: rural path etc. (4WD, walking) (m)*
Socioeconomic Data: Spatial Relationship	*Distance from Camping, Sports areas, etc. (m)*

Results

The results emphasize distinct patterns regarding regional fire ignition in the study area (e.g. Figure 2 and Figure 3). The results show that spatial patterns of wildfire ignition are strongly associated with human access to the natural landscape; proximity to urban areas and roads are found to be the most important causal factors.

Our findings highlight the importance of considering socioeconomic variables when modelling and predicting the spatial distribution of wildfire ignition risk in Spain. The models produced using the independent variable groups of Group 4 (sev and sv-ei) and Group 2. (sev and sv-ca) are better than the models using Group 1. (sev-dm and sv-ca) and Group 3. (sev-dm and sv-ei;) sev-dm / sv-ei and sev-dm / sv-ca. The first group of models is more accurate (see also Figure 4 and Figure 5).

Figure 2. Ignition Risk Map. Model 1. Four months Group 2. (sev and sv-ca).

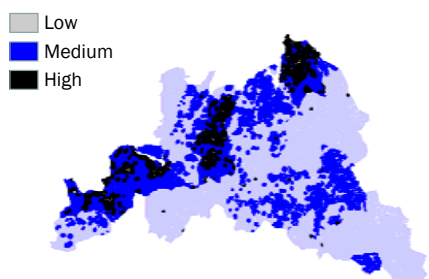


Figure 3. Ignition Risk Map. Model 1. Two months Group 2. (sev and sv-ca).

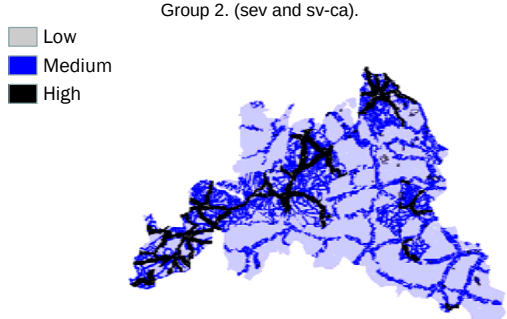


Figure 4. Density of Ignition Points (Number of Ignition Point / ha * 10000)

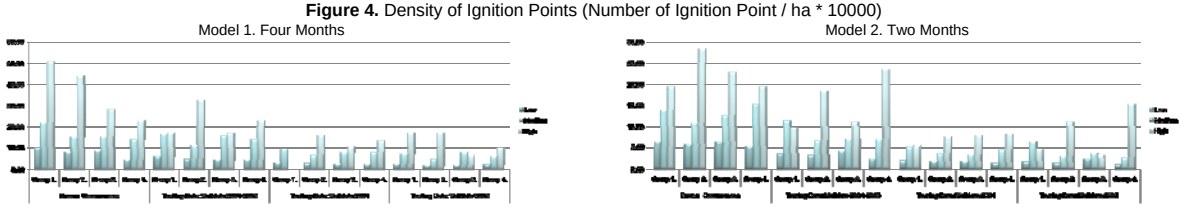
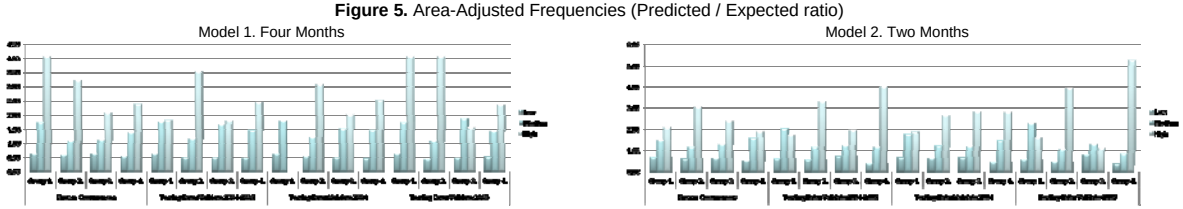


Figure 5. Area-Adjusted Frequencies (Predicted / Expected ratio)



Implications and Conclusions

We suggest the methods and results presented here will be useful to optimize time and human resources in areas where the urban-forest interface is increasing and where human activity is an important cause of wildfire ignition. Our findings suggest the importance of socioeconomic variables modelling for the explanation and prediction of the spatial distribution of wildfire ignition risk (structural risk) in the study area.

Socioeconomic variables need to be included in models of wildfire ignition risk in the Mediterranean and will likely be very important in wildfire prevention and planning in this region.

Reference

Romero-Calcerrada R, Novillo CJ, Millington JDA and Gomez-Jimenez I (2008) GIS analysis of spatial patterns of human-caused wildfire ignition risk in the SW of Madrid (Central Spain). Landscape Ecology. 23: 341-354