

Orchestrating Criteria and Resources in Forest Fire Defence Planning: Some Results of Practical Application

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Abstract

Forest fire defence planning has many facets. During the last years a number of methods have been presented to help fire managers tackle with all components regarding prevention, vigilance, extinction and evaluation of losses due to wildfires. Nevertheless, there is not a concise, easy-to-follow and significant procedure of orchestrating defence criteria in the planning of resources and infrastructures for a territory.

Based in the experience in a region of Spain, this paper shows a rationalised procedure of how to incorporate all elements of forest fire defence planning while including every specific criteria. To accomplish this task, several phases have to be completed, namely, the analysis of forest fire defence demand, in which many factors take place like topography, meteorological conditions, forest fuels and socio-economic aspects; the establishing of defence criteria, expressed as response times; the analysis of the current forest fire defence offer, embracing infrastructures and aerial and ground forces; and finally the analysis of areas which are under defective or excessive coverage in terms of fire defence.

The final result will be a number of actions on the modifiable components which will be ranked in terms of priority and impact on the final plan and sorted in a time table for their execution. Some practical results in Madrid province (Spain) are also shown.

Facts

Forest fire defence planning tackles with a number of factors which are time and space dependant. Some of them are modifiable factors on which planning can directly act, and others are non-modifiable factors which must be predicted and modelled to complete planning on possible scenarios. May I remark that, although we are dealing with a large number of variables, in the practical realm we will focus first on those that explain most of the forest fire landscape and its evolution.

Among non-modifiable factors may we focus on topography, weather and wind, these are components that can be inventoried or predicted. For the modifiable factors we are limited to act on the forest fuels, either on the type and composition and the spatial distribution, and on some of the causes of fires, in particular those which have human origin. To complete the components, and in the side of forest fire defence, we will focus on the infrastructures, such as access roads, vigilance towers, water points and bases, and the aerial and ground means for forest fire fighting.

All the mentioned components are not independent. In fact they are linked by their position in space and time, and it is the matching of the moment and place of action that entails fire events and conditions their evolution.

Information systems, throughout spatial analysis, will help us noticeably in finding such combination of hypotheses and to simulate actions on the modifiable factors to see the consequences. Typically, this analysis of territory has focused on the values obtained for every cell in the raster map, assuming uniform conditions for every one.

Instead, and as a result of practical application, it is proposed the use of cross-sections of the territory, obtained from every point and along all the surrounding directions. Thus, the fire potential class of every point will be ranked depending on the fire intensity and spread rate values found along the analysed profile, and not just because of its own point-wise values. In this way every point will be typified by its potential to initiate, consolidate and propagate the fire.

In the analysis of profiles it has been found a number of transition areas (TA) which will drive the main criteria of forest fire defence planning:

- Zone A. Ignition
- Zone B. Initial fire
- Zone C. Consolidation
- Zone D. Jump to crown fire
- Zone E. Interfacing with urban areas and areas of ecological value

The occurrence and evolution of such transitions have to deal with the matching in time and space of the governing factors and, as part of the fire landscape, infrastructures and fire fighting resources which will meet defence demand in time and space.

Together, the occurrence of fire in every transition has an associated elapsed time, which will be the main link with the evolution of fire fighting operations. To put it in a single way, in the end, planning of fire extinction operations is the analysis and co-ordination of such times to avoid transitions of B, C, D and E zones, while preventive operations will deal also in avoiding A zones.

In this point it is interesting to notice that before a fire starts, and under certain weather and wind conditions, planning and preparedness of fire defence is based on the discrimination of such transition areas of all territory. But also, and particularly, after a fire has started, such zones are found progressively along fire front during its evolution. In the first case the method will be applied for preventive strategies, while in the second situation the method will help to plan specific fighting operations.

Proposal of method for integrated planning

In light of the above, it is proposed a combined analysis of factors to co-ordinate defence criteria and apply the results in the final planning. Information systems will help us noticeably in this task, which is intrinsically complex due to the spatial and temporal variability of factor

In order to simplify the approach, it is proposed to identify which parts of the territory could entail transition areas A, B, C, D and E and how to tackle with it by programming preventive actions and forest fire fighting capacity.

To identify such parts it is proposed a simplistic but meaningful approach by merely comparing spatially the values of forest fire defence offer and forest fire defence demand. From the nature and amount of such difference a list of defence actions and priorities can be easily identified.

Forest fire defence demand

Fire defence demand can be understood as an index which embraces the main factors of territory and that can be particularised for every point. For the calculation of forest fire defence demand it is proposed, first, to make a detailed inventory on the mentioned factors and store the information in raster, cell-based maps.

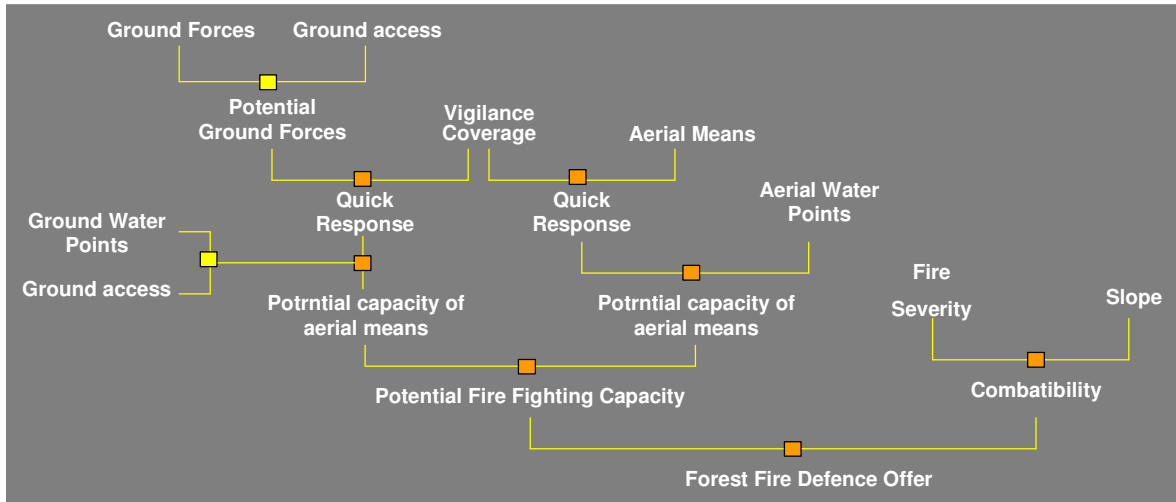
For every resulting cell, a number of calculations are made, namely:

- Fire intensity and fire spread rate, which combined give an idea of the destruction potential of a fire. This has to do with the identification of B, C and D and E zones.
- Ignition probability and historical pressure, which combined gives an idea of how prone a point is to ignite. This has to do with the identification of A zones.
- Both combined components, fire potential and fire prone likelihood, can be re-combined thus obtaining an integrated index of fire effect
- In the other side, ecological value and social use of territory can be combined into an index embracing a simplified expression of terrain value. This has to do with D zones.
- Finally, by combining forest fire effect and terrain value a final, simplified index is obtained that could be understood as forest fire defence demand, which explains, for a certain weather and wind conditions, how much fighting capacity is asking the territory for.

The combination of values are done using re-classification matrixes. Broad ranges such as Low, Average, High and Very High are used instead of numerical values in the matrixes. Re-classification rules are obtained by consulting a representative number of experts and managers who have to deal with all the implied factors in the analysis.

Forest fire defence offer

A similar approach of re-classification of maps using matrixes can be followed for the calculation of forest fire defence offer. In this case the components which are considered are shown in the following scheme:



As seen above, ground accessibility is a key factor in the whole scheme. In fact, road and access lane network has a double effect in the sense it provides access both to the fire area and the water points. In case of E zone, roads give essential support in the evacuation and rescue operations.

The spatial distribution of ground forces, that is, the type, number and location of bases, is weighted for every according the accessibility to such point for every type of vehicle. It has been observed that almost any fire fighting vehicle can access through the lanes to the fire area, but what discriminate ground mobility is the movement of forces within the fire area, particularly by cross-country and through mechanised lanes. In such cases, just a number of specialised vehicles, and in certain conditions of slope, firm and rock presence, can actually move.

The potential fire fighting capacity has taken into account the combined operations of aerial means and ground forces, each one with own restrictions and accessibility to specific water points.

Consideration about combatibility, that is, the degree of easiness and effectiveness in the fighting operations due to local conditions and fire severity, is a key component in the evaluation of final values of forest fire defence offer.

Identification of actions and priorities

The spatial, direct comparison of fire defence demand and fire defence offer will have a positive or a negative value between -3 and +3:

		OFFER			
		L	A	H	VH
D E M A N D	L	0	+1	+1	+3
	A	-1	0	+1	+2
	H	-2	-1	0	+1
	VH	-3	-2	-1	0

Final comparison matrix Offer vs. Demand

L Low
A Average
H High
VH Very high

1	-3	VH	L	ZONE 1
2	-2	VH	M	
3	-2	H	L	
4	-1	VH	A	
5	+3	L	VH	ZONE 2
6	+2	M	VH	
7	+1	H	VH	
8	+1	M	H	
9	-1	H	M	ZONE 3
10	-1	M	L	
11	+1	L	H	
12	+1	L	M	

This process is applied to every cell in the territory, hence it can be identified a number of areas and associated actions which are prioritised according their impact on the territory, namely:

- Zone 0. Very low priority. Well covered area. It is equilibrated area, nevertheless it has to be characterised the nature of equilibrium (stable, unstable)
- Zone 1. Defective offer. Actions: Reduction of fuel load or change fuel type. Improve road network. Improve number and position of ground and helicopter bases. High priority
- Zone 2. Excessive offer. Actions: Move resources to Zone 1 where it is possible. Change budget and reallocate it. Average Priority
- Zone 3. Less impact. Act in the sense as shown in ZONE1 and ZONE 2. Low priority

Conclusions

The combined analysis of factors in the forest fire lanscape gives the opportunity to effectively orchestrate fire defence criteria by acting accompededly on modifiable components. To make the process simpler, it is proposed to focus on the most significant factors and to inventory or predict them accurately.

Co-ordinating times is a key skill that forest fire extinction managers have to develop in consonance with planners of preventive actions, particularly on the chapters of forest fuel management and improvement or extension of road and access lanes network.