

A Model for the Financial Assessment of Forest Fire Prevention Plans in Mediterranean Forest Ecosystems¹

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Summary

Current developments in the organisation and management of the prevention of forest fires addresses a line of work which will enable an in-depth insight into the interrelation between budgets invested and the results of those investments. Historically, budget management has never been subjected to an objective, scientific and justifiable procedure, but rather the process has been governed by expansive growth of costs and by demand, and in the majority of cases there has been no mid-term investment planning.

When circumstances change and the availability of funds is restricted there is a under valuation in forest management which impedes the maintenance and availability of budgets on previous levels, and when this happens it is necessary to document and justify the request for public funds to deal with genuinely necessary costs. In this phase and with a view to finding an efficient and planned response to the problem, there is a need for a work tool which is able to integrate, not only factors associated with the variables of financial analysis but also the consideration of factors and parameters involved in the presence of forest fires in areas needing protection. This has motivated the instigation of a research programme to develop a model able to create a cohesive interest and relation of all the variables regarding relations and activities associated with the management of forest fire prevention schemes. The philosophy of development behind the model was to devise a solid and yet polyvalent basis for exportation of the model results so that although a specific area of land was taken to develop the models in its design, definition and experimental stages as well as for its application, the material obtained should permit its application to other zones, bearing in mind the necessary adaptations.

The importance of obtaining an initial model in Mediterranean areas which includes the results of the means of suppression and particularities of the suppression procedures used, such as the abilities of different forest systems to recover following the impact of fire, focuses on obtaining a model based on economic criteria of the procedure, or a work tool which aids assessment and planning in the application and monitoring of defence plans.

Execution of the project will include an investigation to determine objectively the relations between the options proposed by forest fire prevention programmes and the consequences reached in terms of cost and foreseeable loss in the quantity and the quality of resources which may be affected after the impact of fires. Therefore, it should be understood that the focus of the methodological process of the investigation will be the cost –benefit analysis applied to defence and protection programmes.

In order to establish the basic conditions it is necessary to make an in-depth analysis and to acknowledge the statistical basis for forest fires and to make the requisite connection of real fire data (conditions and particularities of the first attack and extended attack) originating in the specific zone chosen for the experiment.

The identifying features of the evaluation models, since they were first devised, have

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been conceived as management tools, thus the concepts and basics of pure investigation have been relegated to the phase of definition of instruments and requirements of economic nature. The development model will be presented in computerised format to facilitate calculation and so that operability is guaranteed and providing generalised application for users with direct responsibility in the organisation and management of fire-fighting programmes.

General Description of the project stages

The work involved in obtaining the model comprises the following stages:

1. Documentary stage, collating bibliography.
2. Knowledge stage, breakdown of the structure and operational basics of the NFMAS model
3. Bibliography review.
4. Historical compilation of real applicable cases and results obtained from the NFMAS model in USA.
5. Selection of functions, relations, loops and commands which are genuinely exportable from the NFMAS model for use in creating the model to be developed for application to Mediterranean areas.
6. Territorial recognition state and selection of work areas, for which management of prevention and fire-fighting programmes will be analysed.
7. Creation of the databases required to implement the model.
8. Development of the model.
9. Computer programming of the model and link with GIS tools (Geographic information systems).
10. Calibration and verification of the model in the field. Operation in actual fire-fighting conditions.
11. Compilation of user manuals and application of the model.
12. Presentation of material produced.
13. Training for system users.

Factors to be taken into account.

The model has basically been developed in relation to the principles and tools of economic nature based on:

1. The theory of marginal analysis
2. The inclusion of criteria for economic efficiency expressed in terms of “cost+net change in the value of resources”,
3. Estimation of the magnitude of change in production as a result of specific changes in the quantity of one or more of the inputs taken into account in the evaluation process
4. An analytical, formal and objective process.

From the perspective of model capacity the following operative and calculating possibilities were considered:

1. The assessment and comparison of efficiency and effectiveness of a protection programme and its options.
2. The measurement of burned areas and the number of fires classified by size and intensity which will result in analysis time and for a proposal for a specific programme of prevention and protection.
3. Evaluation by means of a specific simulated model able to examine the protection options against specific types of fires proposed and the strategies for dispatch of resources according to the specific conditions of these. The following variables were considered with this in mind:
 - The occurrence of historical risk
 - Cartography of fires occurring within the historical period under analysis and the areas of analysis of fire prevention management programmes
 - Potential risk of fire occurring
 - Differentiated incorporation in the map of potential hazards in areas of analysis of forest fire prevention management
 - Mobilisation time and access to resources
 - Land conditions
 - Difficulty in executing fire suppression work
 - Fire behaviour
 - Productivity of active resources
 - Specific size of control and time required
 - Evaluation of potential for escaped fires
 - Forest fuels
 - Seasonality and frequency of dominant meteorological phenomena
4. Capitalisation of the experience gained from the procedures followed in fighting forest fires. In addition to the detailed analysis of results obtained in suppression work, through research in the last ten years in the national database of fires, data has also been compiled on the real time (direct monitoring of fires in the field) results, effectiveness and costs of suppression of fires occurring in 2002 and 2003.
5. Determination of the Superficial Contraction Factor (SCF). This factor permits the integration of the effectiveness of suppression resources and is based on the reduction of surface area covered by fire when action is taken to control and finally suppress it, the numerical value is obtained by making a comparison with the theoretical surface obtained by freely developed simulation (without taking into account fire-fighting elements).

Input Parameters of the model

In order to economically assess the fire-fighting and protection scheme the following parameters have been considered as entrance values:

- **Fire behaviour, defining as work tools:**
 1. level of linear intensity of the fire front
 2. speed of propagation
 3. speed of fire propagation in crowns
 4. generation of secondary fires
 5. transition from surface fire to canopy fire
 6. flame length
 7. classification of intervals of flame length in order to obtain types of intensity level of forest fires
- **Derivatives of behaviour and productivity of fire-fighting resources**
 1. Surface and perimeter control for each intensity level of forest fires
 2. time to reach the control perimeter
 3. team forces
- **Organisation and procedures for suppression**
- **Methods for expediting human and material resources. Incorporation of the table for selection of options with specification of :**
 1. individual resources
 2. attack teams
 3. team forces
- **Recognition and inventory of linear systems of prevention (firebreak lines , firebreak areas) and other infrastructures for prevention of forest fires already in existence.**
- **Economic evaluation in analysis zones of management resources for forest fires, taking into account the following:**
 1. timber
 2. pasture
 3. underbrush
 4. fruit
 5. water resources
 6. fish resources
 7. fauna resources
 8. leisure and recreation
 9. hunting resources

10. landscape resources

- **Determination and evaluation of fixed annual maintenance costs for the prevention and control programme.**
- **Determination and evaluation of suppression costs taking into account the following:**
 1. Unit costs per mission/fire-fighting operation
 2. Average cost per hectare relative to the initial attack
 3. Average cost per hectare relative to the extended attack
 4. Average cost per hectare relative to the suppression of large-scale fire
 5. Obtaining the net change in the value of resources for each of the previous situations
- **Economic evaluation of post fire recovery operations in affected areas, with prior determination of resilience of the system.**
 1. Recognition of the effect of fires on resources
 2. Spatial identification of these effects
 3. Quantification of the effects and development of economic measure
 4. Determination if annual production in the absence of fires.
 5. Determination of total production for the planning period in absence of forest fires
 6. Determination of total production for the planning period in the presence of forest fires

Minimum components considered for carrying out analysis and calculation using the SINAMI model computer programme.

In developing the model, the strategy of simultaneous creation of computerised structure of the programme was employed to permit calculation in accordance with the following components and applications:

- Control commands for management of programme utilities
- Printing options of documents produced by the model
- Management of files produced by the document, storage, recovery and indexing
- Identification of the work unit, protected space, forest land, local area.
- Information on the zones of analysis of management of prevention and control programmes also known as zone of analysis of fire management (ZAFM) (figure n° 1)

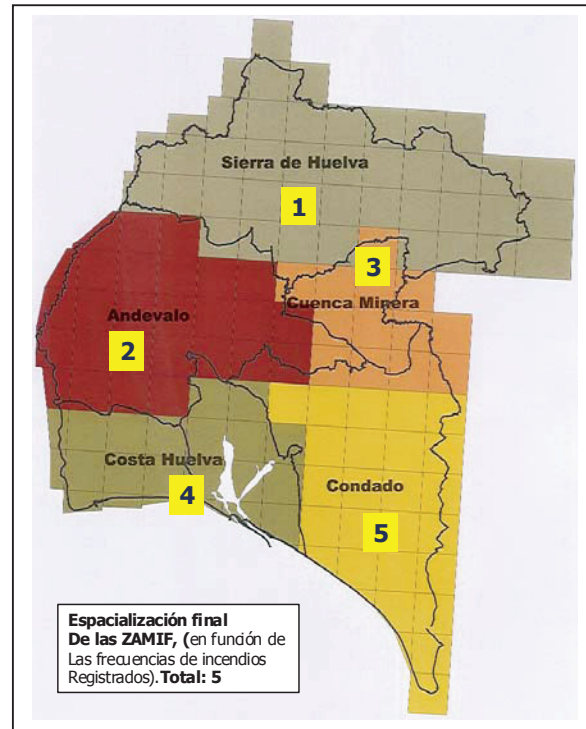
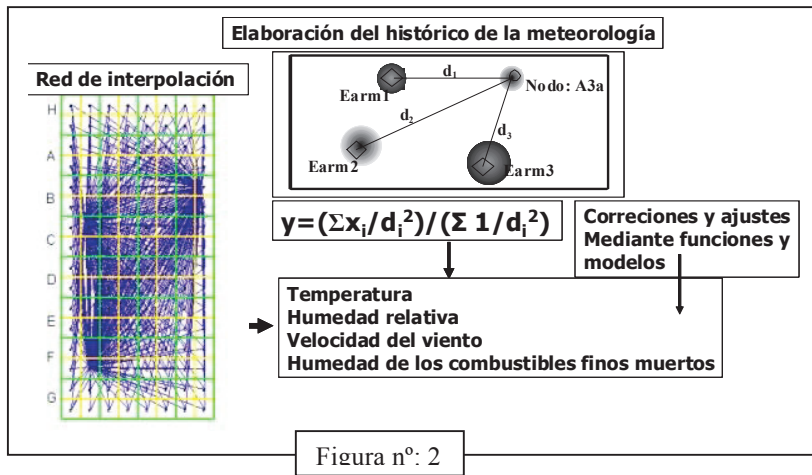


Figura nº: 1

- Limits for escaped fires
- Thematic cartography models of fuels and forest cover
- Presentation of fires per year and per level of intensity
- Speed of propagation to 50 and 90 percentile
- Dimensions of surfaces affected to detection
- Obtaining history of fire occurrence referenced geographically using national statistical database of forest fires.
- Determination by zone of most frequent meteorological conditions using historical data (ASCII format) from the National Meteorology Institute (NMI) and the incorporation of methods of interpolation for determination of meteorological parameters (figure nº: 2)

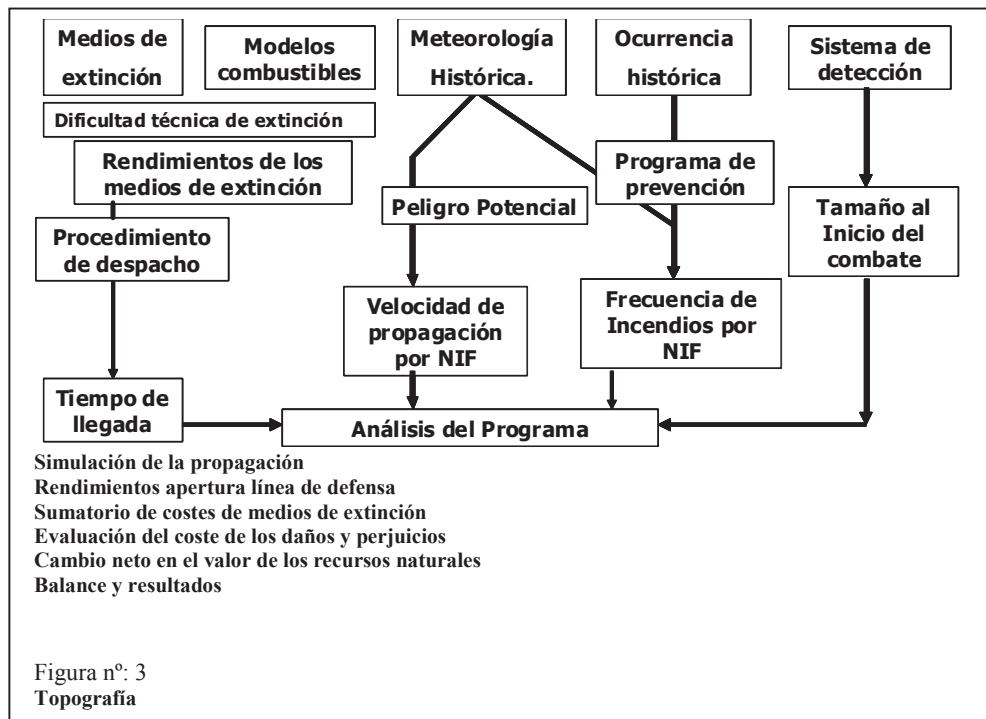


- Determination of the potential evaluation of damages tool for application in economic evaluation. This application serves for evaluation land areas (including zones of analysis and management of forest fires) both prior to a fire and for real measurement and estimation in the case of fire.

General flow line considered in the execution of the model

- **Base model obtained in accordance with:**
 1. Analysis of historical antecedents of forest fires
 2. Analysis of programme of interrelation of entrance parameters
 - Individual means of fire suppression
 - Fire suppression attack teams
 - Fire suppression teams
 - Models of fuel stocks
 - Difficulty of suppression determined by means of calculation of Suppression Technical Difficulty Index (Rodríguez and Silva, 2000)
 - Potential hazard determined by means of calculation of the Potential Hazard Index (PHI), (Rodríguez and Silva, 2000)
 - Meteorological history
 - Historical analysis. In order to integrate historical antecedents calculus and analysis models were used proposed by the NFMAS system (González-Cabán, 2000) developed by the USDA Forest Service, which include models which qualify specific characteristics of the analysis zone and management of fires with greater intensity. The models serve to incorporate, by establishing typical relations “entrance values- exit values”

the required data for the model in order to carry out an economic analysis of the forest fire prevention programme under study. The modules considered are as follows: available suppression means, (types results, and costs) fuel models, topographical aspects, historic occurrence in relation to the fires , detection procedures and times, technical difficulty in suppression, dispatch procedure, arrival times, potential hazard in each zone of analysis and management of forest fires, speed and frequency of fires classified by each level of fire intensity, size at the start of suppression work and final analysis of the programme based on establishing comparisons between the results of suppression resources and the perimeter developed by fire behaviour, the costs and resources and the net change in evaluation of natural resources (figure n°: 3).



- Results of suppression means determined by incorporation of result curves of opening of lines of defence according to fuel models (Porrero M., Chico F., 2000)
- Detection system
- Prevention programme
- Dispatch system of fire-fighting resources
- Arrival times

- Detection size
 - Speed of propagation by intensity level of fire
 - Frequency of fires by level of intensity of forest fire
 - Determination compared between the speed of development of the line of defence (in the establishment of the line of control) and the speed of growth of the fire perimeter. For the development of this phase the forest fire simulator “Visual-Cardin” (Rodríguez and Silva, F. 2002) was included in the model as a calculus tool (figure n°: 4)
3. Initial calculation using registered historical information
 4. Calibration and link up with the planning process

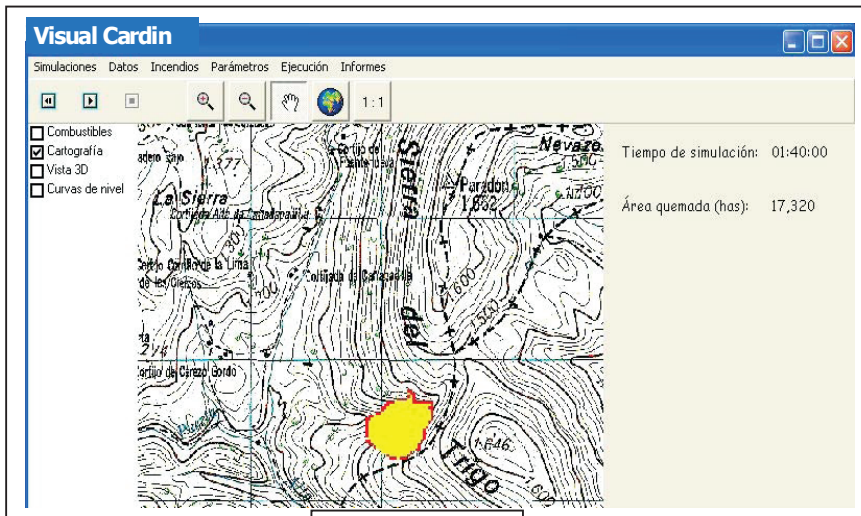


figura n°: 4

- **Evaluation of initial attack taking into account:**
 1. Options from the control programme and budget for each zone of analysis making consultations with the tables compiled from historical information according to:
 - Control language of work
 - Mobilised resources
 - Selection of options
 - Average cost per hectare
 - Escaped fires from expected control
 - Unit cost per mission

2. Contained fires including calculation of affected area.
3. Escaped fires including calculation of pre-affected area
4. Number of fires per size and level of intensity
5. Area affected per size and level of intensity
6. Means used and number of dispatches per annum and per level of fire intensity
7. Forest fire suppression costs
8. Estimation of effects of fire and evaluation of resources
9. Total costs plus net change in value of resources
10. Identification of most efficient defence programme
11. Determination of annual budget
12. Monitoring and evaluation

This application has been defined to enable its methodological extension to evaluation of both extended attack and large-scale fire attacks. This extension of analysis and calculation although determined in its flow line has been postponed for incorporation in the second version of the model.

Selection of zone for development and experimentation of the model

The territory proposed for this study for development and experimentation of the model is the Autonomous Community of Andalusia (region in the south of Spain) and within this area the province of Huelva was chosen. This choice was made on the basis of forest surface, the history of registered forest fires, information on available thematic land cover, information on preventive infrastructures and existing prevention and control programmes. In general the choice of Andalusia for investigation was considered on the basis of its professional organisation and an experienced system of prevention and suppression of forest fires, as well as the fact that it has a concentrated database of registers, compiled from information obtained on past forest fires.

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