P1.1 VALIDATION OF FARSITE MODEL IN MEDITERRANEAN AREA

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## 1. INTRODUCTION

In the last two decades several deterministic models for predicting fire behaviour have been developed. One of the most common fire growth model is the computer program Farsite (Finney, 1998), based on the Rothermel's original fire spread equation. Farsite describes the spatial and temporal spread and behaviour of fire under different terrain, fuels, and weather conditions. It is currently used by many wildland fire managers in the United States to simulate characteristics of prescribed natural fires and wildfire (Keane et al., 2000).

This model is composed of a series of routines that require topography, weather and fuel parameters as input. Realistic predictions of fire growth depend on the consistency and accuracy of the input data layers needed to execute the program.

A generalized description of fuel properties based upon average fuel conditions, called as fuel model, is used typically to describe the physical characteristics of a fuel class in an area. The most commonly used fuel model in the U.S. are the 13 fire behaviour fuel models proposed by Anderson (1982). Recently Scott and Burgan (2005) proposed a new set of fuel model applicable to fire behaviour modelling system that use Rothermel's surface fire spread model. Despite the availability of several fuel model, the final fuel model selection by the user must be based on experience with fire behaviour in the fuelbed under consideration.

This aspect is particularly important in areas of Mediterranean basin where fuel is mainly represented by living vegetation characterized by high specific and structural heterogeneity and complexity. So that for Mediterranean maquis the different fuel models require a local validation in order to improve the agreement between simulated and actually observed fire behaviour.

The main aim of this study is to analyze the effect of fuel models, weather conditions, and topography on the accuracy of FARSITE simulations, in order to illustrate the capabilities of FARSITE model in forecasting the fire spread in Mediterranean areas.

## 2. CASE STUDY

The analysis was carried out on a human-caused fire that occurred in August 2004, on an area of 150 Ha located in North East Sardinia (Agrustos, lat. 40° 43', long. 09° 42', 100 m a.s.l.), Italy.

The area is characterized by the typical sub-arid Mediterranean climate; most of the yearly rainfall (annual mean of 650 mm) occurring during autumn and winter months, while a remarkable water deficit can be observed from May to through September. The mean annual value of temperature is 17° C, but on the summer period the maximum temperature rises 30° C. The average wind speed is high in both winter and summer, with prevailing flow from the west and the north-west directions in over 50 % of cases. Nevertheless the local wind direction can be modified by the irregular topography of the area.

The burned area was mainly covered (≈ 105 Ha) by the typical shrubland Mediterranean vegetation, with plants height ranging between 1 and 4 meters. Dominant species included *Olea europaea* L. var. *oleaster*, *Cistus Monspeliensis* L., *Pistacia lentiscus* L., *Myrtus communis* L., and *Genista acanthoclada* DC ssp. *sardoa.* Small surfaces inside the area were covered by open wooded pastures (≈ 41 Ha) and grasslands (≈ 1 Ha).

The fire started on the afternoon of 26 August near a road along the western side of the area (figure 1); the fire spread on east direction carried by a strong wind (about 10 m/s) with prevailing direction from west. Some residential areas on the south boundary were threatened by the fire. Ground attacks were realized by the Forest Service firefighters on the south flank, especially on the interface with residential areas.

## 3. MATERIALS AND METHODS

Simulations of the spatial and temporal spread of the fire were carried out by the FARSITE Fire Area Simulator model (Finney, 1994). FARSITE model describes fire spread as a function of relationships between fuels, terrain and weather conditions; therefore, a number of themes were acquired and managed by a Geographic Information System (ArcGIS 9, ESRI Inc.) in order to obtain input layers needed to execute the model simulations. The grid resolution of all the spatial information was of 20 meters. A digital elevation model (DEM) was used to produce the maps of slope and aspect.

Fuel map and canopy cover were identified by supervised classification of aerial photographs; additional information were obtained by either field sampling or the land cover map of Sardinia realized by the CORINE project (Marini et al., 1993).

Several simulations were run using four standard fuel models (Scott and Burgan, 2005; Anderson,

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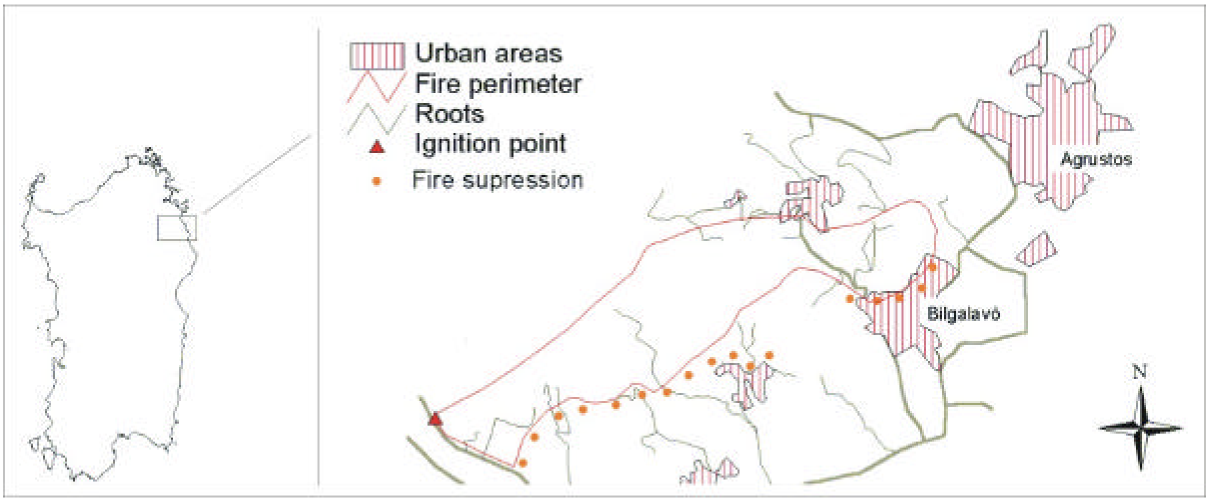


Figure 1 – Topographical map of fire area.

1982) for shrubland vegetation: model n° 4 and 6 of Anderson, model n° 142 (SH2) and 147 (SH7) of Scott-Burgan. Open wooded pastures were assigned to the fuel model n° 2 of Anderson, while grasslands were assigned to the model n° 104 (GR4) of Scott-Burgan. The urban areas were assigned to the fuel model n° 91 (NB1).

The meteorological data used in this study were collected on hourly basis by a weather station of the Sardinian Agrometeorological Service (S.A.R) located 10 km northern the burned area. The following meteorological parameters were used as input: air temperature (T), air relative humidity (RH), wind speed (U), wind direction (W), solar radiation (CC) and rain intensity (P). Values of cloud cover were estimated from solar radiation and extraterrestrial radiation by a regression model. Wind speed and direction were summarized on hourly basis; while the other meteorological parameters were summarized on daily basis.

Spatial and temporal resolution of simulations were regulated by the following parameters: time step (30 minutes), perimeter resolution (30 m), and distance resolution (30 m). The fire behaviour parameters crown fires and embers from torching trees were disabled during all the simulations.

Fire suppression activities were simulated by the ground attack functionality of the model considering that the fire was successfully extinguished by Forest Service firefighting on the south flank of the fire (figure 1). Principal routes were also used as barrier to surface spread.

**4. RESULTS AND DISCUSSION**

The actual fire shape was a regular strip (figure 1); the fire was successful extinguished by fire suppression activities on the south side of the area, whereas on the north boundary, the fire stopped spreading near the ridge-line because of the slope of terrain which suppressed the effect of the wind. The steep terrain and the strong upslope wind didn't allow

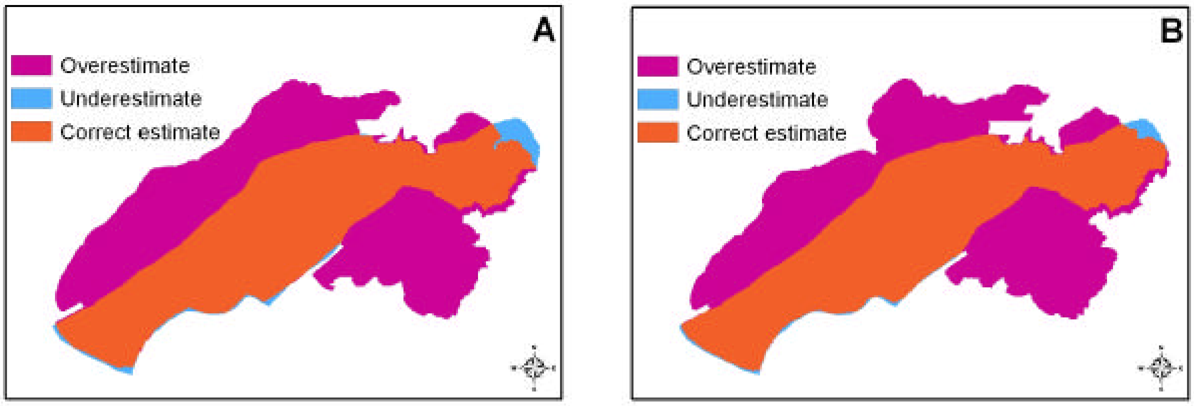


Figure 2 – Comparison between simulated fire behavior and observed fire spread: (A) Model n° 4 with rate of spread adjustment 1.2, (B) Model SH7 with rate of spread adjustment 1.8.

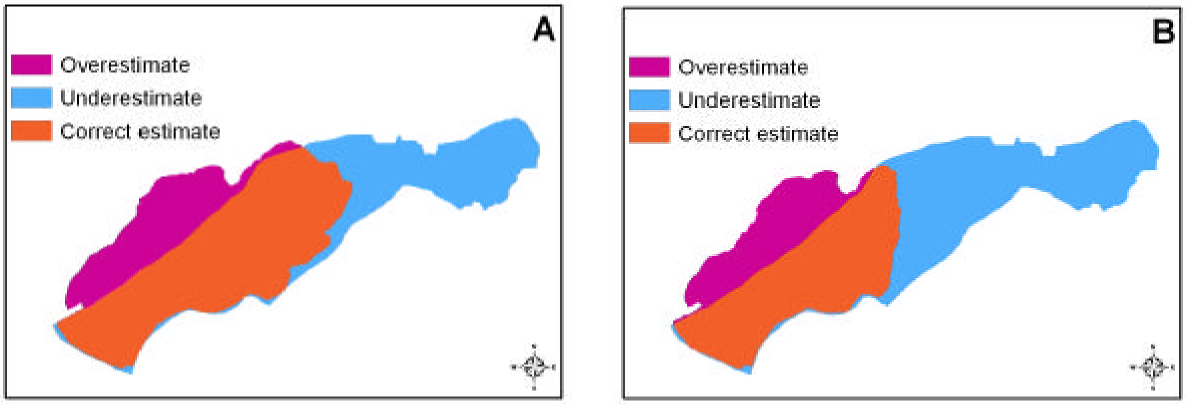


Figure 3 – Comparison between simulated fire behavior and observed fire spread: (A) Model SH2 with rate of spread adjustment 1.2, (B) Model n° 6 with rate of spread adjustment 1.2.

the direct suppression attack on the head of fire. Consequently, the fire rapidly propagated on east direction and only after the 21:00 GMT the spread rate of the fire front decreased, probably due to both downslope wind flow and decreasing wind speed.

All the FARSITE simulations (figure 2, figure 3) overestimated the actual fire perimeter along the north boundary; this behaviour can be explained by a limitation of FARSITE model that does not account for topographic variations that affect wind exposures to surface fires such as ridgetop versus sideslope versus valley (Finney, 1998; Albini and Baughmann, 1979). For the same reasons, an overestimation of the downslope fire perimeter were observed along the south boundary of the fire, near the residential areas (figure 1). Although the fire area was characterized by three different types of vegetation, shrubland vegetation represent about 71 % of the surface and the performances of FARSITE simulations were affected by the characteristics of the standard fuel model used for this fuel type: models n° 4 and 6 of Anderson, models SH7 and SH2 of Scott and Burgan.

The fuel model n° 4 was calibrated using several values of rate of spread adjustment factor; the value 1.2 provided the best agreement with the actual perimeter of fire (figure 2A). Despite the maximum absolute differences between actual and simulated fire area (≈100 Ha), after the calibration the model furnished estimates of the actual fire area with the 95 % of accuracy.

Figure 4A showed the spatial variation of the simulated rate of spread (ROS); maximum values (11-18 m/minute) of this parameter were reached within the first hour after ignition and can be explained with the combined effect of fuel type and strong upslope wind. The steep terrain on the central area of fire resulted in values of ROS ranging between 6 and 9 m/minute. Estimated mean values of ROS are in agreement with actual mean value (≈ 9 m/min). A direct comparison with other published studies was difficult because of the combined effect of vegetation, weather and topographic conditions on ROS; neverthless, values of ROS were in agreement with the mean values

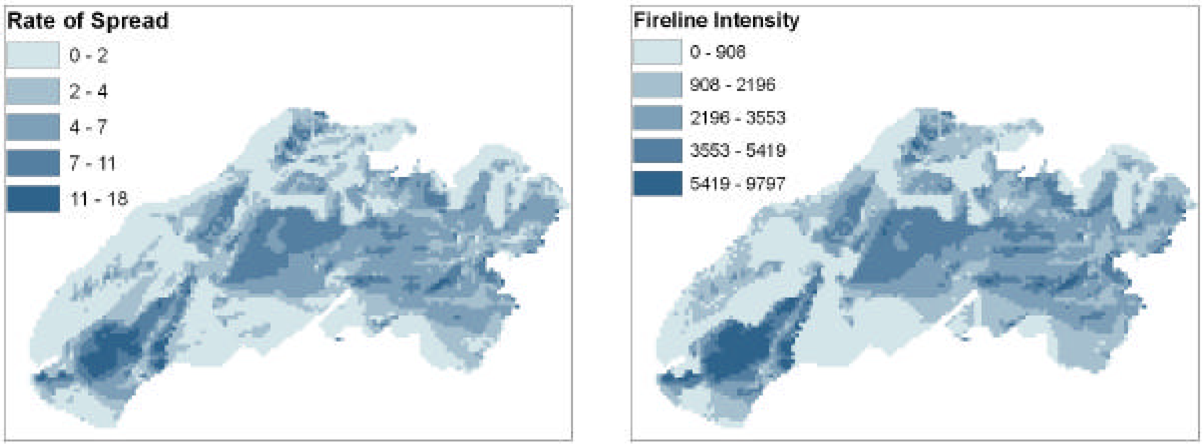


Figure 3 – FARSITE output (fuel model n° 4, spread rate adjustment 1.2): Rate of Spread (m/minute) and Fireline intensity (kW/m).

calculated and measured in Mediterranean shrublands characterized by various specific composition (Martins Fernandez, 2001; Baeza, 2001). Similarly, simulated mean values (figure 4B) of fireline intensity (FLI) are in agreement with values reported by Baeza (2001).

Changing the fuel model 4 with the fuel model SH7 produced an underestimation of the actual fire; therefore, an increase of fire spread adjustment (1.8) was necessary to provide reliable simulation (Figure 2A).

Models n° 6 and SH2 furnished a unrealistic simulation of the actual fire spread (figure 3). Both the models, as reported by the authors (Anderson, 1982; Scott and Burgan, 2005), are characterized by a moderate fuel load and, therefore, by low values of spread rate and flame length.

## 5. CONCLUSIONS

In this work the performance of the fire spread area simulator FARSITE was evaluated in a Mediterranean area. Despite the deterministic structure, the model includes a set of limitations and assumptions (homogeneous fuel, elliptical shape of fire spread, etc.). In addition, FARSITE uses simplified weather and wind inputs. These limitation affect the accuracy of simulations, especially with areas characterized by complex steep terrain. The experimental results confirms the overestimate of actual fire perimeters, and the effect on both the topographic characteristics of the area, and the fuel model. Therefore, the calibration of the fuel model on real fire are needed to test the capabilities of the model in fire management applications. The standard fuel model n° 4 of Anderson provided the better estimation of the fire perimeters in scrubland Mediterranean vegetation.

## 6. ACKNOWLEDGEMENTS

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