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Determination of Fire Danger Based on Weather Measurements Using GIS: A Case Study in Southern and Western Turkey

Abstract

This study presents fire danger for fire prone areas in southern and western part of Turkey. Fire danger was determined based on statistical models developed to predict fuel moisture contents based on weather conditions in normally stocked, even-aged red pine and black pine stands. Geographical Information Systems (GIS) was used to analyze and report the results of the study.

In the case study, fuel moisture contents for 13 different regions were calculated based on daily weather data for the last 11 years during the fire season (April to October). Then digital fire danger maps were produced using GIS. Fire danger was divided into four groups based on fuel moisture contents; low (>%30), moderate (%20-30), high (%10-20), and extreme (%0-10). This way, day to day changes of fire danger among the regions could easily be mapped. The results obtained should be invaluable in all phases of fire management planning.

Introduction

Forest fires have a profound effect on and one of the most important factors threatening the continuity of forest resources in Turkey. The ability to predict fire danger in any area and make the fire planning based on this prediction is extremely important in overall fire management planning. In order to predict fire danger, it is necessary to have comprehensive knowledge of fuel characteristics and fire weather effects on fire danger. The conditions required for a successful fire ignition are related to moisture contents of fine fuel and duff layer on the forest floor (Olsen, 1960; Schroeder, Buck, 1970; Montgomery and Cheo, 1971; Countryman, 1974).

In the recent years, many countries have had their systems set up to calculate fire danger potential based mostly on fire weather measurements. These systems are generally called “Fire Danger Rating System (FDRS). Fire Danger Rating Systems developed to predict fire potential and rate fire danger are decision support tools for fire organizations through providing the needed information. For the system to function properly, information gathered should be accurate, timely and in a usable form. Existing forest inventories have been prepared for necessities of varies forest services and so have different forms. Here, systems are required to collect, store, integrate, manipulate, analyze, and display spatially oriented information in a form necessary for wildland fire planning. In this regard, GIS, which have many application fields, can be quite useful (Bilgili, 1999). One of the most important features of GIS is that due to its capability of spatial analysis and manipulation, it is a decision support tool for fire planning, management and decision-making. Simple or complex, GIS can store, manage, analyze and manipulate geographical information which, otherwise, is not possible to realize by classical methods (Bilgili et al., 2002). GIS could be used effectively for fire prevention, fuel management, pre-suppression and suppression planning.

In this study, fire danger situations were determined for fire prone areas in the southern and western part of Turkey using statistical models (Sağlam, 2002) which were developed to predict fire danger based on the relationships between weather and fuel moisture contents in normally stocked even-aged red pine and black pine stands. Fire danger situations were mapped using GIS and suggestions presented for overall fire management planning.

Material and Methods

This study presents fire danger situation for 13 different regions based on models developed to predict fuel moisture content in standard fuel types and assessments on digital map produced using GIS.

The location of meteorological stations, daily meteorological data derived from these stations and the digital map coverage obtained from completed project (GISLAB, 2002) were entered into the GIS, and fuel moisture contents of 13 different region were calculated using fuel moisture prediction models (Sağlam, 2002). Then, fire danger situation maps were produced using the database. Fire danger was divided into four groups based on fuel moisture contents; low (>%30), moderate (%20-30), high (%10-20), extreme (%0-10). Finally, daily fire danger situations were determined based on meteorological parameters for different regions. Arc/Info™ and Arc/View™ GIS software (ESRI, 1993; 1996) were used to store, analyze and display the results.

Results

Fire danger between the neighbouring regions showed differences during the same days. Figure 1a shows that fire danger calculated based on Fine Fuel Moisture Content (FFMC) was high and extreme on 2 May on Aegean and Mediterranean coasts while it was low and moderate in the inner part of Aegean and Marmara regions. For 6 May fire danger generally increased in some areas, which previously had low level of fire danger on 2 May, especially in the inner part of Aegean region while fire danger decreased in the Mediterranean region (Figure 1b). On the following day, on 7 May, fire danger decreased in some parts of Aegean and Mediterranean coast (Figure 1c).

According to Duff Moisture Contents (DMC) calculations, on 2 May, fire danger was moderate only in Mersin province in the Mediterranean region and low in the others (Figure 1d). In some of these regions, high and extreme fire dangers occurred on 6 May and 7 May (Figures 1e and 1f).

As for the month of July, The fire danger and ignition potential were relatively higher as expected. According to the FFMC, fire danger was high and extreme in the Aegean and Mediterranean regions on 1 July and 5 July (Figures 2a and 2b) but low in the upper portion of Aegean and Marmara regions on 6 July (Figure 2c). According to DMC, especially on 5 July, high fire danger was noted in the part of Aegean and Mediterranean coast (Figure 2e).

According to FFMC, the assessment of fire danger situation with respect to region for September indicated that fire danger was higher in Mediterranean region than in Aegean on 8 September, and fire danger was low especially in the inner part of Aegean and Marmara region (Figure 3a). As for 11 and 15 September, fire danger was high and extreme on the south of Marmara, Aegean and Mediterranean coast (Figures 3b and 3c). Figure 3d shows that fire danger that was calculated based on DMC was high only on the Mediterranean coast, and moderate in other areas on 8 September. For 11 September, in the whole area fire danger was low and moderate (Figure 3e), and for 11 September, no danger was present except for the province of Izmir, Adana and Mersin (Figure 3f).

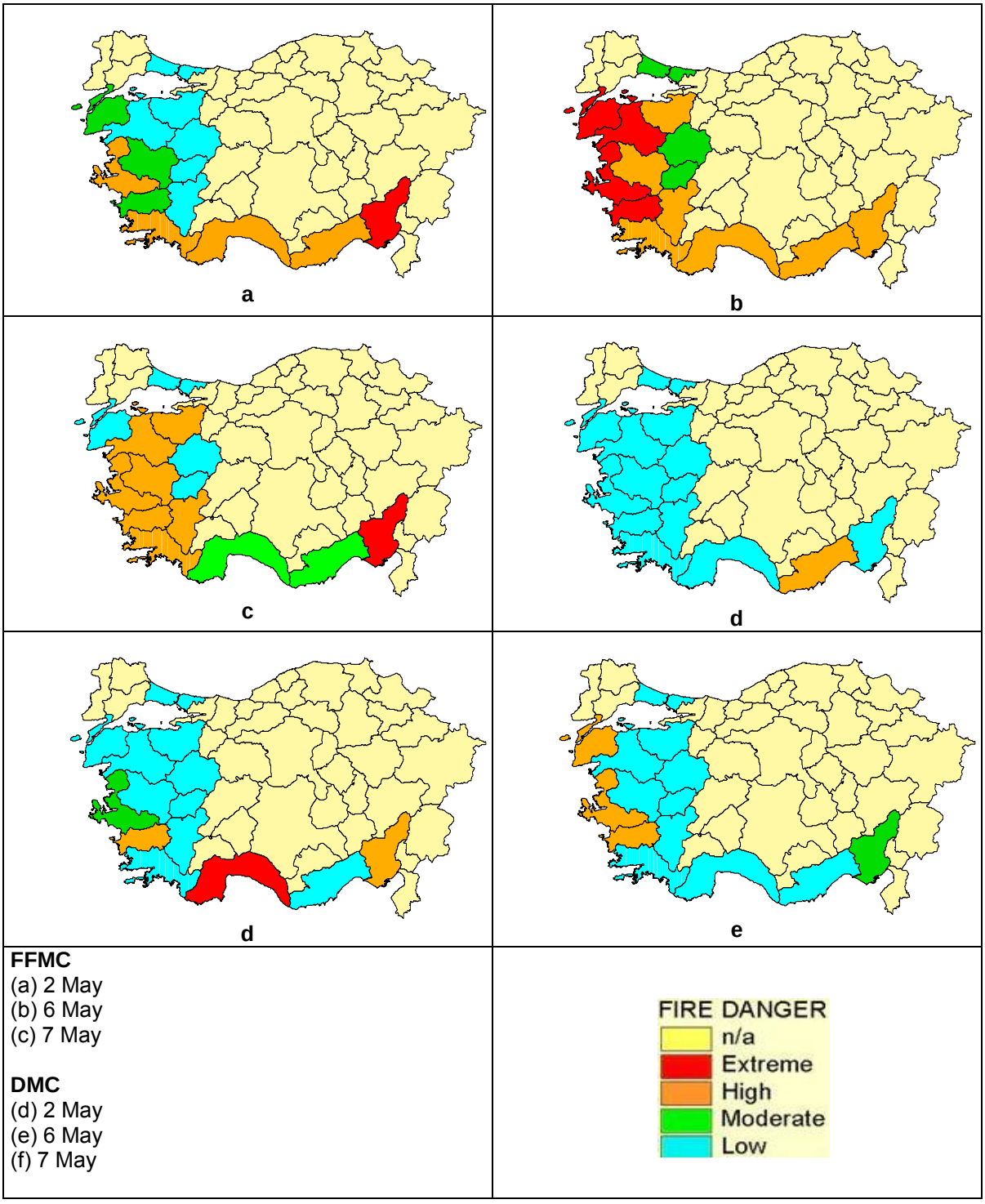

Figure 1. Fire danger situations based on Fine Fuel Moisture Content (FFMC) and Duff Moisture Content (DMC) in early May in Southern and Western Anatolia, Turkey.

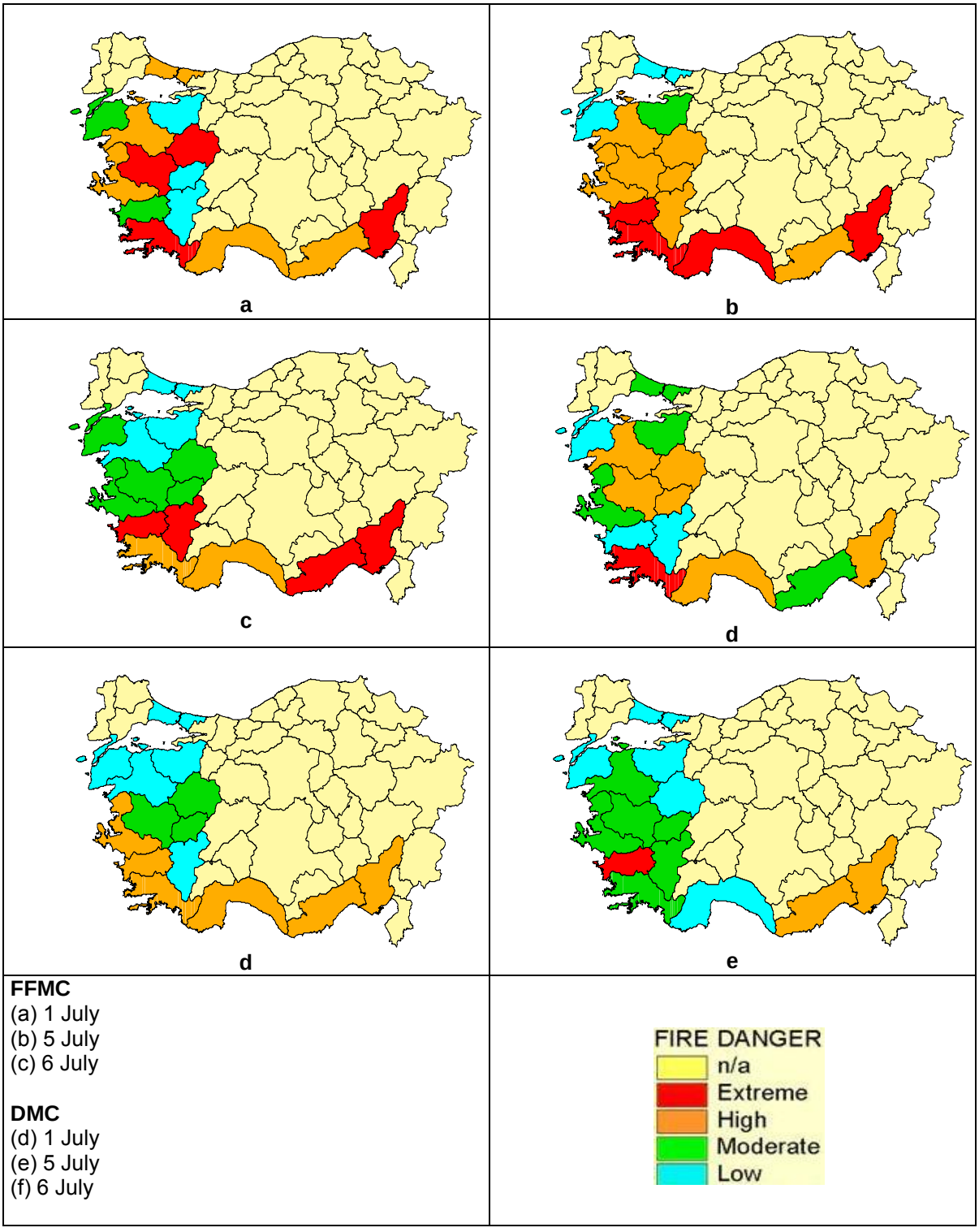

Figure 2. Fire danger situations based on Fine Fuel Moisture Content (FFMC) and Duff Moisture Content (DMC) in early July in Southern and Western Anatolia, Turkey.

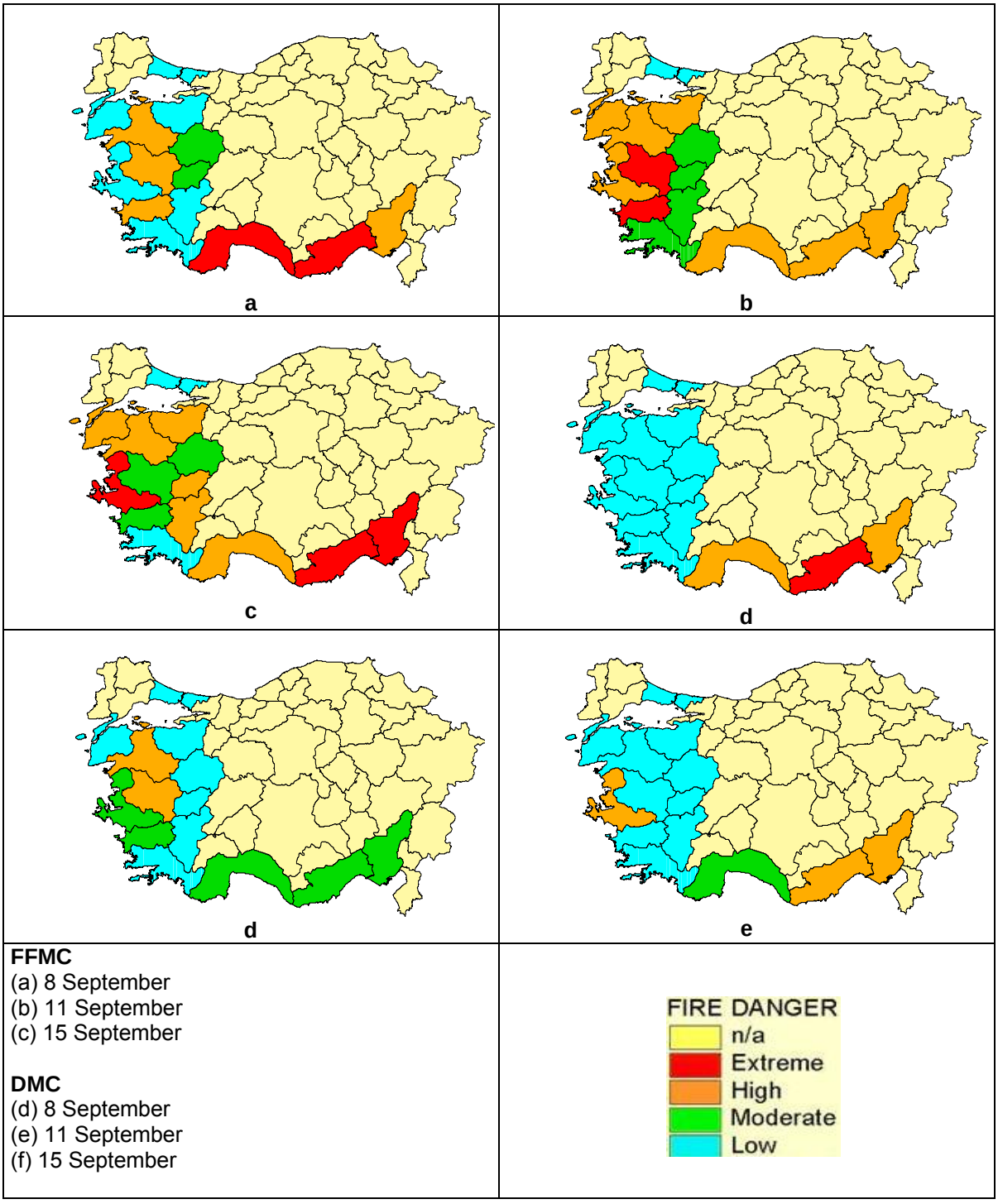

Figure 3. Fire danger situations based on Fine Fuel Moisture Content (FFMC) and Duff Moisture Content (DMC) in September in Southern and Western Anatolia, Turkey.

Discussion

In this study, fire danger situations were determined for the fire prone areas in the southern and western part of Turkey using statistical models which were developed to predict fire danger based on the relationships between weather and fuel moisture contents. Great differences occurred in fire danger, especially in ignition probability as exemplified by the FFMC, on different days in different

regions. These differences were a result of the variations in weather. The results presented in this study clearly shows that fire danger rating is extremely important and should, therefore, be a part of any fire organization.

Fire danger situation for an area where meteorological parameters are available can easily be determined and then presented to fire organizations. But, predictions are only as good as the quality of the weather measurements used in the predictions. It is, however, difficult to obtain fire weather measurements in many areas of Turkey since the network of meteorological stations do not effectively represent the whole area in question. Thus, the fire weather network should immediately be completed in all fire prone areas of the country.

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