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Determination of the Basic Principles of a Fire Prevention Plan: The Case Study Manavgat, Turkey

Abstract

This study evaluates fire risk and danger using Geographical Information Systems (GIS) at Manavgat forest conservancy. For the study, digital maps scaled 1:25,000 were drawn to show stand types, road communication, power lines, fire breaks, landscape relief, arable lands and urban areas. These major factors effecting fire occurrence and fire spread were also loaded in a database. In total, 270 sample plots were chosen in the study area to represent various stand types by means of GPS. In each sample plot, measurements of litter and living fuel were made to determine fuel load. Data were gathered from Antalya meteorological office on local climate and from statistical office on urban and rural settlement. Information on past forest fires were also collected from forestry department records. This information were loaded on GIS, which included date, location (geographic coordinates), forest compartment number, acreage, stand types. Interrelation of forest fires to stand type and vegetation cover was studied in terms of these factors. The study area was divided into 136 parts by a grid of 3x3 km in order to evaluate statistical data. Number of fires and fire-denuded area were taken as dependent variables. While fuel load characteristics, forest area, population, roads, residential areas etc. total 30 parameters were used as independent variables on each square. Regression analyses were made in order to calculate fire risk (number of fires), fire danger (area burned). Areas with high fire risk and danger were determined by regression equations.

1. Introduction

Forest fires are a recurrent phenomenon in Turkish forests. Fifty eight percent (12 million ha) of forestland of Turkey is in a fire sensitive zone. This zone is approximately 1700 km long with a depth of 160 km in the inland, starting from K. Maraş and extending up to Istanbul. Forests in this zone can be divided into five different risk degrees; the highest is 35% followed by 23%, 22%, 15% and 5%, referring to OGM (2002).

Between 1937 and 2002, a total of 72,316 forest fires occurred and 1,549,506 ha were burned. During the last ten years 2100 forest fires were recorded annually with 13,726 ha burned annually and an average of 6.5 ha burned per fire. Despite the increases in the number of fires, total and per fire area decreased in the last decade. This shows that there is a linear interrelation between the population growth and number of forest fire (tourism and recreation activities, human necessity etc.). Decreases in the area per fire can be attributed to the technological developments, consciousness about the importance of the forest, efficiency in the use of resources (communication, aircrafts, irrigators).

In a report prepared in the year 1999 by FAO on Turkey is specified that the expenditures made between the years 1993-1998 for fighting the fires was found on a much more superior level than the damages caused as a result of the fires (OGM 1999). As a result of this circumstances, depends on stable and changeable factors, fire risk and danger must be reveal especially on sensitive forestland. On the other hand the qualified fire plans must include the side plans, which will protect the potential regional future fires and sensitivity of our regional forests to reduce the cost of fire fighting.

The purpose of this paper is to investigate and analyze fire danger and fire risk in Manavgat forests using GIS.

2. Material and methods

2.1 Study area

Manavgat is located in the province of Antalya. Fifty four percent (53.68 % / 48,483 ha) of the conservancy area is forested. A total of 555 fires were reported in the unit between 1978 and 2002, affecting an area of 2,908 ha. The study area falls in one of the most fire sensitive areas. Manavgat Region has 2.6 times higher fire danger and 1.9 times higher burnt space than the average of the region.

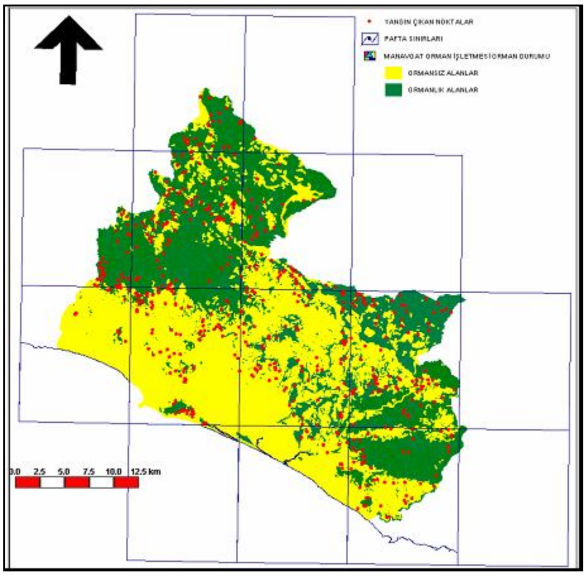

Figure 1. Forested (green) and non-forested (yellow) areas and fire incidences in Manavgat.

2.2 Method

In this study, GIS softwares like Geomedia Professional 4.0, Microstation 95, MF Wofks and IRAS/C are used. Digital and topographic maps (1:25,000 scale) from the General Directorate of Mapping and stand maps of Manavgat were obtained. All maps are rectified according to European 1950 and Universal Transverse Mercator datums.

Some parameters which affect the fire risk and danger, and others needed for prevention and suppression like stand types, stand closure, diameter class, tree species, roads, communication lines, fire and fuel breaks, power lines, landscape relief, arable lands, urban areas, water resources etc. were determined on rectified topographic maps. In addition fire departments and watch towers have been marked also.

A total of 270 sample plots were taken in the study area for the determination of fuel types based on stand age, closure and other stand characteristics. Five fuel classes were established based on the local fuel conditions. For this purpose, maquis and degraded Calabrian Pine (*Pinus brutia*) stands up to 600 m a.s.l. are designated M1, high fire risk areas consisting of young natural and plantation forests as M2, young stands with natural pruning as M3, stands with fuels breaking vertically as M4, and old Calabrian Pine together other tree species stands are designated as M5.

The study area was divided into 136 parts by a grid of 3x3 km in order to evaluate statistical data. 128 of which included forest and is used in the calculations. Two dependent and 21 independent variables were used in the analyses. These variables in each square included forest area (FA), forest area percentage (FAP), non-forest area percentage (NFAP), stand index (SI), agricultural area percentage (AAP), percentage of settlement area (SAP), agricultural and settlement areas border with forest (ASB), population (P), total road (TR), forest area per capita (FAPC), agricultural area per capita (AAPC), interrelation per capita (IPC), road length per capita (RLPC), powerline (PL), average altitude of forest on each square (AAF in Sq.), frequency of wildfire (WF), average slope of square forest (ASF), slope effect on wildfire (SEWF), slope and direction effect on wildfire (SDEWF).

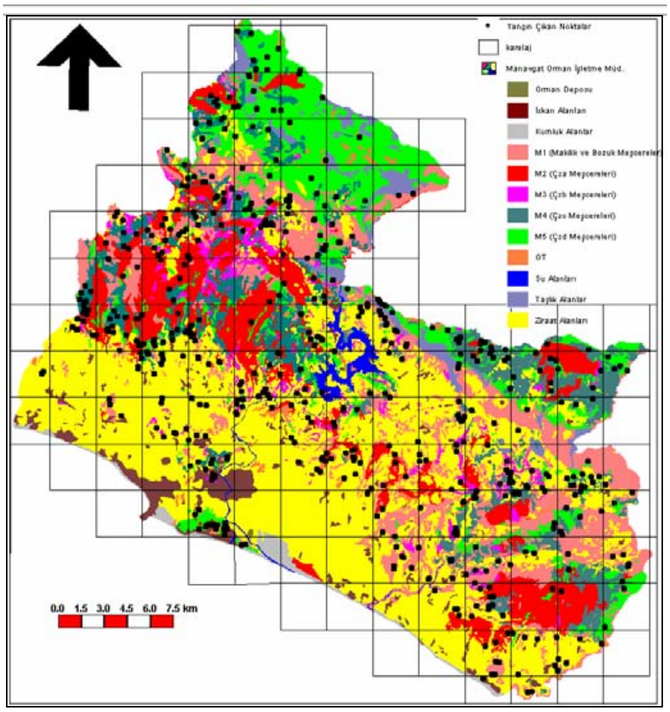

Figure 2. Classified fuel types, non-forested areas (yellow) and the past fires over the Grid system.

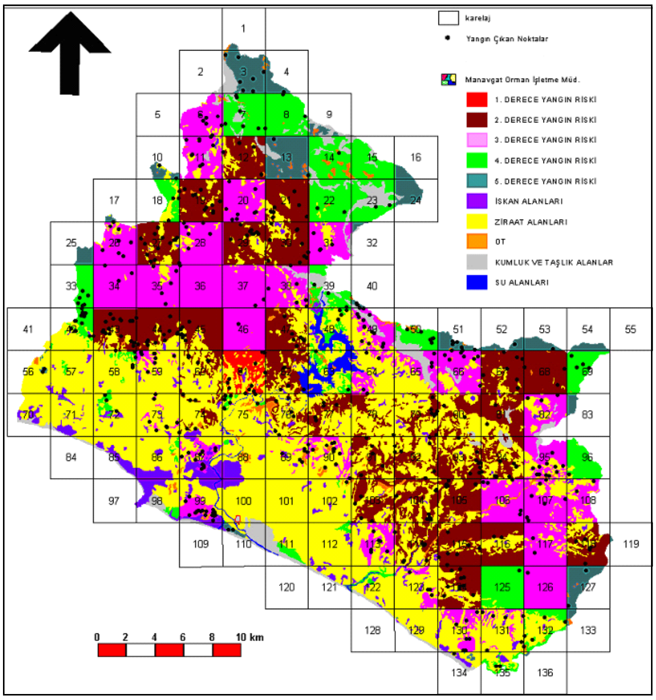

Figure 3. Fire risk map for the study area.

Construction of fire risk and fire danger maps

Using the independent variables, fire risk and danger for 136 squares are calculated and classified. In the classifications, non-forest areas were assigned “0” value. For the other squares, fire risk and danger values were calculated using the regression equations. Difference between minimum and maximum values is divided into 5 and the interval value is found. Depending on this interval values, 5 different classes were obtained for fire risk and danger.

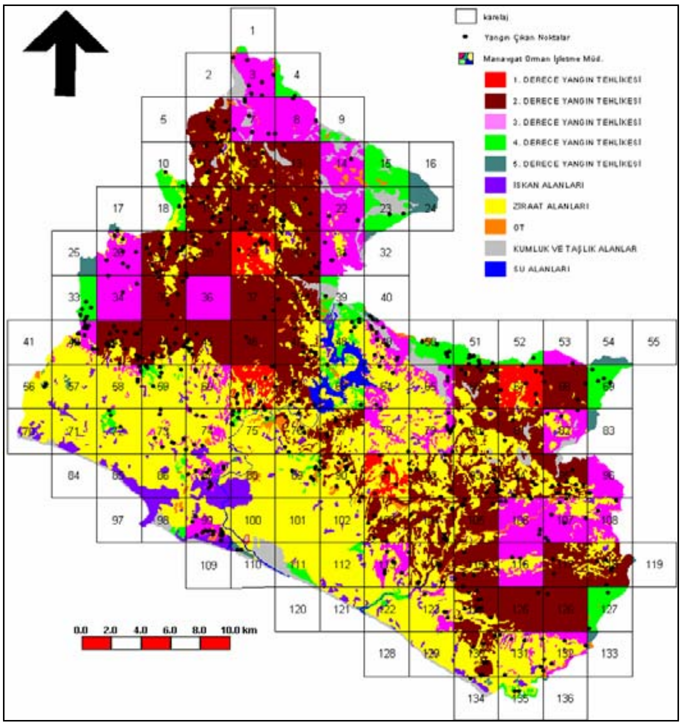

Figure 4. Fire danger map for the study area.

3. Results and discussions

3.1 Statistical analyses of the fire risk

In the analyses, fire risk and number of fires were used as dependent variable and forest areas, percentage of forest, agricultural settlements, without forest areas, total roads, agricultural and settlement areas bordering with the forest, population, forests per capita, agricultural land per capita, rate between population and interrelation, road length per capita, power lines, frequency of wildfire altitude and forest altitude were used as independent variables. Using the Backward method, dependent and independent variables were evaluated for direct regression analyses and reliability level is found as 90-95%. Agricultural and settlement areas bordering with the forest and total road variables had the highest correlation.

The model including the independent variables forest area, total road, rate between population and interrelation, per capita forest area was accepted as the regression model. The model explained 50.3 percent of the observed variation. The regression equation was:

Y= 10.972 +0.01126*Forest area + 0.0002334*Total road + 0.0002993*rate between population and interrelation – 0.101*forest area per capita

Using this equation, fire risk points are calculated, minimum and maximum points are found for each square. Interim values of fire are shown in Table 1.

Table 1. Forest fire risk values

Fire Risk Classes	Fire Risk Level	Classification values	Colour
1	Very high	31.9 – 37.1	Red
2	High	26.7 – 31.8	Bordeaux
3	Medium	21.5 – 26.6	Viola
4	Low	16.3 – 21.4	Light green
5	Very low	11.0 – 16.2	Dark green

3.2 Statistical findings about the fire danger

In the analyses, fire danger, burned area were used as dependent variable and forest area, without forest area, total roads, agricultural and settlement areas bordering with the forest, population, average slope of the forest square, slope effect on wildfire, slope and direction affect on wildfire, stand index and forest altitude as independent variables. Using the Backward method, dependent and independent variables were evaluated for direct regression analyses and reliability level was found 90-95 %. Analyses showed that forest area (0.501), agricultural and settlement areas bordering with the forest (0.456), total road (0.400) and slope and direction affect on wildfire (0.376) variables had high correlation.

Model which included forest area, total roads, rate between population and interrelation, altitude frequency, forest altitude, slope and direction affect on wildfire and stand index variables was accepted as the regression model. The model explained 44.5 percent of the observed variation. The regression equation was:

Y= 4.051 + 0.0006179*Forest area + 0.00007899*Total roads + 0.0001678*rate between population and interrelation – 0.00528*altitude frequency + 0.007756*forest altitude + 1.107*slope and direction affect on wildfire + 0.309*stand index

Using this equation, fire risk points were calculated, and minimum and maximum points found for each square. Interim values obtained for the fire risk map are shown in Table 2.

Table 2. Forest fire danger values

Fire Danger Classes	Fire Danger Level	Classification values	Colour
1	Very high	22.1 – 25.0	Red
2	High	19.1 –22.0	Bordeaux
3	Medium	16.5 – 19.2	Viola
4	Low	13.7 – 16.4	Light green
5	Very low	10.8 – 13.6	Dark green

3.3 To obtain fire risk and danger maps

Using the results of the regression equation, fire risk and danger classification maps were made. The area was classified as a first-degree fire sensitive area. This classification agrees well with the one by Yücel (1987).

Total land area is 90,314 ha, of which 48,483 ha are forested. When whole area is considered first-degree fire sensitive, there exist many disadvantages for fire fighting. So, in order to make a better classification, whole area divided by 5 different sensitivity classes for fire risk and danger. With this information it will become easier to set up an effective fire fighting organization and improve fire suppression efficiency.

4. Conclusions and suggestions

The findings from this study carried out in Manavgat Local Forest Directorate are parallel to previous studies. It was found that there were a linear correlation between fire risk and some parameters such as population, population activities, agricultural activities, roads, etc. Since there was a close relationship between the fire frequencies and road density, it became clear that we should be more selective in construction of roads within the forest. Given the recent fires of high destruction at the wildland urban interface in many countries, prevention measures should be taken in and around forest settlements, tourism facilities and secondary residences.

The purpose of the study is to establish primarily fire resistant forests by making use of GIS technology. It is also within the framework of this study to determine the higher fire risk and danger areas under certain conditions using non- or slow changing criteria such as vegetation types, amounts of flash fuel, steepness, exposure and altitude, and fast changing criteria such as climatological data. Such a pre-estimation may greatly hinder the start of wildfires and may increase the effectiveness of fire suppression activities and at the same time decreases the fire fighting costs. Whereas the interest shown in extinguishment of the fires and the huge investments made in this direction are accepted wholeheartedly, the budgetary allocations of the investments are not sufficient for the activities directed towards the prevention of the fire. The determination of the risk and danger classes will create a firm support to those who defend this thesis.

The databases for fuels and the topographic particularities in this study would be of assistance in making fire behaviour and simulation models. Besides, particularly the data obtained from the GIS environment could be easily used in different forestry studies.

It has become evident that there is an insufficiency of information required in the form of the fire register cards used in the course of this study. The preparation of the fire cards as stand document through a disposition would be an important phase in working out the fire control policies at the regional and national level. A more comprehensive fire database should be established.

Fire risk and danger maps obtained as an output of the project will constitute a basis for the development of justifiable understanding of the fire in the operation field. This study is capable of becoming an example for localities similar in various respects.

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