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Moisture content of live forest fuel of Holm oak (Quercus ilex L.) related with forest fires in Mediterranean part of Croatia

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Abstract

Due to its biological diversity and preservation, the Mediterranean area is an extremely valuable area on Earth. In recent years, the Mediterranean region has been frequently affected by fires. An increasing number of fires are certainly degrading the Mediterranean ecosystem and disrupting its stability, leading to a reduction in biodiversity and an increase in devastated areas. In addition to understanding and knowing the biological and ecological consequences of forest fires and methods of remediation and restoration of burned areas, knowledge of factors that cause forest fires and factors that cause the initial spread of fire is important to reduce burned areas and prepare and conduct preventive activities. The moisture content of living forest fuel is an extremely important factor for the spread of forest fires. It is a factor that is very sensitive and depends on local micrometeorological conditions. The practice is that some very significant variables for forest fires, such as the moisture content of potential fuels, are sought to be obtained by applying various models, although it is known that these models cannot determine the true values of required variables unlike actual, empirical research. The most important meteorological factors that are taken into account when it comes to forest fires are temperature and humidity or water (precipitation). It is a climazonal species in the forest ecosystems of the Mediterranean part of Croatia. The research was conducted at two locations; the island of Rab and Makarska. The results show differences in the influence of meteorological conditions depending on the location of the research. The obtained results confirm that the understanding of meteorological conditions and vegetation characteristics in terms of moisture content of living fuels and their relationship can contribute to improving knowledge about firefighting issues and identify critical periods of high risk of forest fires.

1. Introduction

Due to its biological diversity and preservation, the Mediterranean area is an extremely valuable area on Earth. In recent years, the Mediterranean region has been frequently affected by fires. An increasing number of fires are certainly degrading the Mediterranean ecosystem and disrupting its stability, leading to a reduction in biodiversity and an increase in devastated areas. At the same time, there are high costs of reconstruction that last for decades, there are landscape changes, socio-economic turmoil and conflicts of interest. Among the most important natural destabilizers that cause change are forest fires (Trabaud, 1980; Casal, 1987; Naveh, 1999). When it comes to the factors of occurrence and spread of forest fires, vegetation characteristics, ie combustible material and meteorological factors are the most decisive and most important factors of natural origin and spread of forest fires. Vegetation elements are based on vegetation cover, type, moisture content and availability of combustible material (Pyne *et al.*, 1996; Pellizzaro *et al.*, 2007). Meteorological parameters have a great impact on fires. Thus Viegas *et al.* (1999), Skinner *et al.* (1999), Viegas *et al.* (2004) and Pereira et al. (2005) point out that weather and climate play a key role in determining the fire regime of an area, and the fire regime in turn is very close to climate change. Topographic elements are an important factor influencing the formation and spread of forest fires. Different landforms can be natural barriers or conveniences for forest fires. Slope is a factor on which the spread of forest fires depends. On steep slopes, forest fires spread much faster than on flat terrain. If a forest fire develops uphill, in the direction of rising hot air, it will develop faster, and the rate of spread can further regulate the influence of the wind. At higher altitudes, the temperature is lower, and therefore the intensity of fires is lower. When it comes to the initial occurrence of forest fires, in terms of forest fuels, dead forest fuel plays a key role in the occurrence of fires. It is a fuel that participates in the initial ignition and further flare-up of the fire element, and when a fire develops, in addition to the role of dead fuel, living forest fuel, its

condition and quantity are important for its further progress. The objectives of this study are to determine the moisture content of live holm oak (*Qurcus ilex* L.) for the Adriatic area in Croatia and to analyze the impact of meteorological factors (temperature, humidity and precipitation) on the moisture content of live fuel of this species.

2. Material and methods

2.1. Research area

The island of Rab is located on the northern Croatian coast, and Makarska on the southern Croatian coast. On the island of Rab, research was conducted at the Teaching Experimental Forest Facility Rab, Faculty of Forestry and Wood Technology, University of Zagreb. In Makarska, the research was conducted in an experimental laboratory located within the main meteorological station Makarska.

2.2. Research methods

For two years, once a month, tests were performed at each location. The meteorological data used for the analyzes were taken from the State Hydrometeorological Institute, and were measured at the meteorological station Rab and the main meteorological station Makarska. The moisture content of the tested samples was obtained using a standardized equation for determining the moisture content (percentage of dry weight) by the method of drying in an oven.

The equation is:

$$LFMC = ((FW - DW) / DW) * 100$$

Where is:

LFMC – moisture content of the tested sample

FW – mass of fresh sample

DW – mass of dry sample

3. Results

Table 1. Moisture content of live fuel Holm oak (Quercus ilex L.)

Species	Moisture content of live fuel LFMC (%)	
	Makarska	**Rab**
Holm oak (Quercus ilex L.)	48.99-91.37	66.36-102.86

The moisture content of live holm oak (*Quercus ilex* L.) fuel is higher on the island of Rab than in Makarska. The obtained results indicate that although it is the same type, the moisture content of live fuel is lower on the island of Rab, which belongs to the northern Croatian coast.

Table 2 - Linear correlation of live fuel moisture content (LFMC) for holm oak (Quercus ilex L.) on the island of Rab and in Makarska

Variable	Correlations (Alepski bor – *P. halepensis* Mill. – DI); Marked correlations are significant at p<.05000; N=25					
	LFMC	Mean monthly air humidity	Mean monthly air temperature	Mean monthly maximum air temperature	Mean monthly minimum air temperature	Mean monthly precipitation
Rab – LFMC	1.00	-0.02	-0.44	-0.44	-0.44	-0.43
Makarska – LFMC	1.00	-0.10	0.14	0.14	0.15	0.22

The correlation between LFMC and mean monthly precipitation (0.43 *) is positive, statistically significant and mean, while the correlations are mean monthly air temperature (-0.44 *), mean monthly maximum air temperature (-0.44 *), mean monthly minimum air temperatures (-0.44 *) statistically significant, negative and moderate. In Makarska, the LFMC of holm oak (*Quercus ilex* L.) does not show a statistically significant correlation with the variables used (Table 2.). Makarska belongs to the southern Croatian coast and the role of meteorological factors describing the climate impact is not statistically significant as it is on the island of Rab.

4. Concluding discussion

Fuel moisture content has been identified as one of the most critical factors influencing the occurrence and spread of fires (Van Wagner, 1977; Viegas *et al.*, 1992; Andre *et al.*, 1992; Viegas *et al.*, 1998; Carlson and Burgan, 2003; Chuvieco *et al.*, 2004). Cappelli *et al.* (1983) and Dimitrakopoulos and Papaioannou (2001) found that there is a great connection between the flammability of Mediterranean species and the moisture content in them. The increase or decrease in moisture content of the fuel is the result of weather conditions (Simard, 1968) and depends on the physiological and chemical characteristics of the fuel (Castro *et al.* 2003; Aguado *et al.*, 2007). However, Sun *et al.* (2006) point out that Mediterranean vegetation has structural, morphological and phenological characteristics suitable for the formation and spread of fire in conditions when the amount of available fuel and meteorological conditions are not critical. Therefore, a better understanding of meteorological conditions and vegetation characteristics in terms of flammability and moisture content of fuels and their relationship can contribute to improving knowledge about firefighting issues and identify critical periods of high risk of forest fires. Changes in moisture content are related to meteorological conditions and available soil moisture on the one hand, and the ecophysical characteristics of the species on the other, but also to living conditions in the past (Alessio *et al.*, 2008). Low fuel moisture content is the main reason for the occurrence of fires in early autumn due to drying of fuel during the summer and in the spring before the new leaf mass begins its activities (Rothermel, 1972). According to Pompe and Vines (1966), the occurrence of fires with catastrophic consequences arising in arid conditions is due to the stronger impact of reduced moisture content than high air temperatures. The significant impact of moisture content on fuel flammability can be demonstrated through the evaporation and exclusion of oxygen from the combustion zone (Brown and Davis, 1973). Apparently, the ignition energy is lower with a higher moisture content. On the other hand, the moisture content affects the behavior of the fire, because when combustion is reduced due to fuel humidity and further ignition is limited.

5. References

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