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WILDLAND FIRE RISK MANAGEMENT USING GIS TOOLS – CASE STUDY

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ABSTRACT

In the paper we introduce a general approach to wildland fire risk management that we applied for the Slovensky raj territory. The risk management concept is based on assessment of several risk components: susceptibility in the form of calculation of a priori probability of forest destroying by fire, vulnerability based on calculation of posteriori probability of forest destroying by fire and based on modelling the fire behaviour in FARSITE environment. We also briefly introduce an approach to set the measures to prevent the forest fire occurrence and to manage it to minimize its impacts on human, environment and property (resilience).

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INTRODUCTION

The wildland fires cause the fair-sized material as well as the significant ecological damages. Among them belongs the burning (destroy) of important biotopes, disturbance of forest environment or pollution of an environment by chemical substances. This occurs mainly by the ecologically inconvenient extinguishing substances application. Sometimes, there also occur the highest and hardly expendable damages - the hurt or even dead people.

The most common reason of the wildland fires formation is an anthropogenic activity. It is an activity which is directly related to the human occurrence in the forest. In our country, the wildland fire do not reach the extent of fires occurring in Mediterranean countries like Spain, Greece or Portugal, but according to the increasing intensity of their occurrence it is required to study them.

The prognoses of next climate change progress point out the fact that by the power of global climate change, it will get to the significant warming in our region, too. Due to this prognosis it is likely to expect more common wildland fire occurrence, which extent will also increase.

Here we introduce a model and approaches for assessment of selected wildland fire risk components: susceptibility, vulnerability, exposure and resilience. This model is built over and summarizes all approaches which have been developed in Slovak conditions yet.

PROBLEM

In Figure 1 we introduce the basic structure of the wildland fire risk management model [1]

which should be the integral part of any fire warning system and crisis management in case of fire

This one is going to be transformed to the dependency model that is built in NetWeaver environment to be linked with the EMDS software environment to automate the assessment process.

In the risk assessment we consider 4 components of a risk: susceptibility, vulnerability, exposure and resilience.

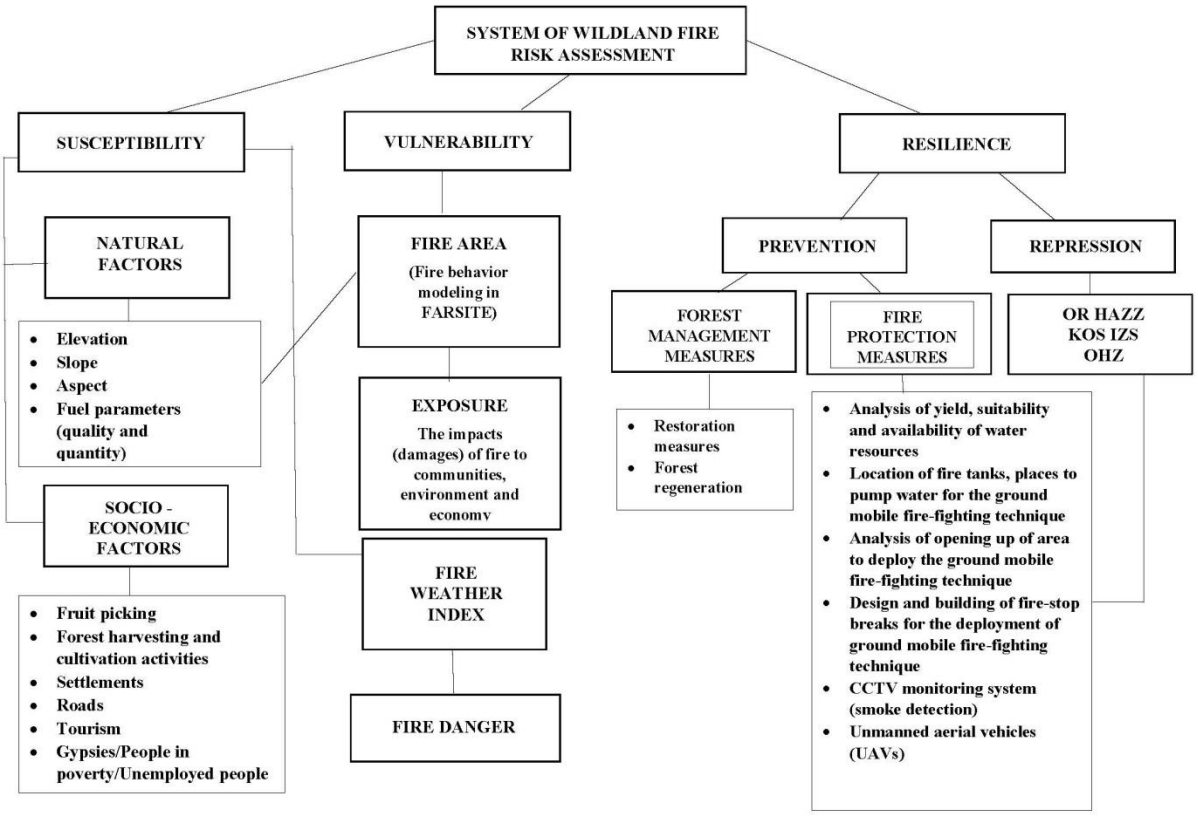

Fig. 1 The complex model to manage the risk of wildland fire occurrence

To illustrate the results of risk components analyses in GIS we introduce the fire risk results we provided for Slovensky raj territory.

The assessment of susceptibility to wildland fire is based on assessment of two groups of factors: natural and socio-economic. The group of natural factors is composed of two subgroups represented by geographical factors [2] (elevation, slope, aspect) and fuel factors (crown fire fuel - tree species composition, forest age, quality and quantity of surface fire fuel). Another group of factors is represented by the socio-economic factors [3] where picking of forest fruits, forest harvesting and forest cultivation activities, the distance from the nearest settlement and road as well as touristic trails and touristic localities, and the localities where the gypsy communities and increased number of people living in poverty or unemployed are located, belong.

For susceptibility assessment also the information on the wildland fire occurrence probability or the probability that the fire will be destroyed by fire in specified age, respectively, is required. To calculate it is necessary to build the geodatabase of

historical fires for the analysed area. For that purpose the data coming out of the register of management activities in forest, containing the subpart focusing on occurrence of negative agents in forest (where also the wildland fires belong), can be applied.

To calculate the susceptibility to fire in GIS environment, the digital elevation model, state, forest roads and touristic trails vector layer, vector layer of forest stand borders and forest types, database containing detailed description of the forests, vector layer of settlements as well as vector layer containing the situation of historical forest fires are required. The producers and providers of those data are Military Topographical Institute in Banska Bystrica, Institute of Forest Resources and Informatics of the National Forest Centre in Zvolen, Mountain Rescue Service of the Slovak Republic. The current analyses are based on the combination of natural (Fig. 2) and social factors analyses (Fig. 3), which are related to the anthropogenic activity in the forest and on landscape mostly.

Fig. 2 The susceptibility of Slovensky raj territory to wildland fire in relation to the geographical and vegetation (stand) factors

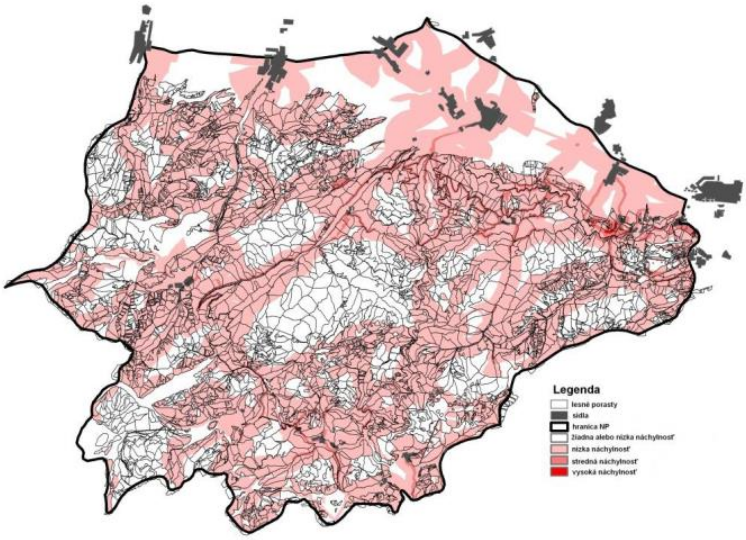

Fig. 3 The susceptibility of Slovensky raj territory to wildland fire in relation to the social factor

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The information on susceptibility of an area to wildland fire (static data) can be combined with the information on meteorological fire weather index (dynamic data - published by the Slovak Hydrometeorological Institute from April to September (Fig. 4) each year (and for each day) and this way we can also compute the actual fire danger for each day and also 3 days ahead, based on the data of Aladin or ECMWF meteorological models. Data on actual fire danger the most important data of any fire warning system.

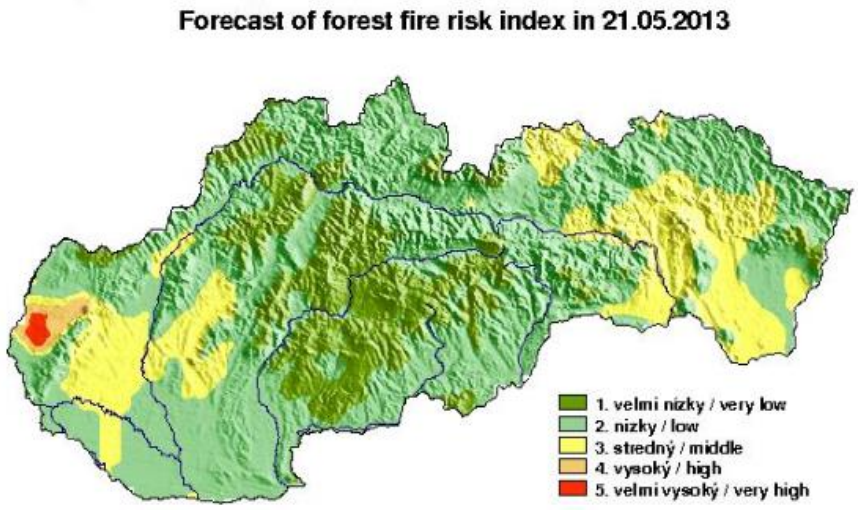

Fig. 4 The meteorological warning against possible fire occurrence in most risky areas due to the current meteorological situation

The vulnerability and also exposure to wildland fire is determined based on the data coming out of the fire behavior modeling in FARSITE environment (Fig.5). It is GIS based system, that combines the Rothermell`s mathematical model of fire spreading with visualization function of GIS environment in particular. Except the fire behavior modeling itself, it also allows consider with the ground and aerial fire attacks in the modeling.

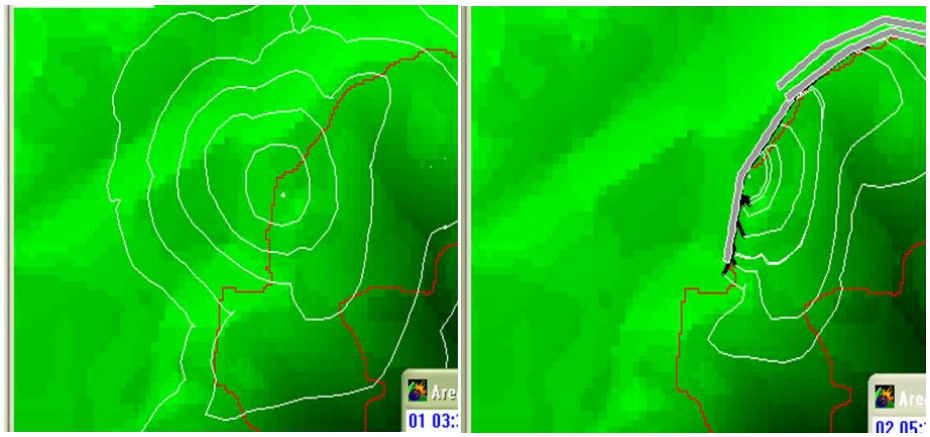

Fig. 5 Results of forest fire modelling in FARSITE environment (without and with fire attacks consideration

Among the input data belong: ASCII raster of elevation, slope and aspect, raster representing the spatial distribution of fuel, fuel models respectively in the analyzed area, meteorological data (precipitations, temperatures, wind speed and wind direction) and data on the quantity and quality of fuel (volume, moisture parameters, calorific value). To precise the data on fuel quantity and quality is required to perform the field and laboratory measurements.

For the assessment of vulnerability to wildland fire is possible to use either results of fire modeling in FARSITE environment (fire place outlines, fire area extent and fire perimeter in specified time steps and other physical parameters of fire) or the statistical approaches like in [4, 2, 5].

The assessment of exposure to fire is focusing on three principal spheres: social (communities), environmental (e.g. biotops of national or European importance), economical (economic losses of timber burnt in fire or due to the cost for reforestation, forest restoration).

To assess the exposure of communities to wildland fire is possible to use the vector layer containing the buildings outlines that should be completed with the data coming out of the citizens register kept at the municipality level. To assess the exposure of an environment to wildland fire, there the geodata providing by the State Nature Conservancy should be used (situation of important biotops, protected landscapes as well as the economic value of those features). To assess the exposure of economic systems to wildland fire is necessary to have the information on the value of feature we would like to assess aswell as the consequences of a fire event on the developments in the markets for those commodities.

The last assessed risk component is a resilience. Resilience represents all of the measures that were accepted and realized as from the prevention point of view as from the view of repression – the measures accepted to minimize the vulnerability – the impact of an emergency. There also the coping capacities to cope with an emergency belong (in case of fire, foresters, fire-fighters, volunteers, medical service, State Nature Conservancy employees, etc.).

In general resilience is in direct portion to vulnerability. If we would like to reduce vulnerability we need to plan and realize sufficient measures in both, prevention as well as repression aspects.

In the scheme (Fig. 1) we introduce the basic division of prevention and repression measures. Prevention measures are divided to two basic subgroups: preventive measures related to the restoration and regeneration of forest to be resilient to fire impacts and measures related to the preparedness of coping capacities to fight the fire. The forest protection and adaptation measures to fire are briefly described also in the Decree of the Ministry of Agriculture of the Slovak Republic no. 453/2006 Coll. of Law on forest management planning and forest protection. The methodologies to solve the analyses and designs specified in the subgroup focusing the preparedness of fire-fighting coping capacities have already been published in [6, 7, 8, 9] (Fig. 6) and they can be applied for any forested area not only in Slovakia.

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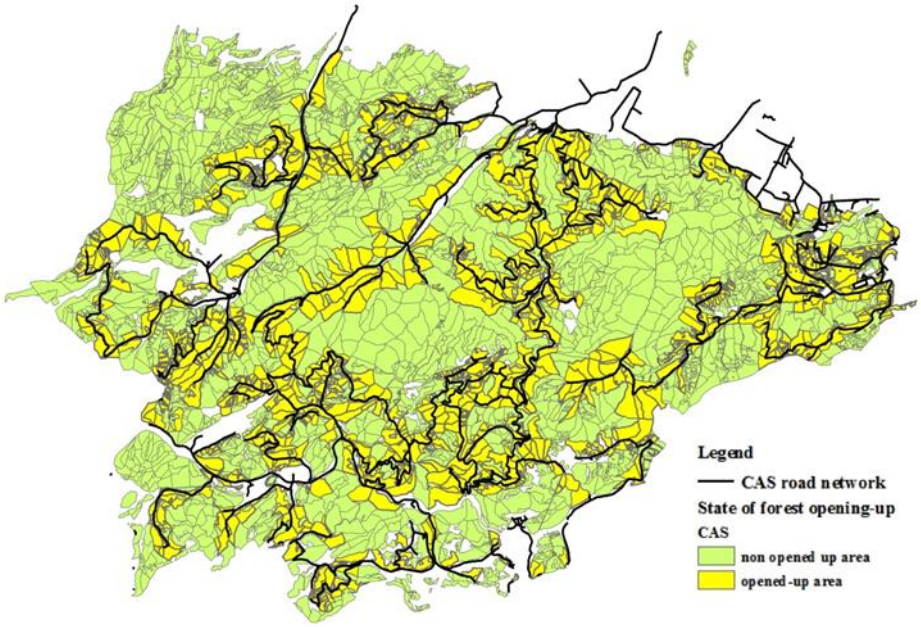

Fig. 6 Results of forest opening-up analysis to use the mobile ground fire equipment [9]

The results of analyses all of risk factors, not only resilience, should be immediately applied as an information (decision) support of fire services intervening in the area (District Directory of Fire and Rescue Corps – acronym OR HAZZ, municipality fire brigade – acronym OHZ), operators of Regional operational centers of Integrated Rescue System (acronym KOS IZS), but also for the state administration bodies, forest administration bodies, etc.

CONCLUSIONS

To cope with the wildland fires is a complex problem. To prevent and to fight the fires effectively it requires using the systematic approach to the management of risk of wildland fire occurrence. In the article we introduced a complex model to assess the particular components of risk using the tools provided by the GIS environment. The approaches and procedures presented in the framework of the model are not generally applied in Slovak conditions. They are applied to solve the fire risk analyses for selected territories with a high risk of fire occurrence mostly due to their geographical conditions or like a measure to analyse the fire risk after a disaster disturbance of a forest (e.g. wind disaster disturbance in the High Tatras Mts, Low Tatras Mts. And Orava and Kysuce region in November 2004).

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