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Small reservoirs and their sustainable role in fires protection of forest resources

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ABSTRACT

The main purpose of this research is examining the compatibility of the spatial arrangement of two of the most important renewable resources: the forests and the water potential of small watercourses, based on the statistically processed data of the observed fires, territorial modeling of Fire Weather Index, the analysis and quantifying the waters needed to extinguish fires, as well as based on researching the favorability of locations to build small hydropower plants (SHPP). The research period is spanned from 2004 to 2012 and it refers to the Republic of Serbia. The results and the conclusions are valid even beyond this territory. The transactional analysis proved a firm spatial and functional correlation connection between the layout of SHPP and the pertaining small accumulations with forest surfaces in the context of decreasing fire risks, which can be used in further research as an additional benefit in defining the justification for SHPP.

With the construction of SHPP and small reservoirs and by putting them in function, less time is needed for extinguishing the fire. Also, consequential or incidental damages are diminished in the destroyed and damaged wood volume. It is reflected in the loss of protective and other functions of forests, appearance of Eolian and water erosion, degradation of forest land, roads endangerment, filling up the water reservoirs, and especially in the environmental damages that are immeasurable.

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1. Introduction

A large number of forest fires and burnt areas of several thousand acres are registered every year in the Republic of Serbia. In addition to

the property damage they cause, extinguishing costs, repairs and new afforestation significantly affect its final “- price.” A plan to protect forests from fires, on the territory of the Republic of Serbia, stipulates water as one of the fastest and most efficient measures for the protection of forests from fire. Hence the need for small reservoirs, in the areas of large forests, especially in coniferous forests, which are more sensitive to ignition and burning due to the presence of resins and essential oils. The construction of such reservoirs would help

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with the production of renewable energy as well as in the fight against forest fires.

The forests in Serbia take up 29.1% of its territory (7.1% in Vojvodina, and 37.6% in Central Serbia), which makes it the country of average forestation [1]. Over the past 50 years, in the Republic of Serbia, a lot of forestation has been done in the areas of bare land together with the melioration of degraded stands of broadleaves. It is estimated that there are over 150,000 ha of successfully planted cultures and conifer forests [2]. The danger of forest fires increased with that trend and thus there is need for more efficient protection measures.

The fires, whether they are natural or man-made, have the same outcome: temporary or permanent loss of forests. In the course of history, strenuous efforts were put toward their control as soon as they appeared. The most important role in preventing the fires from spreading was always the timely detection; the quicker it was detected the quicker it was extinguished. Its appearance is, in most cases, sudden and people are responsible for it in 95% of the cases [3,4]. With the help of certain weather conditions, such as wind and high temperatures, they can spread quickly and compromise large areas.

Fire affects not only the site which is compromised, but it lingers in the surrounding area. Great fires can influence the climate and weather changes, and cause pollution of atmosphere [5]. Carbon-dioxide (CO₂) is released, in the burning process, into the air leading to greenhouse effect, endangerment of biodiversity (flora and fauna) and poor people health (caused by smoke) [6–8]. It takes years to heal from all the consequences, and in most cases the damage is permanent.

Water is the best extinguisher for all kinds of fires if there is enough of it. The Republic of Serbia is one of those countries which are rich in water. Such potential gives the ideal opportunities for construction of small and big reservoirs, and is invaluable as a source of renewable energy [6]. Electricity and drinking water are the prime aims when constructing reservoirs. Nevertheless, they are also one of the main problems because those constructions serve one purpose only and the water, as a renewable resource, is not used enough.

For quick fire extinguishing, in its initial phase, firefighters must have an easy access to water supplies in the forests. Terrain accessibility and roads, leading to water, are the key factors in fire extinguishing. The roads are of the utmost importance, when preventing fires in forests, for they provide preventive and repressive protection. Preventive protection not only stops the fires from breaking out, but it also eliminates all the things that lead to it, as well [9]. Hence the need for constant maintenance of the road network in order to be completely usable during the fire season. Communication is also one of the key aspects in the fight against forest fires. It is vital that the local authorities are notified, as soon as possible, when a fire occurs. The fire, which is discovered at an early stage, is easier to extinguish than the one that is burning, due to lack of communication, for some time. After the fire detection and rapid information flow, firefig-

hters can quickly reach the place of the initial outbreak and try to suppress it.

This research is focused on several aspects that refer to extinguishing forest fires. The general purpose of the research is to analyze the favorability to build and use the already existing small accumulations in forest surroundings so that the accumulated water could be used as defense in case of a fire happening. The research also has the following specific aims that relate to the analysis of the forest fires in the Republic of Serbia from 2004 to 2012, that clearly shows how big the fire affected areas are and that there is a need for a long term planning of water sources for the fires to be extinguished and also to point to the implementation of the forest preservation methodology that could help to a substantial prevention of fire occurrences and their spreading.

That is why the main aim of the research is to examine the compatibility and justification of the strategy to develop two important renewable resource at the same time: the forests and the water potential of small watercourses, based on the statistically processed fires, sorted by regions in Serbia, territorial modeling of the fire risk assessment (Fire Weather Index), analysis of water supplies to extinguish fires and examining the favorability of locations to build SHPP. Damages caused by fires are quantified by regions, by the number of fires, the fired area (ha) and the damaged felled timber (m³). The analysis and the calculations were done for both state and privately owned forests [10], since both sector represent the natural wealth of renewable resources of the biomass that is of general interest.

2. Materials, methods and criteria

Based on the collected data Statistical Office of the Republic of Serbia and the Republic Hydrometeorological Service, a number of forest fires has been noted from 2004 to 2012 in state and private forests, fired areas, damaged felled timber and assessment has been done regarding the hazard of forest fires occurrence. Possible locations for the construction of small reservoirs with multiple purposes (protection against erosion, sediment retention and flood protection, water, fishing, etc.) were named, based on data taken from scientific papers on coniferous stands [11] (which were artificially planted and have already been mentioned as the most endangered). They also used the data from the cadastre of small hydropower plants (SHPP) as a possible convenient location for water use in the event of a forest fires.

When collecting the data in the Republic of Serbia, non-reactive method and its basic techniques was used as a specific scientific method for this research: content analysis or the observation of documents and the use of existing statistics, documents and their secondary analysis [12].

Table 1

Classification of FWI values (Fire Weather Index FWI) according to the Canadian system for determining the danger index of forest fires used by Republic Hydrometeorological Service of Serbia [16].

| FWI—Interpretation of classes | |
|-------------------------------|---|
| Very Low | There are no favorable conditions for fire ignition and the possibility of ignition is slight. If the fire occurs, it spreads slowly or extinguishes. Very little burning material is caught in fire and it is mostly the upper ground layer. |
| Low | Ignition can occur by lasting fire source, like the camp fires. Fire spreading through the woods is slow and medium in open areas. Thus, only leaves burn in small surface (low) fire with weak flames. Fire control is achieved easily and swiftly, so that less effort is needed for fire extinguishing. |
| Moderate | Fire control is not difficult, if the action is fast. A match can cause fire. Fire spreading is medium within the woods, but swift in the open area. The fire burns on the surface in medium flames. |
| High | A match can always cause fire and it spreads fast. Fire can be very hot when transported to the foliage of the trees. A lot of organic mass burns out. Fire control is very difficult. |
| Extreme | Fire can be ignited by a spark. Spreading of the fire is very fast. Fire is very swift and spreads to tree foliage in wider areas. Organic matter starts to burn in deeper layers and normally wet locations. Fire control is extremely difficult. In fire control, extraordinary efforts must be exerted and all available means employed. |

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