1. **Purpose of the visit**

This STSM was intended to be a part of the long lasting tradition of exchanging young researchers and their experiences between the two institutions, Mendel University form Brno and Institute of lowland forestry and environment from Novi Sad. This cooperation leads to widening of scopes of the research among young researchers and also contributes to much more results being acquired and finally to better publications. One of the main purposes of my STSM was also, to bring new methodology in forest fires research. Even though Serbia is very prone to forest fires, not much research was done on the causes and possible, supposedly more efficient ways of prevention. The outcome of the research will also give an insight about the possible quantities of usable wood biomass as a byproduct.

2. **Description of the carried out work**

Introduction

Urban forests are among the most endangered ecosystems during the drought. Many people use the forest as the get-away destination from hot summer days. Unfortunately, not very many people know how to enjoy the nature responsibly so every year there are many cases in which the camping fires have gotten out of hand and caused ecological disasters. One way to prevent these occurrences is to educate visitors but another way, fuel management, has greater potential when looked from various aspects.

Growing concentrations of CO2 and other GHG are giving ever more importance to renewable energy sources recently. Fluctuations of climate factors are demanding strict focus on prevention any potentially hazardous situation which could lead to excessive emissions of GHG. Forest fires waste the biomass which grew for years, emit large quantities of GHG, and demand great effort and fuel consumption for extinguishment and force people to look for other sources of energy which, in most cases, come from fossil fuels. Looking from that aspect, forest fires not only pollute our atmosphere with CO2 from the burnt biomass but also lead to unnecessary usage of other energy sources.

The use of forest biomass is one of the major steps towards the reduction of pollution caused by fossil fuels. Modern technologies made it possible to use even more wood than it was the case years ago. Forestry as science should constantly give new solutions for even greater usable feedstock while sustainably preserving our ecosystem.

Forests of the South European countries are exposed to a high wildfire hazard every year. Hot and dry summers make favorable conditions for the occurrence of wildfires which cause great financial and ecological problems.

The probabilities of wildfire in space and time are not well defined: wildfire may not occur here this year or there next year, but at some scale the spatial loss per time period can be defined. It may be quite difficult to point to a particular stand and define its probability of burning in some given future period, but the probability that substantial areas of dry forest will continue to be burned by severe wildfire is known, and it is high (Agee and Skinner, 2005).

The goal of fuel management is to pre-emptively modify wildfire behaviour through changes to the fuel complex (Finney, 2001). Surface fuel treatment plays an important role in forest preservation. The quantity of surface fuels can impact the severity of the fire as well as its rate of spread. Also, surface fuels can represent a significant quantity of biomass that could potentially be utilized.

Fuels come in all shapes, sizes and arrangements. There are live and dead fuels, herb and shrub fuels, litter, twigs and branches, ladder fuels (small trees), and canopy fuels (larger trees). A fuel reduction treatment might address any or all of these fuels, but depending on which are targeted, the treatment may not be relevant to either the easier suppression of unwanted wildfires, or the ability of the forest to sustain itself in the presence of wildfire (Agee and Skinner 2005).

The increased use of renewable energy sources, including forest biomass, in energy consumption is a marked characteristic in current EU and national energy policies. In forest policies, the use of forest biomass for energy is usually supported as a sustainable form of energy that contributes to social welfare, local development, and forest economy (Stupak et al. 2007). Due to this fact, utilization of harvesting residue would represent a significant increase in the quantity of wood biomass available from forests. Besides that, by improved utilization of harvesting residue, fire hazard would be decreased. This is especially important in fire-prone regions.

Aim of the research

Aim is to research the impact of the harvesting residue on the occurrence and spreading of the forest fires which are becoming an ever bigger climate changing factor. In order to prevent the occurrence of large and devastating forest fires it is important to understand how they behave in various conditions and what could be done to prevent them. The results obtained in this research are planned to be analyzed and processed in BehavePlus software and published in peer reviewed journal.

Data collection

Data collection for stand characterization (before and after thinning)

In thinning it is important to determine the critical surface fire intensity (CSI) for initial crown combustion (kWm-1). It is determined as a function of the canopy base height (CBH, m), and heat of ignition (h, kJkg-1):

CSI = (C x CBH x h)1,5

where h is in turn determined by the foliar moisture content (FMC, %) (Van Wagner 1989, 1993):

h = (kJ kg-1) = 460 + 25,9 x FMC

FMC = usually ranges between 60 to 140 (a value of 100 is suggested) (Cruz and Alexander, 2010)

C = constant = 0,010

Appling these formulas in thinning treatment differences in the crown fire susceptibility before and after treatment also in relation with surface fuel changes could be checked.

Stand Characterization plots

Five circular plots have been chosen for each stand. The plot has a radius of 13m. Following data was collected for each tree with DBH >2,5 cm: species, DBH, total height, crown base height (considering live branches). The canopy base height is the average value of the crown base heights of the trees in the plot.

Data collection for surface fuel characterization

Two type of transects were positioned:

T10 – 4 transects of 10m length for determining the percentage of presence/absence and the volumetric index of each type of fuel before and after the silvicultural treatment. On each linear meter (i.e. 10 data collection along the line) following data was collected:

presence/absence of litter and litter depth

presence/absence of grass and grass height

presence/absence of bush/shrub and its height

presence/absence trees (DBH<2.5 cm) crown base height and total height.

For each fuel (litter, grass, shrubs) the coverage will be estimated by calculating the ratio (in %) between the number of points where it has been detected the presence of a specific fuel, and the total number of points detected.

For each fuel the volumetric index will be estimated by calculating the product of the estimated coverage for a certain plant component and its average height, calculated as the mean height values measured at the points of detection.

For calculating the litter load, samples of litter are collected (without twigs on small plots 4 plots in total – 20x20 cm). Plots with 100 litter coverage are chosen. On the base of this sample (after drying it) the load for square meter is determined and knowing the percentage coverage the load per hectare is calculated.

For calculating the fuel load of grass, the same plots for litter are used. For determining the grass fuel load per hectare you have to estimate the coverage of grass also in the 20x20 plot

For calculating the fuel load of shrubs, samples of shrubs in parallelepiped with a base of 1x1 m and the height equal to the shrubs height are collected. The real volume of shrubs is estimated for determining the load per hectare.

T21 – 4 transects of 21m in length starting from the center point and are directed towards the four cardinal points. Each of them is divided into 3 portions of 7 m:

in the first section (0-7 m) the pieces of fuel of all classes should be counted (1h, 10h, 100h, 1000h);

in the second section (7-14 m) the pieces of fuel of classes 10h, 100h and 1000h should be counted

in the third section (14-21 m) the pieces of fuel of classes 100h and 1000h should be counted

The fuel volume for each of the classes is calculated by the van Wagner formulae

$$V = \frac{\pi^2 \times \sum_i d_i^2}{8 \times L}$$

Two twigs per each time-lag class are collected as a sample for determining the dry bulk density and to know the total load of fuel.

Harvesting method

Harvesting method used in the stands in which the research was conducted place is manual felling by chainsaws. Trees are delimbed and bucked at the stump. Short logs are produced and one meter long fire wood is stacked in the proximity of the stump. Harvesting residue is left scattered on the felling site.

Skidding of the logs is conducted by LKT and adapted agricultural tractors. Tractors move freely over the felling site collecting the logs and extract them to a roadside landing.

Study area

The research was carried out on the territory of the National Park “Fruska gora”, which manages the forests in the vicinity of the city Novi Sad and Sremska Mitrovica in Northern Serbia, or more precisely, Vojvodina. This national park is also the closest national park to the capital city of Belgrade. Following paragraphs are describing each of the study areas.

Study area 1, Lezimir

Study area in Lezimir is located on a very steep and undulating slope (26-30°). Litter is moderately present due to favourable decaying conditions. Grasses and shrubs are rare, there are no weeds. Forest type is Carpino-Quercetum petreae-cerris typicum. It is an even aged coppice stand in optimal phase (by Serbian normative). Stand was attended and has a full canopy (1.0). Overall health condition of trees is moderate, trees are straight and with a slight tapering. Quercetum petrea trees have very long crowns (up to 2/3 of the height) whilst other species have short crowns (1/4-1/3 of height).

Study area 2, Beocin

Study area in Beocin is located on steep but uniform terrain (11-15°), 210-305 meters above sea level and on northern exposition. Litter is moderately present due to favourable decaying conditions. Forest type is Carpino-Polyquercetum fagetosum. It is an even aged coppice stand of Tilia argentea and Fagus moesiaca in the optimal phase (by Serbian normative). Canopy is full (1.0) and the stand was attended. Trees in this stand are curved but with a slight tapering. The length of crowns is 1/3 up to ½ of the height. Overall health condition of trees is good.(The data from management books indicate very dense shrubs and moderately dense grasses and also the pictures seem to present the presence of shrubs but the transects somehow failed to go through the patches of shrubs)

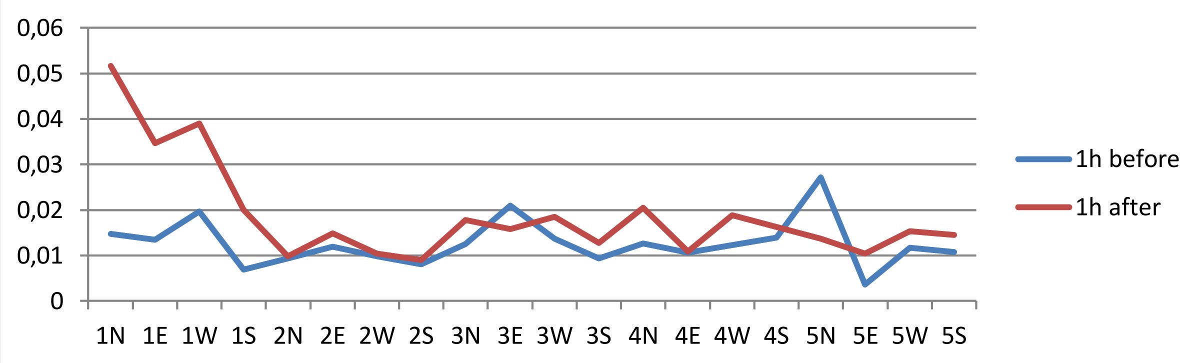
Study area 3, Sremska Kamenica

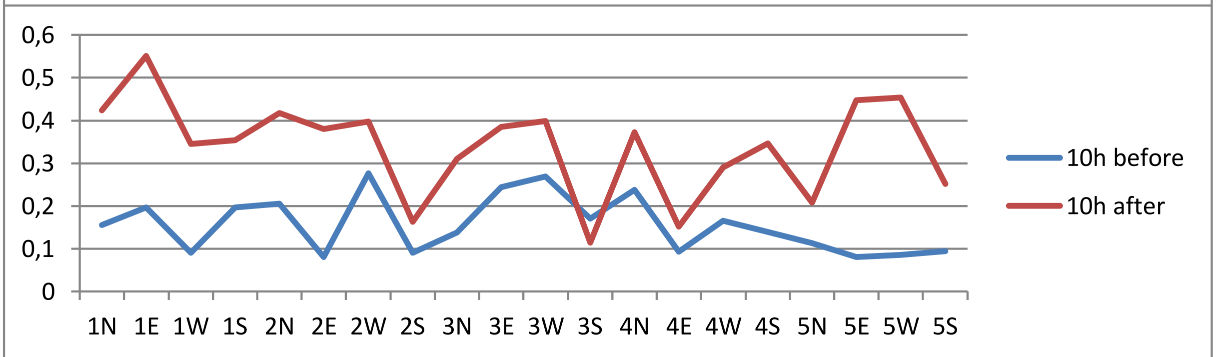
This forest is located on the slope of 11°-15° uniform inclination. Height above sea level ranges from 250 to 295m. Slope exposition is western. Litter is moderately spread which indicates favourable decaying conditions. Moderately dense understorey vegetation. Shrubs are rare. Forest type Quercetum montanum cariecetosum pilosae. It is coppice stem wise mixed stand of sessile oak and lime tree, even aged and in the optimal phase. The stand was well managed. Canopy is dense (0.8-0.9). Overall health condition is good. Susceptibility to pests is moderate. Stems are curved and the tapering is moderate. Dead trees are rare. Crowns are long between ½ and 2/3 of the stem height. The stand is in 2nd level of protection in the National park.

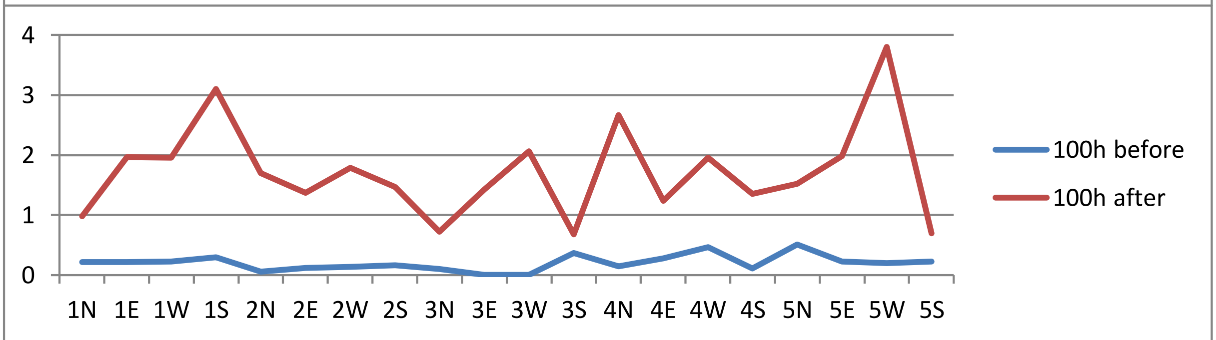
First results

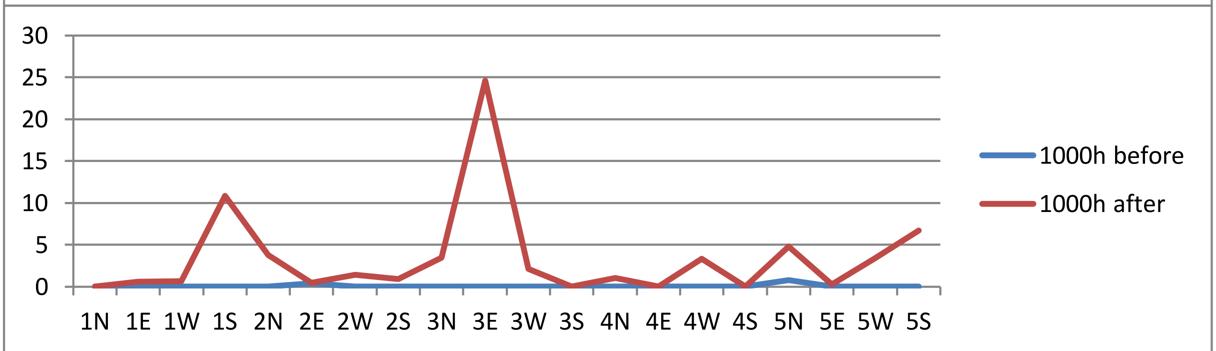
Five plots per area have been positioned on each of the study areas.

Study area 1, Lezimir – quantity of woody surface fuels (except shrubs) before and after the harvest per time lag class (1h, 10h, 100h and 1000h) in [odt/ha]:

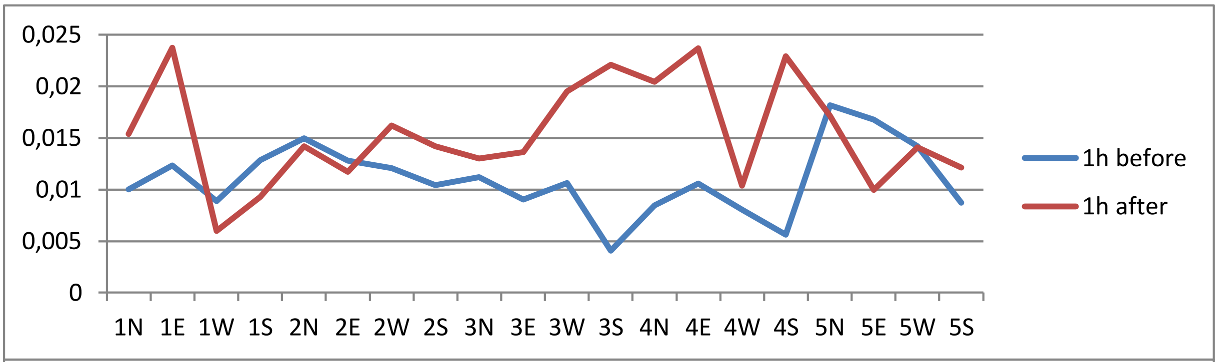


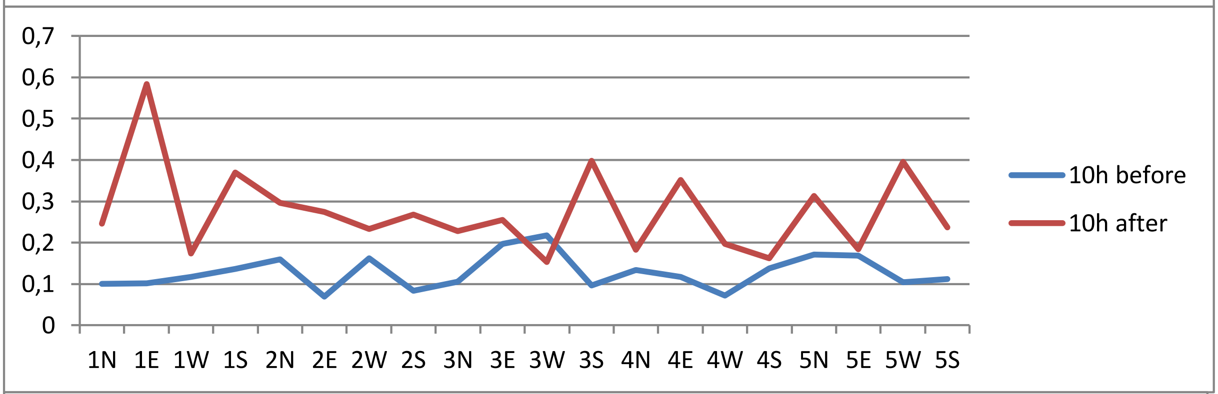


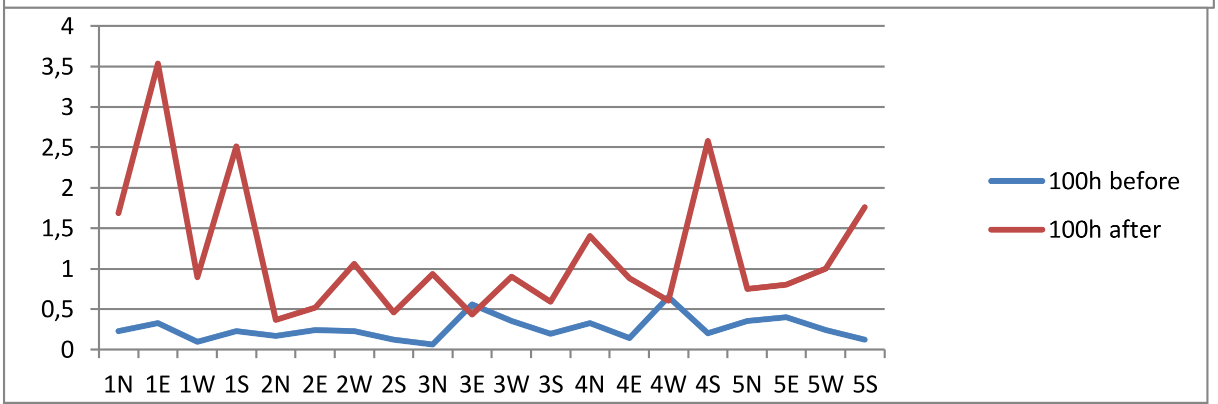


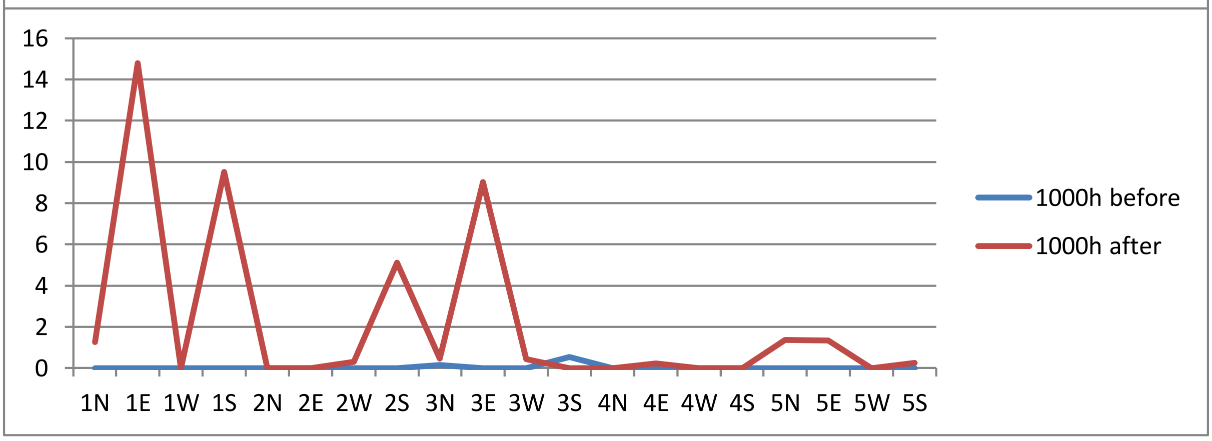


Study area 2, Beocin– quantity of woody surface fuels (except shrubs) before and after the harvest per time lag class (1h, 10h, 100h and 1000h) in [odt/ha]:

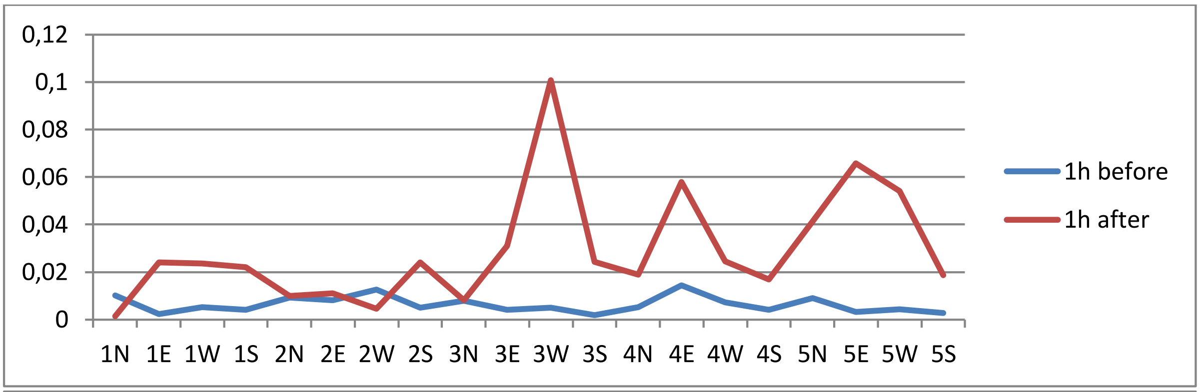


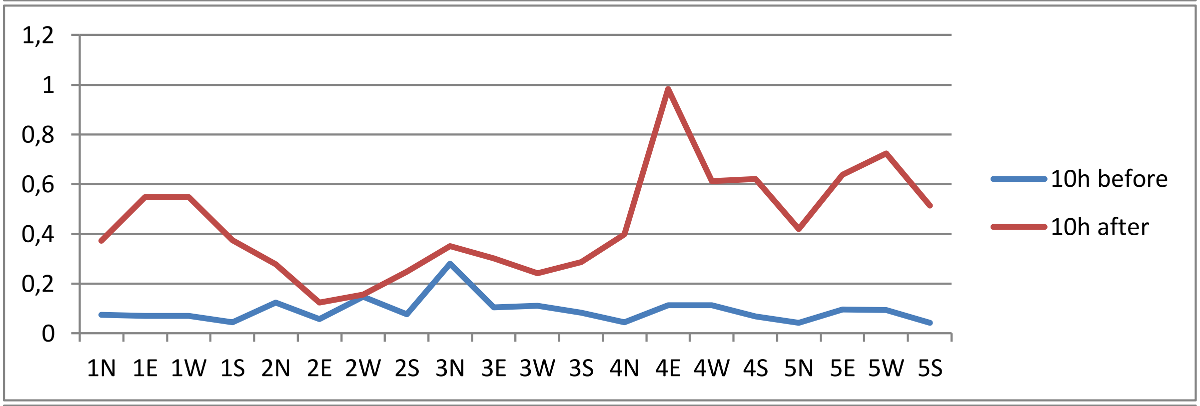


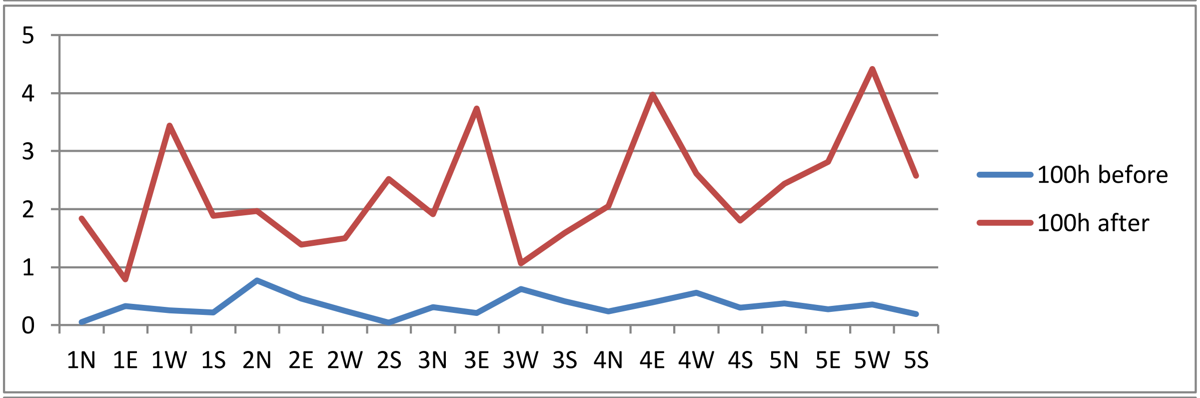


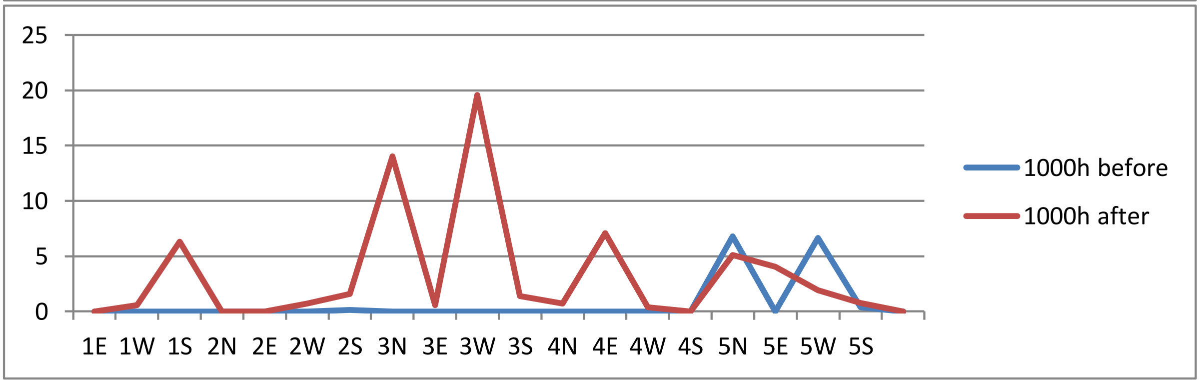


Study area 3, Sremska Kamenica– quantity of woody surface fuels (except shrubs) before and after the harvest per time lag class (1h, 10h, 100h and 1000h) in [odt/ha]:









As we can conclude from the graphs, the quantity of surface fuels is much higher when it comes to the wood biomass. This data and the quantity of biomass from grasses, litter and shrubs will be used as input data for the BehavePlus software where we will get the information on how much would these harvests increase the fire severity.

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4. Future collaboration and predicted publication of the results

This STSM, as previously mentioned is only a part of cooperation between the institutions, Mendel University and Institute of lowland forestry and environment. Research started by this STSM will be continued even beyond this STSM and will hopefully lead to comprehending a much wider area and different conditions which will in the end give us exact information on what can, what should, where and when should be done in order to prevent such hazardous occurrences in the nature.

Further cooperation with the host institution will also be to process all the data in the BehavePlus 5 software and to publish acquired results in some scientific journal. It is planned to finish the calculations and analysis during July (2015) and in the meantime to work on the article. Authors believe that the final outcome will be good enough for scientific journals with IF above 1.0. In that manner and after concluding the article we will start with submission of the article. Starting journal will be “Environmental Modelling and Software”. In case that we will not be successful with that submission, second option will be “International Journal of Wildland Fire”. Third option will be “Fire Ecology”.

The paper is intended to comprehend all of the collected data which was described previously in the chapter “Description of the carried out work”. By having all of that data, we hope to get few conclusions on whether or not harvests impact the risk of fire, can the residues be used as a feedstock for energy production and what can be done to decrease the quantity of unused residues and increase the quantity of financially viable biomass. In case that more data will be needed for such conclusions, results gathered from similar researches that have been done and that are currently being conducted will be added.

5. Acknowledgements

I would personally like to thank COST Action GreeInUrbs FP1204 for providing financing for this research. This research continues and deepens the cooperation between Mendel University, Brno and Institute of lowland forestry and environment, Novi Sad. Also, I would like to express gratitude to the hosts, Institute of lowland forestry and environment, Novi Sad for their help in organizing and fulfilling this research. Last but not least, I am very thankful to the colleagues from National Park “Fruska gora” for letting me do the research in the forests under their management.

6. Summary – press release

The research was conducted in the National park Fruska Gora in the northern part of Serbia. Three big cities are in its vincinity, of whom one is the capital city Belgrade, which makes it very popular for the tourists. Three stands have been chosen for the research. In 2 a thinning was to take place and in one the final cut. In each of the stands, 5 sample plots were positioned. Each of the sample plots consisted of two different transects (T10 and T21) layed down in four dfferent directions and one circular area (radius 13m) for the inventory. The research included the collection of the following data: inventory data, number of dead wood per time lag class, litter presence and depth, grass presence and depth and shrub presence and depth. All of the data was collected before and after the harvest and the first results indicate significant increase in the quantity of surface fuel.