STSM Report: COST Action FP1301

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Surface fuel loads and biomass potential in coppice forests

Background

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

Fortunately, the data published by European Commission in 2010 show the decrease in number of forest fires and the area burnt in this region. As for Italy, the burnt area decreased by 29.2% but still it poses a great threat to the environment (Marchi et al. 2014).

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 STSM

The primarily aims of the proposed short term scientific mission was to quantify the biomass potential in coppice forests and the proportion of utilized and unutilized mass in order to assess how different logging systems (cut to length vs. whole tree system) may affects fire risk level. The surface fuel load and its characteristics strongly affect fire ignition, intensity and rate of spread, and finally fire severity.

Unfortunately in the second half of September a big storm has hit the Tuscany region and in particular the area where the study activities were planned so the research had to be slightly modified. In detail, in was not possible to analyse forest coppice harvesting during the STSM period because cuttings were suspended in coppice and concentrated in the windthrow areas.

For this reason, it was planned to analyse the fuel load in harvested stands that have been harvested during the last 3 harvesting seasons. Also one unharvested stand, where cut is scheduled for the upcoming season, was taken as a control.

The research will give us an insight about the fuel load after the harvest in the stands managed as coppice with standards, and how it changes over a period of time.

All surface fuels were collected, oven-dried and classified into time lag classes.

The main aim was to determine the fuel load and to evaluate how prone these stands to forest fires actually are. By knowing the actual risk, some new practices could be introduced in the future so the quantity of usable biomass is increased and the susceptibility to fire is decreased.

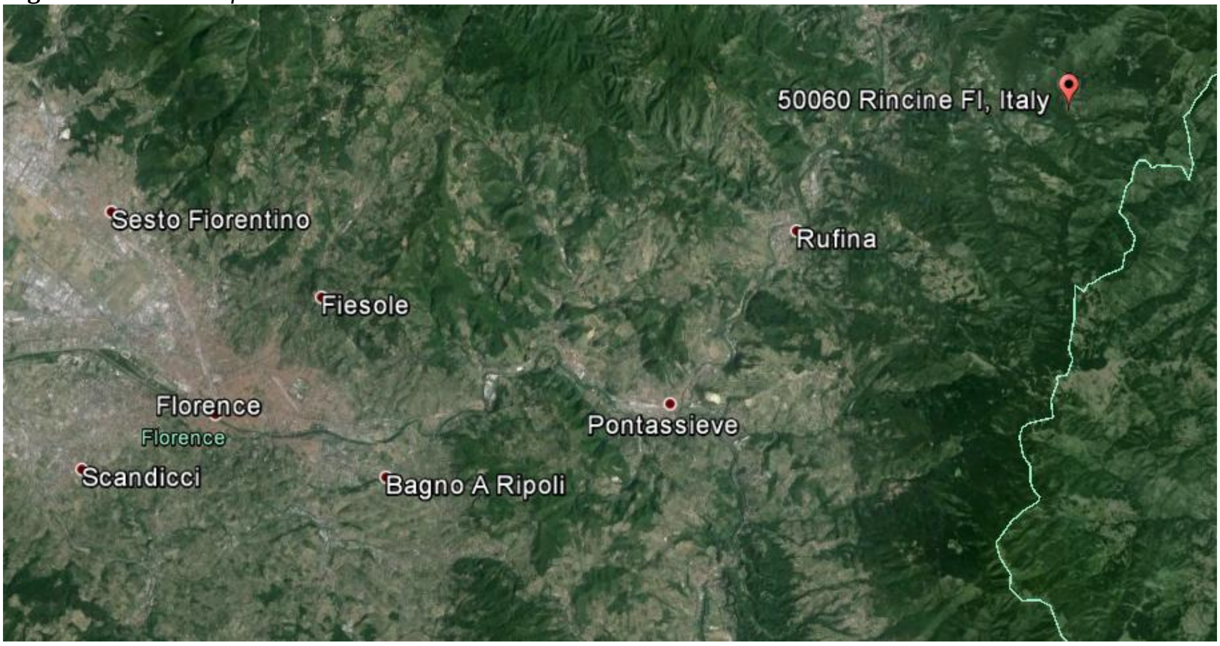
Research site and methodology

Site for this research was chosen to be in the district of Rincine forests. It is located just northeast of Florence, Italy and in the Apennines mountain range. The forests are managed by a public agency. The Rincine forest district covers 1450 hectares of different forests managed under various silvicultural forms. The attitude of the district varies from 400 up to 1400 m above sea level.

According to Dream (2003) the total quantity of wood to be harvested in the district is 67722 m^3 in the period from 2005 to 2019. Majority of wood is to be harvested in the coppices and high forests, 24692 m^3 and 34401 m^3 respectively, but a significant quantity, or more precisely, 4276 m^3 will be harvested from coppice with standards. The rest will be harvested from coppices that are to be converted into high forests.

Access is allowed by 37 km of forest road and 39 km of forest trails, for a total network of a 76 km, evenly distributed throughout the district. The average distance between the edge of a compartment and the closest landing is about 350 m, but in the majority of cases the extraction distance is shorter than than 250 m, and only in 25% of the cases it exceeds 500 m (Marchi et al. 2009).

Figure 1: *Location of Rincine in relation to Florence*



The research was conducted in 4 similar oak (Quercus petrea) and hornbeam (Carpinus betulus) stands. The stands are managed by silvicultural method of coppice with standards. The rotation period is 30 years in which a part of the standards is taken out and approximately 60 standards per hectare are left in the stand until the next rotation. Due to that fact, there are trees of 2 different ages in the stand (30 and 60 by the time of harvesting).

Three oak stands have been chosen in relation to the harvesting year and one that is to be harvested in the next harvesting season. In that sense, one stand was chosen that had been harvested during the harvesting season 2013/2014, one that had been harvested in 2012/2013 and one that had been harvested in 2011/2012. All 4 stands are accessible by a truck road and are inclined so the used method of extraction is gravitational, manually throwing fuelwood down, towards the road. The purpose of the stands is mainly the production of fuelwood. Harvesting is done by the short wood system using manual chainsaws. All trees have been delimbed and bucked at the stump and the harvesting residue was collected into rows that stretch in the direction of the terrain's inclination.

Study area 1

Study area 1 was the only unharvested area that was researched. The area is planned to be harvested during the harvesting season 2014/2015 with same harvesting methods as used in surrounding stands. The stand is composed of oak (Quercus petrea) and hornbeam (Carpinus betulus) with oak being dominant.

Area chosen for the research was 20x20 m in dimensions. In that area, 6 standards were counted and their approximate height was 15m. Due to the fact that there was no harvest, no new stumps nor sprouts were found.

Sample plots in this area were positioned in all corners of the area and one in the middle, i.e. 5 plots in total. The plots were 40x40 cm. Natural regeneration from seeds was counted on the sample plots and in an area 2 m in diameter around the plot.

Figure 2: *Sample plots*

Figure 3: *Study area 1*

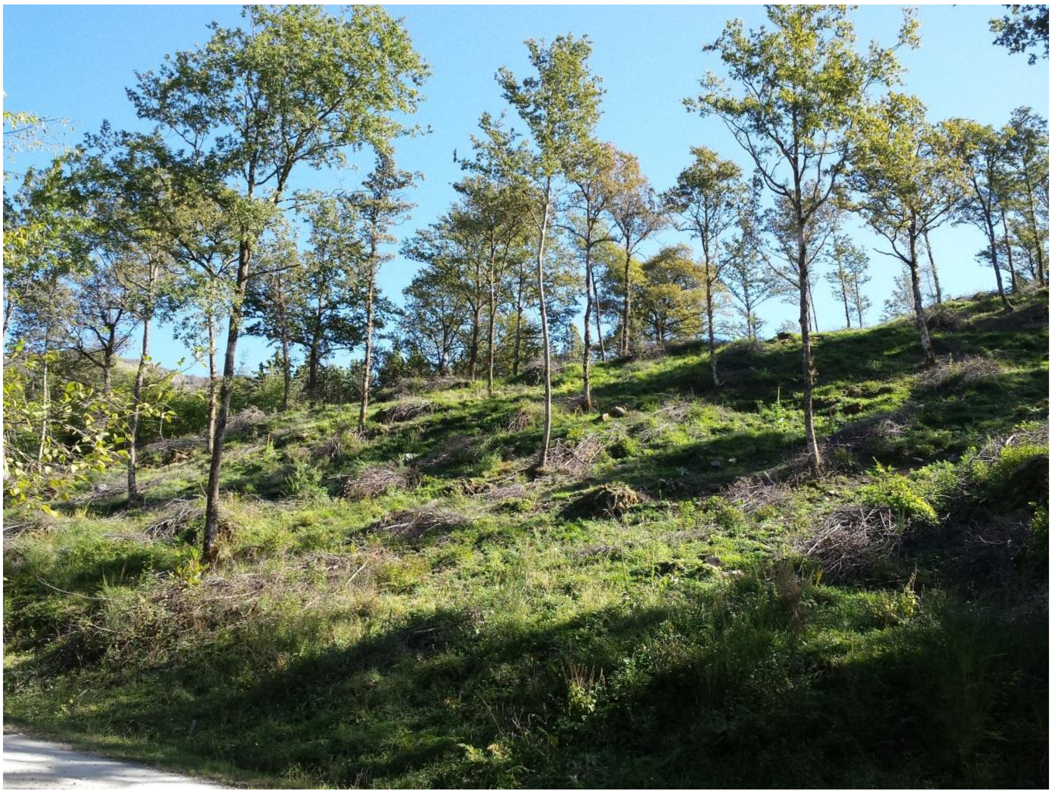
Study area 2

Study area 2 was harvested during the 2013/2014 harvesting season. Regular rows of harvesting residue can be easily spotted. The stand is composed of oak (Quercus petrea), hornbeam (Carpinus betulus) and chestnut (Castanea sativa).

Dimensions of the study area were 27.40x27.40 m. It concluded 4 rows and a half of the distance between rows to the each side of the area. In total, 7 standards were counted on this area and 112 stumps of hornbeam, 19 stumps of oak and 4 stumps of chestnut. Average number of sprouts per stump is 20, and the average height of sprouts is 30 cm. The reason for such a small height is high number of game, especially deer (Cervus elaphus) and roedeer (Capreolus capreolus). Average height of standards was 16 m.

Rows of harvesting residue were 1.6 m in width on average which means that they covered 23.36% of the area. Average height of rows is 71.75 cm.

Figure 4: *Study area 2*



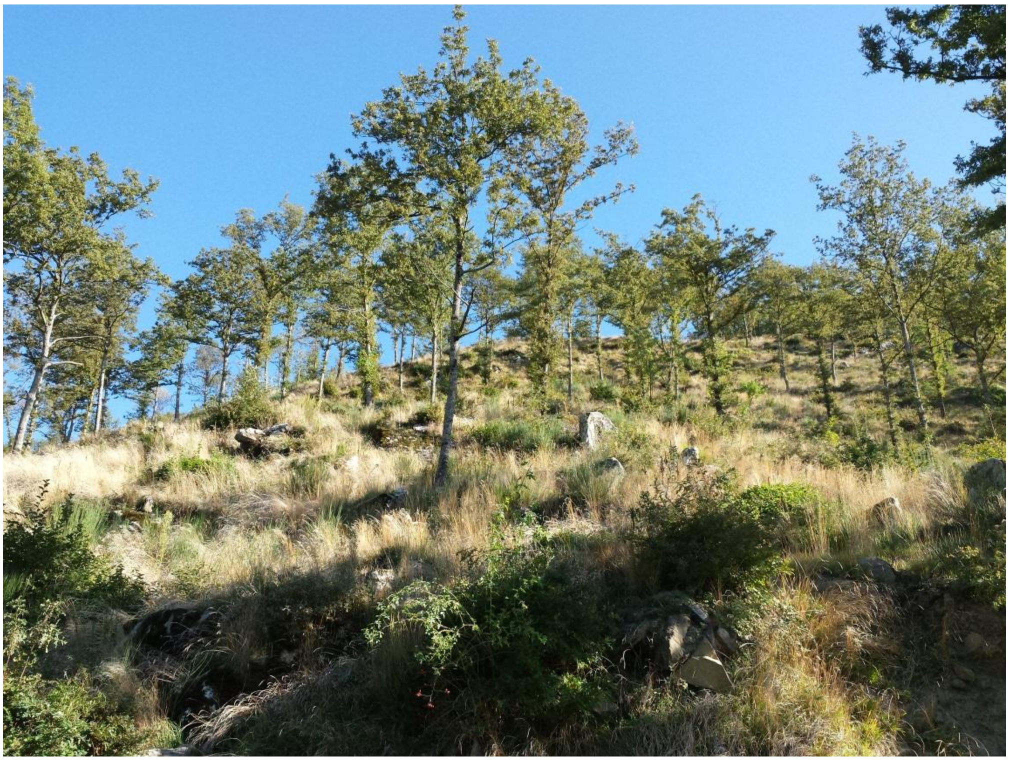
Study area 3

This area was harvested 2 years ago, or more precisely during the 2012/2013 harvesting season. Rows of harvesting residue are not so easy spottable because of many shrubs and high grass which have grown. The stand consists of oak and hornbeam. No chestnut trees were found.

Like the previous study area, this area also concluded 4 rows of harvesting residue and a half of the way between the rows on both sides. The area measured 31x31 m. A total of 9 standards were counted and also 54 hornbeam and 33 oak stumps. Average number of sprouts is 9 and their height is 100 cm. Average height of standards is 15 m. Stumps and sprouts in this area are also heavily affected by game.

Rows of harvesting residue are 170 cm in width on average which means they occupy 21.94% of the total area. Average height of the rows is 32.75 cm.

Figure 5: *study area 3*



Study area 4

This study area was harvested during the harvesting season 2011/2012. Harvesting residue was not collected into rows after cutting and was scattered around the site randomly or in small piles. This stand also consists of oak and hornbeam and without chestnut.

Since there are no harvesting residue rows, the dimensions of the study have been chosen to be 28x28 m. A total of 7 standards were counted and 26 oak and 67 hornbeam stumps. Average number of sprouts is 4 and their height is 100 cm. Height of standards is 15 m on average. This area, likewise all others, is heavily affected by game population.

Harvesting and extraction methods used were the same as in previously described study areas.

Figure 6: *Study area 4*

Methodology

Small sample plots, which were used for collecting of surface fuel, were positioned on the ground. Dimension of sample plots was 40x40cm. The layout of the plots was such that one sample plot was placed on each of the harvesting residue rows and one plot between each of the rows, where rows of harvesting residue existed. In the case of an unharvested area, the plots have been positioned in all 4 corners of the study area and one in the middle. Besides that, sample plots on the rows are positioned on various distances from the road to avoid any possible imperfections. Since the harvesting residue rows and space between them do not take up same surface area, correctional factors will be applied when calculating the total amount of fuel load of the stand. The correctional factors were determined on the basis of the area with or without “slash rows” in relation with the total surface of the study area. By doing that, the percentage of the area covered and uncovered by the rows was obtained and the calculation of the exact average surface fuel load was possible.

The above mentioned method was used only in the stands that were harvested 1 and 2 years ago. The stand harvested 3 seasons ago did not have recognizable rows of harvesting residue. The residue was found to be scattered all around the ground and sometimes in small piles. In that stand a regular net of 9 sample plots was established on an area of 28x28 m in order to acquire a higher level of accuracy.

Actions on the sample plots will include:

1. Noting the surface coverage of: grasses, shrubs, litter and harvesting residue in %
2. Height of the harvesting residue pile in cm
3. Height of grasses in cm
4. Height of shrubs in cm
5. Number of oak regeneration from seed
6. Depth of the litter in cm
7. Collection of each type of fuels into different bag

Following the research activity on the field and collection of the data, collected fuels were to be classified in laboratory into 4 size classes, according to the time-lag classes. The size classes of the fuels are:

1.	<6 mm	Time lag 1 hour
2.	6 – 25 mm	Time lag 10 h
3.	25 – 75 mm	Time lag 100h
4.	> 75 mm	Time lag 1000h

After classification of the fuels, they were oven-dried in order to measure the weight of the dry matter. The quantity of dry matter on sample plots was calculated and then multiplied by the correctional factor in order to get the value of surface fuels per hectare.

Drying was done in a big oven at 103°C and for at least 16 hours. Bigger dimension fuels, namely 100h and 1000h classes, were dried for 24 hours at the same temperature.

The same procedure will be done on all research areas in order to get results of how the quantity changes during the first 3 years after the harvest but also to see the situation in the stand before the harvest.

Main results

Description of the sample plots concerning the coverage and dimensions of the biomass are presented in next tables according to the study area they belong to.

Table 1: *Study area 1*

	Plot N.				
	1	2	3	4	5
Grass coverage (%)	0	50	25	25	35
Shrub coverage (%)	5	0	0	0	0
Litter coverage (%)	95	50	75	75	65
Residue coverage (%)	0	0	0	0	0
Residue height (cm)	0	0	0	0	0
Grass height (cm)	0	30	35	30	15
Shrub height (cm)	10	0	0	0	0
Regeneration	0	5	3	7	0
Litter depth (cm)	5	2	5	1	1

Table 2: *Study area 2*

	Plot N.							
	1	2	3	4	5	6	7	8
Grass coverage (%)	0	20	20	70	70	40	50	50
Shrub coverage (%)	10	0	0	0	20	5	10	10
Litter coverage (%)	0	0	5	0	10	15	5	0
Residue coverage (%)	90	80	75	30	0	0	0	0
Residue height (cm)	90	60	70	67	0	0	0	0
Grass height (cm)	50	50	23	60	30	25	35	15
Shrub height (cm)	70	0	0	0	20	10	20	10
Regeneration	0	0	1	0	0	1	0	1
Litter depth (cm)	5	3	2	3	2	1	1	0

Table 3: *Study area 3*

	Plot N.							
	1	2	3	4	5	6	7	8
Grass coverage (%)	60	90	70	30	80	100	100	90
Shrub coverage (%)	0	0	0	0	0	0	0	0
Litter coverage (%)	0	0	0	0	10	0	0	5
Residue coverage (%)	40	10	30	70	0	0	0	5
Residue height (cm)	40	20	38	33	0	0	0	5
Grass height (cm)	45	30	45	40	60	20	30	92
Shrub height (cm)	0	0	0	0	0	0	0	0
Regeneration	0	0	0	0	8	0	0	3
Litter depth (cm)	2	2	3	2	1	0	1	1

Table 4: *Study area 4*

	Plot N.								
	1	2	3	4	5	6	7	8	9
Grass coverage (%)	95	100	80	0	10	95	60	35	5
Shrub coverage (%)	5	0	15	100	50	0	30	35	90
Litter coverage (%)	0	0	0	0	10	0	0	0	0
Residue coverage (%)	0	0	5	0	30	5	10	30	5
Residue height (cm)	0	0	14	0	20	10	5	10	5
Grass height (cm)	25	30	35	35	20	40	32	20	40
Shrub height (cm)	22	0	40	143	60	0	45	40	120
Regeneration	0	0	0	0	0	0	0	0	0
Litter depth (cm)	0	0	0	0	0	0	1	2	0

As we can see from the tables, the dominant cover in area 1 was litter (72% on average). In area 2, the dominant cover in plots on rows of harvesting residue was harvesting residue with an average share of 68.75%. The dominant cover on plots between the rows was grass with a share of 52.5%. Also, the average height of harvesting residue is bigger in area 2 (71.75 cm) than in area 3 (32.75 cm). Grass coverage was absolutely dominant in area 3 with 92.5% coverage in the plots between the rows and 62.5% in plots on the rows.

Coverage in area 4 is dominated by grasses and shrubs which make almost 90% of the cover on average. Residue height is much smaller which is most probably due to the game animal activity and weather conditions with taking into account that this area had been felled 3 harvesting seasons ago.

Number of regeneration from seeds is biggest in the unharvested area (3 per plot), due to the fact that seeds had the best chances of reaching the soil in those conditions and that were not exposed to mechanical damage during the harvesting.

Table 5 presents the total quantities of all fuels classified into time lag classes and calculated into kilograms per hectare.

Table 5: *Fuel quantity per time lag class (kg/ha)*

	Time-lag class			
area	1 h	10 h	100 h	1000 h
1	11245.13	4765.00	2213.25	0
2	11496.97	16471.09	10635.47	4834.93
3	11157.43	13616.01	17116.50	0
4	13927.01	9571.11	6259.93	0

Preliminary conclusion

The study will be completed in the next months. In particular it was not possible to carry out the statistical analysis of the data and the discussion of the results within the STSM period. For this reason we are now able to make some conclusion only on the basis of the descriptive statistics. These conclusions should be confirmed by more detailed and appropriate statistical analysis.

On the base of the data it seem that no changes were recorded among treatments in the load of 1h time lag class, while in the 10h time lag class the fuel load was higher in the harvested areas in comparison with the control. Moreover, in the same class, fuel load decreases in the harvested areas, with area 2 having the highest values and area 4 the lowest. Also the fuel load in the 100 h time lag class was higher in the harvested areas in comparison with the unharvested one, but no regularities could be observed among the harvested areas. The 1000h time lag class fuel was recorded in only one treatment. This is easily explained because during harvesting logs with diameter higher than 5-7 cm are usually extracted as firewood.

Besides that, the quantity of grasses increases with the age of harvests. The quantity of grasses in area 2 is 1069.7 kg/ha, in area 3 is 4035.1 kg/ha and in area 4 6134.9 kg/ha. Grasses in the unharvested area are calculated to be 679.1 kg/ha.

Shrubs seem to start to occupy the ground more intensively from the third year after the harvest.

Future collaboration with host institution

The collaboration with the GESAAF – University of Florence was great. I had full support with all details concerning my research during the whole time of the mission. I hope that this will only be the beginning of a mutual cooperation and collaboration in the future.

I would like to express special gratitude to the Prof. Enrico Marchi, PhD. and Francesco Neri, PhD. for the support in defining the research methods and all the help provided during the stay. Also, I would like to point out great deal of help that I received from two B.Sc. students, Gemma Navarra and Leonardo Bucca.

Big gratitude goes also to the Union of municipalities of Valdarno and Valdisieve which manage forests in the Rincine forest district and which provided me accommodation while the data collection.

Last but not least, I would like to express great thankfulness to the COST action FP1301 which made this mission possible.

Foreseen publications/articles resulting from STSM

Results from this STSM are intended to be integrated into an article which is to be sent to a peer reviewed journal for publication.

Confirmation of the successful completion of STSM by the host institution

Confirmation of successful completion of the mission can be found attached to this document.

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