WORK PRODUCTIVITY EVALUATION OF DIFFERENT HARVESTING SYSTEMS IN OAK COPPICE STANDS

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ABSTRACT: Turkey oak is one of the most common wooden species in Central and Southern Italy. Turkey oak coppices are mostly utilized for firewood production, since the characteristics of wood are not suitable for timber production. In the last years, the increasing labor costs are making more and more difficult to utilize turkey oak coppices. The solution can be identified by increasing work productivity in such stands, making harvesting costs decrease. The aim of the present work was to evaluate some different harvesting systems in turkey oak coppice utilization, in order to compare the effectiveness of various harvesting possibilities. In particular, the evaluation focused on the extraction through cable skidder, light gravity cable yarder and medium gravity cable yarder. Work productivity resulted relatively low in all the investigated extraction systems, due to the harsh topographic conditions. The highest productivity emerged by cable skidder, with extraction productivity of 0.42 t h^{-1}, while the light gravity cable yarder showed 40% lower level and the medium gravity cable yarder showed 8% lower level.
Keywords: cable skidder, cable yarder, sustainable forest operations, firewood, turkey oak

1 INTRODUCTION

Turkey oak (*Quercus cerris* L.) is one of the most widespread forest species in Italy [1]. Usually turkey oak stands consist of coppices, often old ones, mainly used for firewood production [2]. In the last years the increasing labor costs, along with the phenomenon of abandoning rural areas, has been causing a decrease in the stumpage value of such stands [3]. Therefore, there has been an increasing focus, by the scientific research, in evaluating and proposing alternative harvesting systems for coppices [4,5], whereas they are generally harvested through motor manual felling with chainsaw, and the extraction operation is usually carried out through forestry fitted farm tractor with loading bins or winch. Evaluating work productivity of a given harvesting system is crucial, as this variable is strongly connected to the cost-effectiveness of the forest intervention [6,7]. Obviously, the economic aspect is not the only guideline to be considered concerning the suitability of an harvesting system, since environmental and social aspects are essential to get the aim of sustainable forest operations and management [8–11]. However, literature still shows few papers dealing with work productivity analysis of harvesting systems in oak coppice conversions. According to what written above, the aim of the present work was to evaluate different harvesting systems in turkey oak coppice utilization, in order to compare the effectiveness of various harvesting possibilities. In particular, the evaluation focused on the extraction with cable skidder, light gravity cable yarder and medium gravity cable yarder.

2 MATERIALS AND METHODS

2.1 Study area

One sub-compartment was identified within the regional forest Cuponi (Campania, Italy). Details about the studied area and the investigated harvesting systems are given in Table I, while the different machineries used for extraction are reported in Figures 1, 2 and 3. Finally, a vision of the intervention area is given in Figure 4.

Figure 1: Skidder Forest Ranger.

Figure 2: Light gravity cable yarder Savall 1500.

Figure 3: Medium gravity cable yarder Valentini V400.

Figure 4: Study area after the intervention.

Table I: Characteristics of the sub-compartments and the harvesting systems.

	HS1	HS2	HS3
Avg. slope (%)	50%		
Avg. dbh (cm)	6.5		
Avg. height (m)	8		
Harvested biomass (t_{fm}/ha)	81.73		
Working system	WTS (Whole Tree System)	WTS (Whole Tree System)	WTS (Whole Tree System)
Felling operation	Chainsaw Husqvarna 346 XP	Chainsaw Husqvarna 346 XP	Chainsaw Husqvarna 346 XP
Extraction operation	Cable skidder Forest Ranger 87 kW	Light gravity cable yarder Savall 1500	Medium gravity cable yarder Valentini V400

2.2 Work productivity evaluation

Work productivity evaluation was carried out according to the methodology proposed by [12]. In particular, gross productivity (PHS_{15}) and net productivity (PHS_0) were assessed by measuring working time through a chronometer. Measure unit for work productivity is $t_{35\%}h^{-1}$, thus referring to the tons of biomass at 35% moisture and harvested by the complete working team in one hour. Subsequently, cost analysis was performed according to [13].

3 RESULTS AND DISCUSSIONS

Results related to work productivity analysis of the investigated harvesting systems are given in Table II.

Table II. Work productivity recorded in the studied yards.

		HS1	HS2	HS3
Felling ($t_{35\%}h^{-1}$)	PHS_{15}	6.46	6.46	6.46
	PHS_0	7.28	7.28	7.28
Extraction ($t_{35\%}h^{-1}$)	PHS_{15}	1.95	1.17	1.80
	PHS_0	2.25	2.28	2.97

Considering that felling operation was performed with the same machinery and by the same team, the differences between the three harvesting systems are related only to extraction process. As it possible to notice, the highest gross productivity was reached by cable skidder extraction, while light weight cable yarder and medium gravity cable yarder showed 40% and 8% lower productivity respectively. However, it is worth to notice how HS1 is the system showing the lowest improvement possibility. This brings out one of the major problems in implementing aerial extraction systems in Central and Southern Italy, i.e. the scarce skills of the operators concerning these systems. In particular major problems raised regarding the hooking and bunching phases. Results of costs analysis are then reported in **Table III**.

Table III: Costs analysis.

Harvesting costs € $t_{35\%}^{-1}$			
Operation	HS1	HS2	HS3
Felling	5.53	5.53	5.53
Extraction	48.51	77.82	69.33
Total	54.04	83.35	74.86

The lower productivity achieved by aerial extraction systems negatively affected the harvesting costs. As a consequence, given the usual market price for firewood in the study, these harvesting systems show practically no cost-effectiveness. On the other hand, cable skidder revealed the possibility to be used with acceptable cost-effectiveness.

4 CONCLUSIONS

Applying harvesting systems based on dedicated forest machineries could be part of the solution to the problem of decreasing stumpage value of coppices in

Central and Southern Italy. This study highlights how ground-based extraction is still the best solution in such context in terms of work productivity. Furthermore, the introduction of aerial extraction systems needs implies the operator skills to be increased, as sometimes they are not enough familiar with such equipment at present.

5 REFERENCES

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