FORMEC 2010
Forest Engineering: Meeting the Needs of the Society and the Environment
July 11 – 14, 2010, Padova – Italy

TIMBER EXTRACTION WITH A CABLE CRANE IN SOUTH ITALY (CALABRIA)

Giuseppe Zimbalatti, Andrea R. Proto

Dept. Agroforestry and Environmental Sciences and Technologies,
Mediterranean University of Reggio Calabria
Feo di Vito, 89122
Reggio Calabria, Italy
e-mail: gzimbalatti@unirc.it - andrea.proto@unirc.it

Keywords: cable extraction, time study, roundwood, timber production

Abstract: *The timber harvesting is still one of the most important forestry activities in Southern Italy but the forests are mainly located in steeply sloping mountainous areas where ground-based wood extraction is still the most common harvesting technique employed. The extraction of forest products is a very difficult, expensive and time-consuming operation. This problem is very important because the forests of Calabria are located in mountainous areas. The purpose of this research is to contribute to a growing knowledge of the productivity of a cable system in timber extraction from Calabria's mountainous forests. The productivity of cable crane, tested for roundwood yarding, was assessed to verify if the use of this machine should be efficiently recommended under the forest conditions in Southern Italy. This study investigates the productivity using the methods of work and time study during the extraction of large- and medium-sized wood. The research concludes that some working characteristics of the Greifenberg TG 1100 cable crane such as transportation speed of the carriage (loaded and unloaded), load volume, time consumptions of felling area, productivity of the cable crane and transport distance have an absolute impact on the productivity of the cable crane. The results of this study have shown that the transport of forest products by cable crane operated in areas located in mountainous terrain is a more permanent and efficient haulage method in mountainous forest land.*

1. Introduction

The timber harvesting is still one of the most important forestry activities in Southern Italy but the forests are mainly located in steeply sloping mountainous areas where ground-based wood extraction is still the most common harvesting technique employed. The extraction of forest products is a very difficult, expensive and time-consuming operation. This problem is very important because the forests of Calabria are located in mountainous areas. Calabria is a region in Southern Italy with a forest cover of 31.8%. Calabrian forests are also highly productive since every year the average increase in wood volume exceeds and is sometimes twice that of the increase estimated for other forests in Southern Italy. Despite being such a conspicuous woodland resource, the most common working method in Calabria can be considered as being traditional and still at an early stage of mechanisation (Hippoliti, 1997). It is based mainly on the use of agricultural tractors, sometimes equipped with specific forest machines like winches, hydraulic cranes, log grapples but also, the use of animals for gathering and yarding is still widely used. Chainsaws are the most common machinery for timber cutting operations (Verani and Sperandio, 2003). The low level of mechanisation in Calabrian forests can be attributed to their site features, the characteristics of the property, the small areas of many of the enterprises, the scant knowledge of modern machinery, and the scarcity of relevant studies relating to the use of modern machinery. Wood from Calabria is mainly destined for the production of energy or for building and packing materials. However some wood products are sent for processing firms in other regions, where they are converted into quality products (Zimbalatti and Proto, 2009). Thus, the use of cable cranes in Southern Italy remains limited, particularly in forests for firewood production. The problems associated with the introduction of cable cranes are common to many other forestry areas of the world and include the cost of the machinery, the productivity of work and the commercial value of the extracted material. Cable cranes are, however, among the most important means of yarding and transporting timber and their use in the mountainous regions of Europe is more widespread. Ninety-five percent of timber production in Southern Italy (2.3 million m^3 $year^{-1}$; 25% of the total in Italy) comes from terrain which is classified as having a very steep slope (Tiernan et al., 2004). This limits the use of machines for ground-based extraction. In this context the use of cableways could represent one of the best methods from a technical and environmental point of view (Visser and Stampfer, 1998; Rieger, 2001). This study investigates the productivity using the methods of work and time study during the extraction of large- and medium-sized wood. The research presented aimed at improving the technical knowledge concerning the use of this machinery in Southern Italy and how advisable its extension to other areas would be (Figure 1).

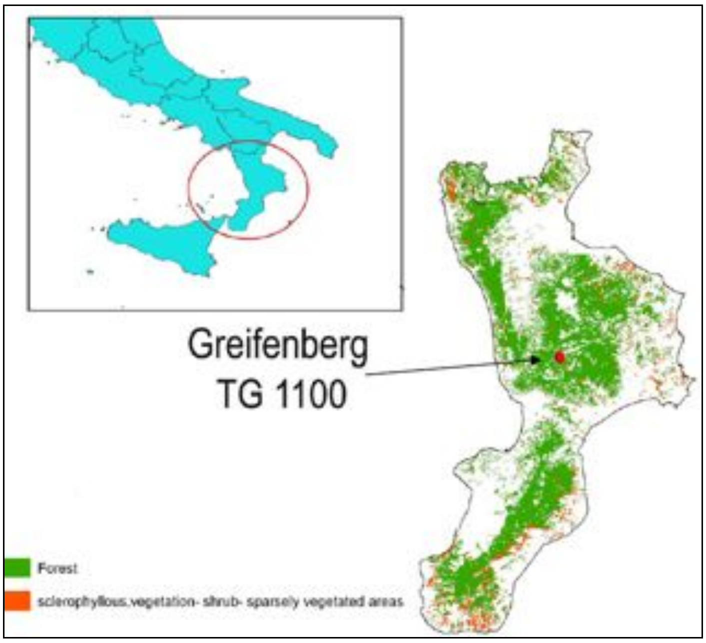

Figure 1. Geographic location of forest distribution and research areas

2. Materials and Methods

The tests were carried out at two sites, both situated in the Sila massif, a significant forested area in Calabria region, South Italy. Their main characteristics are shown in table 1. A Greifenberg TG 1100 cable crane was used with a single span line (Table 1). The times of the work phases were recorded separately for each timber-yard in two different test work sites, indicated with letters A and B and all having heterogeneous site features. As a result, all the data useful to describe the timber yards were collected in the two test work sites by acquiring the necessary parameters for the forests concerned. Altitude was measured using a portable Global Positioning System (GPS), Magellan Triton™ 2000, and the slopes were assessed with a SUUNTO clinometer, PM-5/360 PC. Dendrometric data were recorded in order to obtain the total volume yarded in each area using volume table (double entry) and sample plot (Table 2). In this case, the wood volume was determined through the Smalian formula:

$$V = \frac{S_b + S_s}{2} \cdot h$$

where:

- V = Total tree volume (m^3);

- S_b = Surface calculated at the stem basis (m);
- S_s = Surface calculated at the stem top (m);
- h = Stem height (m)

The average sag calculation was carried out using a stadia. In the timber-yard the Tree Length System (TLS) was adopted; the trimmed stems were cut at the timber-yard and the timber was transported fully suspended. The following parameters were gathered from each work site:

- span and line features;
- working times;
- mounting and dismantling times.

The length of line and the total volume of the transported material, determined in each site, were used to calculate the efficiency of the three cable cranes (Fabiano and Marchi, 2001); the result obtained was a volume of the transported wood of field length of cable crane line (m^3m^{-1}), for each site. Time and motion studies were used to measure main times and by-times (complementary work time). Many studies have concentrated on measuring delay times and indirect work times; constants or percentage-figures are used to predict these time elements. Time consumption is normally calculated per produced unit (Harstela, 1991). The time and motion study was conducted using the repetition timing method to determine the total yarding cycle times, which is the amount of time it takes the carriage to travel from the landing and to the unhooking of the payload. Five yarding elements were identified and timed to determine the total cycle time (*Carriage descent; Hook descent; Bunching; Extraction; Carriage unloading*).

Table 1. Technical characteristics of the cable crane

Characteristics	**Greifenberg TG 700**
Positioning	on trailer
Tower	
• Type	Hinged
• Height (m)	13
Guylines	
• number	3
• diameter (mm)	16
• length (m)	80
Winch	
• main line drum capacity (m)	1100
• main line pulling force (daN)	3500
• skyline drum capacity (m)	1200
• skyline cable tensioning force (daN)	8000
Engine	
• type	Diesel
• power (kW)	95
Carriage	
• type	automatic
• safety brake	present
• loading capacity (daN)	3200

The time data were recorded by two workers: one of them was stationed in the timbers at the bunching location and the second worker was stationed next to the cable system. Communication between workers was maintained by wireless. In the study process, 60 total cycle times were recorded in order to obtain the average performances. In each site the cable cranes were installed and dismantled only once. The time

required for mounting and dismantling the cable cranes in each site, together with the total number of the trips made for each site, was established. This calculation was then applied to the 60 trips carried out. Using the recorded time data, the average duration of a cycle was calculated and rated with the average volume produced in the cycle. This gave the operating time per production unit and technical productivity for the studied activity. The total time recorded is then subdivided into utilised time Ut (productive time) and unutilized time Unt (unproductive time). Direct work time DWt and indirect work time TWt have been calculated from utilized time. Direct work time appearing in productive processes is separated into effective time that occurs during production (main work time MWt), auxiliary times (complementary work time CWt) and unavoidable delay time UDt. Indirect work time that interrupts the productive process was divided into time for preparation Pt and maintenance time Mt.
The method of measurement of time and of productivity employed was similar to that employed in other similar research (Ozturk et al., 2001; Rieger, 2001; Senturk et al., 2007, Zimbalatti and Proto, 2009).

Table 2. Test site characteristics Greifenberg TG 1100

	Work site A	**Work site B**
Place	Spezzano della Sila	Celico
Province – Area	Cosenza – South Italy	Cosenza – South Italy
Altitude (m a.s.l.)	1180	1340
Forest		
• species	Beech	Beech
• silvicultural system	Coppice	Coppice
• treatment	Standard cutting	Clear-cutting with reserve
• age (years)	35	30
• density (trees ha^{-1})	900	840
• volume site (m^3 ha^{-1})	150	130
• logging area (ha)	0.90	1.26
Average slope (%)	65	63
Maximum slope (%)	71	74
Lateral pull (m)	25	30
Yarding direction	uphill	uphill
Roughness	highly	average
Length of line (m)	180	210
Difference in height between the two ends of the line (m)	170	130
Average sag (m)	18	15

3. Result and Discussion

The Greifenberg TG 1100 was used in the two beech (*Fagus sylvatica* L.) woods, both of which were managed and treated similarly. The operating field of the cable crane resulted was about 0.90 ha in site A and 1.26 ha in site B (Table 2). A 180 m geometric chord was traced across site A and a 210 m chord in site B. The difference in level between the two extremities were 170 m in site A and 130 m on average in site B. In site A the sag was 18 m and the bunching distance was 25 m. In the site B the sag was 15 m and the bunching distance was 30 m.
A team of five workmen operated in timber-yard A: a haulage engineman, two workers for yarding and two workers for timber unloading. In timber-yard B there were five workmen: a haulage engineman, three workers for yarding and one worker for timber unloading. The daily productivity, based on an 8-h

working day, was estimated as equal to 83 m^3 d^{-1} in the timber-yard A and 54.5 m^3 d^{-1} in the timber-yard B. A workman produced, on average, 16.6 m^3 d^{-1} in the site A and 10.9 m^3 a day in the site B, whereas the time necessary for the extraction of a cubic meter of timber was equal to 0.10 h in the site A and to 0.15 h in the site B (Table 3). Table 4 and Fig. 2 show that the work phases which took up most of the total yarding cycle time were extraction (42% in the site A – 35% in site B) and carriage descent (31% in the site A – 20% in site B). The total volume of the transported material was 125 m^3 in site A and 80 m^3 in site B equal to 100 m^3 ha^{-1} for site A and 133 m^3 ha^{-1} for site B.
The evaluation of efficiency revealed that for the Greifenberg TG 1100 machine the volume harvested per field length of cable line was 0.70 m^3m^{-1} for site A and 0.67 m^3m^{-1} for site B.

Table 3. The average daily operative results of the work sites examined

	Unit	Greifenberg TG 1100	
		Work site A	Work site B
Number of valid observations	n.	60	60
Mounting and dismantling times	h	0.77	0.85
Yarder cycles			
• Average volume per cycle	m^3	1.45	0.89
• Yarding cycle per day	n.	57	60
• Yarding cycle per hour	n.	11	10
• Average time for one cycle	min.	5.44	5.62
• Standard deviation (σ)	±	(1.71)	(1.55)
• Coeff. of variation	%	19.2	16.4
Productivity			
• Daily	m^3 d^{-1}	83	54.5
• Hourly	m^3 h^{-1}	10.4	6.85
Manpower			
• Operators	n.	5	5
• Work capacity	m^3 h^{-1}-man	2.08	1.36
• Unit time	h m^{-3}	0.10	0.15
• Productivity	h-man m^{-3}	0.48	0.73
• Delay time	min.	168	144

Table 4. Work analysis in total time (min)

Phases		Greifenberg TG 1100	
		Work site A	Work site B
Carriage descent	min	0.37	0.35

	(SD)	(0.20)	(0.09)
Hook descent	min	0.28	0.25
	(SD)	(0.16)	(0.26)
Bunching	min	3.77	3.91
	(SD)	(1.16)	(0.68)
Extraction	min	0.71	0.70
	(SD)	(0.26)	(0.31)
Carriage unloading	min	0.31	0.41
	(SD)	(0.12)	(0.25)
Total	min	**5.44**	**5.62**
	(SD)	(1.71)	(0.89)

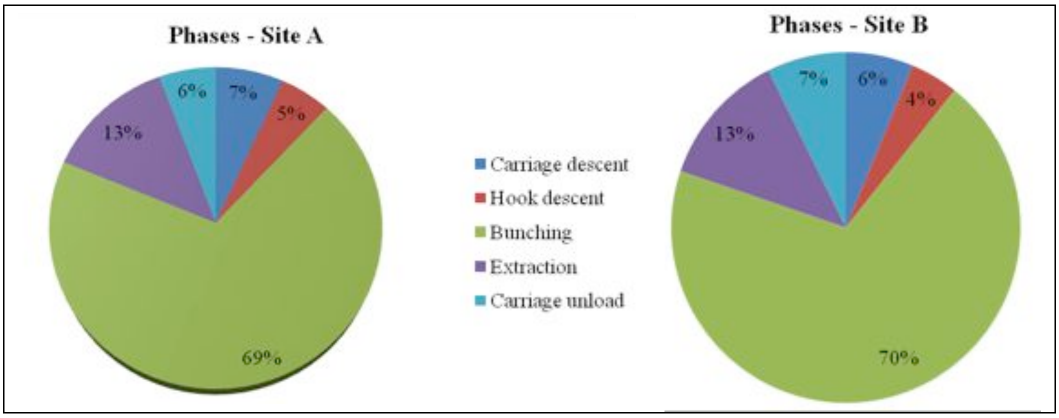

Figure 2. Work analysis in total time (%)

4. Conclusion

In all cases examined the data obtained were, therefore, higher than the 0.5 $m^3 m^{-1}$ value indicated as the minimum necessary for economic logging with traditional cableway and higher than 0.2 $m^3 m^{-1}$ determined as the minimum necessary for economic logging with cable crane (Fabiano & Marchi, 2001). Therefore, the cable cranes tested in Calabria should provide satisfactory results, although a number of organizational aspects could be improved in order to fully exploit their potential. Unproductive time should be reduced by employing workers specialized in cable system operations

If a cable crane system is to be employed in forests, there should be an adequate quantity of wood in the area. In the area where timber haul is to be carried out, forest cable systems should be brought into the area and installed after production operations are completed, and then the haul age operations should be carried out (Senturk et al., 2007). Finally, the high purchase price of this type of machine may be discounted against its minimal negative impact on the environment and the fact that it may be the only viable and sustainable extraction method for the management of sensitive sites (Tiernan et al. 2004).

Interaction between silviculture and logging operations remain particularly important on steep terrain. For cable systems, communication between the forest manager (who marks the trees to be removed) and the logging company (who calculates the location of the lines) is essential.

The results of this study have shown that the transport of forest products by cable crane operated in areas located in mountainous terrain is a more permanent and efficient haulage method in mountainous forest land.

References

Fabiano F., Marchi E. (2001). Gru a cavo forestali: diffusione attuale e possibilità d'impiego. Sherwood, 67, 43–47.

Harstela P. (1991). Work studies in forestry. Silvia Carelica, Vol. 18. Joensuu University Library, Finland. 41 pp.

Hippoliti G. (1997). Appunti di meccanizzazione forestale. Studio Editoriale Fiorentino, Firenze. 318 pp.

Ozturk T., Aykut T., Hulusi A. (2001). Time analyses on Koller K300 cable system on difficult terrain in Turkey. Workshop Proceedings "New Trends in Wood Harvesting with Cable Systems for Sustainable Forest Management in the Mountains", Ossiach, Austria, 18-24 June, 101-106

Rieger G. (2001). Costs and performance of a Koller K300 Yarder. Workshop Proceedings "New Trends in Wood Harvesting with Cable Systems for Sustainable Forest Management in the Mountains", Ossiach, Austria, 18–24 June, 107–112.

Tiernan D., Zeleke G., Owende P.M.O., Kanali C.L., Lyons J., Ward S.M. (2004) "Effect of working conditions on forwarder productivity in cut-to-length timber harvesting on sensitive forest sites in Ireland". Biosystems Engineering, 87, 167-177.

Verani S., Sperandio G. (2003). Coppice wood harvesting in South Italian regions: first results. World Machinery, 6, 30–34.

Visser J. M., Stampfer K. (1998). Cable extraction of harvester-felled thinning: an Austrian case study. Journal of Forest Engineering, 1, 39–46.

Zimbalatti G., Proto A.R. (2009). "Cable logging opportunities for firewood in Calabrian forest". Biosystems Engineering, 102, 63-68.

Zimbalatti G., Proto A.R. (2009). "Prospects of forest utilizations in the South of Italy". IUFRO - Unit 3.06.00 - Workshop Forestry utilization in Mediterranean countries, Reggio Calabria, 2335-2339.

The authors participated equally in all the phases of the present work