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CABLE LOGGING OPPORTUNITIES FOR FIREWOOD IN CALABRIAN FORESTRY

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Abstract: *Cable cranes are among the most important means of yarding and transporting timber and their use in the mountainous regions of Europe is becoming more widespread. In contrast, the use of this kind of machinery in Southern Italy remains limited, particularly in forests for firewood production, where cable cranes are practically not applied. Forests in Southern Italy are mainly located in steeply sloping mountainous areas where ground based wood extraction are still the most common harvesting techniques employed. The productivity of different cable cranes was assessed to verify if the use of these machines should be efficiently recommended under the forest conditions in Southern Italy. The cable cranes tested have been the Greifenberg TG 700, Koller K300 and Greifenberg VSG 2000; the tests were carried out in areas of Calabria (Southern Italy) different for site features, forest management parameters and forestry. The time motion study carried out showed that the productivity of cable crane tested was satisfactory although there is a number of organizational aspects that could be improved in order to better exploit its potential.*

1. Introduction

Calabria is a region in Southern Italy particularly rich in forests (the forest cover is equal to 31.8%) that are also often highly productive; indeed, every year, in Calabrian forests, the average increase in wood volume, which is equal to 6-8 m^3 ha^{-1}, exceeds and sometimes doubles the increase estimated in the other forests of Southern Italy (Ciancio, 1998).

Despite such a conspicuous density of woodland resources, the most common work method in Calabria, defined as traditional, can be considered at an early stage of mechanization (Hippoliti, 1997); that is to say, it is based mainly on agricultural tractors, sometimes equipped with specific forest machines (winches, hydraulic crane, log grapple, etc.); the use of animals for gathering and yarding is somewhat widespread. Chainsaws are the most common machinery for timber cutting operations (Verani and Sperandio, 2003).

The low level of mechanization of forest utilization in Calabria is due to the site features of the forests, the characteristics of the forest property, the small dimensions of many forest enterprises, the low knowledge of modern machines and of studies about their application in these contexts. Wood products are mainly destined to the production of energy, or of building and packing material and often sent to processing firms of other regions, which will transform them into quality products.

Cable cranes are among the most important means of yarding and transporting timber and their use in the mountainous regions of Europe is becoming more widespread. In contrast, the use of this kind of machinery in Southern Italy remains limited, particularly in forests for firewood production where cable cranes are practically not applied. Therefore there are two main reasons for accelerating the spread of cableways (Horek and Mauer, 2001): the substantial timber production associated with orographical difficulties and the growing need to safeguard the environment. 95% of timber production in Southern

Italy (2.3 million m^3/year; 25% of the total in Italy) comes from terrains classifiable as very steep slope (Tiernan et al., 2004); consequently many of these sites present limitations on the use of machines for ground based extraction. In such conditions there is no doubt that cableways represent one of the best methods from a technical and environmental point of view (Owende et al., 2001; Rieger, 2001; Visser and Stampfer, 1998).

This experimental research, carried out in Calabria, was focussed on the time motion study of cable cranes with mobile power station; it was intended to start a process of adaptation and diffusion of this skidding means in Southern Italy, just starting from a wood product, with a low commercial value, like firewood, whose production is very important in such a wide reference area.

2. Methodology

The experimentation was carried out in 3 different timber-yards, situated in three Calabrian provinces, by using 3 different models of single-span cable cranes with mobile power station. 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 timber-yards were collected in the 6 test work sites by acquiring the necessary silvicultural parameters about the concerned forests, the various altitudes, measured through a portable GPS, and the slopes, assessed with a SUUNTO clinometer.

In the first timber-yard, in the Sila Massif, where a Koller K 300 (Tables 1, 2) was used, the Short Wood System (S.W.S.) was applied; in fact, timber was arranged in piles composed of about 1 metre-long logs; the volume of the single skidded logs was estimated through the Huber formula:

$$V = D^2 \cdot \pi \cdot L/4$$

where:

- V = Total tree volume (m^3);
- D^2 = Mid-height diameter (m);
- L = Length (m)

In the second timber-yard, in the Aspromonte Massif, the Greifenberg VSG 2000 cable crane was used (Tables 1, 3). The Full Tree System (F.T.S.) was adopted, which implies trimming and cutting at the timber-yard. 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)

In the third timber-yard, set in the Serre Vibonesi Massif, the Greifenberg TG 700 cable crane was used (Tables 1, 4). The Tree Length System, (T.L.S.) was adopted; the trimmed stems were cut at the timber-yard. Also in this case the volume of the timber assortment was estimated through the Smalian formula.

The following parameters were gathered from each work site:

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

The method of continuous measurement of time was employed using the methodology proposed by Berti et al. (1989) and in accordance with other similar research work (Ozturk et al. 2001; Rieger, 2001; Tunay and Melemez, 2001; Cavalli et al., 2004) in order to define the productivity. The time motion survey model was synthesized as follows.

The available work time ("T") of a machine is equal to the sum:

$$T = TL + TP + TT$$

where:

- TL = Gross work time;
- TP = Preparation time;
- TT = Transfer time.

Gross time is given by:

$$TL = TN + TM$$

where:

- TN = Net work time, during which men and equipment are actively engaged in carrying out one of the operations to which the work is target-oriented;
- TM = Down time, during which men and equipment are present at work, but are not occupied (they are not carrying out phases of the operations).

Net work time is given by:

$$TN = TNE + TNA$$

where:

- TNE = Effective net work time, during which men and equipment are actively engaged and a productive phase of the operation is being carried out;
- TNA = Additional net work time, during which men and equipment are actively engaged at work, but not in carrying out a productive work phase (the time passing from one prepared tree to another, etc).

Analogously down time is equal to:

$$TM = TMS + TMA + TMO + TMV$$

where:

- TMS = Subjective down time of the operator (cigarettes, rest, physiological needs, etc);
- TMA = Accidental down time, caused by machines (breakdowns, refuelling);
- TMO = Organization down time;
- TMV = Miscellaneous down time (various unforeseen events).

Then, the work capacity and productivity of the three tested cable cranes were determined on the basis of the recorded times.

Table 1: Technical characteristics of the cable crane

Characteristics	Koller K 300	Greifenberg VSG 2000	Greifenberg TG 700
Positioning	on lorry	on lorry	on trailer
Tower			
• Type	Hinged	Hinged	Hinged
• Height (m)	7	9	13
Guylines			
• number	4	3	4
• diameter (mm)	15	12	12
• length (m)	30	40	40
Winch			
• main line drum capacity (m)	400*	1200	700
• main line pulling force (daN)	1800	2200	2200
• skyline drum capacity (m)	390	1000	700
• skyline cable tensioning force (daN)	4500	5000	5000
Engine			
• type	Diesel	Diesel	Diesel
• power (kW)	45	69	84
Carriage			
• type	automatic	automatic	automatic
• safety brake	present	present	present
• loading capacity (daN)	1000	2000	2000

(*) the forest entrepreneur placed a steel surrounding plate, 2 cm wide, along the flanges of the drum
to increase drum capacity.

3. Results

In the two Turkey oak (*Quercus cerris L.*) woods, different for both management and treatment, where the Koller K 300 was used, the operating field of the cable crane, that is the net hauling area, was about 2.16 ha in A and 0.34 ha in B. A 330 m geometric chord was traced in A and a 100 m one in B, the difference of level between the two extreme points of the line was 53 m in A and 29 m in B. In site A the bunching was 3.90 m and the extraction distance was 36 m. In contrast, in B the bunching was 3.10 m and the extraction distance was 15 m from the line (Table 2). The team of workmen of timber-yard A was composed of 4 units: the haulage engineman, two workers for yarding and a worker for timber unloading. On the contrary, in timber-yard B there were 5 workmen: the haulage engineman, two workers for yarding and two workers for timber unloading. The daily productivity, based on a 8-hour working day, was estimated as equal to 15 m^3 d^{-1} in timber-yard A and 25.7 m^3 d^{-1} in timber-yard B. A workman "works" an average of 3.76 m^3 a day in A and 5.12 m^3 in B, whereas the time necessary to skid a cubic metre of timber was equal to 0.52 hours in A and 0.31 hours in B (Table 5).

The Greifenberg VSG 2000 was used in two Holm oak woods (*Quercus ilex L.*), managed following a coppice system. In site A the bunching was 3.70 m and the maximum extraction distance was 50 m. In contrast, in timber-yard B the bunching was 3.30 m and the maximum extraction distance was 35 m from the line. The operating field of the cable crane was about 5 ha in A and 3.36 ha in B. The geometric chord was equal to 500 m in A and 480 m in B; the difference of level between the two extreme points of the line was 68 m in A and 79 m in B (Table 3). In both test work sites there were 3 workmen: the haulage engineman, a worker for yarding and a worker for timber unloading. In order to handle about 13 m^3 of timber a day in each test work site (A-B), 17 and 18 trips were made. During an hour, workmen skid about 5.34 m^3 in test work site A, almost 6 m^3 in B (Table 5).

The third timber-yard used a Beech wood (*Fagus sylvatica L.*), managed following a reserve cutting coppice system. The two test work sites, managed by three workmen, covered an area of 3.74 ha (A) and 3.2 ha (B). The geometric chord, traced by the Greifenberg TG 700, was equal to 340 m in A and 400 m in B; the difference of level between the two extreme points of the line was 50 m in A and 77 m in B. In site A the bunching was 2.85 m and the maximum extraction distance was 40 m from the line (Table 4). In both test work sites the highest work productivity was recorded, in comparison with the other two tested timber-yards, with an amount of skidded timber per worker of about 0.90 m^3 (A) and 0.78 m^3 (B). The time necessary to skid a cubic meter of timber was equal to 0.36 hours in A and 0,42 hours in B; 48 and 44 trips were respectively necessary to skid 21.76 m^3 in site A and 18.92 m^3 in site B (Table 5).

In table 6 and in figure 1 the time of the single phases, composing the skidding operation carried out with the tested cable cranes, are shown in detail.

Table 2: Test site characteristics Koller K300

	Work site A	**Work site B**
Place	Campodimanna	Diga Ampollino
Municipality	S.Giovanni in Fiore	S.Giovanni in Fiore
Province – Area	Cosenza – South Italy	Cosenza – South Italy
Altitude (m a.s.l.)	820	1280
Forest • species • silvicultural system • treatment • age (years) • density (trees ha^{-1})	 Turkey oak Coppice Standard cutting 20 822	 Turkey oak High forest Clear-cutting with reserve > 70 790
Average slope (%)	69	67
Maximum slope (%)	73	71
Logging area (ha)	2.16	0.34
Max skidding distance (m)	36	15
Yarding direction	uphill	uphill
Terrain unevenness	highly	average
Length of line (m)	330	100
Difference in height between the two ends of the line (m)	53	29
Sag (m)	3.90	3.10

Table 3: Test site characteristics Greifenberg VSG 2000

	Work site A	**Work site B**
Place	Crasti	Limina
Municipality	Canolo	Canolo
Province – Area	Reggio Calabria – South Italy	Reggio Calabria – South Italy
Altitude (m a.s.l.)	929	978
Forest • species • silvicultural system • treatment • age (years) • density (trees ha^{-1})	 Holm oak Coppice Clear-cutting with reserve 25 775	 Holm oak Coppice Clear-cutting with reserve 20 680
Average slope (%)	65	71
Maximum slope (%)	71	78
Logging area (ha)	5	3.36
Max skidding distance (m)	50	35
Yarding direction	uphill	uphill
Terrain unevenness	average	highly
Length of line (m)	500	480
Difference in height between the two ends of the line (m)	68	79
Sag (m)	3.70	3.30

Table 4: Test site characteristics Greifenberg TG 700

	Work site A	Work site B
Place	Buda	Fossa del lupo
Municipality	Chiaravalle Centrale	Chiaravalle Centrale
Province – Area	Catanzaro – South Italy	Catanzaro – South Italy
Altitude (m a.s.l.)	820	800
Forest		
• species	Beech	Beech
• silvicultural system	Coppice	Coppice
• treatment	Clear-cutting with reserve	Clear-cutting with reserve
• age (years)	20	20
• density (trees ha^{-1})	700	740
Average slope (%)	64	71
Maximum slope (%)	70	76
Logging area (ha)	3.74	3.2
Max skidding distance (m)	55	40
Yarding direction	uphill	uphill
Terrain unevenness	average	highly
Length of line (m)	340	400
Difference in height between the two ends of the line (m)	50	77
Sag (m)	3	2.85

Table 5: Daily operative results of the work sites examined

	Unit	Koller K 300		Greifenberg VSG 2000		Greifenberg TG 700	
		Work site A	Work site B	Work site A	Work site B	Work site A	Work site B
Carriage							
• Yarding cicle	n. d^{-1}	27	37	17	18	48	44
• Load volume	m^3	0.75	0.54	0.79	0.69	0.45	0.43
• Total time for one yarding cycle	min.	9.63	3.57	19.20	10.71	7.48	8.01
Productivity							
• Daily	m^3 d^{-1}	15.03	25.67	13.55	12.30	21.76	18.92
• Hourly	m^3 h^{-1}	1.87	3.20	1.69	1.53	2.72	2.36
Manpower							
• Operators	n.	4	5	3	3	3	3
• Work capacity	m^3 h^{-1}- man	0.47	0.64	0.56	0.51	0.90	0.78
• Productivity	h-man m^{-3}	2.13	1.56	1.78	1.96	1.11	1.28
Work time	h						
• Transfer time		0.833	0.749	0.250	0.250	0.499	0.416
• Mounting time		2.006	1.367	6.997	5.997	5.172	5.352
• Net time		4.418	2.199	5.437	3.211	5.981	5.861
• Delay time		2.856	1.500	2.560	4.785	2.015	2.136
• Dismantling time		0.533	0.333	4.998	3.998	1.582	1.721
Total		10.645	6.148	20.242	18.241	15.249	15.486
Unit time	h m^{-3}	**0.52**	**0.31**	**0.59**	**0.65**	**0.36**	**0.42**

Table 6: Work analysis in total time (min)

	Koller K 300		Greifenberg VSG 2000		Greifenberg TG 700	
	Work site A	Work site B	Work site A	Work site B	Work site A	Work site B
Crab descent	2.96	0.65	3.46	1.42	0.88	0.94
Hook descent	0.64	0.36	1.33	0.66	0.62	0.73
Extraction	1.05	0.64	10.88	6.52	3.67	3.81
Skidding	4.09	1.27	2.55	1.42	1.48	1.62
Crab unloading	0.89	0.65	0.98	0.69	0.83	0.91
Total (min)	**9.63**	**3.57**	**19.2**	**10.71**	**7.48**	**8.01**

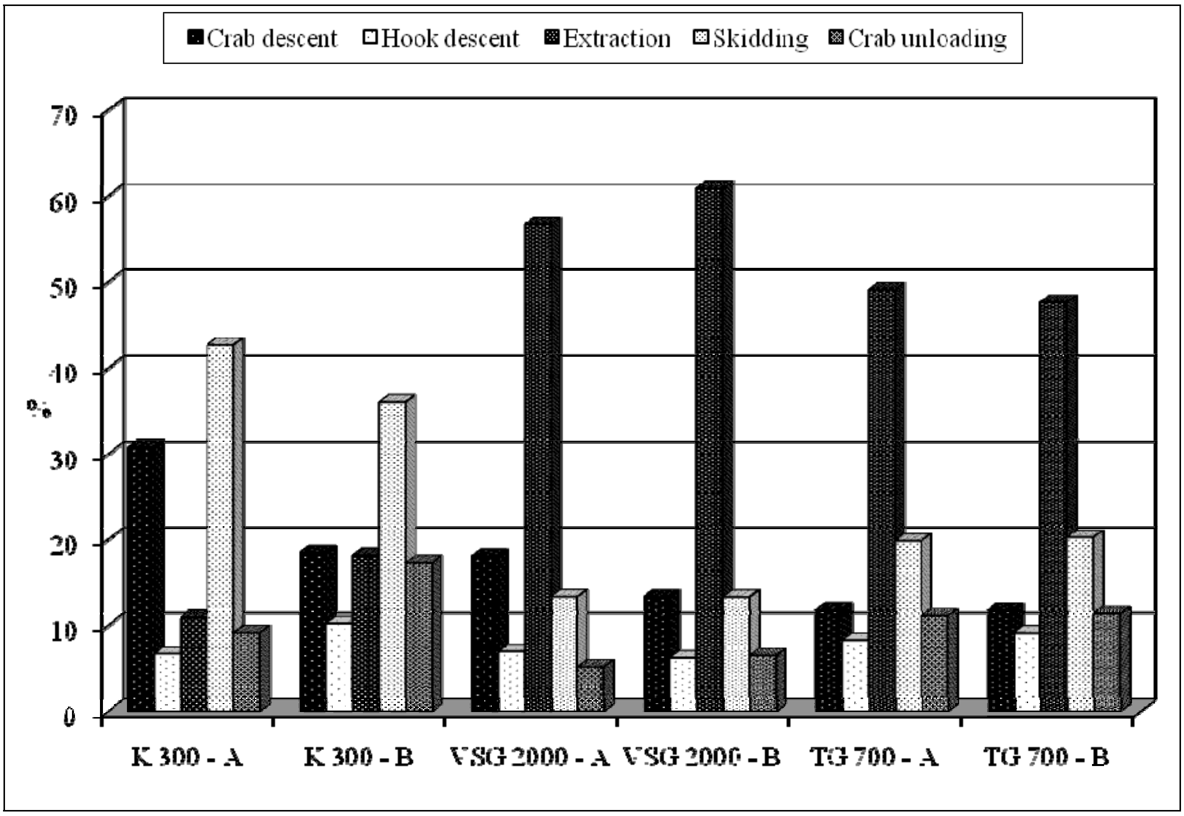

Figure 1: Work analysis in total time

4. Conclusion

From the comparative study of the six line trends, we can see that, although with different trends in the six different areas, productivity decreases with increase of bunching and extraction distance. A comparison of results of the present initial study with similar ones, mainly relating to the same machine, reveals related levels of work productivity; the same performance was also observed when work time did not take into consideration line assembly and dismantling times (Hippoliti and Piegai, 2000; Ozturk et al. 2001; Tunay and Melemez, 2001).

Therefore the three cable cranes tested in Calabria guaranteed highly satisfactory working results, although a number of organizational aspects could be improved in order to better exploit its potential. A further evaluation of efficiency in organizational and economic terms revealed for Koller K300 a hauled volume of 0.62 m^3 m^{-1} of field length of cable crane line in A and 0.58 m^3/m in B; for Greifenberg VSG 2000 revealed a hauled volume of 0.85 m^3 m^{-1} of field length of cable crane line in A and 0.68 m^3 m^{-1} in B. As regards the Greifenberg TG 700, the result was a hauled volume of 0.64 m^3 m^{-1} of field length of cable crane line in A and 0.55 m^3 m^{-1} in B. In all cases 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 than 0.2 m^3 m^{-1} indicated as the minimum necessary for economic logging with cable crane (Fabiano and Marchi, 2001).

Increased recourse to cable cranes would represent a valid solution to the numerous areas in which the price of stumpage is reduced or even negative. Moreover, the need of a higher productivity of the timber-yards can encourage the introduction of such machines, even with the involvement of third parties to overcome purchasing and management costs like in other skidding systems and means (processor, forwarder, skidder).

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

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