Development of Improved Cable Yarding Productivity in Southern Africa for Small-Sized Trees

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ABSTRACT

Production rates of cable yarding by fixed skyline in Southern Africa were found to be low, usually between 50 m^3 to 60 m^3 of timber per day on average. Investigations identified four major sources of lost productivity. Implementation of simple techniques selected to reduce losses resulted in a quadrupling of productivity though only a tripling is expected in the long term.

Keywords: *cable yarding, skyline, highlead, harvesting, extraction, production economics, productivity, work study.*

INTRODUCTION

Due to an increasing use of cable yarding in Southern Africa, the author was directed by the commercial forestry industry in South Africa to undertake research to improve cable yarding productivity. At this stage no formal research on cable yarding had been undertaken in the country. Two forms of cable yarders are currently being used. Initially the small Scottish highleads were introduced in the late 1970s in commercial forestry. This was a running skyline of 0.4 t load capacity operating from a double-drum winch mounted on a tractor. In 1985 the author encouraged the introduction of larger fixed skyline cable yarders of 1 t to 3 t load capacity in commercial forestry. This paper is devoted to the latter, hereafter referred to as skylines. The South African Department of Forestry had skylines in operation prior to this date [2], but at that time there was almost no transfer of information from the public sector to the private sector.

An initial survey showed that normally, in Southern Africa, skylines produced 50 m^3 to 60 m^3 daily with occasional rates of 80 m^3 to 120 m^3 being achieved. The first objective of this research was to investigate whether it was possible to increase production rates and describe what work system, equipment and/or machinery was needed to achieve such improvements. Results were reported [1]. The second objective was to implement these findings and certify that they were indeed practical and achievable. Results of this application are described in this paper.

A skyline, the Howe-line Mk II, was designed and manufactured in consultation with the author, so that it incorporated, *inter alia,* all tackle and machine designs indicated by the research. The cable yarding operation was undertaken by a contractor following the researched work system.

TACKLE, MACHINERY AND WORK SYSTEMS USED

The initial research sited above revealed that the major sources of lost productivity were slow turn-about times, particularly when choking; slow carriage speeds; excessive delays and unduly low load masses. Overcoming these losses required the selecting and matching of tackle, machinery and work systems. Although these modifications are in themselves not necessarily new, their selection and integration and their practical application to achieve the highest possible productivity required considerable investigation and development. The four sources of loss and ways in which they were reduced are discussed individually.

Turn-About Times

It was shown in the original research that by using two tag lines, to permit prechoking of logs, choking times could be reduced greatly. This technique was adopted. Each tag line was a length of cable, about 10 m long, that was attached to the end of the haul-in line by means of a snap link and carried the required number of chokers chains. The exact length of a tag line is determined by the maximum side haul distance. One tag line was attached to the haul-in line and arrived infield with the carriage. This was released and replaced with the other tag line that had had its chokers set while the previous load was being extracted. To avoid the difficulty of having to haul out cable to reach the logs, at the landing and before dechoking, the carriage was run out drawing the tag line through it to beyond the

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snap link. After dechoking, the tag line was hooked back on to the haul-in line using a notched plate or stop bar.

Slow Carriage Speed

Slow carriage speed resulted chiefly from bad design in both the skylines and their carriages. Skylines were simply not designed to propel carriages at high speed, and non-locking carriages were being used. Investigations revealed that with all the Continental carriages the snap link triggered off their locking mechanism, rendering them unable to accommodate the snap link required for tag-lining. They are thereby precluded from this considerable advantage unless modifications are made. Further, these were double-locking carriages that were self-powered hydraulically, which required highly skilled technicians to repair and maintain. This sophistication could make their use awkward and expensive in remote areas in "third world" countries. Use of a simple single-locking carriage that could accommodate tag-lining was, therefore, indicated. The Scottish, Smith's carriage, was originally chosen. However, the manufacturers of the Howe-line designed a mechanically operated single-locking carriage that could accommodate snap links and this was used in these studies. With a single-locking carriage, the haul-back line holds the carriage while breaking out.

The Howe-line was designed to provide carriage speeds of 9 m/s (540 m/min, 1,771 ft/min) when hauling out and 5 m/s (300 m/min, 984 ft/min) hauling in. Power to the winch drums was provided by a six-cylinder air-cooled engine operating a hydrostatic drive with control valves that gave full power at all winch drum speeds. The engine was not altitude compensated and, at an estimated altitude of 1,500 m, developed about 65 Kw. The Howe-line carriage had a load bearing capacity of 4 t.

Delays

Delays were principally due to the employment of unskilled workers, poor management and badly designed tackle, or lack thereof. The worst features causing cable wear were, firstly, the use of too small diameter sheaves that were constructed from incorrect materials. Secondly, tackle lacked the inclusion of swivels to release spiralling in the cables which resulted in snapping of even new cables. It was noted that fibre-core cable was commonly used and that this tended to crush much easier than steel-core cable when cross-laid on winch drums, which also reduced cable life noticeably.

Swivels were included in the haul-back and haul-in lines and, although it was not a feature that would affect the short duration of the studies, correct diameter sheaves made of suitable fibre (where applicable) were used in the skyline and its carriage.

Load Mass

Load masses were low mostly to avoid excessive cable breakages and reduce lengthy choking times.

The operating team was comprised of the machine operative, two choker setters and a person at the landing to dechoke. The person dechoking released the stems and hooked the tag line back as described above. While the previous load was being extracted, the choker setters selected and choked stems which were clear of the skyline cable and the haul-back line. On arrival of the carriage infield, the one choker setter released the notched plate while the other choker setter unhooked the incoming tag line from the snap link and attached the set one. Both choker setters then vacated the danger area and radioed to the machine operative that the load was ready. The load was broken out and hauled in until it was locked in the carriage, then the haul-back line was released and the load extracted. Stems lying within the danger zone of cables were choked only after the arrival of the carriage when all the cables were slack. The team had been working with the system for a number of months and were thus competent and had been achieving consistently similar extraction times to those later attained during the study.

TIMBER PRESENTATION AND SITE LAYOUT

Trials were conducted in a clear-fell operation in 25 yr old *P. patula*. Slopes ranged from 14% to 25% (8^0 to 14^0) with an average of 18% (10^0). Although the skyline was capable of lead distances of 660 m, the particular compartment only permitted 350 m. The swath width was 80 m. Trees were felled down the slope with an attempt to direct them towards the centre of the swath in a rough "herring bone" pattern. They were then topped and delimbed and the brush stacked straight up and down the slope at the sides of the swath. Stems were not cross cut during the study.

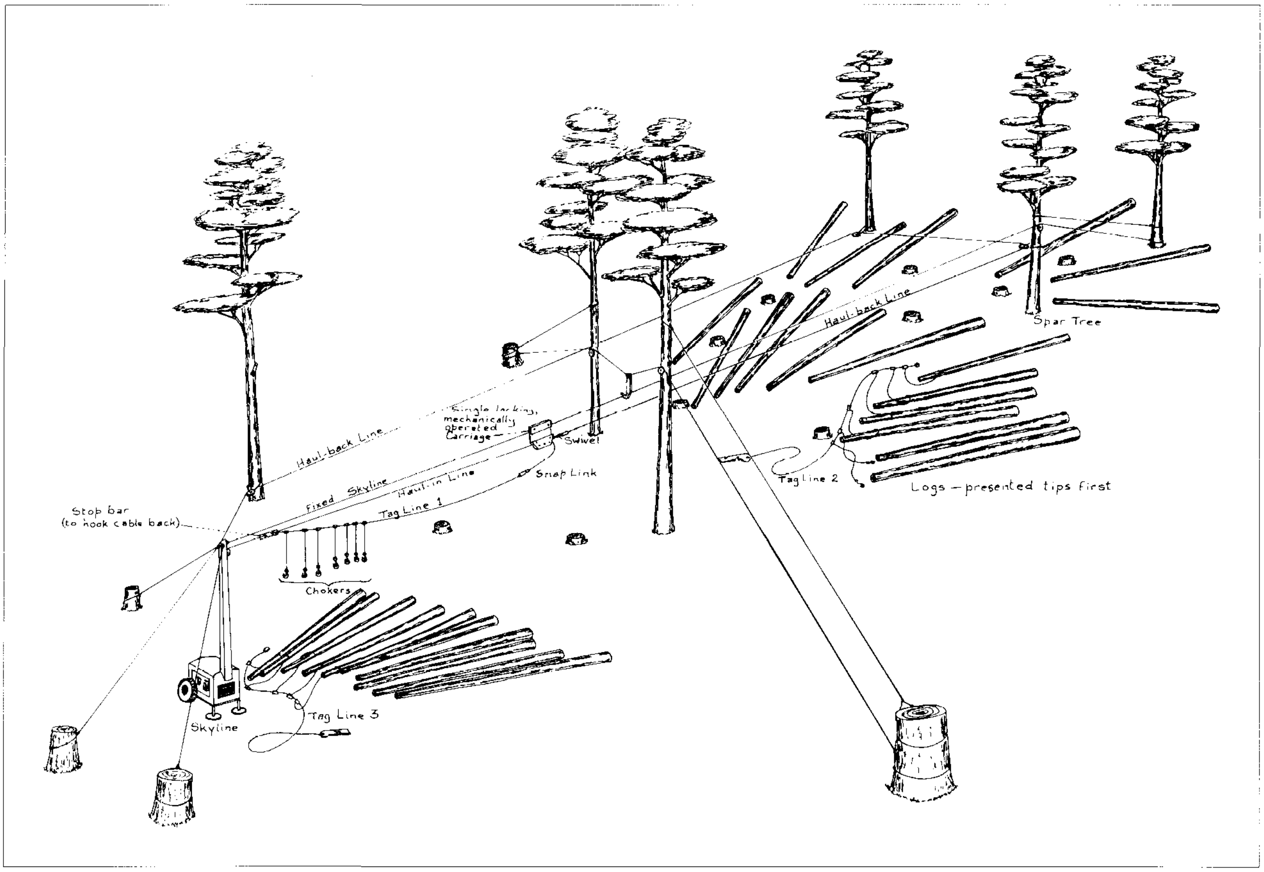

Figure 1. Diagrammatic layout of work site. Logs are presented so tips will be choked. Where butts are choked, distances to the carriage will be greater, increasing the benefit of being able to prechoke logs.

The skyline was erected first at the bottom and then at the top of the swath with its cable located roughly through the centre. Due to the low slope, it was necessary to have four intermediate supports spaced at regular intervals. The supports were comprised of two anchored trees with a sling between them carrying the skyline cable's support. A three-wheel Bell loader was deployed to clear timber from the landings. The figure below illustrates the layout.

STUDY TECHNIQUES

Two studies were undertaken, one downhill and one uphill, using the same site so as to be able to compare as accurately as possible any effects the extraction direction may have. Stems were taken at regular intervals over the full length of the site, leaving a sufficient number behind in the first study to provide adequately for the second.

A continuous time study was taken to record performance. To ensure the highest accuracy, avoid any loss of data and be able to review details, the operation was recorded on video with hours, minutes and seconds being imprinted on the tape. On arrival at the landing, the load number was written on each stem and the number of stem in each load recorded. Diameters and lengths of all stems were measured to calculate their volume. Distances of each side haul and main haul were also recorded.

All distances and load data were analysed statistically to obtain the appropriate means and standard deviations or regression models to describe the performance and to determine the significance and hence reliability of the results.

Only one setting up of the operation was timed. This included rigging the 4 intermediate supports, but excluded travelling.

STUDY RESULTS

The studies were undertaken during August 1991. Details of the work site are as follows:

Slope		18 % (10^0)
Swath:	width	80 m
	length	350 m
	area	2.8 ha
Estimated mean stem volume		1.162 m^3
Stand density		412 stems/ha
Estimated timber volume in swath		1,340 m^3

The downhill study lasted 2.67 h during which time the operation had to stop several times while video cassettes and batteries were changed and various measurements taken. An estimated volume of 144 m^3 was extracted in 43 hauls, which gave a mean load volume of 3.24 m^3. The highest load volume was 5.7 m^3, which was unintentionally high and caused by poor assessment on the part of the choker setters.

The uphill study lasted 2.04 h and yielded 101 m^3 in 32 hauls, giving a mean load volume of 3.16 m^3.

The trailing end of the stems dragged on the ground and it was found that on this particular terrain that there was a sharp increase in stems breakages with carriage speeds of over about 4 m/s (240 m/min, 787 ft/sec). Below this there were very few breakages.

Tag line usage was part of the system. In the downhill extraction, tag lines were hooked back as described. With uphill extraction, though, the workers felt that this was unnecessary. However, the slope was too low for gravity to feed the cable out thus there was a considerable and needless time, wastage hauling the cable out until the snap link was reached.

Cable spiralling was completely eliminated with the use of swivels in both the haul-in and haul-out lines.

Times recorded in seconds on the video tape were converted to centiminutes for analysis. Minutes for hauling out and in were regressed individually on their related lead distances. Linear regressions in all cases gave the highest correlation coefficients. No significant correlation between side haul times and distances was obtained. The reason for this unexpected result was that, although the swath was a maximum of 40 m either side of the carriage, the felling pattern lessened this distance and by the time the stems had broken out a too short side haul distance remained to register a significant influence.

Details of the regression models are given below:

Downhill:

$DHO = 0.092087 + 0.001705\ LD$
$r = 0.9626$
$P < 0.01$

$DHI = 0.064194 + 0.004456\ LD$
$r = 0.9738$
$P < 0.01$

Uphill:

$DUO = 0.194694 + 0.001587\ LD$
$r = 0.7672$
$P < 0.01$

$DUI = 0.032518 + 0.005025\ LD$
$r = 0.8226$
$P < 0.01$

Where:

DHO = downhill haul out
DHI = downhill haul in
DUO = uphill haul out
DUI = uphill haul in
LD = lead distance in metres

Means and standard deviations of remaining activities are as follows:

Activity	**Minutes**	
	Mean	**SD**
Both downhill and uphill:		
Change tag lines infield	0.420	0.140
Setters withdraw to safe area	0.159	0.097
Tension cable to break out	0.104	0.046
Break out	0.148	0.055
Total	0.831	
Downhill only:		
Tension cable before hauling out	0.087	0.062
Run carriage out to hook tag line back	0.183	0.031
Dechoke stems	0.623	0.215
Total	0.893	

Uphill only:			
Dechoke stems		0.485	0.191
Haul tag line out infield:	75 m	0.417	0.149
	175 m	0.613	0.222
	225 m	0.700	0.220

Delays totalled 9.49 minutes over 280 minutes including the part of operation that was studied in detail and the rest of the operation that was timed on a watch, but not videoed. This gave a time loss of 3.4% or an operation availability of 96.6%.

Time taken for breaking the operation down and setting it again for uphill extraction was 3 h 43 min including rigging up the four intermediated supports, but excluding travelling time.

DISCUSSION

The availability of 96.6% is regarded as being extremely high. Where productivity is monitored over an extended period, additional delaying factors may occur such as travelling to sites that are far apart; cables, tackle and machinery becoming worn; inclement weather reducing productivity and/or workers being unwell or being replaced by inexperienced workers requiring training. An availability of 70% to 80%, therefore, is regarded as being preferable to 96.6% for practical purposes.

Production rates based on the data given are listed below with the timber volume per load corrected to 3 m^3, the specified capacity of the Howe-line, and include a setting up time increased to 4.5 h to allow for travelling between sites.

Downhill extraction:
Mean time per haul 2.96 min
Mean number of hauls per hour 20

	Percentage availability		
	96.6	80	70
Production rates:			
m^3/h	36	31	28
m^3/8h day	291	248	221

Uphill extraction:
Mean time per haul 3.31 min
Mean number of hauls per hour 18

	Percentage availability		
	96.6	80	70
Production rates:			
m^3/h	33	28	25
m^3/8h day	265	225	200

The extraction times obtained in this study were typical of those normally being obtained by this cable yarding team. When the above production rates are compared with those of 50 m^3 to a maximum of 120 m^3 that was being attained by the industry, dramatic improvements were clearly possible.

A major source of unnecessary delays in forestry companies was the employment of completely unskilled labour in this particularly complex operation. In addition, management of operations in many cases was poor. Unless suitably skilled and trained workers are employed under adequately trained and experienced management, implementation of the findings of this paper will fail.

Where stems are light, the number required to obtain a full load may make dechoking times undesirably long. In this situation, it could be preferable to use a third tag line. After depositing the load at the landing and running the carriage out past the snap link, the tag line is unhooked from the snap link and the third tag line attached. It is hooked back using its notched plate as with the double tag line arrangement and work proceeds as before.

Although the Howe-line was used in these trials and performed impressively without fault, it is possible to adapt the principles described here to other cable yarders of a range of sizes.

CONCLUSIONS

Production rates obtained and described herein substantiate the evidence previously published [1] that there was, and currently still is, a serious loss of productivity being experienced in cable yarding in Southern Africa. Through selecting and matching appropriate tackle and equipment and through using the system of work described in this paper, it is possible to obtain substantial increases in productivity. Where cable yarding is to be undertaken by employees, it is vital to appoint adequately skilled and trained staff and to ensure that their management is adequate.

Results also indicate that a cable yarder of 3 t capacity, if suitably designed and operated within the system described, may be able to compete successfully against far larger machines especially where smaller timbers are being extracted.

REFERENCES

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