

Motor-Manual Harvesting System for Large Dimensioned Timber (LDT) on Steep Slopes Supported by Skidders Equipped with a Traction Stabilising Winch

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Abstract:

The harvesting system is suitable for softwood as well as hardwood stands with large tree dimensions on steep slopes (up to 50 %). Harvesting machines access the stands by skid trails in distances of about 40 m in dip line. The large tree dimensions don't allow harvesting operations by standard harvesters and forwarders. In such stands trees will be felled by well trained 2-man felling teams, whereas the felling directions are in principle free but adapted to stand and tree crown conditions.

The tree length will be cut into length of 3 to 6 m depending on market and customer demands if in operating distance of the skidder crane. Stem sections out of range will be kept as multiple length and cut to length after pre-skidding on to the skid trail.

The pre-skidding process of short length and multiple lengths will be carried out by a skidder which, in addition to its state-of-the-art equipment, includes a strong crane with a front traction stabilisation winch. This winch is the most important point of the whole harvesting system. It enables the machine driver to fully concentrate on log manipulation with the crane despite extreme skidder positions due to steep slopes.

After carrying out missing cross cuts and cutting off last branches, the short length will be hauled by strong forwarders also equipped by a traction stabilisation winch on to the forest road.

The described harvesting system for large dimensioned timber on steep slopes is not yet completely established in practice. Nevertheless, it can be evaluated as ergonomically favourable, very efficient and so far economically comparable to traditional solutions. But the most relevant criteria are the high adaptability to complex and severe stand conditions in terms of heterogeneity and tree dimensions. The results are high protection of the stand structures, low logging damages and almost no slip of skidder wheels with respect to lowered risk of soil erosion in the tracks.

One point of concern has to be outlined: Due to the high productivity of skidder and forwarder precise planning is necessary.

Keywords: large dimensioned timber, traction stabilising winch, steep slopes

1 Introduction

In Germany about 1.8 million ha of the forest area is situated on sites with slope gradients of more than 30%. This represents 17% of the German total forest land. Up to 30% slope gradient the use of harvesters and forwarders is possible, on slopes with more than 50% cable cranes are used. Slopes of 30 to 50 % gradient are normally made accessible by machine tracks, from where timber is harvested as long stems usually by cable skidders. Often these harvesting systems are not very ergonomic and include high risks for damages on standing trees and natural regeneration. To the same time high harvesting costs come up with those systems whereas timber prices are the same as they are achievable for timber from easy terrain. The outcome of harvesting operations under those conditions is lower profitability. Additionally, through the described economic conditions often we see an accumulation of large dimensioned timber in those stands. The estimated amount of standing large dimensioned timber on slopes is about 93 million m³. Large trees from dbh 60 cm and more are only with problems or not at all harvestable by highly mecha-

nised harvesting systems. In central Europe we recognise increasing demand for especially softwood logs, meanwhile independent of their dimensions.

During the last years the forest machine development reacts to the described facts. There are nowadays harvesters and forwarders developed and available for slopes. Last development steps show often traction stabilising winches for these machine categories and have allowed highly mechanised harvesting of up to medium-sized conifer trees on slopes to become standard practice. However, this harvesting equipment reaches its limits for large dimensioned timber primarily because the safety of the felling operations, the processing and handling of felled trees and cut log sections cannot be assured.

A traction stabilising winch supports the movement of the machine while its activity as harvesting machine, especially it avoids slip of the wheels and so far further damage on the soil and skid track.

The technical principal of these traction and stabilisation giving winches inbuilt and integrated in harvesting machines allows the further development of known harvesting systems. In the following one of those new systems for slopes will be introduced.

2 The developed harvesting system

2.1 Stand description

The trials were carried out in typical mixed conifer and broadleaved stands in Baden-Wuerttemberg, which were both in an age of 60 to 130 years, characterised by high proportions of large dimensioned trees of more than 50 cm dbh. The stands showed natural regeneration on almost the whole stand area. Partially, some of the young trees developed groups of mid-aged trees, which should be protected throughout the harvesting operations as good as possible. The slope gradient was determined between 30 to 55%, changing along the slope.



Figure 1: Forest skidder fitted with a traction stabilising winch extracting logs

2.2 Technical description of the forest machines

The innovation of fitting of a modern forest skidder with a traction stabilising winch was the inspiration of a forest enterprise and machinery producer. This equipment was tested in a pilot experiment involving motor-manual felling of large dimensioned timber on (steep) slopes in combination with a forest skidder fitted with a traction stabilising winch.

⇒ Forest Skidder HSM 905 (used in both trials)

Engine: IVECO, NEF 6-Zyl., Common Rail/Turbo, 136 kW, 2300 U/min

Power transfer: Rexroth Hydrostat

Weight: 15 t / 15.8 t incl. traction stabilising winch

Crane: Epsilon S 120 / R68, range 6.8 m, max. lifting force 54 kNm, swing range 185°, no tilt

Winch: ADLER HY 20 Sg, length of cable 120m at 12 mm diameter Pyton R&F, tensile force 2x85 kN

Traction stabilising winch: ADLER EHY 16 L SG, length of cable 200 m Dynema at 16 mm diameter

Manufacturer: HSM / Neukupfer, www.hsm-forstmaschinen.de

⇒ Forwarder Forcar FC 2000 (Schoenmuenzach)

Engine: CUMMINS, 6-Zyl., Tier2, 142 kW, 2300 U/min

Power transfer: hydrostatic transmission, max. 30 km/h

Weight: 19.2 t incl. traction stabilising winch

Crane: LOGLIFT 91F, range 10 m, max. lifting force 88 kNm, swing range 360°, tilt 23° (50%)

Traction stabilising winch: Ritter Spillwinde, length of cable 200 m steel cable at 16 mm diameter

Manufacturer: Herzog Forsttechnik, www.herzog-forsttechnik.ch

⇒ Forwarder Valmet 860.4 (Loewenstein)

Engine: 66 CTA, 6-Zyl. Turbo Common Rail, Tier3, 145 kW, 2000 U/min

Power transfer: hydrostatic transmission, steered by MaxiForwarder, 8-wheel-drive, differential locks front and rear, max. 20 km/h

Weight: 18.5 t incl. traction stabilising winch

Crane: CRF 11, range 9.5 m, max. lifting force 126 kNm, swing range 360°, tilt -5° / +21°

Traction stabilising winch: Ritter Spillwinde, length of cable 400 m steel cable at 14 mm diameter

Manufacturer: Komatsu Forest GmbH, www.komatsuforest.de

2.3 Description of the harvesting system

The cut-to-length harvesting system for flat terrain and slopes up to 30% gradient developed in the southern Black Forest region in Todtmoos was implemented and adapted for a harvesting situation in a conifer stand in the northern Black Forest and in a broadleaved stand near Heilbronn on steep slopes from September until the end of November 2011. The performance and costs were assessed in time studies.

The system is suitable on accessible sites for forest machines with slope gradients up to 50% on which a system of skid tracks parallel to the slope at distances of about 40 m apart has been developed in the stands.

The trees are motor-manual felled by well trained 2-man felling teams and employ the most advanced felling techniques. With this system of skid tracks, operators can choose the felling direction towards the closest track and also avoid stand sectors where the natural regeneration is already well developed. This gives flexibility to the acting fellers which helps to pay attention to an ergonomically and safe work flow and enables them to avoid stand damages. Thus, only the branches on the upper side of the stem need to be removed at the felling site. Here the stems are also cut into standard log lengths, occasionally to logs with multiple section lengths. Furthermore, choice of felling direction according to the nearest skid track decreases hauling distances.

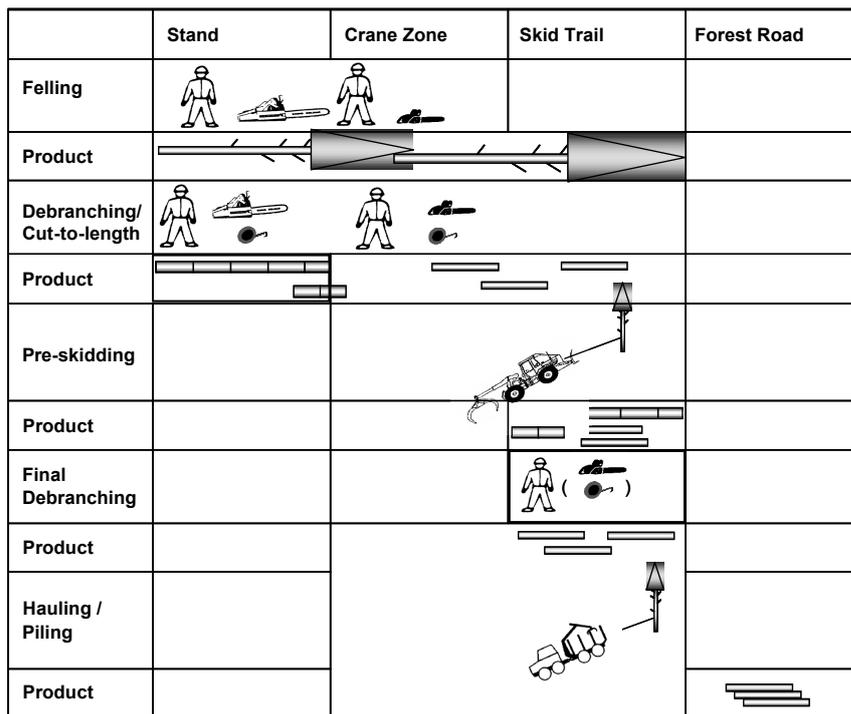


Figure 2: Scheme - LDT on steep slopes supported by skidders equipped with traction stabilising winch

The standard and multiple length log sections are hauled to the extraction tracks. As far as the crane of the skidder can reach the short logs they are extracted by the crane through carrying them out of the stand. At the skid track they are completely delimiting and multiple length are cut-to-length. A modern forest skidder fitted with a traction stabilising winch primarily is used for this operation. The forwarder, also fitted with a traction stabilising winch, ensures the efficient hauling of logs to the forest road. The traction stabilising winch helps these machines maintain traction on slopes while in motion, preventing slip. This ensures that the skid tracks remain accessible for forest machines and reduces erosion potential arising from wheel ruts.

The harvesting system was found to be highly efficient. In comparison to alternatives like extracting long stems in dip line upwards by conventional skidders with cut-to-length after hauling the calculated costs are even lower, due to the efficient forwarders.

3 Results

3.1 Productivity and costs

The calculated productivity is only based on the time studies, which was differentiated to single processes during all phases of the harvesting operations, starting with felling, delimiting and cut-to-length processes in the stands, pre-skidding, final delimiting and hauling of the logs by forwarders. Costs for fellers are calculated on the basis of labour rates of the state forest of Baden-Wuerttemberg. The machine costs are calculated according to guidelines of KWF e.V./Germany.

Table 1: Productivity and costs for trials „Loewenstein (broadleaved)“ and „Schoenmuenzach (softwood)“

	Large dimensioned broadleaved Harvested stand		Large dimensioned softwood Harvested stand	
dbh over bark cm		45		48
m ³ under bark / tree		2.4		2.7
Work productivity				
Felling / delimiting				
(2 Men)	m ³ / hr	6.8	(2 Men)	6.5
Processing	m ³ / hr	111.4		50.0
Extraction	m ³ / hr	36.6		41.7
Forwarding	m ³ / hr	8.6		9.1
Costs*				
Felling/delimiting	€ / m ³	9.6		10.1
Processing	€ / m ³	0.3		0.7
Chainsaw compensation (time% 46)	€ / m ³	0.3		0.5
Extraction	€ / m ³	2.4		2.1
Forwarding	€ / m ³	10.1**		12.2
Total costs	€ / m ³	22.7		25.6
*Rates	felling / delimiting / processing		extraction with forest skidder with traction stabilising winch	forwarding with forwarder with traction stabilising winch
Machines € / operation hours			55	75
Wages + employer contributions € / hr	32.60		33.30	36.30

**If the total harvest were extracted as short logs, then the forwarder costs would be higher and forwarding rates lower.

3.2 Stand damages

In each trial stand the stand damages on standing trees were estimated along transect lines of a total length of more than 2000 m representing about 20% of the stand area. The outcome showed a remarkable positive result with 8.1% damaged trees in the case of the harvesting trial of softwood in Schoenmuenzach, respectively 10.7% in Loewenstein dominated by broadleaved trees. Due to the large crowns of the harvested trees more than 50% of the damages occurred as felling damages.

Damages on the natural regeneration are difficult to interpret. Nevertheless, the analysed damage percentages of 22 and 14 show, that the silvicultural aim will be reached without any restriction.

4 Discussion

The described pilot studies of the developed motor-manual harvesting system for large dimensioned timber on slopes between 30 to 50% gradient can be summarised with a general positive assessment. Some major results should be taken into focus to draw the right conclusions for an implementation into the praxis:

With the system of skid tracks (40m), the fellers can choose the felling direction towards the closest track and can also avoid stand sectors where the natural regeneration is already well developed. Owing to this flexibility, the harvesting system is ergonomically safe and minimises stand damages. In particular, the support of machine cranes during the processing and handling of logs permits ergonomically safe working practices in accordance with work health and safety regulations.

Furthermore, choice of felling direction according to the nearest skid track decreases also hauling distances, and, because most of the logs are lifted out of the stand by a crane arm as a rule, this eliminates the impact of skidding logs along the forest floor, thereby reducing stand damages.

The forwarder, also fitted with a traction stabilising winch, ensures the efficient hauling of logs to the forest road. The traction stabilising winch helps these machines maintain traction on slopes while in motion, preventing slip. This ensures that the skid tracks remain accessible for forest machines and reduces erosion potential arising from wheel ruts.

The harvesting system was found to be highly efficient, yet the timing of the components must be well coordinated and planned due to the high performance capacity and overhead costs of the forest skidder and forwarder.

5 Conclusions

The observations and assessments made in the two pilot studies of the motor-manual harvest of large dimensioned timber on sloping sites supported by forest skidders and forwarders fitted with traction stabilising winches, described above, revealed largely positive outcomes in relation to work health and safety, performance, costs and stand damages. It is anticipated that this timber harvesting system will be more widely used on sloping sites, and could become in the described form or slightly modified and adapted to other stand characteristics established as a standard practice in future.

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6 References

- Erler, J., Goltz, H. von der, Pausch, R., Sauter, U.H., Siemes, P., 2008: So lange wie möglich - so kurz wie möglich. *Forst & Technik* 20 (5) 38 -40, 42, 44.
- Niemz, P., Scharer, W., Sauter, U. H., Becker, G., Glos, P., Moring, S., Teischinger, A., 2006: Verwendung von Starkholz und wenig genutzten Holzsortimenten, Conference-proceedings ETH, Zurich, Switzerland, 19 December 2005. *Schweizerische Zeitschrift für Forstwesen* 157 (12), 570.
- Sauter, U.H., Leenen, M., Pfeil, C., Hehn, M., 2006: Bereitstellung und Rundholzaushaltung von Nadelstarkholz für die zukunftsorientierte Sägeindustrie. *Schweizerische Zeitschrift für Forstwesen* 157 (12), S. 551-555.
- Sauter, U.H., Wehner, T., 2005: Aspekte der Holznutzung und der Technikfolgenabschätzung beim Waldumbau im südlichen Schwarzwald. In: Teuffel, K.; Baumgarten, M.; Hanewinkel, M.; Sauter, U.H.; Wilpert, K.; Konold, W.; Spiecker, H. (hgg.): *Waldumbau*. Berlin, Heidelberg: Springer-Verlag.
- Sauter, U.H., Hehn, M., Pfeil, C., Herbst, P., 2004: Verfahren zur Mobilisierung von Nadelstarkholz - Aufarbeitung und Bereitstellung in kurzer Form. *Holz-Zentralblatt* 130 (46), S. 613-614.