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3 authors:

Mohammad Reza Ghaffariyan
University of the Sunshine Coast

Mauricio Acuna
University of the Sunshine Coast

Pierre Ackerman
Stellenbosch University

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Review of new ground-based logging technologies for steep terrain

Mohammad Reza Ghaffariyan[1,2], Mauricio Acuna[1,2]
Pierre Ackerman[3]
[1]CRC for Forestry
[2]University of Tasmania
[3]Faculty of AgriSciences, Stellenbosch University, South Africa

Introduction

Harvesting steep sites presents a range of challenges. Choosing the appropriate technology to use on these sites requires careful consideration of cost, productivity, safety and environmental impacts. Although current ground-based harvesting systems are generally less expensive than cable systems, they may cause an unacceptable level of damage to steep sites in terms of soil compaction, erosion risk, damage to residual stands, and reduced aesthetics. Cable systems are widely used internationally for harvesting steep sites, but the higher costs of these systems can limit their application. This bulletin reviews some recent ground-based technology currently in use in Europe and North America that may be able to be applied in Australia to harvest steeper sites without the high costs of cable systems while minimising negative site impacts.

Felling and processing

Harvesters and feller-bunchers equipped with self-levelling technology and tracks with a firmer footprint can operate safely in steep terrain. Figure 1 shows different types of harvesters and their slope capabilities.

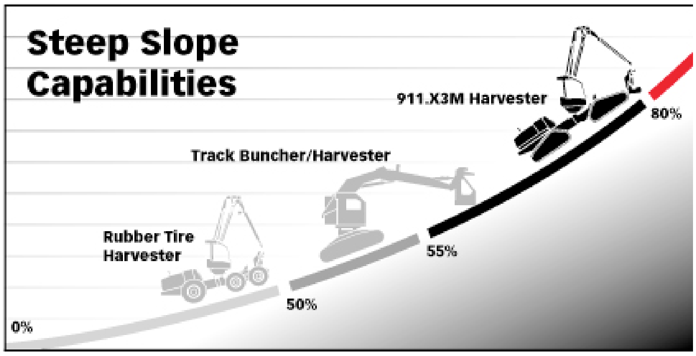

Figure 1: Different types of harvesters (Jaffe & O'Brien, 2009)

Table 1 presents a summary of some recent published studies of the performance of harvesters and feller-bunchers in steep terrain. In some new trials of steep terrain logging in New Zealand, the feller-buncher or harvester (or a secondary machine) is fitted with a large winch. A wire rope in the winch is used to tether the machine, enabling safe harvesting on the steep slope. (Amishev & Evanson, 2010).

Figure 2 shows a Valmet 911.3 harvester operating in steep terrain in Austria.

Figure 2. Valmet 911.3 harvester (Source: BOKU, Vienna)

Forwarding

Cable forwarders are an option for forwarding on steep terrain. In Germany, the PistenBully 300 W (a snow-grooming vehicle with a winch) was connected by cable to the rear towbar of a Timberjack 1010B forwarder (Figure 3). The forwarder was able to operate on downhill slopes of up to 85% without slippage, at an average productivity of 6 m^3/PMH_0. This decrease in slippage minimised soil disturbance (Bombosch et al., 2003). In Southern Austria, a Gremo 950R forwarder was used to extract logs cut and piled by a harvester (Figure 4, Table 2). This forwarder used a cable fixed to a standing tree in order to enable safe operation on steep slopes of up to 85% (Wratschko, 2006).

Table 1. Harvesters and feller-bunchers studied in steep terrain

Machine/system	Reference	Area	Productivity (m^3/PMHo)	Slope (%)	Tree size (m^3)	Soil and stand damage
Koenigstiger tracked harvester	Weixler et al. 1997	Southern Germany, Switzerland	16–21	40	0.26	15% of residual stands were damaged. Low soil disturbance for tracked harvester.
Valmet 911 tracked harvester	Stampfer & Steinmüller, 2001	Austria	22	22–56	0.61	15–30% of residual trees damaged mostly at stem and roots. Low soil compaction for this harvester.
Valmet 911.3 tracked harvester	Lileng, 2007	Western Norway	29	59	0.39	–
Valmet 500T harvester (self-levelling)	Spinelli & Hartsough, 2003	California, USA	25 (in native forest) 11 (in plantation)	30 19	0.36 0.12	– –
Valmet 445 EXL self-levelling feller-buncher	Acuna et al., 2011	Victoria, Australia	138	51	0.80	–
Prototype winched excavator with felling head	Amishev & Evanson, 2010	New Zealand	65	70	0.85	–

Figure 3. PistenBully connected to forwarder (Germany) (Bombosch et al., 2003)

Figure 4. Gremo 950R cable-forwarder (Austria) (Source: BOKU, Vienna)

Table 2: Forwarders studied in steep terrain

Machine/system	Reference	Area	Productivity (m^3/PMHo)	Slope (%)	Tree size (m^3)	Soil and stand damage
Timberjack 1010B cable-forwarder	Bombosch et al., 2003	Germany	6	85	–	Low impact on soil in skid trail
Gremo 950R cable-forwarder	Wratschko, 2006	Austria	20	39	0.70	–

Skidding

Tracked and wheeled skidders are typical primary transport vehicles. They can be equipped with a grapple and/or cable winch. The tracked skidders and wheeled skidders are restricted to operate in moderate slopes less than 55% and 35% respectively. Their characteristics are described in Table 3. Since skidding the trees can disturb the soil and damage standing trees or seedlings, skid trails need to be carefully planned and constructed before skidding to minimise site impacts.

Table 3. Skidders studied in steep terrain (Parker & Bowers, 2006; Sarles & Luppold, 1986*)

Machine/ system	Productivity (m^3/PMH)	Max. down slope (%)	Tree size (m^3)	Soil and stand damage	Road access requirements	Additional capabilities or flexibility
Tracked skidders ('crawler tractors')	Low to high (9–13 m^3/ PMH)*	45–55%; downhill skidding preferred	Capable of handling all sizes in design range of machine (load size per turn: 1.4–8.8 m^3)*	Medium to high soil compaction potential; possible damage to residual stands	Up to max. distance of 330 m possible; less than 230 m preferred; smaller landings required	Crawler tractors can also be used for building roads and landings, installing culverts, and treating slash
Wheeled skidders	Low to high (7–50 m^3/ PMH)*	35–45%; downhill skidding preferred; limitation on mobility and efficiency in rocky and steep trails	Capable of handling all sizes in design range of machine (load size per turn: 1.8–6.5 m^3)*	Medium to high soil compaction potential; possible damage to residual stands	Up to max. distance of 330 m possible; less than 230 m preferred; medium landings required	Skidders can be used for treating slash

Some of the new skidding technologies in use are described below:

Woody 110 wheeled skidder: This cable skidder (shown in Figure 5) is a small (7 t and 2.2 m width) powerful tractor that is effective for thinning in difficult terrain. It has a 10 t maximum payload, and is a good choice for steep terrain logging compared with other wheeled skidders because of its remotely controlled winch and tractor (Marence & Kosir, 2007).

Werner 1700 wheeled skidder: This wheeled skidder/forwarder has dual winches, and a planetary axle with a mounted hydraulic steering front axle. Both axles have limited-slip differentials for improved mobility and driving comfort in slopes. The 8.4 m reach boom is equipped with a grapple to extract bunched logs/trees and has an average productivity of 7–14 m^3/PMH_0 (AUSTROFOMA, 2007).

Figure 5. Woody 110 wheeled skidder in steep terrain (Slovenia) (Marence & Kosir, 2008)

Take-home messages

- Tested technology options are available to enable ground-based mechanised equipment, traditionally limited to flatter terrain, to operate in steep conditions in Australia. These options include new cable-winch-assisted harvested and forwarders.
- Negative machine impacts on soil and residual stands can be minimised by:
  - selecting appropriate technology equipped with a wide firm footprint, a low centre of gravity and assistance on steep slopes, which combine to reduce slip, lower the risk of roll-over and minimise compaction
  - pre-planning skid trails.

More information

For more information, visit the CRC for Forestry website at *http://www.crcforestry.com.au/research/programme-three/index.html* or contact the project scientist: Mohammad R. Ghaffariyan: **Mohammad.Ghaffariyan@utas.edu.au**

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