TECHNICAL DEVELOPMENT

INTERNAL PROJECT INFORMATION NOTE 17/06

Title:	**Presentation of Brash for Baling from Clearfell Harvesting**
Number:	**500S/29/06 & FR06058**
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Internal Project Information Note 17/06

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SUMMARY

This Internal Project Information Note (IPIN) reports on a study of three different methods of presenting brash for baling and the operational issues associated with integrating brash baling into a conventional mechanised clear fell operation.

Brash from the different presentation methods was recovered by a brash baler and the performance of the harvesting and brash baling operations assessed. This IPIN also includes the determination of the volumes of three bales, one from each presentation method.

The outputs of the harvesting and presentation of brash ranged between 21.70 m^3 /shr and 23.35 m^3 /shr.

Brash bale production from the three presentation methods exceeded the output of 20–30 bales per hour stated by the manufacturer. Bales produced from the stem wood RSBALE had the highest energy content with a large amount of the small branches and needles being left on site.

The average volume of the bales produced was 0.513 m^3

Further work is needed to provide site selection guidance for forest managers.

INTRODUCTION

There is a strong political commitment both nationally and internationally to reduce the dependency on finite resources of fossil fuels and to increase the use of renewable resources such as wood and forest residues. The potential to recover forest residues from harvesting operations is being considered by the forest industry in the United Kingdom (UK).

Residues form an important part of the forest ecosystem and there may be potential economic benefits in residue removal and subsequent restocking. However, depending on certain soil types and underlying geology, complete or even partial removal of residues may have negative effects, causing soil nutrient depletion and increased acidification of surrounding ground water. Forest Research is currently developing a site selection protocol to provide further guidance to forest managers. The baling of residues[1] from harvesting operations is common practice in Finland and other Scandinavian countries. Brash is compressed into bales or composite residue logs (CRL), extracted by forwarders and transported using timber haulage vehicles to large power generation plants or to specialist bale burning plants.

The construction of bioenergy power generation plants in the UK has created a new marketing opportunity for forest residues. Technical Development (TD) has been commissioned by Forestry Commission Wales (FC W) to investigate the operational practices associated with mechanised clearfelling (short wood system) and residue presentation for baling.

The objectives of this study were to:

- Review existing information and technical data from research publications on harvesting and management of brash.

[1] Residues and brash are defined as all the above ground components of a tree that are left once the main stem has been cut into timber products

- Organise and time study the following operations:

    1. The mechanical harvesting of three brash presentation methods and one control method.

    2. The extraction of timber from the three methods and one control plot.

    3. The production and extraction of the CRLs from the three brash presentation methods. To be carried out in two stages, Stage one (1) shortly after harvesting and stage two (2) in 4–6 months time.

- Determine the volume of CRLs using an appropriate method. Brash bales were submerged in a tank of water and the volume calculated from the difference in water levels.

- Investigate the issues relating to the road transport of CRLs (efficiency in terms of roadside stacking, transport, handling and cost per km).

This IPIN includes the harvesting, presentation of brash, forwarding of timber, production and extraction of brash bales at stage (1). Brash bale production and extraction at stage (2) will be added as an additional section, which will be incorporated in the final IPIN.

EXISTING INFORMATION

There was found to be very little information on methods and systems for brash presentation and baling of residues in the UK. In 1996 TD carried out a brief trial in North East Scotland of a prototype self-contained baler unit mounted on a converted forwarder. Bales were produced in an enclosed chamber, 1.2 m wide and outputs from felled Sitka Spruce brash were 11.6 – 12.6 bales per standard hour.

More recently brash baling technology has developed and there are several machine manufacturers such as Pinox, Komatsu Forest and John Deere producing baling machines.

The management of brash is an important aspect of all harvesting operations. Guidance on best practice is contained within the following documents:

- *Whole-Tree Harvesting, A Guide to Good Practice* (Forestry Commission, 1997).

- ,TD Technical Note 19/97 *Clambunk System – Residue Availability*.
- *Forest and Water Guidelines, 4th Edition* (Forestry Commission, 2000).

- *FCTN011 Protecting the Environment during Mechanised Harvesting Operations*, (Forestry Commission 2005).

During the trial best practices for brash management were followed. This IPIN focuses on the operational issues associated with presentation of brash for baling and subsequent removal from site.

THE TRIAL

Site and Crop Information

Trial site and crop information was provided by Coed Y Gororau Forest District and is shown in Table 1. Soil maps indicated an upland brown earth soil type. This was further clarified by soil sampling by Technical Support Unit (TSU). An area *c*. 0.9 ha within the felling coupe was identified as being suitable for the trial.

The residue from this trial included all live and dead standing trees. Only stems with advanced decay i.e. those that would disintegrate during handling by the harvester were not included.

Table 1: Trial site and crop information

Cae Weirglodd, Cloceanog Forest, North Wales	
Altitude (m)	370 a.s.l
Grid Reference	SJ 053552
Soil Type	Upland Brown Earth
Species	Sitka Spruce
Age (years)	53 (P53)
Slope (trial area)	14%
Previous treatment	Line thinned, every 4^{th} row removed
Average DBH (cm)	23
Average volume per tree (m^3)	0.45
No. of trees per hectare	1210
Average volume per hectare (m^3)	546
Dead Trees	
Average DBH (cm)	10
Average volume per tree (m^3)	0.059
No. of trees per hectare	445
Average volume per hectare (m^3)	39.9

The trial site (Appendix 4) was divided into 8 drifts, each 13 m wide and approximately 83 m long.

BRASH PRESENTATIONS METHODS

Integrating the brash baling operation into a conventional mechanised clearfell harvesting operation, without compromising timber production or environmental standards, required a clear understanding of the implications of each operation. Pre commencement site discussions provided the opportunity for the site manager and operators to share their knowledge and contribute to the trial proposals.

The aim was to present and extract both timber and brash bales without contamination and in such a way to avoid reducing timber production or increasing environmental impact on the site. The brash mats would be used for stage (2) of the trial, baling and extracting brash bales 4–6 months after harvesting.

The working method on most FC clear fell sites, where wheeled or tracked harvesting machines are used, is to create brash mats to aid machine floatation and travel. This reduces the risk of soil damage. Timber is presented in product stacks in a timber zone next to the brash mat. It was therefore decided that this proven method of working would be continued in the trial.

The working method on the site was to harvest a drift *c*. 13 m wide (6 rows[2]) in an uphill direction. The harvester operator felled trees into the standing crop (from left to right) and processed in front of the machine to create a brash mat on which it travelled. The timber produced was stacked in the timber zone to the right of the machine. The area created by felled trees on the right of the machine served as the timber zone of the next harvester drift. (Figure 1).

The main requirements for the baling operation were:

- Residue for baling should be orientated in the same direction for loading, preferably at 90º to the machine and loosely compacted.
- No short (< 0.5 m) butt lengths.
- A clear distinction between brash mats and residue for baling, where these are adjoining.
- No stems with roots attached or any contaminants which would affect the cutting ability of the chainsaw.

[2] Standing timber excluding the previously removed line thinning

- If the baling machine is to travel on the adjacent brash mats the distance from brash to be recovered has to be within 10 m, the maximum reach of the machines loader. Where possible the distances between brash mats should be reduced.

Harvesting

Harvesting was undertaken by the Wales Harvesting and Marketing (WHAM) harvesting fleet using a John Deere 1270D harvester with H480 harvesting head (Appendix 2 for Technical Specifications). At the time of the trial there was a strong demand for short logs and fencing material and the cutting specification for the trial is shown in Table 2.

Table 2 Cutting specification of timber products

Species	Product	Length (m)	Min. TDUB* (cm)	Max.TDUB (cm)	Max Butt Diameter UB (cm)
Sitka Spruce	Logs	2.50	22		46
	Logs	3.75	18		46
	Bars	1.90	14	20	30
	Fencing	1.90	7	13	15
	Chip	2.8	7		65

- Top diameter under bark

Methods trialled

The four different methods used in the trial are described below and illustrated in Figure 1. For comparative reasons three different presentation methods and a control method, which was the conventional method of working were used.

1. CO – Current mechanised harvesting method on this clearfell site with all the residue placed in the brash mats. This was the control.

2. NBRBALE - Mechanised harvesting with narrow drift width to create brash mat in between extraction routes for brash baling. The baler would travel on the adjacent brash mats. Drift width was retained and brash recovered with the machine travelling on bare ground.

3. RSBALE – Current mechanised harvesting method with a proportion of residue (stem wood only up to 50%) presented within a separate zone of the next drift for baling.

4. BRBALE – Current harvesting method with a proportion of brash (up to 50%) presented within the timber zone for baling

Figure 1 Methods of working

Not to scale or sequence of working

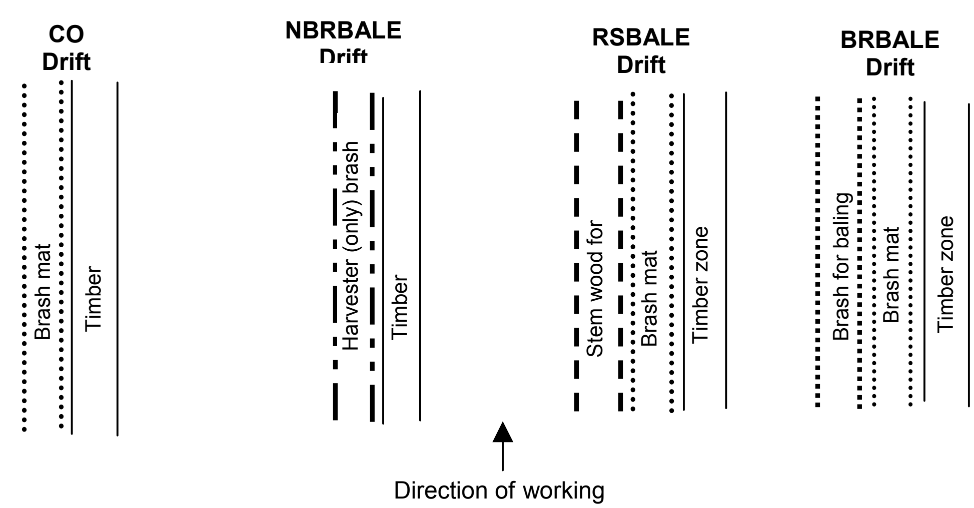

Plate 1 – RSBALE drift stem wood for recovery to the left of the brash mat

It was proposed to reduce the width of the drift (NBRBALE). However brash recovery could be achieved with the existing drift width and some of the brash mats were needed for the second stage of the trial. Reducing drift width would reduce harvesting output (TD Technical Note 14/98*, Harvester Output: The Effect of Drift Width*) and the amount of brash available for both brash mat construction and presentation for baling. The brash baler would travel on the two adjacent brash mats. The existing harvesting drift width was maintained.

On sites with low ground bearing capacity an increased amount of brash would be required for machine floatation. Narrower drift widths reduce the quantities of brash available for brash mats and baling.

The presentation of brash for baling from mechanised clearfell harvesting in the UK is relatively new and no guidance is available on system management and the quantities of brash that can be presented for baling without compromising the integrity of the brash mats. Consideration was given to the additional machine movements of the baler and forwarder and 50% of brash was decided to be the maximum quantity of brash that would be reasonable to present for baling. The actual quantity of brash presented from each presentation method was at the discretion of the harvester operator, however on this soil type and relatively flat ground with no ditch or stream crossings the desired amount of brash (i.e. 50%) presented for baling was achieved. On sites with uneven terrain, hollows, wet areas, ditch or stream crossings a higher proportion of brash may be required for brash mat construction.

The proposed methods of working were completely new to the harvester and forwarder operators. Creating a brash or stem wood baling zone in the conventional drift working reduced the width of the timber zone by approximately 50% in the RSBALE and BRBALE methods. This reduced width for stacking of the five timber products, some of which were similar both in length and diameter resulted in some timber products becoming mixed during harvesting.

The presentation of timber products from all brash presentation methods was the same throughout, apart from one NBRBALE drift where, due to operator concerns about timber presentation for the forwarder, trees were felled in the opposite direction to create a wide timber zone (see Appendix 4 Site Map). Strong gusts of wind during the harvesting of this drift caused difficulties handling the larger trees and it was decided for the remainder of the trial to fell trees into the standing crop. In windy conditions greater directional control can be achieved by felling into the standing crop.

The average width of the brash mats from all presentation methods was 4.6 m. Control drifts 5 and 6 rows wide were also harvested and output is shown below.

Time study data were collected for each method and the results are shown in Table 3.

Table 3 Harvesting costs and outputs

Presentation Method	Output* (m^3/shr)	Cost** (£/m^3/shr)
BRBALE (6 rows)	21.70	3.00
NBRBALE (6 rows)	23.35	2.78
RSBALE (6 rows)	22.07	2.95
CO (5 rows)	18.52	3.51
CO (6 rows)	21.57	3.01

* Standard outputs (shr) include an allowance of 20% for other work and 18% for rest.
** Cost based on a charge of £65.00 per hour for the harvester.

Discussion

From Table 3, the most productive method with lowest cost was the method NBRBALE with 23.35 m^3 produced per standard hour. The lowest output and most costly being the CO (5 rows). The NBRBALE method is the conventional method of harvesting for operators with all the brash being placed in front of the machine to form brash mats. The BRBALE and RSBALE are new working methods that included additional operating elements. Despite these additional elements the outputs and costs are in the same range.

Forwarding of Timber Products

Forwarding was carried out using a JD 1110D forwarder with a carrying capacity of 12000 kg. All timber was extracted per product before brash baling. There were no mixed products per load.

The extraction of timber provided the opportunity to investigate any operational issues associated with the presentation methods. The short lengths and similar diameters of some of the timber products in the cutting specification required some sorting of products before loading.

It was not possible to identify any clear differences between the different presentation methods. However the difficulties linked to products being mixed in the RSBALE and BRBALE methods made the loading element of the forwarding operation more difficult. Presentation for the forwarder could be improved with a cutting specification of fewer products and longer lengths.

BRASH BALING

The baling machine, a John Deere 1490D (Appendix 1 for Technical Specification) was operated by MG Harvesting and contracted to UPM Tilhill. It is the only known residue baling machine currently operating in Britain. Permission was granted by UPM Tilhill to use the baler for the trial.

Method development for baling brash from mechanised clear fell harvesting sites in the UK is still in the early stages. Considering the soil types on which the baler is likely to operate, it was decided that, where possible the baler would only travel on the brash mats created by the harvester. The maximum loader reach of the brash baler is 10 m and therefore brash for baling had to be presented within 10 m of an adjacent brash mat.

Plate 2 Brash baler

The brash baler is an eight-wheeled forwarder chassis with a loader and baling chamber mounted on the rear bunk. Costs and outputs from the trial are shown in Tables 4 and 5 respectively.

The chamber can rotate depending on operating position. During the trial it was set at 90^0 to the length of the drifts and brash was fed into the baler from right to left. Brash is continuously loaded, using a four-pronged residue grab into the baling chamber where it is compressed by several hydraulic rams into a cylindrical shape. The bale is then bound with nylon string, usually twice every 40 cm along the bale. Reels of string are contained within the nine fixed casings. These revolve around the compressed bale. The transfer from a used reel to a new one is automatic. At a pre-determined length set by the operator a chainsaw at the discharge end of the bale chamber is activated and the cut bale falls onto the ground.

The length of bales that can be produced range from 2.4–3.2 m and the average bundle diameter is between 0.7–0.8m. The length of bales specified in the trial was 2.5 m.

Presentation of brash for baling should be orientated the same way, in line with the bale chamber, loosely compacted with no harvesting debris or any contaminants that will reduce the sharpness of the chainsaw or affect the combusting ability of the bales. There should also be a clear distinction (i.e. break between the brash mat and brash to be baled) in situations where these two zones are next to each other.

Baling of the residues from one drift of each presentation method was carried out in two stages. The first stage shortly after felling and the second stage once the needles had fallen from the branches. The second stage baling is expected to be between 4–6 months after felling, March – May 2007.

The first baling operation was carried out eight weeks after felling. On the BRBALE and RSBALE drifts the machine worked in a downhill direction (slope 14%) travelling on adjacent brash mats. The operator preferred the downhill working method due to the greater visibility from the cab.

The NBRBALE (harvester brash) zone was within the reach (maximum 10 m) of the loader mounted on the baler from adjacent brash mats. However the distance was too great to grab the entire residue pile from one brash mat and the machine would travel on both brash mats to recover the material. This method was tried, however after operating for a short period of time the operator considered this method to be too unproductive. Baling the NBRBALE from adjacent brash mats required higher levels of concentration by operator.

The solution was to allow the baler to travel on bare ground adjacent to the NBRBALE drift. Ground conditions were suitable and no significant ground impact was observed.

The operator did not identify any significant advantages with any presentation method.

Costs and Outputs

Table 4 John Deere 1490D Brash baler machine costs

John Deere 1490D Brash Baler	
Capital cost (£)	290 000
Residual value (£)	29 000
Life in years	5
Hours per year	2000
Interest (%)	5
Discount factor	0.7835
Equivalent annual cost	0.2310
Capital cost (£/hr)	**30.87**
Operating costs (£/hr)	
Repair and Maintenance	9
Fuel	7
Insurance	3
Operator (including oncosts)	20
Operating costs	39.00
Total Hourly Charge (£)	**69.87**

Table 5 Baling of green brash

Presentation Method	Number of Bales produced	Number of Bales/shr*	Cost /Bale	Cost/solid (m^3)**	Solid (m^3/hour)
BRBALE	30	36	£1.94	£4.13	16.88
RSBALE	16	33	£2.12	£3.50	19.97
NBRBALE	42	41	£1.70	£3.62	19.23

*Standard (shr) outputs include an allowance of 20% for other work and 18% for rest
** Based on solid volumes shown in Table 7

Discussion

Brash bale production from the three presentation methods exceeded the output of 20–30 bales per hour stated by the manufacturer.

Both the BRBALE and RSBALE drifts contained 50% of the available brash for baling. The NBRBALE drift however contained 100% of the brash available. This was the brash mat on which the harvester travelled. Machine movement on brash to be recovered increases the risk of contamination and compaction, although this was not observed during the trial.

The reduced quantities of brash within the brash mats in the BRBALE and RSBALE drifts and additional machine movement of the baler and forwarding of the bales will result in the quicker deterioration of the brash mats. BRBALE method is recommended where 50% of stem wood and brash are most appropriate for the site. During stage (1) of the trial all the brash mats supported machine movement satisfactorily, without the need for any thatching. However this may not be the case for stage (2) of the trial and additional brash may be needed to prevent ground damage.

The NBRBALE drift was the most productive with 41 bales produced per standard hour. The brash presented in this drift was denser than the other two drifts enabling a greater amount to be loaded per grab. An important factor to be considered is the calorific value of each bale. The bales produced from the RSBALE drift had the largest amount of solid wood (Table 7) and highest calorific value.

Production of solid cubic metres from the RSBALE drift was the highest and cheaper than the other two methods. Also a higher proportion of the needle and small branch material was being retained on the site. This method is recommended where maximum stem wood recovery and maximum brash retention is required.

Extraction of Brash Bales

A John Deere 1110 D forwarder (Appendix 3 for Technical Specification) was used to extract the brash bales, nine weeks after harvesting. Outputs for the extraction of bales are shown in Table 6. The forwarder travelled on the brash mats during extraction. Bales were loaded and unloaded individually in the same sequence as timber products, apart from two instances when the operator started by unloading bales from the top of the rear bunk. Settling of bales on the bunk during extraction created difficulty in positioning the timber grab around the circumference of a single bale. Some damage was caused to the binding string of the bale although it remained intact.

There was no visual damage caused to the brash mats of each presentation method. However the key extraction route outside the trial area could have benefited from additional brash. There can be seasonal variation in the bearing capacity of some soil types. With the increased machine movements due to the additional operations it would be preferable to plan operations in the drier periods of the year.

The operator identified that brash bales could be used to repair brash mats, damaged from repeated machine movement. However the baling operation would need to take place before the timber products were extracted.

Table 6 Extraction of brash bales

	Output/shr* (no. of bales)	Apparent Bale Volume (m^3/shr)	Solid Volume (m^3/shr)
RSBALE	45	43.29	27.22
NBRBALE			21.11
BRBALE			21.11

*Standard (shr) outputs include an allowance of 20% for other work and 18% for rest

Further output and cost information will be included after stage (2) of the trial.

Roadside stacking

The limited designated stacking area and the five different timber product specifications meant that some timber products were dispatched from the site to create sufficient space for the stacking of the brash bales. Bales were stacked in double rows of three bales high to an approximate height of 1.9 m.

VOLUME DETERMINATION OF BRASH BALES

A bale produced from each presentation method was randomly selected and weighed on a private weighbridge. There is no known method of determining the actual volume of brash bales, so the basic method adopted was to calculate the volume by the displacement of water. Bales were fully submerged in a tank of water and the difference in water levels measured. Immediately after submersion the bales were suspended over the tank to allow water to drain out. Although most of the water was allowed to drain back into the tank, a small quantity remained within each bale.

Needles became detached from each bale and remained floating on the surface of the water in the tank. Additionally there would be a small amount of water displacement by the sling. This was considered minimal and was not calculated separately from the bale. There may also be very small quantities of water absorbed into the cut surfaces of the material within the bales.

Due to these limitations and as only one bale was sampled for each method, the results can only be taken as indicative, a larger quantity would be required to give statistical validity. However there is a very clear difference between the weight and solid volume of the RSBALE bale, which contains a higher proportion of stem wood than the NBRBALE and BRBALE bales. The energy industry requires bales with the highest energy content.

Table 7 Volumes and measurements of the bales

Presentation Method	Weight (kg)	Measurement (m^3)	Water Displacement Depth (mm)	Volume (m^3)
RSBALE (Stem wood)	540	1.034	200	0.605
NBRBALE (Harv. Brash)	440	0.935	155	0.469
BRBALE (50% brash)	440	0.807	155	0.469

The calorific value of each bale is an important factor, particularly for the energy producers. Table 8 shows the energy per bale in Gigajoules (GJ) at a range of moisture contents (MC).

Table 8 Energy values

Wood MC % (Wet Basis)	Energy Value (GJ/m^3)[3]	RSBALE (GJ/bale)	NBRBALE (GJ/bale)	BRBALE (GJ/bale)
60 fresh	5.187	3.318	2.433	2.433
55 fresh	6.122	3.703	2.871	2.871
50	7.057	4.270	3.310	3.310
40	8.930	5.402	4.188	4.188
30	10.801	6.535	5.066	5.066
20	12.673	7.667	5.943	5.943

With fresh coniferous wood the MC is likely to be between 50 – 60%.

TRANSPORT

None of the bales have been uplifted and hauled from the stacking area on site, therefore there has been no opportunity to investigate the handling and transport issues associated with road transport of the bales.

From personal communication with ConFor[4] the cost of road transport of round timber in the UK is £1.71/km on forest roads and £ 0.93/km on Class B roads. The physical characteristics of round wood and brash bales are very similar and the procedures for stacking, loading, unloading and securing loads of timber during transport should be followed. *(Road Haulage of Round Timber, Code of Practice 3rd Edition*).

The relatively lower density of bales compared to timber indicate that the maximum legal weight for road transport of bales would be achieved with a high MC (50 – 60% wet basis). This was confirmed by discussions with a timber haulier. Indications show that, with an articulated timber trailer with a centrally mounted loader, the maximum net weight per load would only be achieved with bales with a high MC, > 50% (wet basis). This is based on a maximum trailer capacity of approximately 60 m^3.

The rates of drying at roadside is not known, however results from a storage trial in Scotland in 2003 indicate 6 months to be the ideal time for storage and the tops of bales should be covered to prevent rainwater ingress. (Forestry Contracting Association, DTI Report /W2/00710/00REP). It is assumed that the longer the bales are stacked the more brittle the material within the bales will become due to the reduction in MC. Mechanical handling issues may occur after long periods of roadside stacking, particularly if the binding material has degraded or the contents have become very brittle. Bales will retain their physical shape for longer if they contain long lengths of stem wood.

3 Aberdeen University, Wood Supply Research Group 1990
4 Confederation of Forest Industries (UK) Ltd

CONCLUSIONS

The harvesting of brash from a mechanised clearfell harvesting operation and subsequent baling of residues was successfully achieved on an upland brown earth site in Wales. However, the methods and systems required to integrate brash baling into clearfell harvesting operations require further investigation and development.

Good coordination is required between the harvesting, brash baling, extraction of timber products and brash bales. Where this is undertaken by different contractors clearly defined working practices will be required to ensure good productivity.

Bale production output exceeded that specified by the manufacturer for all three presentation methods. The operator's preferred method for baling was baling in a downhill direction due to greater visibility rather than uphill working.

On sites with a lower ground bearing capacity and those with stream and ditch crossings, a greater amount of brash will be required for brash mat construction.

The RSBALE method has a greater volume, weight and energy value than the other presentation methods and a higher proportion of small branches and needles are being retained on site.

Presentation of brash for baling should be orientated in the same direction, in line with the baling chamber and free from contamination

The best method of brash recovery from this trial was RSBALE. There was an increased amount of stem wood recovery and therefore a high energy content per bale and the small branches and needles are left on the site maintaining nutrient capital.

RECOMMENDATIONS

The trial was an initial pilot study of brash presentations for baling. Further studies with greater statistical validity and the monitoring of the effects of brash removal on site conditions are required before proven guidance can be provided. Forest managers require better site selection guidance and TD should work in collaboration with Tom Nisbet to achieve this.

A desk study comparison should be made with other baling machines with the benefits and differences identified.

Brash production from other harvesting operations such as wire rope extraction should be investigated and the potential for baling from different harvesting systems assessed
Roadside storage, transportation and processing of brash bales at the power plant should be further investigated. The financial and environmental implications of brash baling on ground preparation, restocking and future tree growth also need to be considered.

The use of high floatation tyres on forwarders, for the removal of brash bales 4 – 6 months after harvesting would reduce ground damage to weak brash mats.

The damage caused to the soil, in terms of compaction and the effects on growth and restocking from repeated machine travel should be considered for further investigation.

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Finlay McAllister, Technical Development Forester

Appendix 1

Technical Specification

John Deere 1490D	
Engine	
Make	John Deere 6068 HTJ
Power	136kW (274 hp) @ 1900rpm
Torque	779 Nm @100 rpm
Turbo	Yes
Air/water cooled	Water cooled
Transmission	
Type	Hydrostatic-mechanical 2 –speed Gearbox.Release of Rear-wheel Drive
Tractive force	175 kN
Speed	8 – 22 km/h
Steering	
Type	Proportional Frame Steering, Steering Angle +/- 42°
Brakes	Service and working brakes are hydraulically actuated, oil-immersed multi-disc brakes. Spring-actuated parking and emergency brakes ISO 11169
Axles/Bogies	
8 – wheel	Balanced gear bogies axles at the front and rear. Band tracks fitted to the rear bogies
Electrical System	
Voltage	24v
Batteries	2 x 145 Ah
Alternator	140 A (28 V)
Working lights	10 x 140W Twin Power
Hydraulics	
Pump volume (cm^3)	190
Working pressure (Mpa)	24
Hydraulic tank (l)	140
Boom CF5	
Maximum reach lengths (m)	10
Gross lifting torque (kNm)	102
Slewing torque (kNm)	24
Slewing angle	380°
Cab	Safe and conformity with ISO standards
Measuring and control system	TMC Timbermatic 700
Measurements	
Transportation length (m)	11.105
Working position (m)	12.165
Transportation width (m)	2.958
Transportation height (m)	3.816
Ground clearance (m)	0.605
Bundling Unit	Integrated TMC control for bundling process
Length (m)	6.2
Feed opening - Height (mm)	800
Width (mm)	1020
Turning of turntable (^{0})	300
Tilting of turntable (^{0})	10
Bundling string	Agri. nylon and sisal strings, 9 reels
Bundle length (m)	2.4 – 3.2
Bundle diameter (m)	0.7- 0.8
Cutting	Automated chainsaw
Saw guide	¾"
Yield	20 – 30 bundles/hour

Appendix 2

Harvester Technical Data

Refer to **www.JohnDeere.com** for further machine information.

John Deere 1270D Harvester	
Engine	
Make	John Deere 6068 HTJ
Power	160kW @ 1400–2000 rpm
Torque	1100 Nm @1400 rpm
Fuel tank (litre)	480
Transmission	
Type	Hydrostatic-mechanical 2-speed Gearbox
Tractive force (Nm)	160
Speed (km/h)	Mode 1: 0–8; mode 2: 0–25
Steering	
Type	Proportional Frame Steering, Steering Angle +/- 40^0
Axles/Bogies	Balanced gear bogie axle at front and rear rigid axle; Hydro-mechanical differential lock at the front and the rear. Band tracks fitted to the front bogies and water ballasted tyres
Electrical System	
Voltage	24V
Batteries	2 x 140Ah
Alternator	140A (28V)
Working lights	14 x 140W Twin Power and 4 single lamps on the boom. Xenon lights also available
Hydraulics	Load-sensing, pressure compensated
Pump volume (cm^3)	190
Working pressure (MPa)	24/28
Hydraulic tank (l)	220
Boom 210H	
Maximum reach lengths (m)	8.3/ 9.0/ 9.7/ 11.5
Gross lifting torque (kNm)	178
Slewing torque (kNm)	43.6
Tilt angle	-13° to +25°
Slewing angle	220°
Control System	PC/Windows-based Timbermatic 300
Cab	
Standard	Fixed cab
Option	Rotating and levelling cab
Sideways	15°
Forward/backward tilt	11°
Turning angle	50°

Appendix 3

Forwarder Technical Data

Refer to **www.JohnDeere.com** for further machine information.

John Deere 1110D Forwarder	
Engine	
Make	John Deere 6068 HTJ, 6-cylinder, 6.8 litre, turbo-charged intercooled
Power	120 kW @ 2000 rpm
Torque	719 Nm @ 1400 rpm
Fuel tank (litre)	150
Transmission	
Type	Hydrostatic-mechanical 2-speed gearbox
Tractive force (Nm)	150
Speed (km/h)	Mode 1: 0–8; mode 2: 0–23
Steering	
Type	Proportional frame steering, steering angle +/- 44°
Axles/Bogies	Balanced gear bogie axles Hydro-mechanical differential lock at the front and the rear. Band tracks fitted to rear bogies
Electrical System	
Voltage	24 V
Batteries	2 x 145 Ah
Alternator	100 A (28 V)
Working lights	8 x 140 W twin power Xenon lights also available
Hydraulics	
	Load-sensing, with power control
Pump volume (cm^3)	125
Working pressure (MPa)	21.5
Hydraulic tank (l)	140
Boom CF5	
Maximum reach lengths (m)	7.2/ 8.5/ 10.0
Gross lifting torque (kNm)	102
Slewing torque (kNm)	24
Slewing angle	380°
Control System	TMC or PC/Windows-based Timbermatic 700
Load rating (kg)	12 000

Methods of Working