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Extraction Route Trials on Sensitive Sites

TECHNICAL NOTE

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SUMMARY

The use of large-scale timber extraction machinery during harvesting places high load-bearing forces on extraction routes. Minimising this impact is particularly important on more sensitive sites. This Technical Note gives the results from two trials that assessed extraction route formations on deep peat sites. Information is provided on the evaluation of route construction materials, including straw, low impact route construction and extraction, including reducing the size of forwarder loads, and type of harvester and provision of brash.

INTRODUCTION

During harvesting operations the use of large-scale timber extraction machinery places high load-bearing forces on extraction routes. These routes must therefore be carefully constructed and maintained in order to safeguard their continued use. If the ground surface is unable to support heavy machinery, incorporating additional surfacing materials and modifications to the harvesting method can increase the load-bearing capacity.

This study describes operational experience of timber extraction routes constructed from various biodegradable materials and gives a measure of their performance in supporting machine travel (Figure 1). The experience and information gathered can be applied to similar types of site.

This trial, located near the Solway coast, covers an area of 350 ha and prior to afforestation was an upland raised bog with deep peat to a depth of approximately 10 m. The overlying soil surface and ground vegetation consisted of pine and spruce needle litter, heather, moss, lichens and liverworts. Following tree removal, it was intended to restore the site to an upland raised bog. The two trial sites were located close to the end of the access road that had representative conditions of the area to be harvested. These sites and the proposed key access route are shown in Figure 2; the crop descriptions are given in Table 1.

In order to minimise the impact of timber harvesting on bog restoration, the site specification stated that no imported stone could be used to construct access routes and only 30% of the area of Sitka spruce (SS) could be left with a cover of brash following harvesting. Biodegradable materials which included agricultural straw, wood chips, Geomatting fabric and brash bales were therefore used in combination with ‘lop and top’ (the non-saleable components of the tree) for route construction. A harvester equipped with a 9.90 m long reach loader was used in the Sitka spruce crop to reduce the resultant area of the site covered by brash.

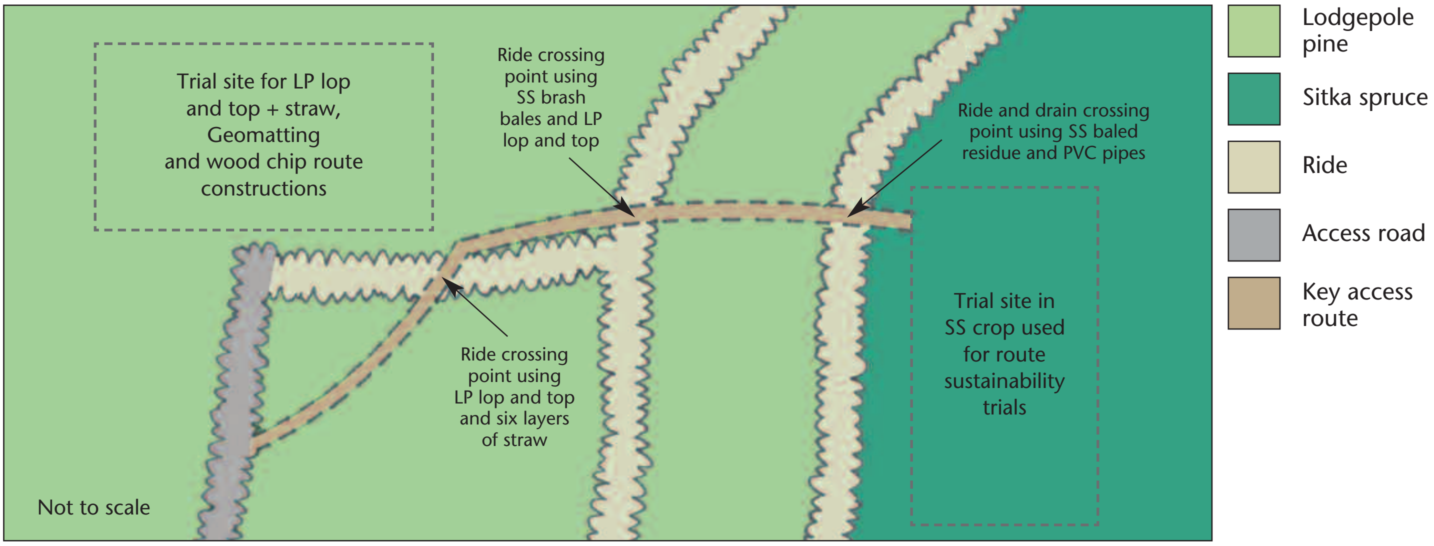
Figure 1

Forwarder travel on extraction route incorporating straw.

Table 1 Trial crop descriptions.

	Lodgepole pine site	Sitka spruce site
Age (years)	34	22
Yield class	12	12
Live trees ha^{-1}	*c.* 1000	*c.* 2000
Mean DBH (cm)	20	11
Mean tree volume (m^3)	0.26	0.037
Volume (m^3 ha^{-1})	297	80

Figure 2 Site plan.



EVALUATION OF ROUTE CONSTRUCTION MATERIALS

The first trial involved devising a specification for a brash extraction route that would allow access to and harvesting of a partially windblown lodgepole pine (LP) crop without the machinery becoming bogged. This trial used a Timberjack 1270 and Ponsse H16 to harvest the crop and a Timberjack 1210 and Ponsse S16 to carry out the extraction trials. Both harvesters were fitted with Eco bandtracks and wheel chains to ensure flotation during this phase of the trial. The eight-wheeled forwarders had 700 mm wide tyres and no traction aids to ensure that there was no premature degradation of the trial routes.

Route description

All the LP route constructions were evaluated with the forwarder fully loaded. Descriptions of the routes are shown in Table 2.

Construction materials

Extraction routes were constructed from a variety of different materials. Detailed costs for each trial route are shown in Table 3. Straw was brought to site as round bales that were rolled out along the route length. One bale provided enough straw for an area 25 m by 1.3 m to a depth of about 7 cm. Two 1.3 m wide parallel strips were rolled out to allow the forwarder access.

Table 2 Routes constructed from lodgepole pine lop and top and other materials.

Route description	Comments	
LP lop and top + 6 layers of straw + Geomat	Lop and top was cut to 4 m lengths and used to form a brash mat which was covered with layers of straw; protruding pieces of timber were cut by chainsaw. Straw bales were transported by forwarder and unrolled by a two man team. Geomatting fabric was placed over the straw and covered with a final two layers of straw to prevent puncture of the fabric. Total height of straw and matting was 45–60 cm.	Extraction carried out by Ponsse H16 (weight: 19.98 t)
LP lop and top + 2 layers of straw	Two layers of straw were placed over the brash mat to determine a minimum machine support requirement.	
LP lop and top + 4 layers of straw + Geomat + wood chips	Lop and top was positioned as the harvester processed the trees; snapped tops and large stumps were cut by chainsaw prior to laying out straw. Bales were transported to site by 4 tonne dumper truck and four layers rolled out by a two man team. Geomat was transported to site by dumper truck and unrolled by hand, completely covering the straw. The dumper truck was filled with wood chips, which were spread by hand with shovels and rakes to completely cover the route.	Extraction carried out by Timberjack 1210 (weight: 18.30 t)
LP lop and top + 6 layers of straw	A lop and top base layer was formed as for the first. A forwarder deposited additional roundwood and lop and top from adjacent drifts to allow the route to cross an unplanted area. Straw was transported by dump truck and rolled out by hand; 24 bales were used along the 50 m length allowing a 6-layer straw route of approximately 42 cm depth.	

Table 3 Track construction materials and costs.

Route	Materials	Cost (£ linear m)	Total cost (£ linear m)
LP lop and top + 6 layers of straw + Geomat	Straw 24 bales: Layout of straw: Cost of Geomat: Layout of Geomat:	3.13 0.72 12.00 0.10	15.95
LP lop and top + 2 layers of straw	Straw: Layout of straw:	1.05 0.22	1.27
LP lop and top + 4 layers of straw + Geomat + wood chips	Straw + layout: Geomat + layout: Wood chips + transport + layout:	2.80 12.10 7.50	22.40
LP lop and top + 6 layers of straw	Straw: Layout of straw:	3.13 0.72	3.85

The wood chips chosen for route construction were brought in from a sawmill. They were a by-product of the butt reducing process, and had a longer strand length (4–9 cm) and therefore greater bonding property than smaller chip types such as those used for paper manufacture.

Extraction trial results

The forwarder travelled forwards and then reversed back along the length of each route repeatedly, until a break in the brash mat occurred that made the route unusable. The routes were then assessed and scored on their general condition and the depth of rutting. The depth of rutting score was only applied to the underlying peat, rather than the condition of the overlying route formation. Assessment scores range from 0 (lowest impact) to 4 (greatest impact) as shown in Table 4.

Results of the route performance are shown in Table 5. Scores in parentheses are for the route at the point of failure if different from the rest of the route.

Table 4 General route and rutting condition scores.

Score	Route condition	Rutting condition
0	Brash mat laid and unused	Untravelled
1	Very little disturbance, slight stem disturbance	Light travel, no rutting
2	Disturbance occurring, breaking of timber	Rutted (compressed) depth, 0–5 cm
3	Well used, evidence of compaction, mud in brash	Rutted depth 5–15 cm
4	Completely sunk or buried	Rutted depth >15 cm

Route performance

No repairs to the extraction routes were made during the evaluation, but by repairing the routes as damage occurred, their useful life could have been increased. The principal findings of the route performance were:

- Routes that included straw in their construction withstood a large combined machine and produce weight.
- Routes that incorporated six layers of straw showed little rutting effect despite the layers of straw being compacted in places by up to around 40 cm (Figure 3).

Figure 3

Route constructed from LP lop and top and six layers of straw after completion of the extraction trial.

Table 5 Trial results.

Route description	Forwarder loading	General route condition	Rut condition	Total cost (£ linear m)	Total weight (t)*	No. of passes route sustained
LP lop and top + 6 layers of straw + Geomat	Fully loaded	1	1	15.95	589	20
LP lop and top + 2 layers of straw	Fully loaded	2	2	1.27	177	6
LP lop and top + 4 layers of straw + Geomat + wood chips	Fully loaded	1 (2)	1	22.40	1198	40
LP lop and top + 6 layers of straw	Fully loaded	1	1 (2)	3.85	1347	45

*Total weight in tonnes = machine weight + timber weight supported by the route.

EVALUATION OF LOW-IMPACT ROUTE CONSTRUCTION AND EXTRACTION

Having determined that mechanised access over the deep peat site was possible with appropriately constructed extraction routes, the second trial used a Timberjack 860B harvester with a boom reach of 9.90 m, capable of felling a wide (approximately 20 m) harvesting face in a SS crop.

An attempt was made to keep 70% of the harvested area free of brash in order to help the restoration of the area to upland raised bog. The wider harvester reach meant that the extraction routes could be spaced further apart leaving a greater area free of brash and proportionally more brash per route for construction.

To gain access to the SS site all machinery travelling into and out of the site had to traverse an area consisting of partially windblown LP, three sections of unplanted ground (one at 25 m and two at 30 m wide) and a deep drainage ditch (around 1.5 m wide and 2.0 m deep). A key access route was constructed as shown in Figure 2. To ensure that this route would sustain predicted loaded and unloaded machines, adjacent areas were felled to give more lop and top, and brash bales were imported to provide adequate flotation. Although this key access route was not fully evaluated details of the construction and performance are given in Tables 6, 7 and 8.

Key access route performance

The brash bales formed long-life routes and if maintenance had been carried out they would probably have supported the weight of a larger volume of produce. The bales were not fresh and had been stored for about one year; dry, brittle bales are unlikely to have the same load bearing strength as fresh bales. The evaluation suggested that the rate of failure will increase with the age of the bales used.

Sitka spruce trial route description

Following the successful construction of the key access route, the area of SS designated for the extraction trial was divided into four routes with each subdivided into 4 x 40 m sections. These sections were harvested to produce a specific product and then replicated over the other three routes to enable a comparative assessment to be made with different forwarder load configurations (Table 9).

Table 6 Key access route construction.

Route description	Comments	
LP lop and top + brash bales	Constructed over the three sections of unplanted ground. Involved laying out one-year-old brash bales with a layer of LP residue on top to assist with 'bonding' and reduce the concave effect of the bale contours.	Extraction by Rottne Rapid SMV (weight: 13.80 t)
LP lop and top + brash bales, including drainage pipes to allow ditch crossing	Constructed as above, but including drainage pipes at one point to allow the route to cross a drain. The brash bales and pipes were transported to the site by forwarder.	

Table 7 Key access route construction materials and costs.

Route description	Cost elements	Cost (£ linear m)	Total cost (£ linear m)
LP lop and top + brash bales	Transport brash to site: Transport brash on site: Brash bales: Transport residue:	11.10 4.70 8.60 1.30	25.70
LP lop and top + brash bales, including drainage pipes to allow ditch crossing	Transport brash to site: Transport brash on site: Brash bales: Plastic pipes:	13.20 6.00 8.60 4.70	32.50

Note: Cost of producing bales = £ 6 per bale, therefore the cost per linear metre based on 0.7 m diameter bales = £ 8.60.

Table 8 Key access route trial results.

Route description	Forwarder loading	General route condition	Rut condition	Total weight (t)*	No. of passes route sustained
LP lop and top + brash bales	Fully loaded	3	3	2052	51
LP lop and top + brash bales, including drainage pipes to allow ditch crossing	Fully loaded	2	4	1103	27

*Total weight in tonnes (t) = machine weight + timber weight supported by the route.

Table 9 Routes constructed from Sitka spruce lop and top.

Route description	Forwarder loading	Comments	
SS lop and top (2 m pulp cut)	Fully loaded	Felled tops were cut and laid in the brash mat to support the passage of the machine; the tops were orientated across the bed to maintain a level platform for the machine to travel on.	Extraction by Rottne Rapid SMV (weight: 13.80 t)
SS lop and top (2 m pulp cut)	Partially load		
SS lop and top (3 m pulp cut)	Fully loaded		
SS lop and top (3 m pulp cut)	Partially load		
SS lop and top (random pulp lengths cut)	Fully loaded	Short round wood was produced so the volume of saleable produce could be determined.	
SS lop and top (random pulp lengths cut)	Partially load		
SS lop and top	Fully loaded	Constructed as above, but no short round wood produced; all the produce was cut to 4.5 m lengths and used in the route construction.	
SS lop and top	Partially load		

Route construction materials

No additional cost of route construction was incurred and no extra work was required during the construction of the routes during the second extraction trial; these were produced as part of the normal harvesting operation from harvesting residues.

Extraction trial results

Results of the route performance are shown in Table 10. Scores in parentheses are for the route at the point of route failure if different from the rest of the route. As in the first trial, the forwarder travelled forwards and then reversed back along the length of each route repeatedly, until a break in the brash mat occurred to the extent that the route was no longer usable. The condition of the routes and the degree of rutting were scored as shown in Table 4.

Route performance

As with the first trial no repairs were made to the routes but by repairing the routes as damage occurred their useful life could have been increased. Main findings of route performance were:

- The route constructed from SS lop and top and random pulp lengths fully loaded failed because it had an uneven profile (sloping to one side) which caused the forwarder to pitch to one side; the resulting uneven loading through the forwarder wheels accelerated route failure.
- The route where all the SS produce felled was deposited into the brash mat gave one of the poorest route performances. This may have been partially due to the underlying soil structure rather than the integrity of the route. Further investigation would be required to confirm this.
- Significantly more timber was extracted on the SS lop and top routes before failure occurred when the forwarder carried partial loads rather than full loads.

Table 10 Trial results.

Route description	Forwarder loading	General route condition	Rut condition	Total cost (£ linear m)	Total weight (t*)	No. of passes route sustained
SS lop and top (2 m pulp cut)	Fully loaded	2 (4)	4	Routes were formed as part of the harvesting operation, therefore no additional cost was incurred.	444	14
SS lop and top (2 m pulp cut)	Reduced load	2 (4)	4		1264	64
SS lop and top (3 m pulp cut)	Fully loaded	2 (4)	4		538	18
SS lop and top (3 m pulp cut)	Reduced load	3	2**		1152	56
SS lop and top (random pulp lengths cut)	Fully loaded	3 (4)	4		429	15
SS lop and top (random pulp lengths cut)	Reduced load	3 (4)	4		892	44
SS lop and top	Fully loaded	2 (4)	4		296	11
SS lop and top	Reduced load	2 (4)	4		668	34

* Total weight in tonnes (t) = machine weight + timber weight supported by the route.

** During evaluation failure occurred at the point where the forwarder gained access on and off the route, rather than on the route itself. This meant that the evaluation had to be abandoned, despite the comparatively low damage to the route itself; this explains the low score for rut condition.

CONCLUSIONS

The initial aim of the extraction route evaluation was to develop a route specification that would allow mechanised harvester and forwarder access over a very sensitive site with low load-bearing deep peat soils.

- The use of straw was very effective, greatly reducing disturbance to the underlying peat. Managers and operators should consider using straw for extraction route construction where a reasonably priced supply is available locally.

- No significant advantage was observed where Geomat and straw were incorporated into the route profile compared with straw alone. The additional cost of the Geomat was not justified in terms of providing additional load-bearing support.

- Wood chip offers potential for extraction route construction, although the forwarder wheels tended to push through the chip layer. By contrast straw was cheaper to lay than wood chip and achieved equal if not better flotation results.

- Reducing the size of forwarder loads in the second trial resulted in better route performance than extracting full loads. Between 3 and 4.5 times as many passes and over twice as much timber were forwarded when partial loads were extracted (Table 10). Reducing load sizes increased the number of trips needed to extract the total volume therefore increasing the overall cost of extraction. The time and cost penalty due to making an increased number of trips with reduced load sizes must be offset against the cost and practicality of reinforcing the routes to allow full loads to be carried and the potential cost of any subsequent debogging operations if a route fails.

- Using large woody material for extraction route construction can cause puncturing of the soil surface if snapping occurs; this may have accelerated route degrade by damaging the peat below.

- Using the Timberjack 860B harvester with a boom reach of 9.90 m allowed a wider felling face, extraction routes could be spaced further apart and therefore proportionally more brash was available for route construction. The wide harvester reach allowed greater distance between adjacent routes, minimising the area covered with brash which is an advantage for converting the area back to upland raised bog.

- The unplanted areas that the extraction routes crossed caused major problems during the trial; failure of the routes was mainly due to the lack of lop and top for extraction route construction.

- The adoption of routes using 6 layers of straw has so far enabled the extraction of 30 000 tonnes of timber from 350 ha over extraction distances of up to 1.8 km. The methods employed have allowed successful extraction where previous, conventional route construction methods had failed.

FURTHER READING

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