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TECHNICAL DEVELOPMENT

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Title: CCF Harvesting Method Development: Harvester Head Visibility

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CCF Harvesting Method Development: Harvester Head Visibility

SUMMARY

The use of Continuous Cover Forestry (CCF) can lead to situations where a dense understorey of natural regeneration is produced, particularly with Sitka spruce. In these conditions the visibility for machine operators during harvesting can be obscured, this can reduce productivity and potentially compromise safety.

This IPIN considers options for improving harvester head visibility in areas with dense natural regeneration in the interests of improved productivity and operator safety. The main method improvements identified are:

- Using the harvester head to cut regeneration at the base of the tree prior to felling
- Running the harvesting head down the stem to locate the base
- Combining motor manual felling with mechanised harvesting
- Respacing natural regeneration before harvesting to improve visibility and access

Each of these methods can be used in different circumstances. For example, a combination of motor manual and mechanised harvesting is well suited to large overstorey trees.

Using the harvester head to cut regeneration is perhaps the simplest solution that can be used in a wide range of situations, but will reduce outputs. Based on a limited set of data we have estimated that this could add 3% to the time taken for harvesting. Managers should make allowances for such reductions in output in the interests of improved control over takedown and operator safety.

Future developments in harvesting machinery and systems have the potential to assist operator visibility through the use of technology such as laser scanning. This system is currently expensive and relatively untested in forest harvesting applications but has potential for future application.

INTRODUCTION

In Continuous Cover Forestry (CCF) the presence of dense natural regeneration can reduce visibility during harvesting (Figures 1 and 2). Many of the elements in a harvester work cycle depend on good unobstructed vision of the work area and reduced visibility is therefore a potential limiting factor on speed and safety. This IPIN identifies harvesting methods and technological improvements for harvesting in stands with limited visibility due to the presence of natural regeneration.



Figure 1 Harvester felling mature Sitka spruce overstorey amongst dense natural regeneration



Figure 2 Dense natural regeneration restricting the operator's view to the base of the tree during felling

The findings of this IPIN are based on recent harvesting experience gathered at the CCF National Trial site in Clocaenog Forest, North Wales; general experience of CCF in Britain, and some information on similar operational problems in other countries.

HARVESTING IN NATURAL REGENERATION

The main harvesting issues caused by limited visibility due to natural regeneration are difficulty in:

- identifying rack locations.
- accurately placing the harvester head at the base of the tree.

Identification of rack locations can be improved by marking rack entrances prior to harvesting and if this is combined with other work during site preparation any extra cost is minimised. The issue of accurately locating the base of the tree prior to felling is more complex and possible solutions to this problem are the main focus of this IPIN.

OPERATIONAL EXPERIENCE

During 2007 a time study was carried out to determine outputs and costs in a CCF thinning in Clocaenog forest, North Wales¹ (Figure 1). Visibility was constrained by natural regeneration and poor lighting caused by starting and finishing the working day in the dark (see Appendix 1 for basic stand details and harvester specification use in this study).

Dense natural regeneration at the base of the overstorey trees made it very difficult to accurately place the harvester head to make the felling cut. With larger trees (> 40 cm dbh) two or more felling cuts were often required to fell the tree. When this was required the harvester head had to be repositioned between cuts and each of these movements were constrained by poor visibility.

This study enabled information to be gathered on the requirement to clear natural regeneration from the base of trees prior to felling in a stand of Sitka spruce being transformed to a simple CCF structure, with 50,000 seedlings and saplings/ha ranging in height between 0.5 m and 3 m. The results from this study are shown in Table 1.

Table 1 Number of overstorey trees requiring clearance of regeneration before felling cut and time penalty for the operation

Height of regeneration close to base of overstorey tree	Number of trees studied	Number of trees requiring regen. to be cleared from base before felling	Percentage of trees requiring regen. to be cleared from base before felling	Mean time taken to clear regeneration from the base of the tree prior to felling (seconds)
0 – 2 m	129	11	9	17
2 m +	45	13	29	23
TOTAL	174	24	14	21

The main result of the study was that the operator spent 3% of the total study time clearing natural regeneration using the harvesting head to improve visibility. There was no significant difference in the average time taken to clear regeneration of different heights². The felling head can only be operated at a certain speed, irrespective of the height of regeneration, and this is likely to have been the limiting factor on the time taken to clear regeneration. The data also suggest that taller regeneration was more of a hindrance to felling of overstorey trees.

¹ See Technical Development IPIN 21/07 *Transformation thinning in CCF with advanced natural regeneration Case study: Clocaenog, North Wales* for further information on the results of this study.

² Based on results of one-way ANOVA analysis ($F_{1,22} = 2.6$ $P = 1.12$).

IMPROVING OPERATOR VISIBILITY

A number of ways to improve visibility during felling are discussed the following paragraphs and have been classified either as method improvements or technological improvements.

Method Improvement

Many of these methods require additional input and skills from the operator and may require training and an understanding of management aims. Incorporating these methods may increase harvesting time and reduce outputs: managers should make allowances for this.

- Using the harvester head to cut regeneration at the base of the tree.

This is a simple method to improve visibility used in the Clocaenog study. Initial results suggest a 3% time penalty, although this is likely to vary widely depending on the density and height of the regeneration, and the skill and experience of the operator. If the regeneration is dense enough to restrict visibility it is highly likely there are enough saplings for the regeneration of the stand so that removal of regeneration round a tree due for felling should not hamper future stand development.

- Respacing natural regeneration before harvesting to improve visibility and access.

It is common practice for respacing to be done *after* thinning so that any damage caused by felling and extraction can be taken into account. However, with greater experience of CCF management it may be possible to respace *before* thinning and include removal of regeneration around overstory trees to be felled and those impeding access along racks.

- Running the harvesting head down the stem to locate the base (Figure 3).

This method provides a solution but application is limited with larger trees [6]. Larger trees may require multiple felling cuts with head relocation and this requires an experienced operator. Where visibility to the tree base is restricted, care is required to ensure safety and/or mechanical damage as there is potential that harvester head grip may be lost, particularly with buttressed trees.



Figure 3 Placing the felling head high up the stem and running the rollers down to the base to aid head location for felling

- Combining motor manual felling with mechanised harvesting (Figure 4).

Combining mechanised and motor manual felling enables large trees in dense regeneration to be felled or debutressed for subsequent working by the harvester [5]. This is an effective method for overcoming difficulties with reduced visibility. A shortage of motor manual sawyers skilled in large tree working may limit the use of this method.

If large diameter trees are debutressed, there is a greater likelihood that the harvester operator can run the head down the stem and fell the tree without multiple felling cuts. If multiple felling cuts are required due to their diameter repositioning the head and gripping the tree will be easier because the buttresses have been removed.



Figure 4 Motor manual felling to assist mechanised harvesting in CCF

Where motor manual felling is used to assist the harvester, the chainsaw operator should only undertake work that is outside the capability of the harvester; where possible processing of felled timber should be left for the harvester to maximise productivity.

- Making the felling cut higher up the stem.

This method is a simple way of overcoming issues with visibility and is already used to create standing deadwood habitat. In the Clocaenog study described, if the 14% of trees that required regeneration to be cleared before felling were instead felled at a height of 2 m, log volume would reduce by 5%³. Hence the practice should be minimised in order to reduce the effect on income.

Leaving higher stumps would also go against current harvesting practice and would therefore require a policy change and could have implications for forest hygiene. The practice would require careful management to make sure impact on timber volume was kept to a minimum and this could be difficult to implement effectively and may lead to a culture of leaving high stumps on other harvesting sites.

Technological Improvements

- Painting the harvester head a bright colour to improve visibility.

This is a simple, low cost method to increase head visibility that should be considered.

- Incorporating scanner technology into harvester head designs; infra red, laser or sonar.

Harvester head mounted scanning systems have considerable potential to improve accuracy when placing the head [2]. Laser scanning is common in the sawmilling sector and limited operational trials have been carried out in New Zealand where laser scanning systems have been fitted to harvester heads to improve optimisation of the stem. In Canada underwater tree harvesting and recovery of submerged forests has been carried out using a remotely controlled submarine equipped with video cameras and sonar. The cutting head can descend as far as 300 m from the control barge and all cutting is carried out remotely [3].

³ Based on yield model figures for Yield class 20 Sitka spruce, intermediate thinning, initial spacing 2.0 m.

Though technically possible similar scanning systems are not commercially available as modifications for harvesting machinery used in Britain. They would require evaluation to determine their suitability to assist with accurate head location on the stem. Laser scanning systems are also currently very expensive. Although they offer potential to assist with harvester head placement, they are unlikely to provide a solution in the short term.

- Modified harvester head with improved cutting mechanism for removing regeneration.

No such attachment is commercially available and this is an unlikely development in the short term.

- Head mounted lighting to improve localised lighting at the base of the tree in regeneration.

While technically possible, additional lighting on the harvesting head or on the machine is likely to be of limited benefit, because issues with visibility are due to the physical barrier to the operator's line of sight.

- Video camera mounted on the harvester head.

A harvester head mounted video camera is a technical possibility. There is capacity in the harvester head electronics to carry a video signal. However, currently no commercially available video system has been developed for harvester heads. Forwarder mounted video cameras are currently in use (mounted on the back of the bunk) and assist operators with visibility when reversing. So the technology exists and could be modified. Camera durability and cleanliness would be issues [1,4].

Mounting the camera in a position to give a useful view of the head in relation to the tree would be difficult as any projection not built into the head or crane would be vulnerable to damage during felling. Any system would need to be well shielded against damage, as would head mounted lights. The greatest obstacle is likely to be the inability of the camera to function adequately given the limited light below canopy among dense regeneration.

- A self-levelling cab, cushioned against vibration.

The facility to independently adjust the position of the cab by rotation and levelling enables the operator to position the cab accurately to maximise visibility. Some larger harvesters provide a higher operator seating position (e.g. John Deere 1470D compared to 1270D) which could help with visibility in dense regeneration. However this cab type is unlikely to give a significant visibility improvement.

- Increasing the size of harvesting machinery.

Larger machines offer a higher operator position (as identified above) and are compatible with larger felling heads, therefore avoiding problems with larger tree sizes in regeneration as a greater proportion of trees can be felled with a single cut. Increasing the scale of harvesting machinery can restrict suitability to operating in a range of crop sizes and requires considerable investment however.

OPERATIONAL SAFETY

When large tree sizes are harvested, multiple felling cuts can be needed which require head repositioning. With reduced visibility, safety can be compromised if a secure grip on the stem cannot be maintained.

Combining motor manual felling and/or debutressing with mechanised harvesting provides an effective solution. However, combining motor manual and mechanised harvesting requires careful management and systems of communication to enable safe systems of work. In particular, a working method is essential so that the motor manual operator can remain outside the risk zone of harvesting machinery.

Debutressing trees prior to mechanised harvesting can be carried out safely, providing that correct methods are used; see Forestry Commission Technical Note 005 [5].

CONCLUSIONS

Several methods are available to improve the operator's view during mechanised harvesting in stands with dense natural regeneration. The simplest technique, with trees that can be felled with a single cut, is to place the harvester head on the stem above the regeneration and run it down to the base, guided by the feed rollers.

With large trees that require multiple felling cuts the simplest method for improving visibility, is to cut the natural regeneration with the harvester head before felling. Where management aims to minimise damage to natural regeneration, visibility can be improved by motor manual respacing for subsequent mechanised harvesting. Alternatively motor manual felling or debutressing in combination with mechanised harvesting is a useful method where visibility is restricted and management aims to minimise harvesting impact on regeneration. If motor manual sawyers are not available, the felling cut can be made higher up the stem with a loss in timber volume.

Large and/or coarse trees beyond the felling and/or processing capability of the harvester can be felled motor manually. When motor manual felling is combined with mechanised harvesting, the chainsaw operator should only carry out the minimum work necessary, with the harvester taking over to maximise productivity.

Technological improvements in harvester specification such as the use of increased lighting, raised operating position are unlikely to provide significant benefits to the operator.

Video and scanning attachments for the harvester head, although potentially beneficial and technically possible are not currently available from manufacturers. These systems are currently expensive and require considerable further development to become commercially viable.

OPERATIONAL GUIDANCE UPDATE

The operational guidance booklets shown in Table 2 are relevant to this subject. Table 2 also indicates where updates to the current Forestry Commission OGB series are required.

Table 2 Operational Guidance

OGB	Version	Relevance	Update required
7 Managing Continuous Cover Forests	Under edit	Guidance for managing forests under continuous cover silviculture	OGB is currently under review (2008). The revision references the findings of this internal report.

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Site Characteristics

P Year	Area	Windthrow Hazard Class	Terrain Class	Slope
1949	0.956 ha (net)	4	4.2.2.	20 degrees

Crop Characteristics

Species	Yield Class		Basal Area m ² /ha	Overstorey Stems per ha (net)	Mean Tree Volume (m ³)	Stand Top Height (m)	Mean dbh (cm)
Sitka spruce	20	Pre thin:	41.8	283	1.78	30.35	42
		Post thin:	20.8	113	2.24	30.6	47

Harvester Specification

Base machine	John Deere 1270D
Number of wheels	6
Tyres – Front	Nokian Forest King F 710/45/26.5
Tyres – Rear	Nokian TRS L2 700/55/34
Bandtracks	Clark F10, side-link tracks fitted to front bogie
Crane	210 H (9.0 m reach)
Head	480H
Hours on clock	1414 (at time of study)
Nominal weight	c. 19.5 tonnes (including bandtracks)
Machine length	7.70 m
Machine width	2.86m (excluding bandtracks)
Engine	John Deere 6081 HTJ, 6 cylinder, 8.1 litre turbo
Power output (kw)	160 kW @ 1400 – 2000 rpm
Transmission	Hydro-mechanical
Speed (km/h)	0 – 25