Current operational constraints in the harvesting-silviculture interface: A scoping study

Simon Ackerman and Diana Rietz

simon.ackerman@icfr.ukzn.ac.za
diana.rietz@icfr.ukzn.ac.za

Institute for Commercial Forestry Research, PO Box 100281, Scottsville, 3209, Pietermaritzburg, South Africa

This technical note forms part of an ongoing collaborative initiative between Forest Engineering Southern Africa (FESA) and the Institute for Commercial Forestry Research (ICFR).

Summary

Through development of this pilot study, the following key findings have been identified:

- The quantity and distribution of slash left after harvesting operations is a major challenge to the efficiency of silviculture operations, whether they are manual or mechanised;
- Mechanised silviculture operations are also negatively affected by high stumps left after harvesting;
- Inefficiencies in mechanised harvesting operations arise mainly from orientation of tree rows on a slope;
- Uniform, planted stands tend to have more efficient harvesting operations than those that are not;
- The efficiency of both mechanised harvesting and silviculture is affected by tree row spacing;
- There are many opportunities to improve the synergy between harvesting and silviculture.

Introduction

Plantation management is a cyclical process involving harvesting, site preparation, planting, tending and growing, through to harvesting again. However, the management of plantations is often not performed or viewed as a continuum, but rather as discrete independent steps, usually managed by different individuals or sections within a company that are not necessarily aligned with the activities that occur prior to or after their components. Due to the compartmentalised nature of this form of management, operational inefficiencies as a result of sub-optimal optimisation between the individual parts of the forestry value chain have occurred and the efficiency over the entire process can be further optimised and improved.

In South Africa, concerns have been raised that one of the areas where operational inefficiencies occur are at the interface between harvesting and silviculture operations. In the past, investigations have quantified the effects on, either stand productivity (e.g. the effect of machinery damage during timber harvesting and extraction on stumps and coppice ability (Little and Oscroft, 2010)) or operational efficiency for harvesting on silviculture although the effect of silviculture on
A collaborative project was established between Forest Engineering South Africa (FESA) and the Institute for Commercial Forestry Research (ICFR) to determine challenges to the interface between harvesting and silviculture, and to propose solutions to these challenges. This report is the first step in this process and details the challenges as determined by key members of the South African forestry industry.

Materials and Methods

In order to obtain a comprehensive set of relevant information from stakeholders, a structured questionnaire was developed. The questionnaire was formulated to determine the operational challenges experienced between harvesting and silviculture in commercial forestry in South Africa. This questionnaire was also designed to enable the comparison and analysis of stakeholder responses across the companies and their individual situations. The aim of the questionnaire was to determine:

- Whether manual, semi-mechanised or fully mechanised harvesting and silviculture operations were currently employed within the company.
- If the company was considering altering their harvesting and silviculture operations in the near future, and if so, what these changes would likely be.
- What challenges resulting from harvesting operations reduced the efficiency of silviculture operations, what the relative size (large or small) of these challenges were, and if they varied with site.
- What challenges arising from silviculture operations reduced the efficiency of harvesting operations, what the relative size (large or small) of these challenges were, and if they varied with site.
- If the stakeholder would consider it beneficial to establish an industry harvesting and silviculture working group to discuss their challenges on an industry level, and to work with other working groups and organisations (such as FESA, ICFR, the fire working group, small growers working group and Sirex Operations Committee) to resolve challenges that face the entire industry.
- Potential ways in which a greater synergy between harvesting and silviculture operations could be attained.

The South African forestry companies and co-operative companies selected for the scoping study included large enterprises (Merensky, KLF, Mondi, Sappi, and York) and medium grower and small grower (farmers) representative companies (NCT and TWK). It was assumed that these producers represent the majority of the dominant facets of the South African forestry industry. Companies and other stakeholders currently omitted will form part of future work to be carried out in this study.

Key stakeholder representatives responsible for operational harvesting and/or silviculture operations within these companies were approached, and guided through the questionnaire. Their responses were noted by the authors, and situations unique to that specific company’s operating practices were discussed thoroughly to ensure completeness and clarity.

These responses were collated and, due to the variation in operations over a rotation for different end-products, were separated by the product required by the company, i.e. into pulp or sawtimber producing companies. Challenges to silviculture created by harvesting operations, and the challenges to harvesting created by silviculture operations were determined from the responses.

Results and Discussion

Mechanisation of silviculture and harvesting operations within the forestry industry

Although the primary focus of this report was not to identify the extent of mechanisation of harvesting and silviculture operations within the South African forestry sector, it is an important factor for assessing the main challenges posed to these operations. Due to the costs associated with conversion from manual to mechanised operations, as well as the ability to ensure these operations are economically viable (i.e. scale of implementation), mechanisation has occurred to the greatest extent in the large companies. Of the two operations, more emphasis has been traditionally placed on mechanisation of harvesting operations rather than silvicultural operations. However, responses from the questionnaire revealed that there have been investigations into mechanisation of various silviculture operations. However, as before, this is more of a priority in the large, rather than in the small to medium sized companies, although some private growers are
exploring mechanised operations. As with the mechanisation of harvesting operations, challenges associated with mechanisation of silviculture operations include the scale of the operation and the social impact of reduced employment by the forestry sector. Despite the former challenge, most companies are interested in investigating the application of mechanisation in silviculture in the future. Companies mandated to employ labour (parastatal companies) have expressed no interest to convert to mechanised silviculture operations at this time.

Challenges experienced between harvesting and silviculture

In order to simplify the responses from the survey, these were grouped according to whether they were common as follows:

- Across the entire industry
- Intended end-product uses, i.e. sawtimber or pulp and poles (including both Eucalyptus and Pinus sp.)
- Scale of operation, i.e. large or medium and small growers

These responses were further grouped into the perceived size (relative based on opinions) of the challenge (Table 1). The issues surrounding each challenge are explained in more detail below.

Harvesting impacts on silviculture

Slash management and utilisable timber-waste

Slash management and utilisable timber-waste is considered one of the largest factors reducing the efficiency of silviculture operations. The distribution of slash within a compartment is often dependent on the harvesting and timber extraction operation that was used on the site. Some harvesting operations/systems can result in uneven slash distribution, in the form of large piles within a compartment, or near roadside. Piles within the compartment are problematic for silvicultural operations of pitting and planting, whether by manual or mechanised means, and provide an increased potential fire hazard, while piles near roadside also limit compartment accessibility by machinery and labour. Timber-waste, either utilisable or non-utilisable, exacerbates this problem. Possible causes for timber-waste include the breakage of felled timber, dead trees, sub-optimal log length assortments and, in some instances, ineffective operational management of contractors.

In most cases silviculture foresters favour burning of residues, as it is the cheapest option and results in a “clean”, easy to manage site from a silviculture and fire risk management perspective. However, this, may also pose risks to site nutrient sustainability (Dovey, 2012). Other potential slash management options include collection for use in bio-energy production or mulching, although these do not appear to be economically feasible at present. Utilisable timber-waste appears to be a bigger problem for large companies, as these generally employ contractors where poor management of these entities can lead to increase timber waste if it is not economically viable for them to easily collect. These companies also have less capacity to harvest diverse products from a compartment (e.g. removal of timber for poles). Timber waste is managed in a more effective manner when harvesting is done on private farms versus large corporate. However, hands on management is the key in most cases.

Stumps

Previous rotation tree stumps do not generally affect the efficiency of manual silviculture operations. However, high stumps affect the efficiency of mechanised operations as a physical impediment for machinery access to a site as well as having implications for increased machinery maintenance (particularly tyres). High stumps are less frequently found in sawtimber areas due to long rotation lengths which enable decomposition of stumps, particularly for Pinus sp. which decompose faster than that of Eucalyptus sp. However, high stumps can occur in Pinus sp. sawtimber and Eucalyptus sp. stands where deep soil and slash layers develop, limiting the ability of mechanised harvesting heads to cut near the ground surface. In weedy or overgrown plantations, obstructed views by machinery operators, particularly in pine sawtimber compartments, has been shown to increase stump heights when harvesting is done mechanically. Previously coppiced stands also tend to have high stumps, particularly in areas that have had more than one coppiced rotation. This phenomenon is generally present in communal plantations or in multi coppice pole production from Eucalyptus sp. compartments.

Stump coppice-ability

Depending on the harvesting system used, stumps can be damaged and affect stand stocking in coppiced compartments. This is only problematic in Eucalyptus stands in which mechanised harvesting or loading operations are used. Responses obtained from companies where this occurs, did note that in general, the occurrence of reduced coppicing due to stump damage has substantially decreased through better management and limited use of certain machinery, in particular three wheelers. However, this aspect is still a concern for some areas and companies.

Rutting and compaction

Rutting and compaction resulting from the use of harvesting and timber extraction machinery, particularly under wet soil conditions, not only has implications for growth and uniformity of trees, but also for ease of access of silvicultural equipment and efficiency of planting operations. However, questionnaire results show that this was not considered a large impediment to the efficiency of silvicultural operations, although it is evident that good management would limit rutting and compaction through dedicated machine trails and appropriate timing of mechanised operations to reduce the site impact of machinery.

Compartment accessibility in steep terrain

Timber extraction operations in steep compartments can result in the build up of rocks and slash at roadside through timber being dragged through the compartment. This often leaves the compartment inaccessible for silviculture operations.
Furthermore, areas in which rocks and slash have accumulated often lead to ‘dead’ areas in the compartment where it is difficult to plant and can pose a fire risk or heavy weed infestation. Access to steeper compartments from high road verges need to be carefully planned to limit disturbances to the road that can lead to increased maintenance.

**Silviculture impacts on harvesting**

**Orientation of planting lines**

The orientation of tree rows, particularly on sloped areas, can impact the efficiency of mechanised harvesting and timber extraction operations. Tree rows are traditionally planted across slopes, generally following contours, which also benefits mechanical site preparation (e.g. ripping) if used. However, mechanised harvesting and timber extraction operations are more efficient and safer if performed up and down to the slope. Interestingly, responses from the medium-small companies indicated that the efficiency of the harvesting and timber extraction operations employed was not affected by tree rows planted along contours on a slope, as the operational planning is adapted for these situations. However, this case can merely be an anomaly to the norm experienced by most growers.

**Weeding and tending**

Additional potential impediments to efficient mechanised harvesting operations are those of natural regeneration and woody weeds within a compartment. Although no research has been undertaken to confirm this, there is a perception that the presence of natural regeneration and woody weeds slows machinery movement within the compartment, increases harvester head maintenance and blocks operator visibility. From the questionnaire responses obtained, this problem is mainly limited to long rotation sawtimber plantations and, depending on the extent of the problem, has resulted in pre-harvest compartment cleaning operations. This not only increases costs, but there are concerns around safety in motor-manual pre-harvest compartment cleaning operations. Pulpwood plantations may have similar problems if poor silviculture has led to excessive weeds being present at the time of harvesting.

**Spacing**

Tree spacing is generally determined by the species to be planted, site characteristics and the required productivity and end-product (Maree et al., 2012; Kotze and du Toit, 2012). However, spacing also influences the efficiency of mechanised thinning operations (Ackerman, 2013). This is mainly limited by the physical machine access (i.e. size limitations) to the compartment between tree rows, and the number of trees in neighbouring rows that can be safely reached by machine booms (Ackerman, 2013). The full implications of changing planting espacements to optimise mechanised operations on stand productivity and uniformity have not been investigated in South Africa (pers comm; 2013; T. Morley, Growth and Yield project leader, ICFR). Responses from sawtimber companies indicate that they are considering lowering planting density in very steep areas, i.e. those only suitable for cable yarding harvesting, to avoid first thinning costs, while maintaining site and machine productivity.

Further considerations to take into account include the balance between tree size and harvester productivity. Closer spacing leads to smaller more slender trees while larger spacings the opposite. Harvesting productivity is closely aligned to tree size and needs to be matched according to the particular system. The increase in mechanised silvicultural tending and integrated fire management has also led to the planning of compartments to, in some cases, create wider rows at certain intervals for access to the compartment.

**Coppice management**

Coppicing is generally used to reduce re-establishment costs and typically only affects those companies that produce pulp and poles from Eucalyptus sp. Harvesting of coppiced compartments is less efficient than that of planted compartments (Ramantswana, 2012) and can lead to higher stumps (with associated loss of wood volume) and so impact machinery access. However, rapid site re-establishment and associated cost savings in silvicultural operations often make coppicing a viable management option. Where this is practiced, companies have the policy to coppice only once, reducing the disproportionally large stumps that affect wood quality (‘elephants foot’) and access into the compartments.
Table 1. Consolidated results of questionnaire responses investigating the effects of silviculture operations on harvesting operation efficiency and vice versa, across the industry, end-product producers, and size of companies.

<table>
<thead>
<tr>
<th>Sector of the Forestry Industry (no. of respondents)</th>
<th>Effects of Silviculture on Harvesting</th>
<th>Effects of Harvesting on Silviculture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>All (7)</td>
<td>- None</td>
<td>- Spacing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawtimber producers (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Weeding</td>
<td></td>
<td>- Spacing</td>
</tr>
<tr>
<td>- Orientation of tree rows</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulp and pole producers (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Coppice re-growth</td>
<td></td>
<td>- Orientation of tree rows</td>
</tr>
<tr>
<td>- Utilisable timber waste</td>
<td></td>
<td>- Weeding</td>
</tr>
<tr>
<td>Large growers (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Coppice</td>
<td></td>
<td>- Spacing</td>
</tr>
<tr>
<td>Medium to small growers (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Coppice</td>
<td></td>
<td>- Spacing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Slash refers to plant biomass remaining after a harvesting operation and includes utilisable timber waste.

* Depends on terrain or steepness of areas.

** Can be a problem on some sites.

*** Mainly due to multiple products from site and slash and farmer operations.
Conclusions and future research

Responses obtained from the various commercial forestry companies in South Africa indicate some common areas where changes in silviculture and harvesting operations could improve efficiencies within these operations. The biggest challenge to silvicultural operations from harvesting activities, whether manual or mechanised, is slash and utilisable timber-waste left on a site after harvesting. For harvesting operations the greatest impact from silviculture is the orientation of tree rows on slopes, except in some isolated experiences, and to a lesser extent spacing, and the use of coppice as a regeneration technique although these impacts mainly apply to fully mechanised operations. There are a number of other challenges within these operations; however, these are specific to the type of operation (manual versus mechanical), end-product [saw vs. pole or pulpwood] and size of harvested area [economy of scale]. However, what was consistently evident in the responses collated is that there is a great need for research and development to facilitate the seamless interaction between harvesting and silviculture.

It is proposed that opportunities to improve the interaction between harvesting and silviculture be identified as a matter of priority in the short-term. These opportunities may include facilitation of increased communication and improved interactive planning between these two facets of the value chain, as well as practical solutions based on currently available research. Thereafter, any knowledge gaps will be identified and research around these prioritised to ensure long-term synergy between harvesting and silviculture.

Future immediate research identified and not limited to, include:

- Tree spacing for mechanised harvesting and silviculture;
- Seedling requirements for mechanised silviculture;
- Quantification of changing the stump height felling technique on harvesting head maintenance;
- Use of harvester head chemical application to reduce follow-up manual treatments;
- Development of a management system/technique to highlight and facilitate harvesting and silviculture interaction, in conjunction with an industry working group;
- Aligning South African practices with those in similar areas abroad (i.e. fully mechanised operations in Brazil).

Acknowledgements

The authors would like to acknowledge the following individuals for their time and insight in compiling this report: Andre Möller, Anton Shekwa, Craig Norris, Dave Malloch-Brown, Dirk Längin, Jan Jansen, Johan Nel, Kudakwashe Phairah, Leander Jarvel, Paul Viero and Pieter van der Merwe. A number of reviewers are also thanked for their contributions to the manuscript.

References

Ackerman SA. 2013. The effect of irregular stand structures on growth, wood quality and its mitigation in operational harvest planning of Pinus patula stands. MSc Thesis. University of Stellenbosch, Stellenbosch, South Africa


Little KM, Oscroft D. 2010. Coppice growth as influenced by damage occurring during reduction operations and control of secondary coppice regrowth. ICFR Technical Note 02/2010. Institute for Commercial Forestry Research, Pietermaritzburg, South Africa


Institute for Commercial Forestry Research (ICFR)

PO Box 100281, SCOTTSVILLE 3209, South Africa • Tel: +27 33 386 2314 • Fax: +27 33 386 8905 • www.icfr.ukzn.ac.za

Registration No. 026-368-NPO

The recommendations contained in the ICFR Technical Note Series are based on the results of research conducted at the ICFR and reflect our current understanding of the complex inter-relationships involved. The ICFR reserves the right to subsequently modify recommendations in the light of new evidence from ongoing research and no guarantees are provided, either explicitly or by implication. The ICFR must be acknowledged whenever information contained in this document is reproduced or used in any form.