Arbetsrapport

Från Skogforsk nr. 797–2013

Spatial distribution of logging residues after final felling

– Comparison between forest fuel adapted final felling and conventional final felling methods

Trädresternas rumsliga fördelning efter slutavverkning

– Jämförelse mellan bränsleanpassad och konventionell avverkningsmetod

Staffan Jacobson & Jörgen Filipsson

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In the Arbetsrapporter series, Skogforsk presents results and conclusions from current projects. The reports contain background material, preliminary results, conclusions, and analyses from our research.

Titel:
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Abstract

The spatial distribution of logging residues after final felling was investigated by surveying 20 clear-cuts, 10 in central Sweden and 10 in southern Sweden, in summer 1998. Half of the logging sites in each area had been felled using a method aimed at harvesting the residues as forest fuel, while conventional final felling methods were used in the other half. Not unexpectedly, logging residues was more spatially concentrated when the felling method took forest fuel into consideration. On average, the proportion of the clear-cut area covered by logging residues was approximately 10% less after energy wood felling than after conventional felling (52.7% and 62.3% respectively). On the forest fuel sites, an average of 87% of the logging residue quantity was concentrated in the piles.

Little difference was observed between southern and central Sweden. On average, for all conventionally felled sites, 40% of the logging residue quantity had been driven over by logging machines. On the energy wood sites, an average of 10% of the logging residue volume had been driven over. The results from this study can provide information for use in the design of future field experiments, for example in studies of the effects of forest fuel harvest on leaching of nutrients and tree increment.

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Sammanfattning

Med syfte att få en bild av trädresternas areella fördelning, både efter bränsleanpassad- och konventionellt utförd slutavverkning, inventerades under sommaren 1998 totalt 20 hyggen, varav 10 stycken i Mellansverige och 10 i södra Sverige. Hälften av objekten i respektive område var avverkade enligt en bränsleanpassad metod.

Inventeringen utfördes som en systematisk provyteinventering. Trädresternas täckningsgrad- och medeldjup registrerades i kontinuerliga skalor på hundra provytor per objekt. Ett mått på risets volym erhölls genom att på varje enskild provyta multiplicera täckningsgraden med dess medeldjup.

Inte oväntat var trädresterna mer koncentrerade efter bränsleanpassad avverkning. I genomsnitt var andelen ristäckt areal på hygget ca 10 % lägre efter bränsleanpassad avverkning jämfört med efter konventionell avverkning (52,7 % respektive 62,3 %).

Efter indelning av materialet i olika risdjupsklasser blev skillnaderna i riskoncentration mellan de olika avverkningsmetoderna tydliga. På de icke bränsleanpassade objekten var i genomsnitt 45 % av risvolymen koncentrerad till högar med ett risdjup överstigande 20 cm. Motsvarande siffra för bränsleanpassade objekt var 82 %. Med hjälp av utjämnande grafik upprättades samband mellan trädresternas relativa volym och areella täckning.

På de bränsleanpassade objekten var i genomsnitt 87 % av rismängden koncentrerade till de bränsleanpassade högarna. Skillnaderna mellan södra och mellersta Sverige var små.

I genomsnitt för alla icke bränsleanpassade objekt var 40 % av rismängden överkörd av avverkningsmaskiner. I de bränsleanpassade objekten var i genomsnitt 10 % av risvolymen överkörd.

Resultaten från denna studie kan tjäna som underlag vid utformning av framtida anläggningar av fältförsök, exempelvis vid studier av skogsbränsleuttagets effekter på näringsutlakning och trädtillväxt.

Summary

The spatial distribution of logging residues after final felling was investigated by surveying 20 clear-cuts, 10 in central Sweden and 10 in southern Sweden, in summer 1998. Half of the logging sites in each area had been felled using a method aimed at harvesting the residues as forest fuel, while conventional final felling methods were used in the other half.

The study involved a systematic survey of experimental plots. The degree of coverage and average depth of the logging residues were recorded using continuous scales of 100 plots per site. The volume of the logging residues was obtained by, on each individual plot, multiplying the degree of coverage by its average depth.

Not unexpectedly, logging residues was more spatially concentrated when the felling method took forest fuel into consideration. On average, the proportion of the clear-cut area covered by logging residues was approximately 10% less after energy wood felling than after conventional felling (52.7% and 62.3% respectively).

Once the data had been divided into different logging residue depth classes, clear differences appeared in concentration between the two felling methods. On the sites felled using conventional methods, an average of 45% of the logging residue volume was concentrated in piles, with the depth exceeding 20 cm. The corresponding figure for forest fuel adapted final felling sites was 82% of the logging residue volume. Adjusted graphics established the association between the relative volume and the spatial coverage of the logging residues.

On the forest fuel sites, an average of 87% of the logging residue quantity was concentrated in the piles. Little difference was observed between southern and central Sweden.

On average, for all conventionally felled sites, 40% of the logging residue quantity had been driven over by logging machines. On the energy wood sites, an average of 10% of the logging residue volume had been driven over.

The results from this study can provide information for use in the design of future field experiments, for example in studies of the effects of forest fuel harvest on leaching of nutrients and tree increment.

Background

Forest fuel harvest, where logging residues is extracted after final felling, removes extra nutrients and organic material from the site. An important and often discussed aspect is the extent to which logging residue harvest can affect leaching of nutrients from the site during the clear-cut phase, and the extent to which this may influence subsequent tree growth. In a number of experiments where these issues have been studied, the effect of the total removal of logging residues has been compared with the effect of leaving all logging residues spread evenly over the surface. However, with current mechanical felling systems, logging residues are not evenly distributed, and is more or less concentrated to the routes taken by the machines. As knowledge about how logging residues is actually distributed over clear-cuts is negligible, a project was initiated to carry out a study on a number of newly clear-cut sites in southern and central Sweden.

Logging residues are harvested on approximately 50 percent of the annual final felling area in Sweden (Skogsstyrelsen, 2012). In southern Sweden, logging residues are harvested on nearly 80 percent of all clear-cuts (Skogsstyrelsen, 2012). In forest fuel harvest, the felling process is usually adapted so that the logging residues can be removed efficiently (forest fuel adapted final felling). The harvester operator, where ground conditions allow, avoids driving over the logging residues, and instead tries to accumulate the residues in piles alongside the harvesting route. Forest fuel adapted final felling reduces productivity of the harvester. However, the performance of the forest fuel forwarder increases with forest fuel adapted felling, compared to when the residues are removed after conventional final felling. Furthermore, the fuel quality is better and the harvest per hectare is greater.

Aim

The aim of the study was to investigate spatial distribution of the logging residues on the clear-cut, after forest fuel adapted final felling and conventional final felling.

The results of this study were also intended to provide information for use in more realistic field experiments, for example in studies of the effects of forest fuel extraction on nutrient leaching and tree growth.

Materials and methods

In summer 1998, a total of 20 clear-cuts were surveyed, 10 in central Sweden and 10 in southern Sweden. Half of the sites in each area were felled in a way that was adapted to forest fuel harvest. All the sites in central Sweden were situated in Uppland and those in southern Sweden were situated in Småland.

STANDS

For inclusion in the study, the sites were to satisfy the following criteria:

- Spruce-dominated (≥70%) stands, suitable for forest fuel harvest.
- Clear-cut size: >2 hectares. No shelter or seed tree stands, and not too many retention trees. Small retention plots were accepted.
- Site quality index ≥G 24 (central Sweden), ≥G 28 (southern Sweden)
- Even surface structure, not too undulating or stony.
- Good-quality solid ground. No damp sites or larger wet depressions that could affect the felling pattern.
- Felled when ground was frozen. To reduce the compressing effect of snow on the logging residues, the sites should preferably also be felled after snow fall in 1998.
- Harvesting machine: single-grip harvester.

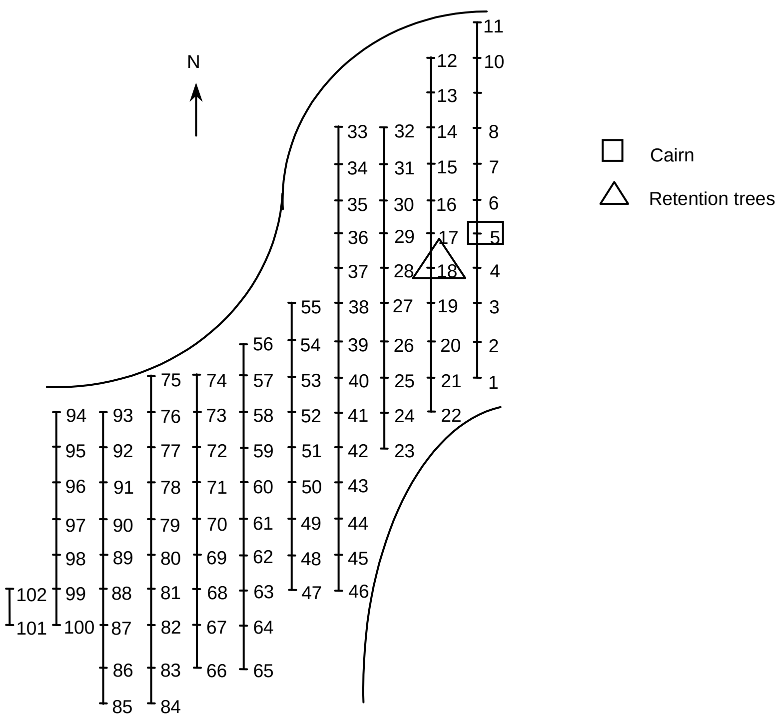

Figure 1.
Diagram showing the survey model.

SURVEY

The survey was carried out as a systematic plot survey, with 100 plots set out per site. The area of each plot was 3.14 m^2 (1 m radius) and the plots were 10 m apart. The starting point was chosen randomly. The orientation of the transect took some consideration to the shape of the clear-cut and the route of the harvester. If possible, the transect was placed at an angle of approximately 45 degrees to the dominating harvesting route. The centre of the plot was marked with a ribbon to help systematise the work. Plots that landed on retention plots, cairns, or other deviatory environments were recorded as blank plots. The distance between the plots was measured by pacing, and was calibreted regularly with a measuring tape.

The coverage of logging residues on the plot was estimated and recorded on a continual scale (%). The average depth of the logging residues was estimated and measured on the covered area using a continual cm-scale. The logging residues were slightly trampled before the depth was measured. Individual branches and twigs were recorded as part of the logging residue coverage they represented. The interval between small branches, where needles had fallen, was regarded as comprising 100-percent cover for, for example, spruce branches.

Figure.
Pile of logging residues on a clear-cut with forest fuel adapted felling.

Logging residue volume was measured on each plot by multiplying the logging residue coverage with its average depth. The proportion of the logging residues that the harvesting machines had driven over was also estimated.

On the forest fuel felling sites, it was recorded if the logging residues were concentrated in piles. The plots that fell on the side of a logging residue pile were recorded as 'pile', even if individual branches were also spread around.

Results

The data was divided into classes according to logging residue thickness, and the results presented in tables. In Tables 1 and 2, the average results are shown for all sites, according to type of felling. The results for each individual clear-cut, and the average figure by area, are shown in the appendix.

The quantity of logging residues was consistently higher on the forest fuelsites. For this reason, the results are presented as relative numbers.

Not unexpectedly, the logging residues were more concentrated after forest fuel felling. On average, the degree of coverage of the logging residues was approximately 10% lower than conventionally felled sites (52.7% and 62.3% respectively) (Tables 1 and 2).

Table 1.
Degree of coverage and volume of the logging residues, divided according to logging residue depth classes. Average figures for all conventionally felled sites.

		Logging residue coverage			Logging residue volume			
Logging residue depth (cm)	Number of plots	m²	Prop. of total area (%)	Prop. with logging residue cover (%)	m³	Prop. of total vol. (%)	(acc) %	(acc) %
>80	0.1	0.3	0.1	0.2	0.3	1.1	100	1
41–80	1.1	3.2	1.0	1.6	1.8	8.0	99	9
21–40	9.6	27.9	8.9	14.6	7.9	35.5	91	45
11–20	12.9	34.9	11.1	18.3	5.3	26.2	55	71
6–10	14.7	38.1	12.1	18.6	2.8	13.9	29	85
1–5	60.6	91.4	29.1	46.7	3.1	15.4	15	100
0	1.0							
Σ	100.0	195.8	62.3	100.0	21.2	100.0		

After dividing the data into different logging residue depth classes, the differ-rences in concentration between the two felling methods became marked. When logging residue depth exceeded 20 cm on conventionally felled sites, this corresponded to 45% of the logging residue volume, and covered 10% of the area of the clear-cut. This volume comprised approximately 16% of the logging residue-covered area (Table 1). Corresponding figures for forest fuel sites were that 82% of the logging residue volume covered approximately 17% of the clear-cut area and 33% of the logging residue-covered area (Table 2). These figures have also been presented graphically (Figure 3).

Table 2.
Degree of coverage and volume of the logging residues, divided according to logging residue depth classes. Average figures for all forest fuel adapted felling sites.

		Logging residue coverage			Logging residue volume			
Logging residue depth (cm)	Number of plots	m^2	Prop. of total area (%)	Prop. with logging residue cover (%)	m^3	Prop. of total vol. (%)	(acc) %	(acc) %
>80	4.8	14.4	4.6	9.3	15.5	37.0	100	100
41–80	6.9	20.1	6.4	12.2	12.1	29.4	63	63
21–40	7.5	19.4	6.2	11.9	6.1	15.5	34	34
11–20	8.5	19.8	6.3	12.0	3.1	8.1	18	18
6–10	9.5	19.1	6.1	11.7	1.5	4.0	10	10
1–5	60.7	72.9	23.2	42.9	2.2	5.9	6	6
0	2.1							
Σ	100.0	165.6	52.7	100.0	40.5	100.0		

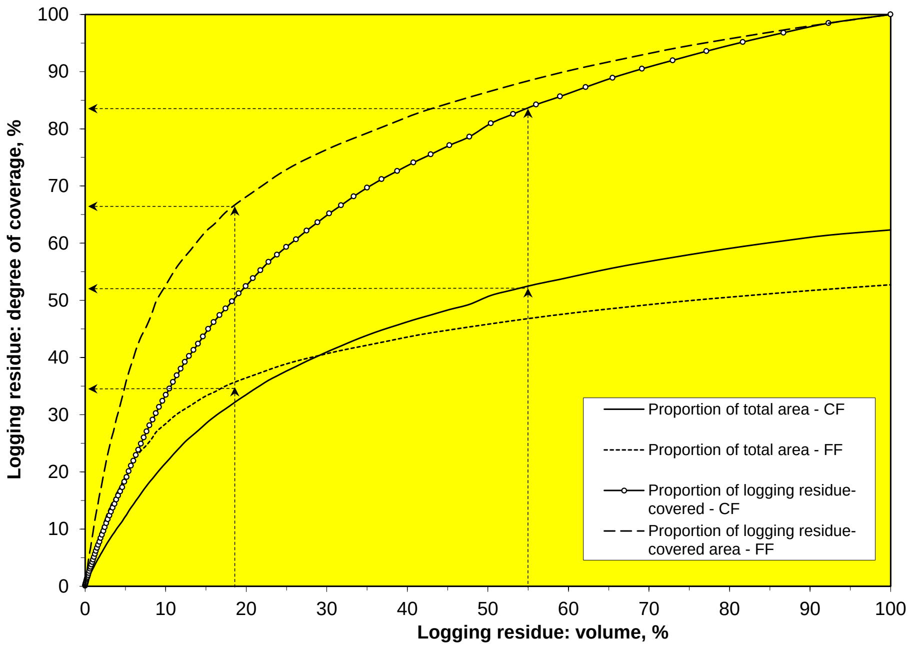

Figure 3.
Relation between the relative volume of logging residues and 1) spatial distribution on the clear-cut, and 2) proportion of the clear-cut area covered with logging residues. Average figures for all sites for the two felling methods: 'FF' = forest fuel adapted felling; 'CF' = conventional felling, no forest fuel extraction.

Figures 3–5 show the relation between the relative volume proportions of the logging residues and its spatial coverage. An example that illustrates the differences in logging residue concentration between the two felling methods can be read from Figure 3 as follows:

Forest fuel felling: 20% of the logging residue volume accounts for approximately 70% of the total coverage of the logging residues, and so the remaining 80% of the logging residue volume accounts for approximately 30% of the total coverage of the logging residues.

Conventional felling: 20% of the logging residue volume accounts for approximately 50% of the total coverage of the logging residues, and so the remaining 80% of the logging residue volume accounts for approximately 50% of the total coverage of the logging residues.

On average, the logging residue volume for all sites was approximately 30% higher on sites in southern Sweden (see appendix). Logging residues was more concentrated on sites in central Sweden. This applied to both forest fuel felling and conventional felling. On average, the degree of coverage of logging residues on clear-cuts was approximately 10% lower in central Sweden than on sites in southern Sweden (see appendix). Differences between the areas were small for the relation between the relative volume proportions of the logging residues and its degree of coverage.

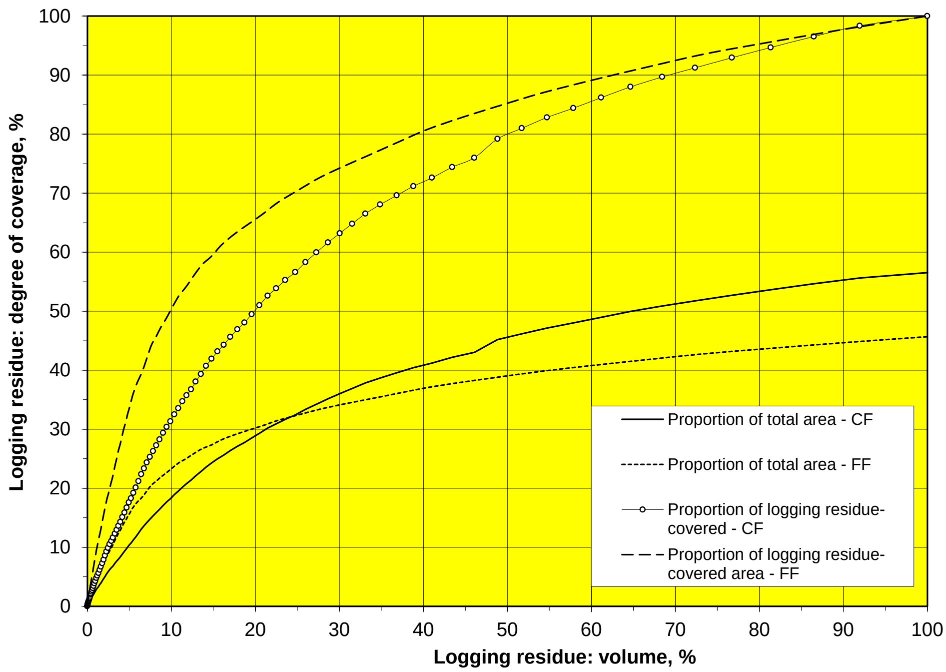

Figure 4.
Relation between the relative volume of logging residues and 1) spatial distribution on the clear-cut, and 2) proportion of the clear-cut are covered by logging residues. Average figures for five sites for each felling method in central Sweden: 'FF' = forest fule felling; 'CF' = conventional felling, no forest fuel extraction.

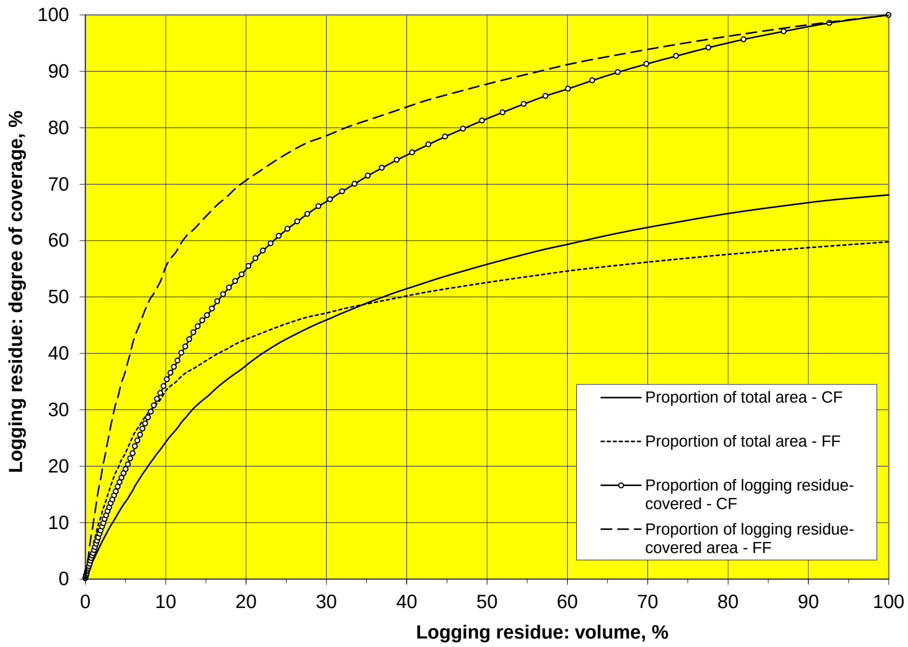

Figure 5.
Relation between the relative volume of logging residues and 1) spatial distribution on the clear-cut, and 2) proportion of the clear-cut are covered by logging residues. Average figures for five sites for the two felling methods in southern Sweden: 'FF' = forest fuel felling; 'CF' = conventional felling, no forest fuel extraction.

On the forest fuel sites, on average approximately 87% of the total logging residue quantity lay in piles (Table 3). The differences between the two areas were small. The spatial coverage of these piles could not be calculated, as the spatial proportion of 'pile' on the individual plot was not recorded in the survey. By assuming that all logging residues driven over by machines were not part of the forest fuel piles, and by deducting the spatial coverage of these logging residue quantities, the spatial coverage of the piles could be estimated at approximately 19% of the clear-cut area, comprising approximately 37% of the total degree of coverage of the logging residues (Table 3). However, these estimated degrees of coverage are probably over-estimated. According to the surveyor's assessment, the number of piles was approximately 120–150/ha^{-1}, and the average size of the piles was approximately 10 m^2. This would mean that the piles had a coverage equivalent to 1 200–1 500 m^2/ha^{-1}, or 12–15% of the area.

Table 3.
Quantity of logging residues in energy wood piles.

	Proportion of logging residue degree of coverage, % [a]	Proportion of total area, % [a]	Proportion of logging residue quantity, %
Area – central Sweden			
Fullerö	25.2	12.1	78.8
Knivsta1	48.4	18.1	90.0
Knivsta2	49.9	24.4	89.4
Knivsta3	44.4	18.1	88.4
Väddö	32.9	17.3	84.4
Average	40.2	18.0	86.2
Area – south Sweden			
Attsjö	37.1	17.3	88.8
Gåtahult	29.5	19.2	79.8
Lillegård	32.0	18.9	87.5
S. Åreda	40.1	26.7	90.6
Tubbatorp	29.3	18.1	91.3
Average	33.6	20.0	87.6
AVERAGE (all)	*36.9*	*19.0*	*86.9*

[a] = estimated value

Figure 6.
Plot with 100 % of the logging residues driven over by machines. Conventional felling.

In order to avoid causing deep ruts, the route taken by the felling machines was concentrated to the logging residues in the areas that were not planned for energy wood extraction. On average, for all conventional felling sites, 40% of the logging residue volume was driven over by harvesters and forwarders (Table 4). On the forest fuel sites, an average of 10% of the logging residue volume was driven over.

Table 4.
Quantity of logging residues driven over by machines.

		Proportion of logging residue degree of coverage, %	Proportion of logging residue quantity, %
Conventional felling (CF)	Area – central Sweden		
	Adamsberg	55.8	49,0
	Borrlövsta	33.5	26,1
	Ekeby	53.8	55,0
	Ekeby2	51.5	44,8
	Ununge	44.7	49,1
	Average	47.9	44,8
	Area – south Sweden		
	Getahult	54.8	49,3
	Holmsryd	47.2	28,8
	Kosta	61.6	45,3
	Målen	51.7	34,4
	Skogstorp	44.2	33,0
	Average	51.2	35,4
	Average (CF)	*49,5*	*40.1*
Energy wood felling (FF)	Area – central Sweden		
	Fullerö	41.7	16,9
	Knivsta1	13.5	2,0
	Knivsta2	27.6	8,6
	Knivsta3	27.9	4,0
	Väddö	39.4	15,4
	Average	30.0	9,4
	Area – south Sweden		
	Attsjö	30.7	10,5
	Gåtahult	33.9	11,6
	Lillegård	28.0	10,0
	S. Åreda	30.1	15,7
	Tubbatorp	38.3	6,4
	Average	32.2	10,8
	Average (FF)	*31,1*	*10.1*

Discussion and conclusions

Logging residues on conventionally felled sites covered an average of approximately 62% of the area, which is higher than figures reported in previous studies. In a study in Småland, Svensson (1989) reported that logging residues covered 55% of the area of the clear-cut after final felling using a single-grip harvester. The proportion of large logging residue piles was also small on the conventionally harvested sites. The depth of most of the logging residue volume (71%) was less than 20 cm, while this logging residue volume comprised approximately 85% of the logging residue-covered area, or just over 50% of the total area.

In the forest fuel debate, it has been claimed that current final felling systems cause uneven distribution of the nutrient-rich logging residues, which could impair growth in the forthcoming tree generation, regardless of whether or not the logging residues is to be used for energy purposes. However, it should be remembered that the relatively uneven spatial distribution of logging residues are actually reasonably evenly distributed over the clear-cut, along the routes of the harvesters. In view of the spatial distribution of the logging residues shown by this study, and the fact that the distance between the harvester routes is normally only 10–15 m, the conclusion must be that it is unlikely that current felling systems in themselves could lead to any significant subsequent impairment of growth.

On the forest fuel sites, an average of 87% of the total volume of logging residues lay in concentrated piles. Because of wastage when these piles are forwarded, this study indicates that an utilisation degree of logging residues greater than 80% would be difficult to attain. The forest fuel piles covered on average a maximum of 19%, but more probably less than 15% of the clear-cut area. If it is assumed that the piles are allowed to remain on the clear-cut long enough so that all needles are shed, the needles (which on average account for half of the logging residue's total nutrient content) would be concentrated on less than one-fifth of the area of the clear-cut.

The proportion of logging residues driven over by machines was considerably higher on the conventionally felled sites. The possible effect of this compression on the speed of mineralisation and any leaching of other nutrients has yet to be studied. However, the use of logging residues also protects the surface, reducing the risk of soil damage. The damage caused by machines can also lead to negative effects in the form of increased nutrient leaching.

There are many factors that influence the concentration and spatial distribution of logging residues on the clear-cut. The form and size of the stand, terrain obstacles, retention plots, machine type, unit, and method of working affect how logging residues is spread in both conventional and forest fule adapted felling methods. Whether simple or double-sided felling is applied on the logging sites could not be ascertained in this study.

In the forest fuel fellings, the harvester operator's interest and habits may greatly influence the number and size of the residue piles. The choice of route taken by the forwarder operator also affects how much logging residue is driven over by the machines.

On the southern sites, several operators and wood purchasers reported that it was not unusual for the logging residues to be actively redistributed, by the harvester or the forwarder, on the conventionally-felled sites. This can explain the somewhat greater spatial distribution of the logging residues in this area. Thicker and longer stems may be another explanation.

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Appendix 1

Table B1. Degree of coverage and volume of logging residues, according to logging residue depth classes. Conventionally-felled sites in central Sweden.

Table B2. Degree of coverage and volume of logging residues, according to logging residue depth classes. Conventionally felled sites in southern Sweden.

Table B3. Degree of coverage and volume of logging residues, according to logging residue depth classes. Forest fuel felled sites in central Sweden.

Table B4. Degree of coverage and volume of logging residues, according to logging residue depth classes. Forest fuel felled sites in southern Sweden.

Table B1.
Degree of coverage and volume of logging residues, according to logging residue depth classes. Conventionally-felled sites in central Sweden.

			Logging residue coverage			Logging residue volume		
Site	Logging residue depth (cm)	Number of plots	m^2	Prop. of total area (%)	Prop. of logging residue covered (%)	m^3	Prop. of total vol. (%)	(acc) %
Adamsberg	>80	0	0.0	0.0	0.0	0.00	0.0	0.0
	41–80	1	2.2	0.7	1.2	1.10	5.9	5.9
	21–40	11	31.1	9.9	17.6	8.0	43.0	48.9
	11–20	11	24.2	7.7	13.7	3.5	18.8	67.7
	6–10	20	46.6	14.8	26.4	3.6	19.4	87.1
	1–5	56	72.4	23.1	41.0	2.4	12.9	100.0
	0	1						
	Σ	100	176.6	56.2	100.0	18.5	100.0	
Borrlövsta	>80	0	0.0	0.0	0.0	0.0	0.0	0.0
	41–80	1	3.1	1.0	1.3	2.0	9.4	9.4
	21–40	8	24.9	7.9	10.3	7.7	35.5	45.0
	11–20	10	28.6	9.1	11.9	4.2	19.4	64.4
	6–10	17	47.7	15.2	19.8	3.5	16.0	80.3
	1–5	64	136.2	43.4	56.6	4.3	19.7	100.0
	0	0						
	Σ	100	240.5	76.6	100.0	21.7	100.0	
Ekeby 1	>80	0	0.0	0.0	0.0	0.0	0.0	0.0
	41–80	0	0.0	0.0	0.0	0.0	0.0	0.0
	21–40	1	3.1	1.0	1.7	0.7	5.7	5.7
	11–20	11	29.8	9.5	16.2	4.6	37.6	43.2
	6–10	16	44.0	14.0	23.9	3.4	27.9	71.1
	1–5	71	107.3	34.2	58.2	3.5	28.9	100.0
	0	1						
	Σ	100	184.3	58.7	100.0	12.2	100.0	
Ekeby 2	>80	0	0.0	0.0	0.0	0.0	0.0	0.0
	41–80	1	2.5	0.8	2.0	1.8	13.7	13.7
	21–40	5	12.7	4.1	10.0	3.2	24.6	38.3
	11–20	13	34.2	10.9	27.0	5.0	38.8	77.1
	6–10	6	11.5	3.7	9.1	0.8	6.2	83.3
	1–5	70	65.8	21.0	51.9	2.2	16.7	100.0
	0	5						
	Σ	100	126.7	40.3	100.0	12.9	100.0	
Ununge	>80	0	0.0	0.0	0.0	0.00	0.0	0.0
	41–80	0	0.0	0.0	0.0	0.00	0.0	0.0
	21–40	15	44.6	14.2	27.9	12.0	58.7	58.7
	11–20	13	34.3	10.9	21.5	4.9	24.1	82.9
	6–10	7	17.1	5.5	10.7	1.2	5.9	88.8
	1–5	63	63.7	20.3	39.9	2.3	11.2	100.0
	0	2						
	Σ	100	159.8	50.9	100.0	20.4	100.0	
Average of 5 sites	>80	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	41–80	0.6	1.6	0.5	0.9	1.0	5.8	5.8
	21–40	8.0	23.3	7.4	13.5	6.3	33.5	39.3
	11–20	11.6	30.2	9.6	18.0	4.4	27.7	67.0
	6–10	13.2	33.4	10.6	18.0	2.5	15.1	82.1
	1–5	64.8	89.1	28.4	49.5	2.9	17.9	100.0
	0	1.8						
	Σ	100.0	177.6	56.5	100.0	17.1	100.0	

Table B2.
Degree of coverage and volume of logging residues, according to logging residue depth classes. Conventionally-felled sites in southern Sweden.

			Logging residue coverage			Logging residue volume		
Site	Logging residue depth (cm)	Number of plots	m^2	Prop. of total area (%)	Prop. of logging residue covered (%)	m^3	Prop. of total vol. (%)	(acc) %
Getahult	>80	0	0,0	0,0	0,0	0,0	0,0	0,0
	41–80	1	3,1	1,0	1,7	1,9	8,0	8,0
	21–40	13	35,5	11,3	19,4	10,3	44,1	52,1
	11–20	18	46,3	14,8	25,3	7,2	30,5	82,6
	6–10	9	22,5	7,2	12,3	1,8	7,9	90,5
	1–5	58	75,6	24,1	41,3	2,2	9,5	100,0
	0	1						
	Σ	100	183,0	58,3	100,0	23,5	100,0	
Holmsryd	>80	0	0,0	0,0	0,0	0,0	0,0	0,0
	41–80	0	0,0	0,0	0,0	0,0	0,0	0,0
	21–40	10	28,5	9,1	13,0	9,0	42,0	42,0
	11–20	11	30,9	9,8	14,1	4,9	22,6	64,7
	6–10	20	53,0	16,9	24,2	3,8	17,8	82,4
	1–5	59	106,4	33,9	48,6	3,8	17,6	100,0
	0	0						
	Σ	100	218,8	69,7	100,0	21,5	100,0	
Kosta	>80	1	3,1	1,0	1,6	2,7	10,5	10,5
	41–80	3	9,4	3,0	4,7	4,6	18,2	28,8
	21–40	9	28,0	8,9	13,9	7,8	30,8	59,6
	11–20	10	28,6	9,1	14,2	4,6	18,0	77,7
	6–10	13	33,5	10,7	16,7	2,4	9,5	87,1
	1–5	64	98,2	31,3	48,9	3,3	12,9	100,0
	0	0						
	Σ	100	200,9	63,9	100,0	25,3	100,0	
Målen	>80	0	0,0	0,0	0,0	0,0	0,0	0,0
	41–80	3	9,3	3,0	4,6	5,7	19,8	19,8
	21–40	16	46,1	14,7	23,0	12,5	43,2	63,1
	11–20	13	34,0	10,8	17,0	5,3	18,5	81,5
	6–10	14	33,8	10,8	16,9	2,7	9,2	90,7
	1–5	54	77,2	24,6	38,5	2,7	9,3	100,0
	0	0						
	Σ	100	200,3	63,8	100,0	28,9	100,0	
Skogstorp	>80	0	0,0	0,0	0,0	0,0	0,0	0,0
	41–80	1	2,2	0,7	0,8	1,3	4,8	4,8
	21–40	8	24,8	7,9	9,3	7,5	27,1	31,9
	11–20	19	57,8	18,4	21,7	9,4	34,1	66,0
	6–10	25	70,8	22,6	26,6	5,2	19,0	85,0
	1–5	47	111,1	35,4	41,6	4,1	15,0	100,0
	0	0						
	Σ	100	266,7	84,9	100,0	27,4	100,0	
Average of 5 sites	>80	0,2	0,6	0,2	0,3	0,5	2,1	2,1
	41–80	1,6	4,8	1,5	2,4	2,7	10,2	12,3
	21–40	11,2	32,6	10,4	15,7	9,4	37,5	49,8
	11–20	14,2	39,5	12,6	18,5	6,3	24,7	74,5
	6–10	16,2	42,7	13,6	19,3	3,2	12,6	87,2
	1–5	56,4	93,7	29,8	43,8	3,2	12,8	100,0
	0	0,2						
	Σ	100,0	214,0	68,1	100,0	25,3	100,0	

Table B3.
Degree of coverage and volume of logging residues, according to logging residue depth classes. Forest fuel felled sites in central Sweden.

			Logging residue coverage			Logging residue volume		
Site	Logging residue depth (cm)	Number of plots	m^2	Prop. of total area (%)	Prop. of logging residue covered (%)	m^3	Prop. of total vol (%)	(acc) %
Fullerö	>80	2	6.3	2.0	4.1	5.8	23.0	23.0
	41–80	5	15.7	5.0	10.4	9.1	36.0	59.0
	21–40	4	9.0	2.9	5.9	2.7	10.8	69.8
	11–20	8	22.0	7.0	14.5	3.0	11.6	81.4
	6–10	14	29.2	9.3	19.2	2.1	8.4	89.9
	1–5	67	69.6	22.2	45.9	2.6	10.1	100.0
	0							
	Σ	100	151.7	48.3	100.0	25.3	100.0	
Knivsta 1	>80	7	19.5	6.2	16.5	21.1	48.1	48.1
	41–80	9	25.9	8.3	22.0	16.1	36.7	84.8
	21–40	6	10.5	3.4	8.9	3.3	7.6	92.4
	11–20	5	10.1	3.2	8.5	1.4	3.1	95.5
	6–10	7	10.8	3.5	9.2	0.9	2.0	97.5
	1–5	60	40.9	13.0	34.8	1.1	2.5	100.0
	0	6						
	Σ	100	117.7	37.5	100.0	43.8	100.0	
Knivsta 2	>80	7	20.9	6.7	13.6	19.5	42.7	42.7
	41–80	8	23.2	7.4	15.1	13.0	28.5	71.2
	21–40	7	19.6	6.3	12.8	5.7	12.5	83.7
	11–20	11	26.5	8.5	17.3	4.0	8.8	92.5
	6–10	15	24.2	7.7	15.7	2.0	4.3	96.9
	1–5	51	39.2	12.5	25.5	1.4	3.1	100.0
	0	1						
	Σ	100	153.7	48.9	100.0	45.6	100.0	
Knivsta 3	>80	7	22.0	7.0	17.0	27.5	58.2	58.2
	41–80	6	16.3	5.2	12.6	9.6	20.3	78.5
	21–40	6	17.0	5.4	13.1	5.6	11.8	90.3
	11–20	6	10.8	3.5	8.4	1.6	3.4	93.7
	6–10	12	19.7	6.3	15.2	1.5	3.3	97.0
	1–5	61	43.4	13.8	33.6	1.4	3.0	100.0
	0	2						
	Σ	100	129.2	41.1	100.0	47.2	100.0	
Väddö	>80	3	8.3	2.7	5.0	8.3	27.8	27.8
	41–80	2	5.8	1.9	3.5	3.0	10.1	37.9
	21–40	14	36.4	11.6	22.0	11.7	39.1	77.0
	11–20	9	21.8	7.0	13.2	3.4	11.2	88.2
	6–10	8	16.7	5.3	10.1	1.2	3.9	92.1
	1–5	63	76.2	24.3	46.1	2.4	7.9	100.0
	0	1						
	Σ	100	165.2	52.6	100.0	30.0	100.0	
Average of 5 sites	>80	5.2	15.4	4.9	11.3	16.4	39.9	39.9
	41–80	6.0	17.4	5.5	12.7	10.2	26.3	66.3
	21–40	7.4	18.5	5.9	12.6	5.8	16.3	82.6
	11–20	7.8	18.3	5.8	12.4	2.7	7.7	90.3
	6–10	11.2	20.1	6.4	13.9	1.5	4.4	94.7
	1–5	60.4	53.9	17.1	37.2	1.8	5.3	100.0
	0	2.5						
	Σ	100.5	143.5	45.7	100.0	38.4	100.0	

Table B4.
Degree of coverage and volume of logging residues, according to logging residue depth classes. Forest fuel felled sites in southern Sweden.

			Logging residue coverage			Logging residue volume		
Site	Logging residue depth (cm)	Number of plots	m^2	Prop. of total area (%)	Prop. of logging residue covered (%)	m^3	Prop. of total vol (%)	(acc) %
Attsjö	>80	5	15.7	5.0	10.8	17.9	47.8	47.8
	41–80	3	6.3	2.0	4.3	2.8	7.5	55.3
	21–40	11	26.7	8.5	18.3	9.4	25.2	80.5
	11–20	13	27.0	8.6	18.5	4.4	11.8	92.2
	6–10	7	13.2	4.2	9.0	1.0	2.8	95.0
	1–5	56	57.0	18.1	39.1	1.9	5.0	100.0
	0	5						
	Σ	100	145.9	46.4	100.0	37.5	100.0	
Gåtahult	>80	2	6.3	2.0	3.1	6.4	16.7	16.7
	41–80	11	31.6	10.1	15.4	20.4	52.9	69.6
	21–40	1	3.1	1.0	1.5	0.8	2.0	71.7
	11–20	12	32.4	10.3	15.8	5.5	14.3	85.9
	6–10	10	25.1	8.0	12.3	2.0	5.2	91.2
	1–5	63	106.1	33.8	51.9	3.4	8.8	100.0
	0	1						
	Σ	100	204.6	65.1	100.0	38.5	100.0	
Lillegård	>80	3	9.4	3.0	5.1	10.2	26.9	26.9
	41–80	7	22.0	7.0	11.9	14.1	37.2	64.1
	21–40	7	19.0	6.1	10.3	6.1	16.2	80.2
	11–20	8	16.3	5.2	8.8	2.7	7.3	87.5
	6–10	9	21.4	6.8	11.5	1.8	4.7	92.2
	1–5	64	97.0	30.9	52.4	3.0	7.8	100.0
	0	2						
	Σ	100	185.1	58.9	100.0	38.0	100.0	
S. Åreda	>80	4	12.6	4.0	6.0	12.6	23.9	23.9
	41–80	12	34.9	11.1	16.7	21.1	40.2	64.1
	21–40	14	37.4	11.9	17.9	10.7	20.4	84.5
	11–20	11	26.7	8.5	12.8	4.2	8.0	92.5
	6–10	9	18.7	6.0	8.9	1.6	3.1	95.6
	1–5	50	78.9	25.1	37.7	2.3	4.4	100.0
	0	0						
	Σ	100	209.1	66.6	100.0	52.5	100.0	
Tubbatorp	>80	8	22.8	7.3	11.7	25.7	55.5	55.5
	41–80	6	18.8	6.0	9.7	11.5	24.8	80.3
	21–40	5	15.7	5.0	8.1	4.4	9.5	89.8
	11–20	2	4.6	1.5	2.3	0.7	1.5	91.3
	6–10	4	11.6	3.7	6.0	1.2	2.5	93.8
	1–5	72	120.7	38.4	62.2	2.9	6.2	100.0
	0	3						
	Σ	100	194.2	61.8	100.0	46.3	100.0	
Average of 5 sites	>80	4.4	13.4	4.3	7.3	14.6	34.2	34.2
	41–80	7.8	22.7	7.2	11.6	14.0	32.5	66.7
	21–40	7.6	20.4	6.5	11.2	6.3	14.7	81.3
	11–20	9.2	21.4	6.8	11.7	3.5	8.6	89.9
	6–10	7.8	18.0	5.7	9.6	1.5	3.7	93.5
	1–5	61.0	91.9	29.3	48.6	2.7	6.5	100.0
	0	2.2						
	Σ	100.0	187.8	59.8	100.0	42.6	100.0	

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