Forest Research

The Research Agency of the Forestry Commission

TECHNICAL DEVELOPMENT

INTERNAL PROJECT INFORMATION NOTE 12/98

Project: Chipping Clearfell Tops at East Anglia FD

Number: 1000A/16/98

Month: October **Year:** 1998

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Ref: 1000A/16/98 Title: CHIPPING CLEARFELL TOPS AT EAST ANGLIA FD

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Summary

1. The chipping of p28 Scots Pine was studied at East Anglia FD. The crop had a significant amount of forked stemwood. Average tree size was 0.95 m³ ob with standing timber volumes of between 255 m³ ob/ha and 305 m³ ob/ha.

2. An Akerman H7/Lako 60 harvester felled the crop leaving two different sizes of top in different drifts:

   (a) Short Tops where left after Kronospan smallwood material had been converted (minimum top diameter 6 cm

   (b) Long Tops where left after no smallwood material had been converted with sawlog minimum top diameters of 14 and 16 cm. Forked tops where sawlog conversion was reduced resulted in long top cut off diameters of up to 35 cm.

3. A Bruks 800 chipper was used to chip tops before and after timber extraction with no appreciable difference in site brash clearance.

4. Timber extraction costs per m³ were lower when long tops had been left for chipping with no smallwood conversion.

5. The crop yielded 43 tonnes/ha of chips when short tops were processed and between 75 tonnes/ha and 90 tonnes/ha of chips when long tops were processed.

6. Chipper output per hour increased by 76% when processing long tops, when compared to processing short tops. Chipper working costs reduced by 43% when processing long tops.

Introduction

7. Mature Scots pine crops at East Anglia Forest District can contain significant numbers of stems with single or multiple forks above breast height diameter. These forked stems are predominantly smallwood although some forks contain sawlog grade material.

8. Following earlier Work Study investigations, Technical Development Branch (TDB) were instructed to provide data on conventional shortwood 'short tops' systems and unconventional shortwood 'long tops' systems. In conventional short tops systems, the smallwood element of forked sections is converted and discarded tops chipped. With unconventional long top working, the smallwood element is not converted and long smallwood size tops are left for subsequent chipping.

9. TDB were asked to provide the following data for conventional and unconventional working:

   - Method studies.
   - Chipped tonnages related to tree size and area.
   - Moisture content of fresh felled timber.
   - Output and Cost data.

Site Description

10. Crop details are shown in Table 1.

11. The Terrain Classification was 1.1.1 with slopes less than 5% and the soil sandy. The weather was hot and dry throughout the study period with temperatures up to 29°C on one day.

Plate 1

Forked Stems in Mature SP Crop

Table 1

Crop Details

Age (yrs)	Average Tree Size (m^3 ob)	Average dbh (cm)	Standing Volume (m^3 ob/ha)	Chips (Tonnes/ha)	% of trees forked above breast height
71	0.95	34.0	278	43 to 90	22

12. There was significant heavy forking (Plate 1) in the mid to upper merchantable stem wood of the trees in the Scots pine in compartment 5057. Some of the forked stems contained sawlog material. This crop characteristic had prompted Management to consider selecting forked tops with smallwood material for subsequent chipping as opposed to traditional shortwood working.

Machine Description

13. A standard Akerman H7/Lako 60 tracked excavator harvester was used to fell and process the crop. The excavator was fitted with 600 mm wide tracks with a raised grouser on each track plate.

14. Details of the configuration of the 6 wheeled Hemek Ciceron forwarder with extended bunk (Plate 2) and the 6 wheeled Kockums 84-35 forwarder fitted with a Bruks 800 chipper (Plate 3) are given in Table 2.

Plate 2

Hemek Ciceron Forwarder (Extended Bunk)

Plate 3

Bruks 800 Chipper on Kockums 84-35

Table 2

Machine Details

	Ciceron Forwarder	Kockums/Bruks Chipper
Front Tyres	Nokia 23.1-26 Tractor Special	Nokia 23.1-26 Tractor Special
Rear Tyres	Nokia 22-65	Trelleborg 600\55\26.5 (421)
Traction Aids	None	None
Loader	Cranab 650 XL	Cranab Combi 660

15. The Bruks drum chipper was driven by a 200 hp engine and the chips were stored in a side tipping steel bin (Plate 4). Selected specification details for the latest Bruks 800 CT chip harvester are given in Table 3.

Plate 4

Chipper with Bin Approaching Full Raised Height for Tipping

Table 3

Bruks 800 CT

Drum diameter 800 mm, infeed opening 550 mm by 400 mm
2 adjustable knives, chip lengths adjustable between 25 and 40 mm
Iveco 173 kW diesel engine, belt transmission, pneumatic disc clutch
Chip bin volume 14 m^3, width 2.5 m, tipping height 2 000 mm above chassis
Designed to chip trees up to 30 cm in diameter
Wet weight with feed hopper 6 500 kg

Supplier: Cellwood Eriksson Ltd (Unit 14, Vauxhall Industrial Estate, Greg Street Reddish, Stockport, SK5 7BR, Tel: 0161 429 9437) are UK agents for Bruks chipping equipment.

Working Method

16. Four working methods were studied (Table 4).

Table 4

Working Methods

Section and Method	Tops		Minimum Cut Off Diameter (cm)
	Length (m)	Presentation	
1. Conventional	Short	Right angle	6
2. Unconventional	Long	Parallel	14
3. Unconventional	Long	Right angled parallel	16
4. Unconventional	Long	Parallel	16

17. The forked nature of the crop had prompted management to consider leaving long tops for subsequent chipping. These contain mainly smallwood material and would be stacked on the opposite side of the drift to the processed produce. When long tops are cut the harvester processing of forked material is significantly reduced.

Plate 5

Short Tops

18. Two harvester working systems were used:

(I) Conventional working presented sawlog (SL) and processed smallwood on the nearside of the harvester with tops presented on the offside at right angles to the direction of machine travel. Processing forked tops (conventional shortwood) with a harvester requires extra operator input and concentration compared to processing unforked stems. After cutting the last product from an unforked stem the forked top is usually dropped and the chainsaw used to cut forked limbs. These limbs are then processed using a combination of repeated pass delimbing and conventional one pass delimbing. Some knife opening is also required on curved stem sections. The short top (Plate 5) is then stacked for subsequent chipping. Larger branches are cut off by the chainsaw.

(ii) With unconventional working sawlogs were stacked on the nearside of the harvester and long tops on the offside of the harvester. The majority of long tops (Plate 6) were stacked parallel to the direction of machine travel with shorter tops placed at an angle between parallel and right angles or at right angles. The method of presentation of the tops was specified for each study.

Plate 6

Long Tops

19. With conventional and unconventional working some trees were too large for the first sawlog to be stacked directly into the timber zone. This would be cross cut after felling and delimbing and left in situ. The remainder of the tree was processed and stacked and the first cut sawlog then lifted by the harvester and stacked in the timber zone.

20. Forwarder extraction was conventional with sawlogs extracted first and where present smaller volumes of pallet and smallwood material extracted last. Logs were graded and marked in green or red paint for the forwarder operator. Pure loads of green and red logs were initially extracted with mixed loads of green and red logs extracted to complete the drift and maximise forwarder loads. Logs were stacked in red and green stacks at roadside.

21. Details of products cut are shown in Table 5.

Table 5

Product Specifications

Green Sawlog to 20 cm ub	Red Sawlog to 16 cm ub	Pallet Log to 14 cm ub	Chipwood to 6 cm ob
4.8 m	4.8 m and 3.6 m	2.7 m	2.7 m

22 Small tops with no significant smallwood content were stacked at right angles to machine travel in the drift. Long tops were stacked parallel (Plate 7) to machine travel so that subsequent harvester travel whilst felling and forwarder travel for extraction was not impaired. When long tops were stacked parallel to machine travel the chipper could process them before shortwood extraction took place. Tops were chipped prior to shortwood extraction in Section 4.

Plate 7

Stacking Long Tops

23. The Bruks chipper travelled along each drift and loaded tops presented at right angles directly into the offside side mounted chip infeed mechanism. Parallel stacked tops were slewed and moved for loading into the chipper infeed. In Sections 1 and 2 the Bruks chipper lifted tops from underneath tops as it worked the route followed by the harvester, i.e. earlier felled tops were overlain by later felled tops. This working system was viable because top size was smaller with smallwood and/or pallet material removed. In Sections 3 and 4 the last tops to be felled were the first to be chipped, ie working was in the opposite direction to the harvester. This method was more suitable as cut off diameter was 16 cm and the tops were longer and difficult to remove from underneath long tops.

24. Stem up to c 35 cm diameter were occasionally processed depending on the stem form of the forks.

Results

25. The different working methods were studied and information on products cut, outputs and costs obtained (Table 6 and Table 7).

26. Machine cost assumptions used were:

- Akerman H7/Lako 60 Harvester = £53.16/hr (FE PDC Rate & Labour Cost)
- Hemek Ciceron Forwarder = £38.75/hr (FE PDC Rate & Labour Cost)
- Valmet 840/Bruks 800 Chipper = £50.96/hr (Standard Machine Costing)

27. Standard outputs include the following allowances:

	Personal Needs and Rest (%)	Other Work (%)
Harvesting	18	20
Extract and Chip	15	17

Table 6

Outputs

Working Method	Crop		Product						
			Roundwood Cut (m^3ob/ha)						Chips
	Mean tree (m^3 ob)	Volume (m^3 ob/ha)	4.8 m Green	4.8 m Red	3.6 m Red	2.7 m Pallet	2.7 m Chipwood	Total	Tonnes/ha
1. Conventional. Short Tops. Right Angled Presentation	0.97	275	100.8	107.5	-	12.7	42.9	263.9	43.1
2. Unconventional. Long Tops. Parallel Presentation	0.91	305	125.6	117.5	-	18.7	-	261.8	75.0
3. Unconventional. Long Tops. 90° to 180° Presentation	0.93	255	147.1	-	80.8	-	-	227.9	73.0
4. Unconventional. Measured Drift. Long Tops Parallel Presentation	-	-	164.8	-	93.8	-	-	258.6	90.4

Table 7

Costs

Sections	Crop		Outputs and Costs					
			Roundwood				Tops	
	Mean (m^3)	Volume (m^3ob/hr)	Harvest		Extract		Chip	
			(m^3/shr)	(£/m^3)	(m^3/shr)	(£/m^3)	(Tonnes/shr)	(£/Tonnes)
1.	0.97	275	26.20	2.03	30.70	1.26	4.50	11.32
2.	0.91	305	30.70	1.73	33.20	1.17	7.70	6.61
3.	0.93	255	27.90	1.90	25.00	1.55	8.00	6.37
4.	-	-	-	-	-	-	8.00	6.37

28. Hemek forwarder output was collected in Section 1 and used to calculate all extraction outputs except for 3.6 m SLs. Forwarder Output Guide 7 (1990) was used to calculate 3.6 m SL extraction rates.

39. Extraction outputs (Table 8) for forwarder and chipper have been standardised to 100 m extraction distances. Actual forwarder extraction distances averaged 525 m to roadside and chipper extraction distances averaged 105 m to the chip road transport bin.

Table 8

Forwarder Outputs by Product (100 m Extraction)

Product	Output (m^3/shr)
4.8 m SL	34.88
2.7 m Pallet	20.41
2.7 m Chipwood	21.51
3.6 m SL★	16.50

★This product length was cut to improve quality and was extracted in a single bay which explains the low output.

30. Chipper outputs when processing long tops increased by up to 76% when compared to short top working.

31. The quantity of chips (Table 9) produced by each method was measured and sampled for moisture content per cent wet basis[1]. The quantity per hectare was then calculated for wet tonnes/ha and oven dried tonnes (ODT)/ha.

[1] Moisture Content % Wet basis = $\frac{\text{Wet Weight - Dry Weight}}{\text{Wet Weight}} \times 100$

Table 9

Chip Quantity

Section	Wet Tonne/ha	Moisture Content (%)	ODT/ha
1	43	44	24
2	75	51	37
3	73	52	35
4	90	N/A	N/A

32. The lower moisture content in Section 1 possibly reflects the lower proportion of stem wood due to the smaller cut off diameter.

33. Harvester unit costs were higher when cutting smallwood from forked tops.

34. A higher unit cost was recorded when chipwood was extracted (Section 1) compared to when no chipwood was extracted (Section 2).

35. The higher extraction costs in Section 3 may be due to a lower proportion of 4.8 m logs. Outputs when extracting 4.8 m SL over 100 m were 34.90 m³ ob/shr compared to 16.50 m³ ob/shr extracting 3.6 m SL.

36. In the following tables (Table 10 to Table 13) the figures have been adjusted for poor quality and weight loss.

37. Loading costs are based on figures provided by the District. Costs for a 25 m³ load are estimated as follows:

Labour	£ 9.61	(including 45% oncost)
Forwarder	£20.76	
Total	£30.37	
Cost/m³	£ 1.21	

38. Forest District Staff stated that produce cut during studies was of poor quality. TDB accepted that operators would cut to the usual standard accepted by District customers and did not intervene during studies on quality control.

39. Ten per cent by volume for each product has been down graded to the next product for the "adjusted revenue for poor quality" column.

40. In the last column 20 % weight loss has been assumed for chipwood due to slow pick up for a worst case scenario.

Table 10

Section 1

Product	Roadside Price (£/m^3 ob)	Quantity (m^3 ob/ha)	Chip Quantity (Tonnes/ha)	Adjusted Volume (m^3/ha)	Adjusted Revenue (£/ha) for Poor Quality
4.8 m S/L Green	39.43	100.80		90.72	3 577
4.8 m S/L Red	31.98	107.52		106.85	3 417
2.7 m Pallet Log	25.97	12.67		22.15	(557)477★
2.7 m Chipwood	12.62	42.89		44.10	8 146
Tops	£100/ha		43.08		100
Totals		263.88	43.08	263.8	8 146
Felling, harvesting, extraction & loading costs					1 187
Surplus £/ha (includes tops revenue)					6 958
Surplus £/m^3 ob					26.37

★ 20% reduction for weight loss.

41. In this Section the green 4.8 m SL volume was lower compared to other sections and lower income pallet and smallwood were cut. The adjusted revenue was £30.87/m³ ob and the working costs were £4.50/m³ ob.

Table 11

Section 2

Product	Roadside Price (£/m^3 ob)	Quantity (m^3 ob/ha)	Chip Quantity (tonnes/ha)	Adjusted Volume (m^3/ha)	Adjusted Revenue (£/ha) for Poor Quality
4.8 m S/L Green	39.43	125.62		113.06	4 458
4.8 m S/L Red	31.98	117.53		118.30	3 784
2.7 m Pallet Log	25.97	18.68		30.4	790
Tops	£100/ha				150★
Totals		261.83	75.03	261.8	9 132
Felling, harvesting, extraction & loading costs					1 076
Surplus £/ha (includes tops revenue)					8 056
Surplus £/m^3 ob					30.77

★ Tops revenue adjusted for increased quantity.

42. Adjusted revenue values in this Section are £34.88/m³ ob and working costs are £4.11/m³ ob.

43. It was assumed that the revenue for tops increased from £100/ha to £150/ha to reflect the increased tonnage of material and reduced operator working costs per tonne. Tonnage recovery of chips has increased by 74% in Section 2 compared to Section 1. Tree sizes were similar although Section 1 had 10.8% more standing volume than Section 2.

44. Chipping larger tops in Sections 2 and 3 reduced operator chipping costs by 41% compared to chipping smaller tops in Section 1.

45. Adjusted revenue values are £35.56/m³ ob and unit working costs are £4.66/m³ ob.

Table 12

Section 3

Product	Roadside Price (£/m^3 ob)	Quantity (m^3 ob/ha)	Chip Quantity (tonnes/ha)	Adjusted Volume (m³/ha)	Adjusted Revenue (£/ha) for Poor Quality
4.8 m S/L Green	39.43	147.05		132.35	5 218
3.6 m S/L Red	31.98	80.81		95.51	3 054
Tops	£100/ha		73.03		150★
Totals		227.86	73.03	227.86	8 422
Felling, harvesting, extraction & loading costs					1 062
Surplus £/ha (includes tops revenue)					7 360
Surplus £/m^3 ob					32.30

★ Tops revenue adjusted for increased quantity.

46. Adjusted revenue values are £36.83/m³ ob and working costs are £4.66/m³ ob.

Table 13

Section 4

Product	Roadside Price (£/m^3 ob)	Quantity (m^3/ha)	Chip Quantity (tonnes/ha)	Adjusted Volume (m^3/ha)	Adjusted Revenue (£/ha) for Poor Quality
4.8 m S/L Green	39.43	164.78		148.3	5 847
3.6 m S/L Red	31.98	93.76		110.2	3 525
Tops	£100/ha		90.43		150★
Totals		258.54	90.43	258.5	9 522
Felling, harvesting, extraction & loading costs					1 205
Surplus £/ha (includes tops revenue)					8 317
Surplus £/m^3 ob					32.17

★ Tops revenue adjusted for increased quantity.

47. Contractor chipping costs were lowest in this drift (Section 4) at £6.37/tonne and recovery of chipped tonnes/ha the highest. Tops were chipped prior to produce extraction but there was no discernible reduction in top and branch clearance in this unextracted drift compared to extracted drifts.

48. If chips are sold by the tonne and chipping should take place as soon as possible after felling in drying weather conditions, to reduce possible income loss. Technical Note 6/95 Moisture Loss After Felling details results of moisture loss trials. If chips are sold by calorific value, where tonnage is related to moisture content, moisture loss should not affect revenue.

Safety

49. The Risk Zone displayed on the Bruks Chipper unit is 50 m. This can be compared to the 50 m Risk Zone displayed on the Hafu Chippers (UK) or 60 m displayed on a Scandinavian Bruks unit. A Scandinavian IF 300 Bruks chipper has a 60 m Risk Zone displayed on the machine.

50. During studies a woodchip with a diameter of 4 cm was seen to travel about 35 m in line with the chipper infeed on the machine's offside.

Ground Preparation

51. Brash raking after chipping costs c £114/ha and ploughing after brash raking on sites with stumps costs £65/ha. Brash raking may not be necessary after chipping and this is currently under investigation by the District and TDB. A brash free drift can be seen in Plate 8 and compared to a drift with tops in the right of the photograph. Where brash raking is not necessary ground preparation costs when ploughing or scarifying may fall to c £80/ha.

Plate 8

Brash Free Drift

52. The worst case where tops revenue could be lost and increased ground preparation costs incurred on sites with stumps. Plantable ground would be lost to larger brash windrows with brash raking. Ground preparation costs are not known but could rise to £250/ha.

53. The significance of nutrient loss when chipping and removing tops should be considered and Forest Research contacted for advice.

Revenue for Tops

54. The average revenue for tops when smallwood is cut is £100/ha. This average price is used for Corsican and Scots pine sites.

55. The current District gains from smallwood processing are:

- Revenue from smallwood.
- Revenue from tops.
- Reduced ground preparation costs with brash removal.

56. The disadvantages with current smallwood processing are:

- Increased harvesting costs.
- Unknown operator & harvester head working stresses.
- Forwarder loading costs at roadside.

57. If no smallwood is cut from Scots pine tops an increase in top revenue would be expected because:

- Chipped tonnages increase per ha.
- Contractor working costs reduce by c 43% in wood.
- Chipper output increases by up to 76% when processing long tops.

58. Section 1 indicates that the following revenue/benefits can be expected in when smallwood dries:

- £446 for 42.89 m^3 ob of chipwood (allows for 20% weight loss).
- £100 for tops.
- £1.21 loading cost for smallwood.
- £0.40 increased working costs with smallwood.

59. The income for smallwood and tops could be thought of as £546/42.89 m^3 = £12.73/m^3. This could be reduced by £1.61 when considering working and loading costs, resulting in a gross income of £11.12/m^3 for 42.89 m^3/ha which is £476.90.

60. Where small chipwood is not cut and long tops are chipped income should increase. For tops revenue to increase to a level approaching smallwood revenue a payment of c £500 might be expected. The chipping contractor would then pay c £6.25/wet tonne for chips (£500/80 wet tonne/ha) with processing costs of c £6.50/tonne. Chip cost at forest roadside would be £12.75/tonne.

61. Based on indications from Section 1, Mr M Edwards currently pays c £2.32/wet tonne (£100/43.08 tonne) for chips from Scots pine sites.

62. This comparison assumes the benefit of practically brash free sites would remain with both systems. If contractors are unable to chip small tops when smallwood is worked the costs of clearing brash would have to be identified when costing long top chipping systems. The benefit of brash free sites with long top systems may result in a lower income being acceptable to acknowledge the ground preparation saving.

63. This type of comparison requires an insight into:

- Future smallwood markets.
- The probability of chip marketing
- Benefits to ground preparation systems
- Nutrient status of sites with top removal.

Speculation on Chip Revenues

64. Long tops can be processed for c £6.50/tonne with between 73 tonnes/ha and 90 tonnes/ha of longer tops available per hectare on Scots pine sites. Revenue for wet chips is thought to be c £20/tonne (European data). The cost of chip haulage and the extent of possible chip markets is not known. If haulage costs were c £4/tonne and demand sufficient, future chip markets could offer an alternative to Kronospan markets.

Conclusions

65. Long tops occasionally up to 35 cm in diameter with an appreciable smallwood content were processed by a Bruks 800 Chipper mounted on a Kockums 84-35 with a Cranab Combi 660 loader.

66. Tops were presented by a Akerman H7/Lako 60 harvester, mainly at right angles or parallel to the direction of machine travel on the opposite side of the drift to roundwood. Top presentation did not affect shortwood presentation. The Bruks 800 chipped tops before or after shortwood extraction with no discernable difference in site brash clearance.

67. Chipper output increased by up to 76% when long tops were processed.

68. The 70 year old Scots pine crop yielded 43 tonnes of chips when cutting short tops and between 75 and 90 tonnes/ha from long tops. The average tree size was c 0.95 m^3 ob with standing volumes of c 278 m^3 ob/ha.

69. Extraction costs were lower with long tops and when no chipwood was extracted than when short tops, similar sawlog lengths plus chipwood were cut. When cutting long tops and 3.6 m sawlogs only, extraction costs increased due to the small load sizes carried.

70. Surplus comparisons between short and long top working are not possible because green sawlog content was significantly different between sections.

71. Revenue for tops should increase if no smallwood is cut. Current revenue from tops is £100/ha equivalent to £2.32/tonne of wet chips. Depending upon management considerations this figure should increase to c £6 per wet tonne.

Recommendations

72. It is recommended that further data are gathered to provide management with more information on:

- Chip markets and revenues.
- Expected yields of chips for different crops/sites.
- Chipping machinery.

Acknowledgements

73. I would like to thank the staff of East Anglia Forest District, M Edwards (Chipping Merchant/Contractor) and Colin Saunders (TDB Forester) for their assistance with this Project.

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October 1998

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