INFORMATION NOTE
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Forest Research
An agency of the Forestry Commission
TECHNICAL DEVELOPMENT BRANCH

SUPPLY OF WOOD FUEL FROM SMALL WOODLANDS FOR SMALL SCALE HEATING

Case Study 4
Fell and Extract 2nd Thinning Broadleaves Using Farm Tractor Based Equipment

Introduction

This work forms part of a programme of case studies designed to give indicative costs of producing woodfuel for local use. The work is joint funded by the Forestry Commission and ETSU (on behalf of the Department of Trade and Industry),

The outputs and costs quoted in this Case Study are specific to the conditions described. However, it is intended that these results can, within reasonable parameters, be transposed to similar crops and sites. It should be noted that there are wide variations in the form of broadleaved trees and these will affect the unit costs associated with felling and primary processing.

Some data already exists on harvesting and comminution of timber and timber by-products for use as fuel. The case studies have been chosen to fill the information gaps by matching appropriate equipment with a range of site and crop types. Where possible case study locations have an existing requirement for woodfuel or are considering installing a woodfuel heating system.

The work associated with this Case Study took place at Burwarton Estate in Shropshire. The estate runs two woodfuel heating systems. The manor house is heated by a Swebo/Farm 2000 chip fired 100 kW burner boiler which uses *c.* 120 air dry tonnes of wood fuel/annum. The Forester's house is heated by a 43 kW chip fired system which uses *c.*26 air dry tonnes of wood per annum.

Plate 1

Oak & Norway Spruce Crop

The estate has extensive woodlands and the opportunity arose to study the harvesting of early broadleaf thinnings on easy terrain. A field trial assessed the work methods and costs for producing a wood chip resource from second thinnings in oak crops, using farm tractor based extraction equipment.

Site Description

Key information relating to the study sites is summarised below (Tables 1 & 2). The site was originally agricultural pasture land with some scattered parkland oak trees. Previously used by the MoD as a munitions storage area the site was converted to plantation woodland in 1955.

TABLE 1

CROP DESCRIPTION

Species	Oak
Age	43 years
Crop description & form	Plot 1: Pure oak, reasonably good form and size. Some snow damaged crowns. Plot 2: Original 3 row oak/2 row NS. Oak thinning following on from separate NS thinning. Poor form to oak (Plate 1). Both plots have been thinned at least once in the past. Both plots oak YC 4.
Mean thinning tree size (m^3)	Plot 1 - 0.15 Plot 2 - 0.07
Mean thinning dbh (cm)	Plot 1 - 18 Plot 2 - 13

TABLE 2

SITE DESCRIPTION

Terrain	Mostly level, with no significant slopes or obstructions.
Soil type	Well drained sandy loam.
Vegetation	Brambles and grasses. Brambles had been mown in Plot 1 and pushed down by harvesting operations in the Norway spruce component of Plot 2.
Access	Very good access. Woodland well roaded to supply the old MoD storage buildings.

Case Study Specification

The work specification was to fell marked trees from an early thinning oak crop and extract produce to roadside for subsequent air drying and chipping. All produce had to be stacked at roadside in 2.0 m lengths.

Two harvesting systems were selected for evaluation. These were:

- **Shortwood system;** motor manual felling and extraction to roadside using a farm tractor based forwarder with hydraulic loader.

- **Pole-length system;** motor manual felling, skidding to roadside, chainsaw crosscutting and stacking.

Chipping was not included in this case study.

Equipment Description

All felling and conversion was completed motor manually using a Husqvarna XP266 chainsaw. Four other items of equipment were used for extraction (Table 3).

All the equipment used in the trials was owned and operated by Mr John Barre, a local forestry contractor. Machine prices quoted are for typical second hand units.

TABLE 3

EQUIPMENT DESCRIPTION

Item	Specification	Cost
Forwarder tractor	Zetor 9145 (90 hp) 4 wd	£3 000
Skidder tractor	County 1164 (116 hp) 4 wd	£4 500
Winch	Fransguard TW3500 double drum winch; 1 x 100 m & 1 x 40 m 100 mm wire rope.	£ 800
Forwarding trailer	c 6 tonne timber trailer with FMV crane.	£2 000

Trial Description & Comments

Shortwood System

This system was studied in the pure oak crop (Plot 1). A standard method was adopted with trees felled and crosscut at stump. Small piles were assembled for extraction by the forwarder. Hung up trees were dragged down using a tractor skidder winch.

Key features of the study were:

- Product density - 29 m^3/ha
- Mean piece size - 0.019 m^3.

There were 2 main comments on the study. The first was that it was difficult to impose an organised felling system on the crop. The shape of the crowns made it difficult to maintain a given felling direction. Secondly, there was no formal rack layout and the forwarder had to 'meander' through the crop.

Pole-Length System

This system was used in the mixed oak/spruce crop (Plot 2). The spruce had been removed prior to the thinning of the oak. On occasions the method was unconventional in that extracted poles were converted at an 'in wood' location with a secondary handling operation (forwarder) to take them to roadside. Time associated with this unnecessary operation was removed when calculating work output.

Key features of the study were:

- Product density - 30 m^3/ha
- Mean tree size - 0.07 m^3

The main study comment is that secondary handling operations should be avoided where possible to minimise costs.

Harvesting Work Outputs & Costs

The calculated work outputs for timber volume (m^3) per Standard Hour and their associated costs are shown in Table 4. Work outputs are based on an assumed extraction distance of 100 m in wood and 25 m in road.

Standard costs, which TDB has derived from hire charges for machinery typically associated with small woodlands and wood fuel production, have been used:

- Operator - £8.00/hr
- Chainsaw - £1.50/hr
- Farm tractor skidder - £4.00/hr
- Small farm forwarder - £5.50/hr

The costs of production are converted from volume to weight using a conversion factor[1] of 0.94 m^3/green tonne. The actual moisture content of the wood processed during the trial was 46 % (wet basis).

TABLE 4

WORK OUTPUTS AND COSTS

Component	Shortwood System		Pole Length System	
	Output (m^3/shr)	Cost (£/m^3)	Output (m^3/shr)	Cost (£/m^3)
Fell	1.50	6.33	2.50	3.80
Extract	3.00	4.50	2.30	5.21
Cross Cut	N/A	N/A	8.00	1.19
Total cost (£/m^3)	10.83		10.20	
Cost (£/Green Tonne)	10.18		9.59	

Although the pole length system appears to be the cheaper of the two, the difference is marginal (*c*. 6%). However, the 2 studies are not directly comparable. Although the thinning intensity was similar in both studies, the tree size was twice as large in the plot worked by the shortwood system compared to trees in the plot worked by the pole length system.

If the tree size had been the same in both plots it is likely that the skidder system would have been the cheapest option, by a greater margin than shown in Table 4. The forwarder system will become more competitive as the extraction distance increases.

Total Wood Fuel Production Costs

Using existing output data for chipping and transport, total production costs for the 2 systems have been calculated (Table 5).

TABLE 5

WOODFUEL PRODUCTION COSTS @ 30% mc(wb)

Component	Shortwood System	Pole Length System
	Cost (£/t)	Cost (£/t)
Fell, extract & crosscut	14.04	13.22
Chip	8.08	8.08
Transport (3 km)	5.06	5.06
Cost (£/Air Dry Tonne)	27.18	26.36

The data in Table 5 assumes that the wood is stored in roadside stacks until needed and air dried to *c*. 30% mc (wet basis). The wood is then chipped at roadside and the final product is delivered to the burner using a tractor and silage trailer.

A distance of 3.0 km has been assumed for transporting the chipped product to the burner.

The costs quoted for felling, extraction and conversion reflect the change in moisture content between the time of felling and chipping.

Energy Costs

The amount of water in the wood affects the energy value of it as a fuel product. The energy content of oven dry wood is 19.4 Giga Joules/tonne (GJ/t). At a moisture content of 30% (wb) the net calorific value is 11.6 GJ/t.

Using the data from Table 5, a comparison of the energy costs for the 2 harvesting systems is presented in Table 6.

TABLE 6

ENERGY COST OF WOODCHIPS DELIVERED TO BURNER

Extraction system	Cost (£/air dried tonne)	Energy cost (£/GJ)	Energy cost (Pence/kWh)
Shortwood	27.18	2.34	0.84
Whole pole	26.36	2.27	0.82

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1 Forestry Commission, Booklet No 39 Forest Mensuration, 1998.

The energy costs shown in Table 6 equate to buying oil at *c.* 8.2 p/l (inc VAT). Wood fuel produced and used by the woodland owner does not attract VAT.

If the Estate had to pay for the standing trees a cost of *c*. £4.87/air dried tonne (£4.00/m^3) could be expected. This would increase the energy cost to 0.99 and 0.97 p/kwh. These costs equate to buying oil at a cost of *c.* 9.7 p/l (inc VAT).

The quoted fuel costs assume 100% burner efficiency. Burner efficiency will influence the final energy costs for all fuel types.

Although 30% mc(wb) has been used in the cost analysis, samples collected from the two burners at Burwarton Estate found that they typically burnt wood chip at 37% mc(wb). At this wetness the energy value of the material falls to 10.27 GJ/t and the energy cost rises to 1.1 p/kwh (*c*. 11.0 p/l oil equivalent + VAT).

Conclusions

Both of the systems studied showed themselves to be capable of delivering chips to the burner at a cost of circa £27/air dry tonne (30% mc wb). This equates to an energy cost of *c*. 0.80 pence per kWh and an oil equivalent cost of 8.2 p/l (inc VAT).

The data presented in this report could be applied to crops similar to those described in this report on level, unobstructed terrain.

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