# INFORMATION NOTE ODW 12.02

Forest Research
The Research Agency of the Forestry Commission
TECHNICAL DEVELOPMENT

# WOODFUEL PRODUCTION FROM SMALL, UNDERMANAGED WOODLANDS

## Introduction

This Information Note is one of a series produced for a Technical Development Branch (TDB) Outdoor Workshop (ODW) and is produced as a guide to part of a harvesting system suitable for use in small-scale woodlands. ODWs are a TDB initiative designed to offer practical advice to practical people through presentation, demonstration and user guidance. The ODW programme will involve repeating trials and introducing new systems around Great Britain so that a wide range of sites, systems and practitioners can be included.

*Information has been gathered from equipment and method trials based at a single location. This information therefore must be taken as indicative only. Variation could be expected for other operations where factors such as terrain, crop specification, product specification, operating distances or operator efficiency differ.*

## Summary

A large number of systems are available for the production of woodfuel, some of which are very basic. The economics of using wood for fuel are very dependent on the woodfuel burner/boiler appliances used, the costs of production and the moisture content of the final product. If efficient appliances are used, far higher production costs may be sustained than are acceptable for conventional roundwood markets. Modern woodfuel systems for procurement and use have potential for rehabilitating undermanaged and neglected woodlands.

## Introduction

A range of self-stoking wood burning equipment is available which is suitable for heating individual houses and small complexes or community facilities. Small woods (Plate 1) have the potential to supply a fuel market in addition to those of charcoal and conventional firewood despite frequent poor timber quality and inaccessibility.

Plate 1

Small undermanaged woodland

Research has indicated that woodfuel should be:

- Dried for efficient combustion, ideally to a moisture content wet basis (WB)[1] of between 20% and 30%.
- Either in the form of logs or chips to the size specifications preferred by the individual appliance manufacturer.

[2] Moisture Content % (Wet basis) = $\frac{\text{Wet - Oven Dry weight}}{\text{Wet Weight}} \times 100$

The objectives were:

- To provide advice on systems by which woodfuel can be produced, in a form suitable for use in modern stoker burner central heating equipment, from small woodlands.

- To recommend harvesting, extraction, transport and comminution equipment, which is suited to the main site types, envisaged. To include consideration of existing farm and contractor equipment.

- To provide indicative costs of the systems, where possible relating these to specific feasibility studies.

## The Available Resource and its Potential

There is estimated to be a total of *c*. 350 000 ha of privately owned undermanaged woodland in Great Britain. This is largely broadleaved woodland characterised by:

- Diverse ownership, small size (31% less than 2 ha) and location within farmland.

- Difficult access due to rough steep terrain, poor drainage and a lack of road infrastructure.

- Distribution over large areas frequently remote from main markets.

- Low timber value due to species, genotype and lack of management.

- High wildlife, landscape amenity and frequently sporting value.

Likely yields vary widely and depend on the type and state of the woodland and the management prescriptions. For example, the yield from two recent case studies has ranged from 20 $m^3$/ha (thinnings) to 200 $m^3$/ha (coppice clearfell).

As a guide to domestic consumption, as little as 0.1 ha (0.25 acres) of coppice cut annually could fuel a medium size farmhouse. On a 30 year rotation 3 ha (7.4 acres) would be needed for a sustained supply. Estimated requirements have been given in a previous TDB publication[2]. Anticipated shortfalls from small-undermanaged woodlands could be supplemented by Short Rotation Forestry (SRF) systems[3].

## Woodfuel Production Systems and Indicative Costs

### Felling

The chainsaw is likely to remain the main method unless there are significant mechanised system developments or labour costs escalate.

Forestry Commission output information (Table 1) gives an indication of (piecework) costs for thinning a broadleaved crop (oak). Figures assume a worst case scenario of a small, 0.1 $m^3$ mean tree volume with 40% of trees Ivy covered.

Table 1

Felling cost indications

| Felling System | Whole Pole (Skidder Winch Extraction) | Shortwood (Forwarder Extract) |
|---|---|---|
| Total Cost (incl. Worker owned saw) | £5.42/$m^3$ | £8.04/$m^3$ |

A recent case study in Suffolk[4] indicated shortwood-harvesting costs to be *c*. £6.20/$m^3$. The study consisted of a 2 man team, using a chainsaw and farm tractor forwarder, clearfelling ash coppice with a mean tree volume of 0.12 $m^3$.

### Crosscutting

Chainsaw crosscutting of extracted whole poles at the 'landing' may be necessary. To cut lengths suitable for feeding into firewood processor may cost:

- 2 pieces per 0.1 $m^3$ pole = £1.66/$m^3$

- 3 pieces per 0.1 $m^3$ pole = £1.99/$m^3$

### Extraction

For small-scale operations options are:

- Forwarding, that is loading onto and taking out on forestry trailer. A wire loader is the cheapest equipment.

- Skidding, that is dragging behind a tractor with a winch.

- Pedestrian controlled small-scale extraction units.

- Small portable winches for shorter distances.

2 Forestry Commission (1996) Technical Development Branch, Technical Note 16/96, *Small-scale Woodfuel Heating Equipment for Farms.*

3 Forestry Commission (1996). Technical Development Branch, Technical Note 17/96, *Establishment and Maintenance of a Wood fuel Resource.*

4 Forestry Commission (1995). Technical Development Branch, Technical Note 26/95, *Harvesting in Undermanaged Woodlands: An Initial Investigation.*

- High leading on steep ground. A simple cableway system for an agricultural tractor double-drum winch.
- Log chutes for downhill working on steep ground.
- Horse extraction.

There are many other 'low-tech' systems, such as hand loaded farm tractor/trailer, linkbox, or 'Alice Holt' type drawbar systems for pulling out delimbed poles.

Forestry Commission output guides indicate the following extraction outputs and costs (Table 2). Figures are for broadleaved (B/L) crops unless indicated otherwise.

Table 2

Extraction Cost Indications

| Extraction System Type | Operating Cost (£/hr) | Load Size ($m^3$) | Extract Distance (m) | Treatment and Terrain | Outputs ($m^3$/Shr)* | Costs (£/$m^3$) |
|---|---|---|---|---|---|---|
| Small Forwarder (Agric. Tractor) | 18.0 | 3.0<br>3.0 | 100<br>400 | Clearfell flat, (coppice stumps) | 1.89<br>1.60 | 9.52<br>11.25 |
| Forwarder (Wire loader) | 14.0 | 3.0<br>3.0 | 100<br>400 | Thinnings flat | 1.64<br>1.44 | 8.54<br>9.72 |
| Skidder (Ford County) | 15.0 | 1.0<br>2.4 | 100 & 300<br>100 & 300 | Thinnings moderate terrain | 1.5 & 1.25<br>3.3 & 2.7 | 10.00 & 12.00<br>4.54 & 5.55 |
| Pedestrian Forwarder | 13.0 | 1.24 | 50 to 150 | Thinnings easy terrain | 1.7 to 1.4 | 7.65 to 9.28 |
| Portable Winch | 12.0 | 0.22 | 15 to 25 | Thinnings steep | 3.2 to 2.4 | 3.73 to 5.11 |
| Log Chutes | 18.5 | 0.5<br>0.75<br>1.4<br>(per 10 m setup) | 59<br>64<br>56 | Thinnings steep<br>Thinnings steep<br>Thinnings steep | 0.76<br>1.01<br>2.59 | 24.34<br>18.32<br>7.14 |
| High Leading (Conifer crops) | 24.0 | 0.5<br>0.15<br>0.5<br>0.15 | 120 Rack<br>100 Rack<br>60 Rack<br>60 Rack | Steep thinnings<br>Steep thinnings<br>Steep thinnings<br>Steep thinnings | 2.54<br>0.96<br>2.98<br>1.18 | 9.45<br>25.00<br>8.05<br>20.33 |
| Horse + Arch/ Sledge | 12.1 | 0.15<br>0.15<br>0.38<br>0.38 | 40<br>100<br>40<br>100 | Thinnings steep<br>Thinnings steep<br>Thinnings soft/flat<br>Thinnings soft/flat | 0.97<br>0.47<br>2.04<br>1.66 | 12.47<br>25.74<br>5.93<br>7.29 |

* Standard Time: Standard Hours include relevant allowances for Rest and Other Work. These vary according to the demands of the particular work type

## Woodfuel Processing

There are two main categories of direct 'forestry' derived woodfuel, logs and chips. There is variation within these according to individual burner requirement. Optimal heat values may only be obtained from the correct processing specification. Processing machinery can usually be adjusted to give the product specification required (usually length/size variations). Quality, especially for chip, is dependent on the form of the raw material (eg thinner branchwood gives more slivers).

A range of sizes and capacities of chipping[5] and firewood processing[6] machinery is available. Processing outputs and costs from recent broadleaved working are given in Table 3.

Machine outputs are quoted in 'solid' volume. Unit costs are shown for both volume and weight and assume that 1 $m^3$ of fresh felled timber has moisture content of 50% WB and weighs 1 tonne. Air dry timber is assumed to be 25% moisture content (WB).

Table 3

Woodfuel Processing Output and Costs

| Machine Category | Raw Material | Output ($m^3$ solid) per standard hour | Cost (£/shr) (Inc Labour) | Cost (£/$m^3$) (Solid) | Cost (£/air dry tonne) |
|---|---|---|---|---|---|
| Firewood Processor -complex | Random delimbed lengths | 1.22 | 15.09 | 12.37 | 16.5 |
| Firewood Processor - simple | | 0.49 | 13.22 | 27.18 | 36.24 |
| Woodfuel Chipper[7] | Pulpwood (hand-feeding) whole tree (grapple-fed) | 4.16<br>5.75 | 20.00<br>25.00 | 4.81<br>4.35 | 6.41<br>5.80 |

Total woodfuel production costs, to an air dry state from the above tables example, could vary between *c*. £18/tonne and *c*. £68/tonne. Delivery to point-of-use store could add to costs or be absorbed in extraction costs if, for example, used on the farm.

## Discussion

Production costs may be covered by the value of the heat realised from the woodfuel. A key to efficient heat realisation is the design of the burner/boiler. Modern units (Plate 2) can achieve between 50% and 80% efficiency compared to open fireplaces, which even with very dry wood do not achieve more than 35%.

Plate 2

18 kW log fuelled cooker/boiler (small farm house) shown with loading door open

The calorific value of a cubic metre of wood depends largely on its moisture content. Air-dried wood has a calorific value of *c*.14 GJ/tonne[8]. The assumption that 'air dry' wood has a moisture content of *c*. 25% WB, may be conservative as some recent log store measurements have given values of between 13% and 22.5% WB. Some modern chip fuelled burners can work efficiently with moisture contents of 40%, (Plate 3).

Plate 3

Modern 30 kW moving grate, chip fuelled boiler.
Showing - ceramic lined firebox,
heat exchanger tubes,
feed hopper (at back) and lid open)

5 Forestry Commission (1998). Technical Development Branch, Technical Note 9/98, *Wood fuel Chipping, Field Trials.*

6 Forestry Commission (1995). Technical Development Branch, Technical Note 14/97, *Evaluation of Firewood Processors*.

7 Forestry Commission (1997). Technical Development Branch, Technical Note 3/97, *Trial of Two Small Scale Chippers*.

8 Giga Joule (GJ) = 277.8 Kilowatt Hours, (kWh).

The cost of alternative fossil fuels such as mains gas and oil at spring 2003, was in the range of £3.69/GJ to £8.87/GJ at assumed burner efficiencies of 90% and 60%.

Using the total woodfuel production costs of £18 to £68 and assuming a calorific value of 14 GJ/tonne for 'air dry' wood, gives a realised heat cost of between £2.57/GJ and £9.71/GJ with a 50% efficient burner, and between £1.61/GJ and £6.07/GJ with an 80% efficient burner. Derived values for heat depend on the final moisture content of the woodfuel and efficiency of the burner.

Alternative markets for roundwood have values of *c*. £16/m³ to £22/m³ so woodfuel is a potentially competitive market.

## Conclusions

Production costs from small woodlands are generally higher than those associated with larger scale forestry operations, often because of particular small woodland characteristics and the constraints imposed.

Properly prepared and burnt, woodfuel has a potential to sustain higher production costs than alternative small roundwood outlets.

Woodfuel production could be an effective means of recovering the high costs necessary for the rehabilitation of undermanaged woodlands. The greatest benefit will be if the fuel is consumed locally or within the production holding, as this reduces the cost of transporting a bulky product.

## Recommendations

Efficient modern wood burning equipment should be used to optimise the value of woodfuel.

Woodfuel should ideally be 'air dried' to a moisture content WB of *c*. 25%.

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