Forest Research
The Research Agency of the Forestry Commission

TECHNICAL DEVELOPMENT

REPORT 2/97

SMALL SCALE MECHANISED EXTRACTION: CASE STUDIES

Two portable winches and a modern pedestrian controlled forwarder were evaluated in Welsh upland broadleaved conditions. Winching costs were ,3.23/m; and ,4.40/m; for extraction distances of 14 m and 16.8 m respectively. Pedestrian forwarder costs were between ,7.65 per m; and ,9.63 per m;; per 100 m extracted.

FOREST RESEARCH
TECHNICAL DEVELOPMENT BRANCH
REPORT NO 2/97

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Summary

1. Three items of equipment were tested, the Kolpe and Sollid portable winches and the Oxen pedestrian controlled forwarder. Each was found to be effective in its own particular role. These are discussed fully with other, yet unexamined, potential uses for the equipment. Costs from ,3.23/m; to ,4.40/m; for 14 m or 16 m extracted were calculated for the winches under 1 man operation. The pedestrian forwarder costs ranged from ,7.65/m; to ,9.63/m; per 100 m extracted.

Introduction

2. This project was set up to select and study small scale mechanised equipment suitable for working small upland broadleaved woodlands. A trial took place at Ceredigion Forest District, Wales in the spring of 1994. The Kolpe winch, the Sollid winch and the Oxen pedestrian controlled forwarder were tested.

Machine Descriptions

3. The **Kolpe 500** thinning winch (Swedish).

The complete winch equipment (Plate 1) includes:

- The winch and engine unit, with 35 m of 4 mm diameter wire rope with a terminal hook.
- A metal winch mounting bracket complete with security clips for mounting to a tree.
- A terylene mounting bracket with a ratchet strap, for securing the mounting bracket to a tree.
- A tool kit, owners manual and spare parts list.

4. Additional or alternative equipment includes:

- A mall pulley block with terylene tree strap for deflecting the line of pull.
- Gassfibre choker cones and skid pans.
- Alternative mounting brackets such as a trailer headboard or ATV.
- Winch extension wires complete with terminal hooks.

5. The Kolpe 500 is powered by a Tanaka TIA-305, 31 cc 2 stroke engine producing 1.6 hp at 7 500 rpm. Maximum torque is 1.6 Nm at 5 500 rpm. The engine drives the winch drum via a centrifugal clutch and helical gears (reduction ratio 41.7 to 1). Final drive is by a fully enclosed single row chain to the winch drum sprocket. At the winch drum sprocket, there is a spring loaded black plastic 'T' handle which engages and disengages the final drive.

6. Maximum winch pull is 4.9 kN (c 0.5 tonne) for a bare drum, winch weight of 14 kg. Winch speed is quoted at 0.4 m/s.

7. The engine runs on a 4% fuel/oil mix (25:1) with either leaded or unleaded petrol. A good quality 2 stroke oil is recommended. Engine starting is by conventional recoil mechanism. Ignition is electronic with a well-marked safety switch. Carburation is by a diaphragm carburettor with a choke strangler mounted on the air filter. Engine revolutions are controlled by a short cord, from a lightly sprung lever mounted on the top carrying handle.

8. A tank mounted below the starter mechanism, on the opposite side of the wire drum to the drive chain case, has a capacity of 0.5 litre.

9. **The Sollid "Timberjack"** winch (Norwegian).

The complete winch equipment is enclosed in a metal, box-section chassis (Plate 2). It contains:

- The Honda GX160 four-stroke engine.
- A reduction gear box.
- A final chain drive to a single plate clutch.
- The winch drum and small fairlead tower.

10. At the rear of the chassis is a semicircular set of tree gripping spikes. Two keyhole chain plates, at the top of the short winch tower, locate the winch anchoring chain which is passed around a suitable tree.

11. The 163 cc Honda 4 stroke engine develops 5.5 hp at 3 600 rpm. It runs on 95 octane, lead free, petrol and has a tank capacity of 3.6 litres. Maximum torque is 10.8 Nm at 2 500 rpm. Starting is by a conventional recoil type mechanism. The carburettor is a conventional downdraught type with well labelled choke strangler and petrol shut-off controls. Ignition is transistorised and controlled by a labelled on/off switch. Winch operation is via a short cord to a lever which simultaneously engages the clutch and opens the throttle.

12. The winch drum holds 40 m of 6.5 mm diameter wire rope. Winching speed is quoted at 1 m/sec with a maximum force of 1 000 kg (1 tonne).

13. Overall dimensions are:

- Maximum width 470 mm.
- Maximum length 620 mm.
- Maximum height 800 mm.

Overall weight is quoted at 50 kg.

14. Alternative/optional equipment includes:

- Rope pulley blocks for deflecting the wire rope.
- An attachment for the remote (line) control of the unit.
- Alternative engines (eg Briggs and Stratton).
- Glassfibre skid cones for easier winching.

15. **The Oxen** pedestrian controlled forwarder (Swedish).

The unit tested consisted of a hydrostatic drive, rubber tracked base unit with a hydraulically powered small wire loader and a 4 wheel bogie axle timber trailer (Plate 3).

16. The base unit was powered by a Robin EH34, 338 cc 4 stroke overhead valve petrol engine, developing 11 hp (8 kw) at 3 600 rpm with a maximum torque of 23.6 Nm at 2 500 rpm. The engine directly drives 2 'piggy back' hydraulic pumps giving 140 bar pressure at 36 litres per minute from 3200 rpm. The 25 litre hydraulic tank is built into the base machine chassis.

17. The engine runs on unleaded fuel and has a tank capacity of 6 litres. There is a conventional recoil starter. All controls, choke, ignition switch and fuel cut-off are well labelled and located together on the carburettor side of the engine. An alternative 'dead-man' ignition cut-out is prominently located at the end of the steering tiller arm.

18. The 400 mm wide steel cleated rubber tracks are each located on 3 rubber tyred wheels. The axles are fixed to the main chassis by short metal box sections. The front rubber tyres of each track are grooved for gripping the track cleats and are each hydraulically driven by a motor situated inside the respective box section wheel mounting. Steering and drive is by individually or simultaneously controlling the function of these wheel motors. Two hydraulic spool valve blocks, underneath the engine mounting, are manipulated by the front tiller handlebar and make the base unit very manoeuvrable and easily controlled. Pulling capacity is quoted at 10 kN (1 tonne) and maximum speed at 4 kph (1.1 m/s).

19. The wire loader winch is hydraulically powered and has c 20 m of 4 mm wire rope. Maximum pulling force is quoted at 800 kg. The boom of the loader is manually adjustable to suit the lifting of different product lengths. Loader control is by a line cord which may be attached to an optional, line 'backpack' for remote control. The loader brake can suspend winched loads to assist manual positioning of loads.

20. The twin axle bogie trailer has a carrying capacity of 1 000 kg (1 tonne) and can be adjusted for product lengths from 2 m to 6 m. Trailer stanchion pipes are removable and can be reduced in height to ease manual loading. The trailer has a pivoting trunnion tube on its main towbar where it is connected to the base unit.

21. Optional accessories are:

- A hydraulic Clambunk.
- A deer carrying body and hand loading winch.
- A cargo body with hydraulic tipping option.
- A range of hydraulic powered tool attachments: chainsaw, branch lopper, mining drill, stone/steel cutters.

Supplier and Costs

22. The Kolpe 500 winch (complete) costs c ,750 (June 1997).
Optional pulley block and mounting belt, ,45.50.
Glass fibre skid pan, ,88.50. (all exclusive of VAT and delivery).

The Oxen base machine costs c ,6 885 (March 1997).
The hydraulic wire loader costs ,1 375.
Twin axle bogie, ,895.
Optional Clambunk, ,1 560. (all exclusive of VAT and delivery).

Both the Kolpe 500 and the Oxen are available from:

Image Forestry Ltd
St Agnes
Herne Lane
Rustington
West Sussex
BN16 3EB

The Sollid "Timberjack" winch costs c ,1 172.
There is no UK Agent.

It is available from:

Sollid MEK Verksted A S
6652 Surna
Norway
Telefax 073 - 60383

Operational accessories, line caddy and fibreglass skid pans are available from:

A T Osbourne
Shelley Lane
Ower
Romsey
Hants
SO51 6ZL

Site Description

23. The trial site, within Ceredigion Forest District, was situated at an elevation of 60 m on the south side of the Dovey estuary and had a sheltered west facing aspect. The 3.5 ha site of dense, unthinned, mixed hardwoods, consisted of an overstorey of mainly c 39 year old beech (Plate 4). Some birch had become established in the overstorey.

24. Overall terrain classification[1] was 3:4:3 although there was a wide variation in slope and ground roughness. At the southern end of the trial area, 0.5 ha had a slope of 10% to 20% (Class 2) with a relatively smooth forest floor (Roughness Class 1) and rich brown earth. This area had better oak stems in the overstorey and a considerable number of mainly small, competing beech in the understorey. The remainder of the site ran in a strip to the west of this area and below the boundary forest access road. This strip had a fairly steep rocky slope (Roughness Class 3) along its length. The western edge of the strip was bounded by agricultural upland pasture and a neglected trackway ran through an adjacent flat area.

Treatment Prescription and Product Presentation Characteristics

25. The treatment prescription for the area was multi-purpose to:

- Free the better stems from competition.
- Remove as much of the squirrel-damaged beech as possible.
- Open up the forest floor to light, to encourage the endemic flora such as bluebells, honeysuckle and hazel and enhance visual amenity and wildlife.
- Create refuges for small wildlife by piling lop and top.
- Cause minimal ground damage during operations.

The latter point was important as the work was scheduled for late winter/early spring (Plate 5).

26. It was clear that only fuelwood would be produced. A random 3 m to 5 m product length was adopted to make motor-manual felling and extraction as easy as possible. Product recovery was maximised and lop and top piling made easier by cutting the smaller stems to the longer lengths, with top diameters down to 4 cm to 5 cm. Heavy and awkwardly twisted stems were cut to the smaller lengths.

[1] Forestry Commission (1995). Technical Development Branch, Technical Note 16/95, Terrain Classification.

27. Products were presented in small piles, with 1 end flush and facing towards the direction of extraction. Bent and heavier pieces were left in singles and pairs to minimise effort. On the flatter southern area, piles were arranged so that the Oxen could be driven alongside for loading. On the steeper ground, intended for winching, piles had 1 end raised on a piece of waste wood for easier chokering.

28. During the trial c 0.8 ha of the area was completed and c 30 m; of produce, extracted to roadside (Plate 6).

Working Methods

29. Working methods for the 2 winches were basically similar, in that a suitable 'winching tree' was used and all produce pulled towards it (Plate 7). The Kolpe winch could be easily rigged at the required height to give a good accumulation of winched produce. Having a tree clamp device separate from the main winch body made 1 man rigging very easy (Plate 8).

30. The Sollid winch is too heavy for 1 man to lift. On flat smooth ground, it was possible for 1 man to drag the winch, if put into the skid cone. A choker chain or tree mounting sling was used to pull the cone. Norwegian methods, where the winch is pulled along inside its own skid cone, were rejected after a short trial on flat smooth terrain. There was insufficient control over operations and stability, due to the necessary sideways stance adopted to operate the winch control.

31. The Sollid winch was rigged in off-set fashion as it was too heavy for 2 men to lift up a tree (Plate 9). The optional extra pulley block and attachment strop is used to achieve this. The winch is placed at the bottom of an 'anchor' tree and the block at a suitable height on the 'spar' tree to allow for produce accumulation.

32. Important practical operating points for both winches are:

- The use of a length of cord, attached to the spring loaded operating handles, enables the operator to **always** stand out of the line of the powered rope. This also creates clearer vision as the produce stack is not in the way.

- A skidding cone is essential to prevent rope breakage due to loads jamming on roots, rocks, stumps etc. It also reduces ground friction and, most important, enables subsequent winched loads to ride up over others to form a stack at the winch or spar tree.

- Offsetting the winch to the right (when looking down the winch rack from the spar tree) tended to eliminate many rope twisting problems associated with offsetting the opposite way. Care must still be taken, especially with small diameter winch drums, to avoid this twisting tendency by carrying out early rope rewind procedures.

33. Rope haul out and load chokering procedures are similar with the skid cone:

- When handling wire rope, wear protective gloves.

- Do not attempt to carry the skid cone, let it drag behind.

- Hold the wire rope c 1 m to 2 m in front of the cone when hauling rope out.

- Place the choker chain join in the middle of the load, on the top. If this is **not** done, the skid cone will tend to run sideways and may cause problems.

- When attaching the winch rope, shorten the linkage to the choker chain joint as much as possible.

- With the skid cone still attached to the rope, slide it firmly under the front of the pile making sure all rope slack is pulled through it.

- Finally, walk back to the winch and haul in, keeping a careful watch on load progress.

- If problems occur, stop winching and rectify.

34. Working methods for the Oxen are mainly the same as for other pedestrian controlled forwarders[2]. They have mainly manual (assisted) loading and are similar to horse sledge loading systems. Good route planning and work ergonomics, feature largely in efficient practices.

35. Main attention points with the Oxen are:

- Walk facing forwards as much as possible (Plate 10). **Do not** lead the machine with a twisted body posture or walk backwards. If it is necessary to look behind, stop momentarily.

- If the engine is running, park the machine with the tiller held vertically against the lock-stops (Plate 11). Alternatively, switch the engine off. This will ensure the hydraulic drive system is either firmly locked in 'park' (neutral) or that no drive movements can take place.

- Use a 'line caddy' remote control device (Plate 12) when using the wire loader to be able to maintain safe working distances[3].

- When loading, use appropriate aid tools and protective clothing such as small timber tongs and wire rope gloves as well as normal protective equipment (helmet, boots etc).

- When hand loading, lift the heavier pieces onto the trailer first. Top up with lighter pieces.

- Always use a load binder to secure the load before extraction (Plate 13) as product pieces, especially if smooth barked and twisted, can easily slip on movement.

36. The hydrostatically driven Oxen can deliver maximum power at minimum speed. Careful tiller control can ease the machine up slopes, over obstacles and sensitive ground without track slippage and without causing ground damage (Plate 14).

Performance

37. **Kolpe 500 Winch**: This small, lightweight winch performed very well, was robust and reliable. The operators found it easy to carry and set up which makes it ideal for extracting small thinnings.

38. **Sollid Winch**: Except on level ground, this winch always required 2 operators to re-site it. There were no problems apart from some initial tower pulley damage, caused by rope twisting from off-setting the wrong way. The Honda engine performed in exemplary fashion, as did the other winch mechanisms which were given appropriate maintenance. This winch never achieved its optimum load due to the small stem size of the thinnings and the small load size imposed by the skid cone. It would be capable of much heavier work.

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[2] Forestry Commission (1993). Technical Development Branch, Report 1/93, Extraction by the 'Iron Horse' in Broadleaved Woodland.

[3] Forestry Commission (1995). Technical Development Branch, Report 3/95, Wire Loader Forwarder.

39. **Oxen**: This forwarder proved to be much easier to work and control than previously tested pedestrian controlled forwarders[4]. The major reasons for this were greater engine power, hydrostatic drive system and a metal grousered track which gave good grip. The trailer could hold its 1 tonne rated wood capacity in the 3 m to 5 m product lengths. Manoeuvrability was very good as the hydraulic drive powered **both** tracks at differing speeds when turning. Other machines steer by powering only one track and braking the other. Without the trailer, the Oxen could turn in its own length by driving 1 track forwards, the other in reverse.

40. The Oxen wire loader proved very reliable after an initial problem with a sticking hydraulic spool valve. The winch could hold suspended, pieces of 0.1 m;. However, it was far quicker to load by hand rather than use the loader. An important point was that there was no 'pivot' device (roller, or 'Y' pin) to assist loading. To help chokering the heavier pieces that were handled with the wire loader, a small set of timber tongs was attached to the loader rope. The main problem preventing use of the conventional wire loading system was the bent and twisted nature of the broadleaved product. Use of the clambunk version of the Oxen, to extract whole poles, might have been more efficient but dragging would have caused more ground damage.

41. The Oxen, empty, had sufficient grip to climb slopes of up to 40% in dry conditions. When laden, the machine failed on an uphill slope of 28% and only succeeded when over half the load was removed. Failure was due to the grooved tyres of the front wheel drive losing grip on the inside of the rubber track cleats. The track was stretching, allowing the driven front wheels to throw slack tread in front of themselves, becoming disengaged and slipping. Although the track was thought to be tensioned sufficiently, more tension was applied after referral to the UK Agent. This reduced track slippage. Specifications for track tension from the manufacturer are imprecise and the situation is not improved by stretchable track belting and front wheel drive. The fully laden machine was capable of reversing where it could not go forwards but this is impractical. The machine is good, but could be greatly improved by either less elastic track belting or by exchanging the driven front wheels and stub axle, motor and chassis mounting with the rear wheels.

Output and Costs

42. A summary of outputs and costs for the machines studied is given in Table 1. Standard outputs include an allowance of 20% for Other Work and 25% for Rest. Cost assumptions are given at Appendix I and details of studies at Appendix II and Appendix III.

Table 1

Summary of Outputs & Costs

Machine	Operating Cost (,/hr)	Mean Pile/Load (m;)	Mean Extraction Distance (m)	Output (m;/shr)	Cost (,/m;)
Kolpe winch (1 man)	11.50	0.22	16.00	2.61	4.40
Kolpe winch (1 man)	11.50	0.28	14.00	2.99	3.85
Kolpe winch (2 men)	21.50	0.21	16.75	2.52	8.53
Sollid winch (1 man)	11.25	0.25	16.00	3.44	3.27
Sollid winch (1 man)	11.25	0.22	14.00	3.48	3.23
Oxen (1 man)	13.00	1.43	100 m ride, 25 m road	1.70	7.65
Oxen (1 man)	13.00	1.06	100 m wood	1.35	9.63*

* If the wire loader assists the unloading, there is a cost advantage (,8.67/m; cf ,9.63/m;).

[4] Forestry Commission (1990). Technical Development Branch, Report No 13/90, Vimek Wagon 1300.

43. The maximum distance winched with the Kolpe winch was 23 m and with the Sollid 21 m. The Kolpe winch was much cheaper and easier to move to a new position than the Sollid:

- Kolpe (1 man) time to takedown, move 22 m and set up = 6.28 SM[5] or ,1.20.
- Sollid (2 man) time to takedown, move 30 m and set up = 27.86 SM or ,9.87.

Safety

44. The **Kolpe** winch is well designed with the final drive chain fully enclosed. However, the drive-engaging 'T' handle goes round with the wire drum when it is engaged if it is not used correctly. Correct operating procedure ensures that this item is only engaged/disengaged at engine tickover speeds when it is stationary. Misuse or failure of the centrifugal engine clutch will prevent this being achieved and must be rectified immediately.

45. The safest operating procedure is for the operator to control the Kolpe winch from a short distance. This can easily be done by attaching a short piece of strong cord to the top-mounted operating lever and gives several advantages:

- It removes the operator from the winch line of pull.
- It enables a better line of sight as he is not trying to look over previously extracted material.
- There is no chance of loose clothing being caught or snagged on operating machinery.

46. Care must be taken to prevent rope damage on **all** machinery using small diameter wire ropes. Any kinking or strand damage caused by incorrect chokering/winching procedures or equipment can dramatically reduce rope strength. Small diameter wire ropes **must not** be used to choker logs by hooking back onto themselves. Separate choker slings or chains should be used. Use of a skidding cone not only reduces load friction but prevents rope damage caused by ground friction and loads snagging on obstacles.

47. The **Kolpe** winch is very easy to rig. The lightweight tree attachment device is fitted first and there is little risk of strain to the operator. A single terylene strop is sufficient but it needs to be situated near the top of the metal attachment lug, to prevent any instability caused by rough tree bark etc. Alternatively 2 strops can be used.

48. The **Sollid** winch has a much more exposed final drive chain than the Kolpe. This causes no problem, providing the operating procedures using a short length of cord are **always** used.

49. The Sollid winch requires 2 people to move and attach it to a tree. Attachment is very robust and uses a length of chain. More care has to be taken when rigging this winch and attachment . The anchor tree must be secure and not allow the winch to swing sideways. A small space should be maintained under the large driven chain sprocket, to prevent contact with the ground. A short piece of small diameter wood underneath the chassis skids can help.

50. With all small scale equipment, regular maintenance and machine inspection is essential to maintain safety standards.

51. Prior to the evaluation of the **Oxen**, a short inspection was carried out in conjunction with Forestry Training Services, Training Development Officer. Several shortcomings were revealed including 2 safety points, relevant to UK practice:

[5] Standard Minutes include the allowances for Rest and Other Work.

- There was no control bar mounted safety cut-out.

- The winch could not be operated remotely from the line of pull.

These 2 points, along with several minor ergonomic considerations, were promptly and efficiently corrected by the UK Agent before the trial started.

52. The UK manufactured trailer connects to the standard 50 mm ball towing hitch on the base machine. The trailer tow bar incorporates a trunnion to reduce the effect on the base machine, should the loaded trailer overturn. The trailer does not incorporate brakes and braking is achieved by the hydrostatic drive of the base machine. It is essential to park the control bar vertically in the slots provided to ensure drive is in neutral when stationary. There was evidence of some 'creep' when the machine was loaded on a 28% slope. Operators should be prepared for this.

53. Essential techniques of working a hydrostatic drive machine like the Oxen and a wire loading device are not acquired easily through self-teaching. Skill is also required to use essential aid tools such as hand tongs, line caddy and skid cone. All these aspects can have a dramatic effect on safe working and training from recognised sources is essential to ensure operational safety.

54. Noise levels: Measured at operator's ear were:

Kolpe Winch:	Tick over	=	88 dB(A)
	Full revs	=	101 dB(A)
Sollid Winch:	Tick over	=	70 dB(A)
	Full revs	=	84 dB(A)
Oxen Forwarder:	Tick over (Driving Position)	=	87 dB(A)
	Full revs (Driving Position)	=	93 dB(A)
	Tick over (Loading Position at side of trailer)	=	76 dB(A)

Ear protection must be worn where exposure exceeds 85 dB(A)[6].

Conclusions

55. **Kolpe and Sollid Winches**: The Kolpe winch is easier and cheaper to relocate than the Sollid and is better suited for short, 15 m to 25 m winching distances with frequent moves. The Sollid winch is more suited to slightly longer, 20 m to 35 m winching distances with greater pile and rack volumes requiring a lower frequency of moves.

56. Presentation has the greatest effect on winching efficiency. Poor presentation gives chokering problems.

57. Bent and twisted material reduced the load size which the fibreglass skidding cone could carry. A cone with a wider 'funnel' would accommodate larger loads.

58. Both winches were well made and reliable. The Kolpe is ideally suited for use with one-man chainsaw felling systems. The Sollid winch is not easily portable but has greater power than the Kolpe, although this was not used to best effect in the trials. It would be best suited to more demanding work, such as steeper ground, heavier loads and longer distances.

[6] FASTCo Guide (March 1995), No 801, Noise and Hearing Conservation.

59. Outputs of 3.0 m;/shr and 3.48 m;/shr for a winching distance of 14 m were obtained for the Kolpe and Sollid winches respectively, at costs of ,3.85/m; and ,3.23/m;. Poor presentation reduced outputs and increased costs.

60. The **Oxen** is very easy to use if operators are properly trained and is very robust. Correct track tension was difficult to judge and better guidance is needed from the manufacturers.

61. The stretching of the rubber track bands, under load, in combination with the front wheel drive and uncertain track tension limited the Oxen to a 28% uphill slope. These problems could be overcome.

62. A simple log pivot or roller attachment to the rear stanchion pipes of the trailer would make loading and unloading easier.

63. The forwarder is best used extracting 3 m to 5 m shortwood lengths over distances of 50 m to 100 m on terrain no steeper than 20% to 30%.

64. Outputs ranged from 1.35 m;/shr to 1.70 m;/shr and costs from ,9.63/m; to ,7.65/m; for an extraction distance of 100 m.

Recommendations

65. All 3 machines are recommended for use in small scale extraction of broadleaved thinnings.

66. The Kolpe winch, as a portable accessory to chainsaw felling, should be evaluated pre-bunching whole trees from early thinning for small loader-fed processors.

67. The Sollid winch should be evaluated with a larger skid cone in larger pile sizes.

68. The optional remote line caddy control for the Sollid winch should be tested.

69. The Oxen forwarder base unit should be evaluated in its alternative clambunk form. With whole poles or long logs, it may prove more cost effective by reducing loading and unloading times.

70. The manufacturer of the Oxen should be made aware of the track drive problems and the possible solutions discussed in this report.

Acknowledgements

71. I wish to acknowledge assistance from staff at Ceredigion Forest District, Wales, for all their help, technical assistance and essential felling preparation of this trial site. In particular I would like to thank Mr Robert Spiers (student), for successfully undergoing training and then operating all the equipment.

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Technical Development Branch

Develops, evaluates and promotes safe and efficient equipment and methods of work, maintains output information and provides advice on forest operations.

Appendix I

Cost Assumptions

		Kolpe	Sollid	Oxen
Capital cost ,-	C	1 008	1 100	7 390
Residual value ,-	RV	60	80	739
Life of machine/hrs-	L	2 400	3 600	5 000
Productive hrs/year-	PH	800	900	1 000
Life in years-	n	3	4	5
Interest rate %-	R	6	6	6
Discount factor-	$Dn = \frac{1}{(1+r^*)n}$	0.8396	0.9721	0.7473
Equivalent annual cost	$An = \frac{r}{1-Dn}$	0.3741	0.2886	0.2374
Capital cost (,/hr) =	$\frac{\{C-(RV \times Dn)\}An}{PH}$	0.45	0.33	1.62
Operating cost (,/hr)				
		0.45	0.32	0.50
Repair & maintenance		0.60	0.60	0.80
Fuel & oil		10.0	10.00	10.00
Operator (including oncost)		20.0 (2men)		
Total cost,/hr)		11.5 21.5 (2 men)	11.25	12.92

* $r = \frac{R}{100}$

Appendix II

Summary of Winch Studies

	Kolpe/1 man	Kolpe/1 man	Kolpe/2 men*	Sollid/1 man	Sollid/1 man
Terrain class	2:2:3	3:2:3	3:2:3	2:2:3	3:2:4
Uphill extraction slope (%)	28	28	30	16	39
Mean pile (m;)	0.22	0.28	0.21	0.25	0.22
Mean piece (m;)	0.025	0.034	0.034	0.03	0.026
Mean piece length (m)	4.48	4.96	4.96	4.48	4.43
Mean extraction length (m)	16.0	14.0	16.75	16.0	14.0
Number piles in rack	7	12.0	4.0	8.0	8.0
Volume in rack (m;)	1.54	3.34	0.85	2.01	1.77
Output (m;/shr)	2.61	2.99	2.52	3.44	3.48
Operating cost (,/hr)	11.50	11.50	21.50	11.25	11.25
Cost (,/m;)	4.40	3.85	(2 men) 8.53	3.27	3.23
% Breakdown of productive time					
Pull out rope	19.4	7.3	9.6	14.3	16.9
Choker	5.2	44.3	30.6	23.3	23.3
Walk back	9.4	7.2	8.0	2.9	16.5
Winch load	37.7	23.7	35.8	12.9	24.4
Unchoker	13.7	13.2	13.1	26.6	18.9
Re-choker	8.3	-	-	-	-
Adjust stack	6.3	4.3	2.9	20.0	-

Standard Output includes allowances of 20% for Other Work and 25% for Rest.

* Poor presentation.

Appendix III

Oxen Pedestrian Controlled Forwarder - Study Data

	Site I	Site II	
Terrain class	2:1:1	3:2:1	
Number of loads	1	4	
Mean load (m;)	1.43	1.06	
Mean pieces/load	53	38	
Mean piece (m;)	0.027	0.028	
Extraction distance (m)	168	55	
Terminal Time (SM/load)			
Move to load	4.77 (40 m) 25.82 (20% with wire loader)	2.43 (19 m) 22.04	
Load	-	2.01	
Manoeuvre in wood	10.13 (hand)	10.26 (hand)	or 5.54 (wire loader)
Unload	-	1.39	
Manoeuvre on road			
Total	40.72	38.13	33.41
Travel Time (SM/load)			
In road	0.67 (25 m)	-	
In ride	4.26 (100 m)	-	
In wood	-	3.86 (100 m)	
Out wood	-	5.24 (100 m)	
Out ride	4.19 (100 m)	-	
Out road	0.56 (25 m)	-	
Total	9.68	9.1	
Total Time/load (SM)	50.4	47.23	42.51
SM/m;	35.24/100 m on ride, 25 m on road	44.56	40.10
Output (m;/shr)	1.70/100 m on ride, 25 m on road	1.35/100 m in wood	1.50
Cost ,/m; (,13/hr)	7.65	9.63/100 m in wood	8.67

Standard Time includes an allowance of 20% for Other Work and 25% for Rest.

Plate 1. The Kolpe 500 winch

Plate 2. The Sollid ‘Timberjack’ winch

Plate 3. The Oxen, pedestrian controlled forwarder

Plate 4 The site at start of operations

Plate 5. The site at end of operations

Plate 6. Produce at roadside

Plate 7 The Kolpe winch in action

Plate 8 Rigging the Kolpe winch

Plate 9 Sollid winch rigged offset

Plate 10 Oxen, driving

Plate 11 Oxen, parking

Plate 12 Oxen, wire loading

Plate13 Oxen, load securing

Plate 14 Oxen, final ground impact