

TIMBER TRAILERS FOR AGRICULTURAL TRACTORS

Summary

A wide range of timber trailers for agricultural tractors is available. Prices (1995) range from £1500 for a simple standard non-driven unit to over £17 000 for a sophisticated power driven trailer.

Tractors, loaders and trailers must be properly matched and suited to the work programme for optimum performance.

Initial professional training is essential for safe, efficient working.

Studies are required to give up to date information on potential outputs and costs of a range of modern tractor trailer combinations.

Introduction

Purpose-built timber trailers for agricultural tractors have progressively developed over the last 20 years. They have kept pace with many improvements in forwarders and the increasing availability of small hydraulic loaders and agricultural tractor/forestry conversions. Modern forestry trailers are stronger and lighter, with a full range of size options and power driven facilities. With well chosen loaders and tractors, modern timber trailers should prove commercially viable timber forwarding units. There has been no recent evaluation to determine this potential because they have been overshadowed by larger purpose-built units.

The principles of forwarding, or moving timber on trailers, compared to skidding by dragging it along the ground are:

- Forwarding cut-to-length timber out of the wood keeps it clean and undamaged.
- Forwarders unload into large stacks of sorted products at roadside, making loading by subsequent road haulage easier.

Plate 1

FMV Dual Forestry/Agricultural Trailer



- The limited reach of a hydraulic loader requires a forwarder to travel widely over the harvested area. Winch skidders and wire loading forwarders do not.
- For extraction distances of c. 250 m or more, farm tractor forwarding is usually more economical.
- On a purpose-built forwarding trailer, loads of c. 5 m³ can be carried, compared to 2 m³ – 3 m³ with a similar skidding unit¹.
- Less tractor power is needed to pull a trailed load than a dragged one.
- Forwarding timber generally causes less ground damage than skidding, although care and good planning are always needed for best results.

¹ Forestry Commission (1990), Work Study Branch, Wales Team Report 19/90, *Skidding Winches for Farm Tractors in Broadleaved Woodlands*.

- Even powerful agricultural tractor mounted hydraulic loaders can have difficulty handling logs of c. 1 m³ or more. Winch skidders may then be desirable, although dirt contamination can affect sawmilling, sometimes leading to reduced prices.
- Farm tractor based skidding winches are cheaper than comparable forwarding equipment and are easier to operate.

The purchase of a purpose-built timber trailer may not be justified for small annual amounts of timber, such as firewood. Hand loading onto a conventional agricultural trailer can be onerous. A low-slung flat bed trailer is recommended for hand loading of wood billets. Such trailers may already exist around the farm for bale haulage. However, their low ground clearance often leads to difficulties in the wood and their light construction is easily damaged by heavy timber. *Four wheel, low loading drawbar steered trailers are particularly unsuitable as they cannot transfer any load weight to the towing tractor. This leads to a reduction in tractor wheel grip which can become critical in sloping conditions.*

Small amounts of timber can be forwarded with a conventional 3 tonne single axle, tipping farm trailer and a forestry wire loader. Such trailers cost c. £1000, depending on make. However, there are some disadvantages compared to a purpose-built forwarding trailer.

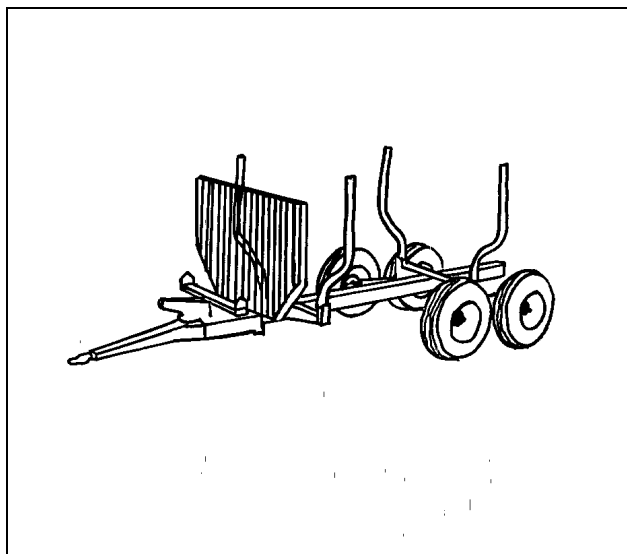
- If the trailer is tipped to unload, untidy stacks are likely.
- A 2 wheel, single axle trailer causes more ground damage and is affected by rough terrain.
- The load is carried fairly high with relatively poor ground clearance.

General Machine Description

Forestry timber trailers are of a 'skeletal' construction in that the maximum carrying capacity is achieved with the minimum weight. Strong cross-members for the trailer wheels assembly, the load carrying bolsters and stanchion pipes are attached to a single, or double chassis spine. A timber headboard (Figure 1) and hydraulic loader may be fitted at the front end. The trailer should always be attached to the tractor by a swivelling ring assembly to ensure safety and the necessary articulation on rough terrain in case of overturning.

Figure 1

Forestry Trailer General Design Principles



Capacities

A wide variety of logging trailers are available. Most popular tractor drawn models have payloads ranging from c. 3 tonnes to c. 8 tonnes. Five tonne models are the most common. Three to 5 tonne trailers are suitable for lower-powered tractors, 37kW (50hp) and part-time usage (Plate 1). Trailers for use with wire loaders cost c. £1500 from Sweden (Plate 2). Further details are available in a TDB publication². Some units are designed specifically for multipurpose agricultural/forestry use and would be suitable for larger, mixed programmes. Medium and larger forestry trailers and tractors of 60 kW (80 hp) are suitable for full time forest operations. Currently available trailers, when matched with suitable tractors and loaders, will cope effectively with annual programmes from c. 800 m³ to 8000 m³ dependent upon conditions and organisation.

2 Forestry Commission (1995), Technical Development Branch Report 3/95, *Evaluation of Tractor Based Wire Loader Forwarder*.

Plate 2

5 Tonne Wire Loader Trailer

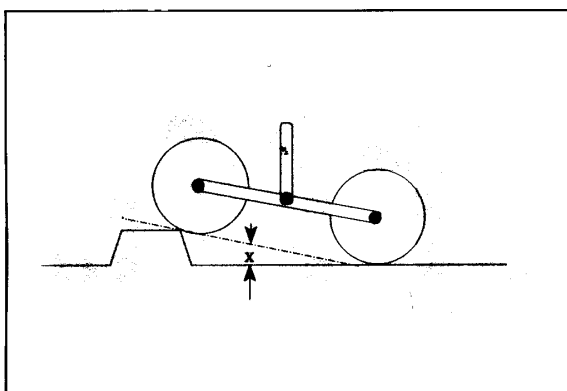


Wheels and Bogies

The smallest capacity trailers may have only 2 wheels but usually most forest models have a 4 wheel 'bogie' construction (Figure 2).

Figure 2

Bogie Design Principles

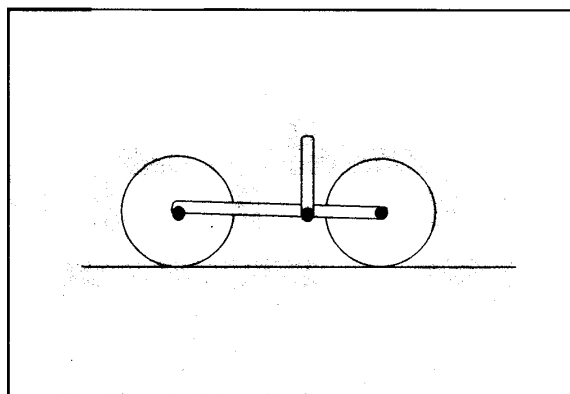


This makes negotiation of rough forest surfaces much easier. Principally it reduces the shock loading on the tractor hitch, caused by the trailed load, compared to both 2 wheeled and conventional double-axle 4 wheeled trailer constructions. It also reduces trailer load swaying. Unlike many agricultural trailer designs, appropriate forestry bogies should permit large vertical wheel movements (about 35E at the bogie arm). The shape of the upright timber stanchions should permit this free movement without contact with the load.

Bogie designs may vary. Sometimes the distance from the bogie pivot centre to the front wheels is longer than that to the rear wheels (Figure 3). This enables the front wheel to lift more easily when encountering obstacles whilst travelling forward. Such an asymmetrical design is suitable for low powered tractors and small diameter wheels.

Figure 3

The Asymmetrical Bogie



Wheels with tyres of approximately 8.50 x 12 are suitable for Wire Loader equipped trailers due to the greater need for a compromise between loading height and ground clearance³. Larger wheels with tyres of 11.5 x 15 to 14.00 x 16 are commonly fitted to give better terrain performance. Powered trailers may have even larger tyres, such as 500 x 22.5.

Generally there is a wide choice of tyres, which includes purpose-made forestry tyre equipment. Specialist tyre suppliers should be able to give the most appropriate advice for what is available.

- Wide section 'flotation' equipment is more expensive but necessary for soft conditions.
- Reinforced tyres may be necessary to resist conditions where there is a high puncture risk.
- High ply ratings are preferred. In general, most trailer tyres used in forest conditions will need ply ratings of between 10 and 14.
- Correct inflation pressures can maximise performance and tyre life.
- Tread pattern is usually a simple ribbed design.

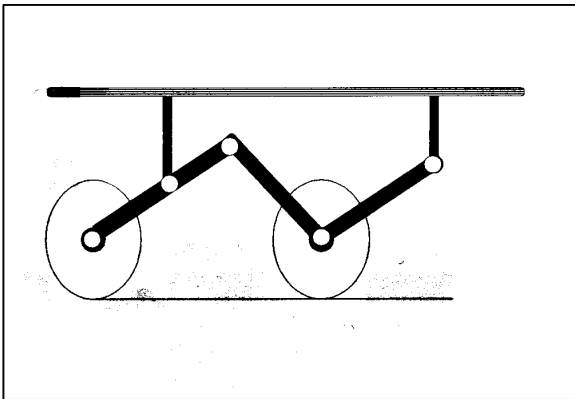
³ Tyres: First figure is width in inches or millimetres and the second is wheel rim diameter in inches.

- Driven wheels will need a cleated tread design to maximise grip. This tends to wear faster when used on hard surfaces. Large amounts of road travel should therefore be avoided.
- Use of band tracks with driven wheels or a 'cage roller' type of wheel drive, can produce high wear rates in cleated tyres. A multi-cleated or 'industrial' tyre will wear less.

The 'Trysil' design of bogie is fairly common in second hand machinery, although no longer manufactured (Figure 4).

Figure 4

The Trysil Trailer



This design allows the front bogie wheels to 'give' on encountering an obstacle and swing backwards and upwards. At the same time, through a rather complicated linkage, the rear bogie wheels are pushed downwards to compensate.

Bogies on driven trailers are always of the conventional, centre-pivoted type. The powered facility usually removes the need for complicated bogie designs, although wheel diameters are usually larger.

Bogie wheel band-tracks may be necessary to get the best from a power driven trailer in difficult terrain conditions. Unfortunately, bandtracks cannot be fitted to all current designs of power driven bogies. This is because there may be insufficient clearance on the inside of the wheels so that the band track fouls the bogie centre support frame. The central steel cage drive used on some driven trailers will also prevent the use of steel band tracks.

The bogie and wheel assembly on non-powered trailers should be movable along the trailer spine. Therefore, a choice of alternative location holes should be provided. This enables optimum weight transfer to the tractor. Different product lengths and loads will necessitate different settings, such as single and double-bunk loads to maximise performance and safety. In many designs, the bogie subframe assembly also serves as a timber bolster. This may prevent ideal weight transference and

load optimisation with some short length, double-bunk products. There is less need for the tractor to tow a powered trailer, so the weight transfer requirement is not as critical, depending on the efficiency of the power drive system. Some designs may best be described as 'power assisted' drives. Weight transference with a power driven trailer depends on the forward displacement of the centre of gravity of the load. This is easiest with a well designed, movable headboard.

Correct bogie design for forestry is a compromise between several beneficial but often conflicting features. For example, wheel spacing should be wide enough for the bogie to 'walk' over most stumps and stones. Too wide a spacing will cause great sideways stresses in tight turns when loaded. Too narrow a spacing will not give the required ride smoothness and may increase sideways swaying of the load. It may be best to purchase an established manufacturer's item, especially for larger models.

Timber Carriage Design

The timber carrying bolsters must be movable along the trailer to allow adjustment for different product lengths. Four bolsters will be needed for double-bunked material.

The upright stanchions, in the bolster ends, should be able to swivel round under impact but return to their original positions afterwards. An alternative is to provide several fixed stanchions to cater for a range of products but this tends to make the trailer heavier. The stanchions are susceptible to being bent and can cause damage to standing trees. Wire loader trailers, which are of small load capacity, must be fitted with specially designed, releasable stanchions. These enable the complete load to be unloaded in one movement and are also constructed in sections for ease of loading.

Headboards are useful for the alignment of timber. More importantly, they prevent timber from sliding forwards into the tractor cab. They are sometimes braced to the loader support or the trailer drawbar for increased strength. Load security in the absence of a headboard can be achieved by tightly binding the load together with a chain and 'beartrap' tensioner, or other suitable device. This technique also aids the unloading of wire loader trailers.

Effects of Loader Position

The hydraulic or wire loader is positioned either on the tractor or the trailer drawbar. In either case, careful matching of the components is necessary to give the desired characteristics. The loader should be able to place a load in any part of the loading area. A longer loader reach is required if the loader is mounted on the tractor but a shorter trailer drawbar may then be used, giving a tighter turning ability.

Loaders mounted on the trailer drawbar impart a considerable twisting effect to the main chassis spine, unless equipped with stabiliser legs. Such stabilisers are easily damaged if not retracted before moving off.

Drawbar mounted loaders must conform to the trailer manufacturer's design specifications and be properly fitted. The loader mounting should be regularly checked, usually during the weekly maintenance schedule. Larger capacity trailers often have a double spine chassis, which increases their torsional rigidity and permits use of higher capacity and/or longer reach loaders. A double chassis increases trailer weight and costs, so may not be found on the smaller models.

Tractor Requirements

If the trailer is to be used with a hydraulic loader, the operating position within the cab must be reasonably comfortable to prevent strain injury. The operator should at least be able to sit facing the trailer when operating the loader controls. Higher capacity and intensively used machinery require more facilities to maximise potential. Highest outputs can be achieved with tractors having a full reverse-facing drive ability, which also enhances safety when loading on sloping terrain.

Reliable traction is essential for safe and efficient performance. The greatest and most reliable aid to traction in forestry conditions is the tractor wheel chain. Types vary and fitting can be difficult, so good advice and training are needed. Wheel chains may also be fitted to the trailer to maximise braking effect and power drive. Chains fitted to the front bogie wheels will have greatest braking effect for a non-driven trailer. The best transfer of drive to the terrain will be achieved by chains fitted to the rear bogie wheels of a driven trailer. However, wheel chains cannot be fitted to a trailer driven by a 'cage-wheel' device.

In general terms, tractor power requirements for non-driven trailers will be approximately:

- 35 hp to 40 hp (26 to 30 kW) for a 3 tonne trailer.
- 50 hp to 60 hp (37 to 45 kW) for a 4 to 5 tonne trailer.
- 70 hp to 100 hp (52 to 75 kW) for a 6 to 8 tonne trailer.

Some 20 hp to 30 hp more engine power may be required for a driven trailer but this will depend on the type of drive and trailer size.

Frame steered tractors are not suitable for use with forestry trailers as the double articulation makes the combination difficult to manoeuvre. Weight transfer from the trailer can adversely affect the tractor when turning.

Effects of Steerable Drawbar

A steerable drawbar is now commonly offered on many trailers. This enables the trailer to follow in the tractor wheel tracks when turning and reduces the need for a wider rack width. It also reduces tyre 'scrubbing' and the tendency for a powered trailer to push the tractor on turns.

The control device should be easily accessible from a forward facing position.

Skill and understanding are necessary for best results. If the load is incorrectly carried with too much weight on the drawbar in a downhill situation, actuating the drawbar steering could cause the trailer to tip⁴.

All timber carrying trailers should be equipped with a pivoting drawbar pin assembly, so that overturn does not affect the towing tractor.

Traction Aids

Tractor travel speed is much slower when extracting timber by trailer than by winch skidding. Relying on speed and momentum to overcome difficult routes is dangerous. Different tractor designs suit differing circumstances:

- Properly equipped, 2 wheel drive tractors may be appropriate for small capacity trailers in firm, dry conditions.
- Four wheel drive tractors give the best traction but correct weight distribution between front and rear axles is important.
- Front axle loading can become very light, even on gentle uphill extraction, especially if a non-powered trailer is used.
- Large diameter front wheels, front weights and a front-mounted hydraulic tank all help, as does parking the loader over the tractor front.

⁴ This happens because the vertically acting weight component, from the load centre of gravity, falls outside the 'triangle of trailer stability'. This is the triangle formed by lines drawn through each wheel bogie pivot and the drawbar pin.

Terrainability

Terrainability varies depending on the combination of tractor, trailer and traction aids fitted. The best equipped and matched combinations should be capable of working on moderate slopes up to 33% or 50% (class 3 or class 4) if ground condition and roughness is exceptionally favourable⁵. Forwarding trailers will need bandtracks or chains and should be power-driven for consistent performance in such conditions.

The towing tractor must have 4 wheel drive, with a tyre 'foot print' area affording a good grip (at least 18.4" section on rear wheels) and fitted with aggressive 'ring' type wheel chains all round. Steep slope working with timber trailers and forestry converted agricultural tractors demands the greatest driver skill. Good training is essential.

The availability of very wide section flotation tyres for agricultural tractors and trailers now gives improved soft ground performance. Although still short of the capabilities of some purpose-built machinery, the lower capital cost of tractor-trailer combinations means that smaller loads can be carried economically in soft conditions. Well planned harvesting, giving good brash mats on extraction routes, will give the best results. In such circumstances, ground conditions class 3 and sometimes class 4 can be traversed.

Roughness class 3 is generally limiting for full trailer loads. Good rack layout and especially a thick brash mat will reduce the problems. Operator skill is required to choose the best route, load correctly and drive at a speed which avoids instability.

Combinations of more than one of the terrain limiting factors can be disastrous, even for the best equipped and set-up machine combinations. As the capabilities of tractor trailer combinations vary so much, the harvesting job should be planned from the outset around the known performance of the machinery.

Cost Indications and Availability

Prices (1995) for non-driven logging trailers can vary between c. £1 500 for standard units and £6250, dependent upon capacity and sophistication. Extra facilities will cost more. Driven trailers can vary from £9 200 to over £17 000. Estimated hourly costs are c. £1.00 and £3.90 for the trailers alone (Table 1).

Many types of trailers are available in the UK. Most are imported from Scandinavia but some are UK manufactured. Most are made by the same manufacturers as the loading devices, which ensure an easy match of components.

Output Information

Information on forwarding outputs with modern machinery in UK conditions is sadly lacking. Case studies of representative examples are required. For the smallest, cheapest machinery used with simple wire loading devices, outputs of around 3 m³ per standard hour have been recorded. Early work with Ford County based equipment and Trysil trailers showed outputs in line thinnings of c. 5 m³ to 7 m³ per standard hour. Improvements to machine, job organisation and technique should considerably improve performance.

Safety

A timber carrying trailer towed by an agricultural tractor is classed as an agricultural trailer for purposes of legislation. As such, current legal requirements apply for braking. Information may be found AFAG Guide 503⁶ Health and Safety Executive leaflet AS16 and the Agricultural Training Board guide to the use of farm vehicles on the road. Most current forestry trailers will have a descriptive plate or be provided with sufficient information to identify their intended capacity. Trailers manufactured after 1 January 1995 will carry the CE mark.

Carrying timber safely on trailers is not simple. To maintain efficiency and prevent accidents requires skill, especially in difficult conditions. Professional training at the outset is always a good investment and is essential to maximise safety and efficiency, which should give good early dividends.

5 Forestry Commission (1996), Technical Development Branch Information Note 16/95, *Terrain Classification*.

6 Arboticulture and Forestry Advisory Group (AFAG) Guide 503, *Extraction by Forwarder*.

Table 1

Cost Assumptions

Cost Assumptions					
		A	B	C	D
Capital Cost£	C	1 500	6 250	9 200	17 000
Residual Value£	RV	150	600	900	1 500
Life of Machine (hrs)	L	8 000	8 000	8 000	8 000
Productive hrs/year	PH	1 600	1 600	1 600	1 600
Life in Years	n	5	5	5	5
Interest Rate %	R†	6	6	6	6
Discount Factor	$DN = \frac{1}{(1+r)^n}$	0.7473	0.7473	0.7473	0.7473
Equivalent Annual Cost	$An = \frac{r}{1 - DN}$	0.2374	0.2374	0.2374	0.2374
Capital Cost £/hr = $\frac{C-RV \times DN}{PH}$		0.21	0.86	1.26	2.36
Repair and Maintenance		0.80	1.00	1.20	1.50
Total Cost £/shr		1.01	1.86	2.46	3.86

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

Assuming a life of c. 8000 hours and repair/maintenance costs of £0.80/hr to £1.50/hr

Conclusions

A wide range of timber trailers is currently available for use with agricultural tractors. Coupled with an equally wide range of loaders, timber forwarding machinery exists for a range of annual production programmes, from 800 m³ to 8000 m³. However, up to date information is needed to give a clearer picture of the range of machine capabilities and costs.

Properly matched, tractors, loaders and trailers give optimum performance.

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Recommendations

Case studies should be made of modern tractor/loader/trailer forwarding combinations across the range of non-powered and powered trailer sizes.

Equipment should be properly matched for optimum performance.

Operators should be professionally trained.

Acknowledgements

I wish to thank all the UK agents and Scandinavian manufacturers who have supplied me with information.

Technical Development Branch

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