WOODLOT TECHNOLOGY
Technical Note TN-123 December 1988

REVIEW OF FORWARDERS

I. Makkonen*

Abstract

This report reviews thirteen forwarder models from six manufacturers that are available in Canada. The engine output of the units sampled varied between 54 kW and 88 kW; their load capacity varied between 4010 kg and 10 000 kg (4 to 10 tonnes). Technical information received from manufacturers or distributors is presented in tabular format. Information on ground pressure with both standard and optional tires is also included in this report.

Introduction

This is the first of a series of three Technical Notes that FERIC plans to publish on wheeled forwarders. The purpose of this first report is to provide an overview of the forwarders available in Canada as of the beginning of 1988, with the exception of the Crabe F2000 forwarder which will be available in the beginning of 1989. The second report of the series, "*Technical Considerations when Choosing a Forwarder*" discusses different technical features and their influence on forwarder productivity and reliability, e.g., machine stability, differential locks, loader features, operator comfort, etc. It will help the reader to understand better the technical specifications of the forwarders discussed in this review. The third report of the series, "*Evaluation of the Timberjack 230 8-ton Forwarder*" discusses this particular forwarder model in detail and includes production studies that were carried out in Nova Scotia.

In the Nordic countries, 95% of the industrial roundwood harvested is extracted with forwarders, both from final fellings and thinning and shelterwood operations. In Canada, forwarders are used mainly in the Atlantic provinces; they are also used, but to a much lesser degree, in southern Quebec and southern Ontario. In 1987, nearly 80% of the wood harvested in Newfoundland was forwarded; in Nova Scotia, it was about 50%; in New Brunswick 30%; in Quebec and Ontario, it was less than 10% [1]. During the past five years, forwarder sales in Canada have varied between 30 and 50 units/year compared to annual skidder sales of about 700 units. In the United States, the annual sale of forwarders is estimated to be 60-120 units. In both Canada and the United States, forwarders represent about 5-7% of the total market of both skidders and forwarders [2]. Many of the forwarders in use in Canada are used in private woodlots.

The unwillingness of the buyer to pay extra for operator comfort and other optional features has kept North American-built forwarders basic and simple. Forwarders built in the Nordic countries usually offer a higher level of operator comfort and have more features to reduce soil and stand damage. However, the Nordic forwarders are generally more expensive to purchase. As a result of their higher prices (which change with currency fluctuations), very few Nordic forwarders are in use in eastern Canada.

Technical Specifications

- All technical information has been received from the manufacturers or the importers.
- The weight includes standard tires and the loader.
- The height is given with standard tires and includes, unless noted, the loader which is the highest point in most forwarders.
- The tractive effort is either calculated or measured; it is not directly comparable but indicative.
- The engine outputs are measured according to either SAE or DIN standards; these differ slightly from each other.
- Some manufacturers supply the forwarder with a "standard" loader; others leave the choice of loader to the customer.
- The lift capacity of the loaders is given in different ways: (a) capacity to lift at a certain distance, or (b) the maximum net lifting moment. The lifting moment presented in brackets is a product of given lift capacity and distance and can be less than the maximum net lifting moment.
- The list prices of the Rottne Rapid and Timberjack FMG 910 forwarders were not provided by the dealer. It is estimated each of these forwarders costs around $220 000.

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KEYWORDS: Forwarders, Product evaluation, Specifications, Ground pressure, Woodlot logging.

Cette Fiche Technique est disponible en français.

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 ISSN 0381-7741

Table 1. Forwarders for woodlot operations

Make and Model	CRABE F2000	VALMET-GAFNER IRON MULE 5110
Manufacturer	Rotobec	Valmet-Gafner Inc. MI, USA
Importer	-	La Have Equipment Ltd
Address	C.P. 189 Ste-Justine, Qc G0R 1Y0	P.O. Box 240 Bridgewater, N.S. B4V 2W8 Tel. (902) 543-2429
Vehicle Weight, kg (lb)	5540 (12 100)	6800 (15 000)
Load Capacity, kg (lb)	4010 (8 900)	4080 (9 000)
Length, m (in.)	7.04 (277)	6.63 (261)
Height, m (in.)	3.00 (118) excl. loader	2.74 (108)
Fuel Tank Capacity, L (Imp.Gal.)	120 (26.5)	76 (16.6)
Tractive Effort, kN (lb)	61 (13 800)	- -
Engine	Cummins 4BTA 3.9	Ford 256 CID-4
Output Gross/Net, kW (hp)	87/- (116/-)	53.7/- (72/-)
Transmission	Hydrostatic, two variable pumps, a fixed-displacement motor on pinion of each axle.	Ford synchromesh, 8 forward and 4 reverse speeds.
Front Axle	Outboard planetary type, no-spin differential lock.	Inboard planetary type, manually-actuated mechanical differential lock.
Rear Axle	Outboard planetary type, no-spin differential lock.	Inboard planetary type, no-spin differential lock.
Service Brake	Hydrostatic drive acts as service brake.	Mechanically-actuated fully-enclosed wet disc brakes.
Parking Brake	Spring loaded dry disc brake.	Mechanical device to actuate service brakes.
Hydraulic System	Load sensing constant pressure system, 20.7 MPa, 114 L/min.	Gear pump with automatic unloading valve 106 L/min, 15.5 MPa (28 US gpm, 2250 psi).
Loader	Rotobec 40F reach at ground level 5.2 m lift capacity 740 kg at 5.2 m (= 38 kNm).	Supplied with Hydra-loader, reach at ground level 3.96 m, lifting capacity 1588 kg at 2.44 m (=38 kNm).
Miscellaneous	Suspended cushion seat, seat belt, dual driving controls, air conditioning, joy-stick loader controls. Loads 1 tier of 8' wood or two tiers of 4' wood. Steering angle 53°.	Suspended cushion seat, seat belt, single driving controls. Load length with gravity point above rear axle is 3 m. Optional equipment: Cab cold climate kit (US$1700). Protective load guard.
Comments	• production model was tested during second half of 1988. Commercially available in the beginning of 1989. • good cab. • tracks in turns. • max. travel speed 10 km/h. • loads all around the unit. The main boom clears cab in its lowest position. • high power to weight ratio.	• introduced in 1987 in U.S.A. • three units in N.S. • wheels track in turns. • good size cab. • narrow machine, often used for thinning work.
List Price and Date	C$109000 F.O.B. Ste-Justine, Qc, January, 1989.	C$85000 (includes loader) F.O.B. Bridgewater, N.S. Sept. 1, 1987.

VALMET-GAFNER IRON MULE 5310	VALMET-GAFNER IRON MULE 5510
Valmet-Gafner Inc., MI, USA	Valmet-Gafner Inc., MI, USA
La Have Equipment	La Have Equipment
P.O. Box 240 Bridgewater, N.S. B4V 2W8 Tel. (902) 543-2429	P.O. Box 240 Bridgewater, N.S. B4V 2W8 Tel. (902) 543-2429
8390 (18 000) 5440 (12 000) 6.63 (261) 2.85 (112) 76 (16.6) -	8620 (19 000) 6350 (14 000) 7.24 (285) 2.85 (112) 76 (16.6) -
Ford 268 CID-4 61.1/- (82/-)	Ford 268 CID-4 61.1/- (82/-)
Ford synchromesh 8 forward, 4 reverse speeds.	Ford dual range synchromesh transmission.
Inboard planetary type, manually-actuated mechanical differential lock.	Inboard planetary type, manually-actuated mechanical differential lock.
Inboard planetary type, no-spin differential lock.	Inboard planetary type, no-spin differential lock.
Mechanically-actuated fully-enclosed wet disc brake.	Mechanically-actuated fully-enclosed wet disc brake.
Mechanical device to actuate service brake.	Mechanical device to actuate service brake.
Gear pump, with automatic unloading valve. 106 L/min, 15.5 MPa (28 US gpm 2250 psi)	Gear pump, with automatic unloading valve. 121 L/min, 17.2 MPa (32 US gpm 2500 psi)
Supplied with Hydra-loader, reach at ground level 3.96 m, lifting capacity 1588 kg at 2.44 m (=38 kNm).	Supplied with Hydra-loader, reach at ground level 4.60 m, lifting capacity 1814 kg at 2.44 m (=43 kNm).
Suspended cushion seat with seat belt, single driving controls. Optional equip.: cab cold climate kit (US$1700). Rear brakes, dual range 8×4 trans., wide axle for high-flotation tires. Optional power package consists of Ford 268 4-cyl. turbo diesel 102 Gross HP, 3×3 power shift and dual driving controls. Load length with gravity point above rear axle is 3.0 m. Protective load guard.	Suspended cushion seat with seat belt, single driving controls. Optional equipment: Cab cold climate kit (US$1700). Rear brakes, wide axle for high-flotation tires. Optional power package consists of Ford 268 4-cyl. turbo diesel 102 Gross HP, 3×3 power shift transmission and dual driving controls. Load length with gravity point above rear axle is 4.2 m. Protective load guard.
• 3 units sold in eastern Canada. • wheels track in turns. • good size cab. • can be equipped with sawlog trailer.	• introduced in 1985 in U.S.A. • good size cab. • can carry a few 6-m logs as a part of a load. NOTE: Gafner was recently purchased by Valmet Logging Inc. They plan to market Valmet forwarders in Canada in 1989.
C$95000 (includes loader) F.O.B. Bridgewater, N.S. Sept. 1, 1987.	C$120000 (includes loader) F.O.B. Bridgewater, N.S. Sept. 1, 1987.

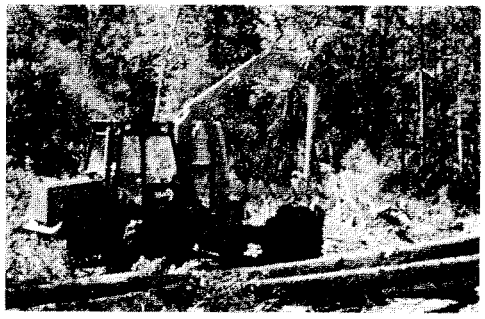


Figure 1. Crabe F2000.

Figure 2. Valmet-Gafner Iron Mule 5110. (Photo from Valmet-Gafner.)

Figure 3. Valmet-Gafner Iron Mule 5310. (Photo from Valmet-Gafner.)

Figure 4. Valmet-Gafner Iron Mule 5510. (Photo from Valmet-Gafner.)

Table 1. (continued)

Make and Model	ROTTNE RAPID 6W	ROTTNE RAPID 8W
Manufacturer	Rottne Industri Ab, Sweden	Rottne Industri Ab, Sweden
Importer	Rocan Forestry Service Ltd.	Rocan Forestry Service Ltd.
Address	703 Malenfant Blvd Dieppe, N.B. E1A 5T8 Tel. (506) 859-9906	703 Malenfant Blvd Dieppe, N.B. E1A 5T8 Tel. (506) 859-9906
Vehicle Weight, kg (lb)	11 600 (25 550)	12 600 (27 750)
Load Capacity, kg (lb)	10 000 (22 030)	10 000 (22 030)
Length, m (in.)	9.71 (382)	9.71 (382)
Height, m (in.)	3.36 (132)	3.36 (132)
Fuel Tank Capacity, L (Imp.Gal.)	115 (25)	115 (25)
Tractive Effort, kN (lb)	145/125 (32550/28060)	145/125 (32550/28060)
Engine	Ford 7710 4 cylinder turbo diesel.	Ford 7710 4 cylinder turbo diesel.
Output Gross/Net, kW (hp)	-/72 (-/98)	-/72 (-/98)
Transmission	Clark torque converter, 3-speed power shift transmission or hydrostatic transmission. Both models have 2-speed transfer case with wagon drive disconnect clutch.	Clark torque converter, 3-speed power shift transmission or hydrostatic transmission. Both models have 2-speed transfer case with wagon drive disconnect clutch.
Front Axle	Outboard planetary type, manually-engaged differential lock.	Bogie axle. Power transmission by gears in the tandem, planetary reductions in wheel hubs, manually-engaged differential lock.
Rear Axle	Bogie axle. Power transmission by gears in the tandems, planetary gears in wheel hubs, no-spin differential lock.	Bogie axle. Power transmission by gears in the tandems, planetary gears in wheel hubs, no-spin differential lock.
Service Brake	Pneumatic-over-hydraulic wet multiple disc brakes beside front differential and on bogie front wheel shafts.	Pneumatic-over-hydraulic wet multiple disc brakes beside front differential and on bogie front wheel shafts.
Parking Brake	Spring-applied wet multiple disc brake on front axle pinion shaft.	Spring-applied wet multiple disc brake on front axle pinion shaft.
Hydraulic System	Unloaded constant pressure system, 14.7 MPa, 110 L/min at 1500 r/m (2140 psi, 29 US gpm).	Unloaded constant pressure system, 14.7 MPa 110 L/min at 1500 r/m (2140 psi, 29 US gpm).
Loader	Rottne GRIP-83 60 kNm, net. Estimated reach at ground level 5.7 m.	Rottne GRIP-83 60 kNm, net. Estimated reach at ground level 5.7 m.
Miscellaneous	Dual driving controls. Suspension seat, tiltable cab. Noise level below N 85 curve. 16 worklights. Electric loader control joysticks are optional. The rear frame can accommodate two 100" tiers.	Dual driving controls. Suspension seat, tiltable cab. Noise level below N 85 curve. 16 worklights. Electric loader control joysticks are optional. The rear frame can accommodate two 100" tiers.
Comments	• A totally new front part - replaces the Blondin model. • Introduced in Sweden in 1985, a few units in eastern Canada today. • Good roomy cab. • With tracks the 8W model has a low ground pressure. • The tractive effort causes large weight distribution changes in bogie wheels.	
List Price and Date	N/A.	N/A.

TREE FARMER C5D 9'	TREE FARMER C5D 12'
Tree Farmer Equipment Co. Inc. Talladega, Alabama, USA	Tree Farmer Equipment Co. Inc. Talladega, Alabama, USA
Hawker Siddeley Canada Inc., Tree Farmer Equipment Div.	Hawker Siddeley Canada Inc., Tree Farmer Equipment Div.
56 Bramsteele Road Brampton, Ontario L6W 3M7 Tel. (416) 450-1133	56 Bramsteele Road Brampton, Ontario L6W 3M7 Tel. (416) 450-1133
9080 (20 000) incl. Cranab 620C loader 4540 (10 000) 7.09 (279) 3.50 (138) with loader 77 (17) 176 (39 450)	10350 (22 800) incl. Cranab 620C loader 6360 (14 000) 7.90 (311) 3.50 (138) with loader 77 (17) 176 (39 450)
Deutz F5L912 74/66 (100/90)	Deutz F5L912 74/66 (100/90)
Spicer 5-speed synchromesh transmission, 2-speed fully-reversing transfer case.	Spicer 5-speed synchromesh transmission, 2-speed fully-reversing transfer case.
Outboard planetary-type, no-spin differential lock.	Outboard planetary-type, no-spin differential lock.
Outboard planetary-type, no-spin differential lock.	Outboard planetary-type, no-spin differential lock.
Hydraulic dual disc brake.	Hydraulic dual disc brake.
Mechanical parking brake.	Mechanical parking brake.
Gear pump 106 L/min, 12.1 MPa (28 US gpm 1750 psi).	Gear pump 106 L/min, 12.1 MPa (28 US gpm 1750 psi).
-	-
Swivel seat with seat belt, suspension seat is optional. Single driving controls. Load deck is 9' long.	Swivel seat with seat belt, suspension seat is optional. Single driving controls. Load deck is 12' long.
• 9' and 16' decks are practical in eastern Canada. • 16' model has higher productivity at long distances. • The cab is small, especially for operating the loader controls. • Windows and heater for the cab available from the factory. • Loader is chosen by the customer. Cranab 620 is the most popular loader in eastern Canada. • Practically all forwarders are delivered with Deutz engine although GM engine is available.	
C$72687 F.O.B. Talladega not including loader May 1988.	C$75062 F.O.B. Talladega not including loader May 1988.

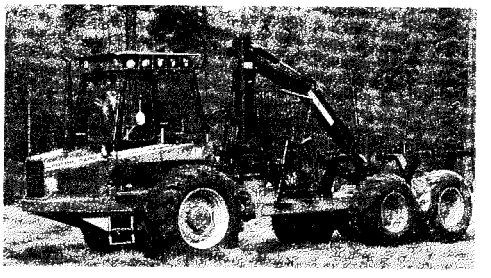


Figure 5. Rottne Rapid 6W.
(Photo from Rottne Ind.)

Figure 6. Rottne Rapid 8W.
(Photo from Rottne Ind.)

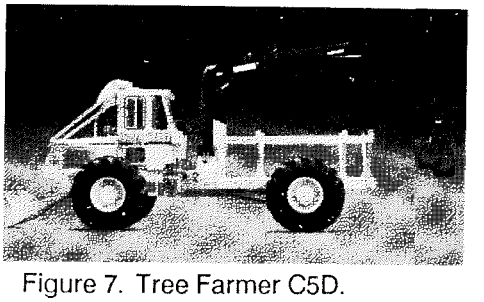


Figure 7. Tree Farmer C5D.
(Photo from Tree Farmer.)

Table 1. (continued)

Make and Model	TREE FARMER C5D 16'	TREE FARMER C6D
Manufacturer	Tree Farmer Equipment Co. Inc. Talladega, Alabama, USA	Tree Farmer Equipment Co. Inc. Talladega, Alabama, USA
Importer	Hawker Siddeley Canada Inc., Tree Farmer Equipment Div.	Hawker Siddeley Canada Inc. Tree Farmer Equipment Div.
Address	56 Bramsteele Road Brampton, Ontario L6W 3M7 Tel. (416) 450-1133	56 Bramsteele Road Bramton, Ontario L6W 3M7 Tel. (416) 450-1133
Vehicle Weight, kg (lb) Load Capacity, kg (lb) Length, m (in.) Height, m (in.) Fuel Tank Capacity, L (Imp.Gal.) Tractive Effort, kN (lb)	12080 (26 600) incl. Cranab 620C loader 7260 (16 000) 9.12 (359) 3.58 (141) with loader 155 (34) 176 (39 450)	13 390 (29 500) incl. Cranab 620C loader 9 760 (21 500) 9.50 (374) 3.76 (148) with loader 273 (60) 185 (41 590)
Engine Output Gross/Net, kW (hp)	Deutz F5L912 74/66 (100/90)	Deutz F6L912 88/85 (120/116)
Transmission	Spicer 5-speed synchromesh transmission, 2-speed fully-reversing transfer case.	5-speed heavy-duty transmission, 2-speed reversing transfer case.
Front Axle	Outboard planetary-type, no-spin differential lock.	Outboard planetary-type, no-spin differential lock.
Rear Axle	Outboard planetary-type, no-spin differential lock.	Outboard planetary-type, no-spin differential lock.
Service Brake	Enclosed one cooled multiple disc brake.	Hydraulic dual disc brake.
Parking Brake	Mechanical parking brake.	Mechanical parking brake.
Hydraulic System	Gear pump 106 L/min, 12.1 MPa (28 US gpm 1750 psi).	Tandem gear pump 2×78 L/min, 12.1 MPa (2×21 US gpm, 1750 psi).
Loader	-	-
Miscellaneous	Swivel seat with seat belt, suspension seat is optional. Single driving controls. Load deck is 16' long.	Single driving controls. Swivel seat with seat belt. Load deck is 17' long. Optional equipment: suspension seat, 60 amp alternator and light kit. Heavy duty axles.
Comments		• The most powerful engine of the forwarders in this review. • Cab is small, especially when using loader controls. • Windows and heater for the cab available from the manufacturer. • Practically all forwarders are delivered with Deutz engine although GM-engine is available.
List Price and Date	C$82355 F.O.B. Talladega not including loader May 1988.	C$91888 F.O.B. Talladega not including loader. May 1988.

TIMBERJACK 230, 5 TON	TIMBERJACK 230, 8 TON
Timberjack Inc.	Timberjack Inc.
-	-
P.O. Box, 160 Woodstock, Ontario N4S 7X1 Tel. (519) 537-6271	P.O. Box 160 Woodstock, Ontario N4S 7X1 Tel. (519) 537-6271
9090 (20 040) 4540 (10 000) 6.85 (270) 3.50 (138) 91 (20) 168 kN (37 800)	10 718 (23 630) 7 260 (16 000) 9.34 (368) 3.62 (142) 91 (20) 149 kN (33 400)
Cummins 4BT 3.9 75/70 (100/94)	Cummins 4BT 3.9 75/70 (100/94)
Eaton 5-speed synchromesh, Eaton fully-reversing 2-speed transfer case.	Eaton 5-speed synchromesh, Eaton 2-speed fully-reversing transfer case.
Outboard planetary type, no-spin differential lock.	Outboard planetary type, no-spin differential lock.
Outboard planetary type, no-spin differential lock.	Outboard planetary type, no-spin differential lock.
Hydraulically-actuated enclosed dual disc brake.	Hydraulic enclosed dry dual disc brake.
Mechanically-applied service brake, one disc only.	Mechanically-applied service brake, one disc only.
Gear pump 106 L/min, 13.8 MPa (28 US gpm, 2000 psi).	Gear pump 106 L/min, 13.8 MPa (28 US gpm, 2000 psi).
Serco 4000 loader reach on ground level 4.7 m, lifting capacity 1814 kg at 3.05 m (=54 kNm).	Serco 4000 loader, reach at ground level 4.7 m, lifting capacity 1814 kg at 3.05 m (=54 kNm).
Suspended swivel seat with seat belt, single driving controls. Loads 1 tier of 100" wood.	Suspended swivel seat with seat belt, single driving controls. Can carry 2 tiers of 100" wood or one tier of 16' sawlogs.
• 650 units of both 5 and 8-ton models (mostly 8-ton) sold between 1970 and 1987. • Other loaders than Serco available through dealers. In the Atlantic provinces, the Cranab 620 loader and its predecessor, model 60 are widely used. • Small cab especially for facing the rear. • Windows or heater for the cab not available from the factory (dealers build their own kits). • The 5-ton model (1 tier of 100" wood) is not as economical as the 8-ton model (2 tiers of 100" wood) because of smaller loads, especially on longer distances. • The wheels of the 5-ton model almost track in turns; the 8-ton model does not track in turns.	
C$89471 (includes loader) F.O.B. Woodstock March 1, 1988.	C$99716 (includes loader) F.O.B. Woodstock, Ont. March 1, 1988.

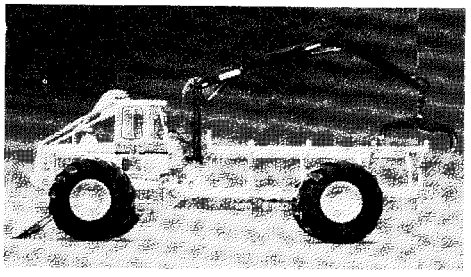


Figure 8. Tree Farmer C6D.
(Photo from Tree Farmer.)

Figure 9. Timberjack 230 5 ton.
(Photo from Timberjack Inc.)

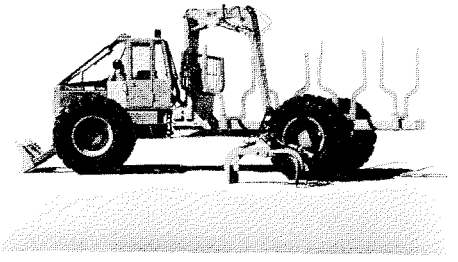


Figure 10. Timberjack 230 8 ton.
(Photo from Timberjack Inc.)

Table 1. (concluded)

Make and Model	TIMBERJACK FMG 910
Manufacturer	Lokomo Forest Oy, Finland
Importer	Timberjack Inc.
Address	P.O. Box 160 Woodstock, Ontario N4S 7X1 Tel. (519) 537-6271
Vehicle Weight, kg (lb) Load Capacity, kg (lb) Length, m (in.) Height, m (in.) Fuel Tank Capacity, L (Imp.Gal.) Tractive Effort, kN (lb)	10 600 (23 350) incl. FMG 364 loader 10 000 (22 030) 8.23/8.63 (324/340) 3.30 (130) excl. loader 100 22 137 kN (30 840)
Engine Output Gross/Net, kW (hp)	Perkins 1004-4T turbocharged diesel 74/81 (100/111)
Transmission	Clark torque converter 3-speed power shift transmission, 2-speed transfer case.
Front Axle	Outboard planetary-type, pneumatically-actuated differential lock.
Rear Axle	Bogie axle, in-board planetaries beside differential, gears in tandem housing. No-spin differential lock.
Service Brake	Pneumatically over-hydraulics-actuated wet multiple disc brakes in front and rear axles.
Parking Brake	Spring-loaded parking brake.
Hydraulic System	Unloaded constant pressure system 16/19 MPa 170 L/min.
Loader	Gross lifting moment 50 to 72 kNm Loader size varies according to the use.
Miscellaneous	Dual driving controls. Suspended swivel seat with seat belt. Tiltable cab for easy maintenance. Noise level in the cab below 75 dB. 12 work lights. Optional equipment: differential with lock between front and rear axle. Oscillation brake between front and rear frame. Long rear frame for two 100" tiers.
Comments	• Good cab. • Best selling forwarder in Finland (about 90 units/year in each of last 3 years). • One unit in Wisconsin. • Introduced in Canada in 1988. • Tractive effort causes small weight distribution changes in bogie wheels.
List Price and Date	N/A.

Figure 11. Timberjack FMG 910.
(Photo from Timberjack Inc.)

Table 2. Ground Pressure, Vehicle Width and Ground Clearance

Front Tires / Rear Tires	Empty Vehicle kPa	Empty Vehicle psi	Loaded Vehicle[1] kPa	Loaded Vehicle[1] psi	Width m	Ground Clearance m
Crabe F2000						
16.9-30	57	(8.3)			2.51/2.82[2]	
16.9-30	28	(4.1)	90	(13.1)	2.51/2.82	
23.1-26	40	(5.8)			2.82	
23.1-26	20	(2.9)	62	(9.0)	2.82	
Gafner Iron Mule - Model 5110						
18.4-26	74	(10.7)			2.41	0.38
18.4-26	25	(3.6)	84	(12.3)	2.41	0.48
Gafner Iron Mule - Model 5310						
23.1-26	63	(9.2)			2.62	0.46
23.1-26	24	(3.5)	80	(11.7)	2.62	0.56
28L-26	52	(7.5)			2.87	0.48
28L-26	20	(3.0)	66	(9.5)	2.87	0.58
66/43.00x26[3]	35	(5.1)			3.63	0.47
66/43.00x26	15	(2.1)	44	(6.4)	3.63	0.57
Gafner Iron Mule - Model 5510						
23.1-26	65	(9.5)			2.62	0.46
23.1-26	25	(3.6)	90	(13.1)	2.62	0.56
28L-26	53	(7.8)			2.87	0.48
28L-26	20	(2.9)	73	(10.7)	2.87	0.58
66/43.00x26[2]	36	(5.2)			3.63	0.47
66/43.00x26	15	(2.2)	49	(7.1)	3.63	0.57
Rottne Rapid 6W						
600-34	65	(9.4)			2.55	0.55
600.26.5	31	(4.6)	92	(13.5)	2.55	0.65
600-26.5 tracks	18	(2.6)	48	(6.9)	2.65	0.66
700-34	56	(8.1)			2.75	0.58
700-26.5	27	(4.0)	79	(11.6)	2.75	0.65
700-26.5 tracks	16	(2.3)	42	(6.1)	2.85	0.66
Rottne Rapid 8W[5]						
600-22.5 (front)	48	(7.0)			2.75	
600-22.5 tracks (front)	25	(3.7)			2.85	
Tree Farmer C5D 9'						
23.1-26	66	(9.6)			2.82	0.45
23.1-26	28	(4.1)	75	(11.0)	2.82	0.45
66/43.00x26[3]	36	(5.2)				0.49
66/43.00x26	17	(2.4)	41	(5.9)		0.49
Tree Farmer C5D 12'						
23.1-26	75	(10.9)			2.82	0.45
23.1-26	32	(4.7)	98	(14.3)	2.82	0.45
66/43.00x26[3]	41	(5.9)				0.49
66/43.00x26	19	(2.7)	52	(7.6)		0.49
Tree Farmer C5D 16'						
23.1-26	86	(12.6)			2.82	0.45
23.1-26	36	(5.3)	112	(16.2)	2.82	0.45
24.5-32	74	(10.8)			2.82	0.54
24.5-32	32	(4.7)	95	(13.9)	2.82	0.54
66/43.00x26[4]	46	(6.7)				0.49
66/43.00x26	21	(3.0)	59	(8.6)		0.49
Tree Farmer C6D						
23.1-26	96	(14.0)			2.82	0.45
23.1-26	40	(5.9)	142	(20.6)	2.82	0.45
24.5-32	82	(11.9)			2.82	0.54
24.5-32	35	(5.1)	121	(17.5)	2.82	0.54
66/43.00x26[4]	51	(7.4)				0.49
66/43.00x26	23	(3.3)	75	(10.9)		0.49
Timberjack 230 - 5 ton						
23.1-26	55	(7.9)			2.56/2.75[2]	0.53
23.1-26	40	(5.8)	87	(12.6)	2.56/2.75	0.53
18.4-34	65	(9.5)			2.47	0.58
18.4-34	47	(6.9)	105	(15.2)	2.47	0.58
28L-26	45	(6.5)			2.77	0.55
28L-26	33	(4.8)	71	(10.3)	2.77	0.55
Timberjack 230 - 8 ton						
24.5-32	54	(7.8)			3.02	0.60
24.5-32	40	(5.8)	104	(15.1)	3.02	0.60
30.5-32	43	(6.2)			3.16	0.64
30.5-32	32	(4.7)	81	(11.8)	3.16	0.64
67/34x26	40	(5.9)			3.07	0.57
67/34x26	31	(4.5)	78	(11.3)	3.07	0.57
66/43x26	34	(4.9)			3.48	0.53
66/43x26	26	(3.7)	64	(9.8)	3.48	0.53
Timberjack - FMG 910						
18.4-34	70	(10.2)			2.48	0.58
13.00-24	56	(9.2)	169	(24.5)	2.48	0.58
13.00-24 tracks	28	(4.0)	77	(11.2)	2.48	0.59
600-34	57	(8.2)			2.63	0.58
600-26.5	32	(4.7)	93	(13.5)	2.68	0.62
600-26.5 tracks	19	(2.8)	50	(7.2)	2.78	0.63
700-34	49	(7.2)			2.89	0.60
700-26.5	28	(4.1)	80	(11.7)	2.88	0.62
700-26.5 tracks	17	(2.4)	44	(6.3)	2.98	0.63

[1] Assumes full load is on rear axle
[2] Reversible wheels
[3] Requires optional (stronger) axle
[4] Requires axle extensions
[5] For rear axle ground pressures see Rottne Rapid 6W

Ground Pressure

High footprint pressures (pressure exerted on the ground by the tires) can cause extensive damage to forest soils, especially on sensitive sites. Although the ruts created by the tires are the most obvious problem, high footprint pressures also result in soil compaction, blocked drainage, damaged root systems of residual trees, and reduced growth of new seedlings. In soft ground, high footprint pressures can also result in low productivity and high operating costs. The main objection that many woodlot owners have to logging activities on their properties is the damage caused by tire ruts to established trails and roads and to the forest terrain. This damage can be minimized by avoiding logging in wet periods of the year and by selecting suitable tires for the forwarder.

In Table 2, the ground pressure of the forwarders is calculated for different tires according to the standard method outlined in Appendix I. The values used in the calculations are from the manufacturers; however, the weights of some options and tires are estimated. The full rated load for each forwarder is assumed to be carried by the rear axle only. The actual load distribution depends on the length of the wood and the forwarder's bunk space. Often part of the weight is distributed to the front axle; at other times when very long wood is transported, the weight on the front axle may be reduced.

The standard tires are the first size listed in the table for each model. The width and the ground clearance of the forwarder are dimensions that depend on the tire size; therefore they are included in the ground pressure table.

For regular forestry tires, the size is marked with a two-number code. The first describes the maximum width of the tire usually in inches (but sometimes also in millimetres). The second number reveals the nominal diameter of the rim in inches. The ply rating is the tire wall strength class and does not refer to the actual number of plies in the tire wall. For example, 24.5-32 16 ply means that the maximum width of the inflated tire is 24.5" (within certain limits) and the nominal rim diameter is 32" (this can be accurately measured only when the tire is dismounted from the rim). The tire wall strength class is 16 ply.

For wide tires, the size is marked with a three-number code. The first describes the nominal outside diameter. The second number describes the maximum width of the inflated tire, and the third stands for the nominal rim diameter. All dimensions are in inches. For example, the marking 66/43.00x26 reveals that the outside diameter of the tire is 66", the width of the inflated tire is 43" and the nominal rim diameter is 26".

According to "Terrain Classification for Canadian Forestry" [3], the ground strength of the forest floor can be divided into 5 classes (Table 3):

Table 3. Ground Strength Classification

Class	1-Very good	2-Good	3-Moderate	4-Poor	5-Very-poor
Description	Very freely drained	Freely drained	Fresh	Moist wet	Very wet
Nominal footprint pressure	200 kPa + (30 psi +)	70-200 kPa (10-30 psi)	40-70 kPa (6-10 psi)	20-40 kPa (3-6 psi)	0-20 kPa (0-3 psi)

When the ground pressure values of the machines presented in Table 2 are compared to the ground strength classification, it can be seen that the forwarders are equipped to work on sites with strength classes 1, 2 and 3. Only a few models equipped with high-flotation (wide) tires, or tracks on bogies, can work in ground strength class 4 conditions. For comparison, a man walking has a ground pressure under his feet in the order of 20-35 kPa (3-5 psi) (ground strength class 4).

The suitability of the tires for a particular operation, the required ply rating and the inflation pressure should be verified with the tire and forwarder manufacturers (e.g., some forwarders require stronger axles when using wide tires because of the higher bending moment incurred).

Conclusions

This report reviews thirteen forwarder models from six manufacturers, encompassing a fairly broad range of machine specifications and operating characteristics. The engine output of the units sampled varied between 54 and 88 kW, and their load capacity ranged from 4010 to 10 000 kg (4 to 10 tonnes).

To best select the proper forwarder for their application, prospective buyers should consider the machines' features in light of their particular operating conditions and needs. The latter may often dictate the choice.

In woodlot operations, forwarders must often be moved and thus the ability to travel on public roads is important. The use of tire chains may not be possible if the unit travels on paved roads. If transported on a float, the height and width of the forwarder may be critical.

Small narrow forwarders with wheels tracking in the turns are usually best suited for small scattered harvesting operations and thinnings. Larger forwarders are more effective in clearcuts where large amounts of wood are piled along the forwarding trails.

Forwarders that exert high ground pressures cause problems in soft terrain. Ground disturbance and fuel consumption are high while travel speed is low. Conversely, wider, more expensive tires may be superfluous where ground bearing capacity is adequate.

Naturally when weighing these alternatives, the availability of good local support for parts, service and warranty work should also factor highly in the choice of forwarder.

References

1. White, T. 1988. Personal communication. Timberjack Inc., Woodstock, Ontario.

2. Prior, R. 1988. Personal communication. Hawker-Siddeley Canada Inc., Tree Farmer Div., Brantford, Ontario.

3. Mellgren, P.G. 1980. Terrain classification for Canadian forestry. Canadian Pulp and Paper Association, Montreal. W.S.I. 2840. 13p.

Disclaimer

Appendix 1

(from Terrain Classification for Canadian Forestry [3])

Object of a "Standard" Rated Footprint Pressure

The manufacturers need "Standard" rated footprint pressure figures to compare their products to competitors'. The users need "Standard" rated footprint pressure figures to select the right machine and tires for particular terrain.

At present there is no uniform, standardized method to calculate rated footprint pressure for off-road vehicles accepted by North American machine manufacturers.

The rated footprint pressure figures should be given in all specifications of logging machines as an important characteristic for the prediction of performance.

A "Standard" method of calculating this is also needed for a "Terrain Classification System for Canadian Forestry".

Proposed "Standard" Ground Contact Pressure for Off-Road Vehicles - Method of Calculation of Rated Footprint Pressure

To make a reasonably fair comparison, footprint area has to be measured in a uniform, standardized manner and at a "standard" sinkage.

A "standard" sinkage of 15% of the overall tire radius is proposed for the following reasons:

1. It is a "tolerable" normal sinkage for off-road vehicles operating on soft ground. At a sinkage over 15%, the motion resistance may start to present problems.
2. It can be proven that RxB is a very good approximation of footprint area at a sinkage of 15% of the radius of the tire. This makes calculation easy.

The same "standard" sinkage is also proposed for tracks.

The "standard" rated footprint pressure for a tire is thus defined as:

$$P = \frac{W}{RxB} \quad psi$$

To convert to metric units, multiply by 6.895; thus 1 psi = 6.895 kPa (kiloPascals).

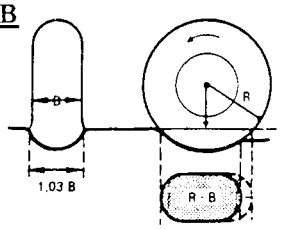
Where W = wheel load in lb
R = tire overall radius (unloaded) in inches
B = tire width (unloaded) in inches

The standard ground contact pressure for a track is defined as:

$$P = \frac{W}{B(1.25\,R + L)} \quad psi$$

Where W = track load in lb
B = track width in inches
R = track wheel overall radius in inches
L = the distance between track wheel centres in inches

Wheel-Tire
Footprint Area = RxB



Track
Footprint Area = B(1.25 R + L)