Productivity of a Tree-Length Forwarder for Logging on Wet Sites

Ben D. Jackson[1],
Louisiana State University Agricultural Center; Baton Rouge, LA, U.S.A.
W. Dale Greene,
University of Georgia; Athens, GA, U.S.A.
and Alvin L. Schilling,
International Paper Company; Hattiesburg, MS, U.S.A.

ABSTRACT

A GEMCO tree-length forwarder was used to harvest pine from wet sites. It produced payloads of 26.9 metric tonnes with an average cycle time of 72 minutes. Hourly production averaged 32.9 metric tonnes per PMH while addition of the forwarder and a second loader to the system increased system cost by US$ 67.97/PMH. Use of the forwarder was less expensive than building all-weather roads to harvest timber in wet weather where volume accessed was relatively low or an extensive road network was required.

Key Words: *Forwarder, Time Study, Logging, Wet Site,Tree-Length*

INTRODUCTION

Harvesting timber from difficult terrain is often constrained by the cost of building access roads. Such constraints exist in many areas where glaciated boulders or steep slopes limit access and increase the difficulty of building roads. In the southern USA, similar problems arise when harvesting timber on wet sites. Drainage systems and fill material are required to construct access roads into wetland timber stands. All-weather roads with ditches and cross drainage often cost US$ 10,000 to US$ 20,000 per mile to construct in wet areas, thus greatly increasing harvesting costs. Most loggers wait until drier weather unless the timber stand contains very high quality material that can justify these higher removal costs.

Instead of building roads, off-road machines can be used to transport wood. Such machines usually have large payloads to compensate for their slow travel speeds. In eastern Canada, Maine, and Scandinavia, clam-bunk skidders and forwarders have been used extensively for years. These machines are widely used for long distance skidding of full-trees since roads are expensive to construct [1] [2][4]. Several Canadian studies found these machines to be economical with long skidding distances, since payloads were very large [5] [6][8]. Use of wide tires or tracks also increase machine flotation and maximize payloads [7] [9]. Loggers who operate regularly in southern wetlands often rely on machines using wide tires, dual tires, or tracks to negotiate poorly drained areas with low soil strength [11].

In 1985 a GEMCO pipe hauler (now sold by ARDCO Industries, Inc.), a vehicle used extensively for off-road material transport on wet sites in the oil and gas industry, was added to a timber harvesting operation and became an effective tree-length forwarder. The GEMCO forwarder was equipped with the following:

1. 5.22 L (318 cu.in.) diesel engine 186 kW (250 hp).
2. 3 planetary axles providing 6-wheel drive.
3. 10 steel-belted, 10-ply 67/43X25 skidder tires.

After some use in the woods, the forwarder received some minor modifications. These consisted of reinforcing the grill on the front of the prime mover and replacing the stock trailer axles with heavier skidder axles. The original axles had shown a tendency to fail under heavy payloads of 32 to 36 metric tonnes (35-40 U.S. short tons).

1. The authors are respectively; Associate Professor, School of Forestry, Wildlife and Fisheries, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, LA 70803, Assistant Professor; School of Forest Resources, University of Georgia, Athens, GA30602, and Project Manager, Forestry and Harvesting, International Paper Company, Hattiesburg, MS 39401. This article is approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript number 88-22-2541.

METHODS & PROCEDURES

The forwarder was added to a logging operation using two feller-bunchers, two grapple skidders, and a spare cable skidder. Two knuckleboom loaders, a delimbing gate, a fuel-service truck, a crew truck, numerous chainsaws, and three diesel logging trucks with pole trailers completed the system. The crew consisted of four operators for the feller-bunchers and skidders, a saw operator at the woods landing, a forwarder operator, three truck drivers, and a supervisor. Either the supervisor, forwarder operator, or a truck driver loaded the forwarder and haul trucks as the situation dictated.

The 69 ha (170 acre) logging site was a 30-year old natural stand of southern yellow pine having 712 trees per ha (288 trees/acre) of small sawtimber- and pulpwood-sized trees. Sawtimber averaged 28 cm (11 in) diameter at breast height (dbh) and 20 m (66 ft) total height while pulpwood averaged 16.8 cm (6.6 in) dbh and 16.5 m (54 ft) total height. The site was moderately hilly with several small drainages and a silty-clay soil. Truck access was provided on a permanent all-weather road along two sides of the timber stand.

Trucks were loaded at one of three roadside landings while the second loader, with help from the skidders, was moved to various locations in the woods. The forwarder was loaded at the in-woods landing with logs moved there by the grapple skidders. Once loaded, the forwarder hauled the wood to the roadside landing where the logs were transferred directly onto a waiting truck or were decked if no trucks were available.

A conventional production time study was conducted on six different days during the winter months from December 1986 through March 1987. Elemental production time and payload information were gathered for the tree-length forwarder, while total cycle time and payload data were collected for the grapple skidders and highway haul trucks. The forwarder was the newest piece of equipment in the logging system and had been in use for about one year. All of the other equipment and men had been in place for seven years. The operation was highly productive with all machine operators near the top of their learning curve in using the equipment.

RESULTS & DISCUSSION

During the study period, 33 cm (13 in) of rain fell. As a result, the soil was at field capacity, standing water was frequently present, and streams were constantly flooded. However, the forwarder (tare weight: 15.9 metric tonnes or 35,000 lbs) was never observed bogged nor unable to negotiate the terrain. During the winter months, the forwarder system lost only two days production, while more conventional tree-length logging operations in the area stopped completely for extended periods. The two days lost were due to excessive rain during working hours, not forwarder limitations.

Results of the forwarder time study are summarized in Table 1. The production results were based on three payloads of sawlog size material, five of chip-N-saw logs, and sixteen for pulpwood loads. Loading, unloading, and delay times varied little across observed cycles. No production delays were caused by the forwarder. Repairs on the roadside loader grapple and difficulty in scheduling available trucks for loading were responsible for the observed delays.

Without production delays, the forwarder completed an average cycle in 49.10 minutes with 72.48 percent of the cycle time spent loading and unloading the forwarder. Only 18.47 percent of cycle time was spent actually moving wood from the woods to roadside and returning. Given an average one-way forwarding distance of 661 m (2,170 ft), the forwarder traveled unloaded at 11.32 km/hr (7.03 mph) and traveled loaded at 7.13 km/hr (4.43 mph). The other seven elements, other than loading, unloading and traveling, amounted to 9.05 percent of the total observed cycle time.

Production dropped substantially when production delays were incorporated into the cycle time. With delays, total cycle time increased to 72.09 minutes with delays consuming 31.63 percent of this time. Loading and unloading elements represented only 49.37 percent of the cycle time. The two travel elements were reduced to 12.58 percent and the miscellaneous elements contributed only 6.42 percent to the total.

Average forwarder payload was 81 stems weighing 26.9 metric tonnes (29.7 U.S. short tons) or nearly 28 cubic meters of wood (11 cords). This volume was about 7 percent greater than the average payload for highway logging trucks. Heavier for-

Table 1. GEMCO tree-length forwarder time study summary.

Element Description	N	Mean	Min.	Max.	Var.
	-#-	minutes			
Travel Unloaded	22	3.51	2.53	4.91	0.29
Turn and Maneuver	20	1.95	1.07	3.13	0.31
Prepare to Load	18	0.36	0.00	1.13	0.15
Loading	24	21.56	11.57	33.97	40.47
Prepare to Travel Loaded	22	0.72	0.00	1.99	0.28
Travel Loaded	24	5.56	4.03	7.27	0.60
Prepare to Unload	23	0.65	0.00	1.54	0.19
Unloading	24	14.04	7.27	21.31	10.49
Prepare to Travel Unloaded	23	0.70	0.00	1.87	0.29
Delays per Cycle	23	22.80	0.00	147.93	1362.79
Cycle with No Delays	18	49.10	35.82	64.27	70.98
Cycle with Delays	17	72.09	35.93	212.20	1782.51

Table 2. Hourly costs for a tree-length forwarder.

Purchase Price	US$130,000	**Fuel** 6 gal/PMH	@ US $0.75
Salvage Value	20%	**Lube** 3 qts/PMH	@ US $0.75
Economic Life (yr)	8	**Maint. & Repair** (% of D)	50%
Interest (% of AAI)	12%	**Labor**	US $8.00
Insurance (% of AAI)	4%	**Fringe**	30%
Taxes (% of AAI)	0%	**Utilization**	68%
Weeks/Year	50	**SMH/Week**	40

4 US qts = 1 US gal = 3.785 l

	US$/SMH	US$/PMH
Fixed or ownership costs —		
Depreciation	6.50	9.56
Interest, Insurance, & Taxes	6.97	10.25
Total Fixed Costs	13.47	19.81
Variable or operating costs —		
Maintenance & Repair	3.69	5.42
Fuel & Lubrication	4.59	6.75
Total Variable Costs	8.28	12.17
Labor costs —		
Wages or salaries	8.00	11.76
Fringe Benefits	2.40	3.53
Total Labor Costs	10.40	15.29
TOTAL HOURLY COSTS	32.15	47.27

warder payloads had been attempted prior to the study, but had caused damage to the trailer and added to equipment downtime. Therefore, the approximate one-to-one forwarder/truck payload ratio was chosen as the best relationship.

Payloads for the forwarder equalled 10 skidder turns. Skidders typically moved nine trees or about 2.80 cubic meters (1.1 cords) per turn. With no delays, two grapple skidders could complete thirteen cycles while the forwarder completed a single cycle. Delays did occur since the skidders were also used for stacking logs at the in-woods landing and for clearing slash at the delimbing gate. The in-woods landing was relocated after the skidders reached a maximum one-way skid distance of 274 m (900 ft) from the loader, permitting the skidders and the forwarder to maintain a balance in their production. This equipment configuration also matched the productivity of the feller-bunchers on this wet site.

Hourly production averaged 32.9 metric tonnes per PMH (36.3 U.S. short tons) or 22.4 metric tonnes per SMH (24.6 U.S. short tons) with the observed utilization of 68 percent.

Hourly cost estimates for a tree-length forwarder were developed using cost factors for an ARDCO forwarder (Table 2). The ARDCO machine is nearly identical to the GEMCO observed during the field study. The GEMCO is no longer on the market after the acquisition of GEMCO by ARDCO Industries. Hourly costs (including labor) for a tree-length forwarder were estimated to be US$ 32.15/SMH or US$ 47.27/PMH. However, to add a tree-length forwarder to a conventional southern logging job, a second loader must also be added. Hourly costs (excluding labor) of US$ 13.46/SMH or US$ 20.70 per PMH were used for a new Prentice 210-C loader [3]. Thus, total hourly costs for a conventional southern logging operation will increase by US$ 45.61/SMH or US$ 67.97/PMH when adding tree-length forwarding capability.

To be justified, use of the forwarder must be less expensive than building roads into the stand. Road construction cost per unit of volume removed depends upon the road mileage required and the volume of timber to be hauled over the roads. Where an extensive road network is required or timber volumes removed are relatively low, tree-length forwarding appeared to be a less expensive alternative (Figure 1). Assume that all-weather logging roads

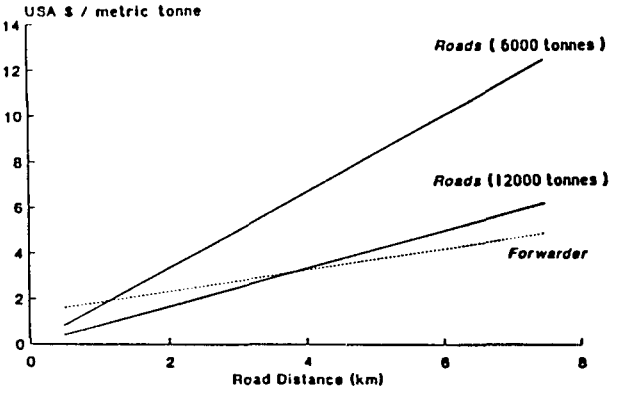

Figure 1. Cost of forwarding versus conventional logging with road building to access 6000 and 12,000 metric tonnes of timber.

cost US$ 10,000 per km (US$ 16,090 per mile) to build. If the road accesses 6,000 metric tonnes of timber, forwarding will be less expensive than road construction if the road distance exceeds 1.5 km (0.93 miles). If 12,000 metric tonnes of timber will be moved over the road, then forwarding is cheaper at distances of 4 km (2.5 miles) or more.

SUMMARY & CONCLUSION

The tree-length forwarder harvesting system represented an improvement over conventional logging operations by increasing production and the number of working days during winter months on wet sites. It was also possible to harvest previously inoperable timber stands and stands with less valuable material.

The forwarder moved logs where skidders could not and with less visible damage to temporary logging trails. This permitted skidders to work short distances from the in-woods landing, enabling them to complete skidding to landings before soil conditions deteriorated. Skidder production was maximized since skid distances were kept short (< 274m). This obviated the need to add additional skidders to maintain production.

One obvious disadvantage to use of the forwarder is the double handling of wood required to load the forwarder and then the highway trucks. This disadvantage is partially offset by the higher quality of merchandising of log products which can occur through increased handling and inspection.

The major advantage of this system was the savings in both money and time associated with building roads. All-weather logging roads are expensive and must often be built several months prior to a logger moving onto a tract of timber. After a tract is harvested, the road becomes an improvement to the timber tract which is typically not owned by the logger or purchaser of the timber. Use of the forwarder permits logging with extensive networks of all-weather roads and allows logging to begin without the delays associated with road construction and seasoning.

Other trucking advantages should be present, although they were not directly measured. Since highway trucks do not leave an all-weather road, maintenance and repair costs should not increase during wet weather. This is often the case where trucks negotiate poorly maintained woods roads, often leaving the woods loaded with the aid of skidders towing them to roadside. Such practices often abuse highway trucks and deposit mud on county roads, leading to understandable public relations problems. By keeping trucks on all-weather roads, lighter trucks could be used to further maximize highway payloads. While these factors were not measured in this study, they will likely be important to many loggers due to the high percentage of logging cost attributable to trucking expenses.

During wet weather, many loggers are forced to move from tract to tract because of deteriorating road conditions. Use of a forwarder should help minimize the need to move, thus increasing weekly production and reducing logging costs. This is an advantage not only to the logger, but also to procurement personnel who must supervise or arrange such moves repeatedly during wet weather.

REFERENCES

[1] Bigger, J.C. 1977. Long-distance grapple skidding: possible cost cutter. Pulp and Paper Canada 78(7):22-24.

[2] Boyd, J.H. and W. Novak. 1977. Estimates of wood cost, productivity, and investment needs for 84 logging system combinations. Pulp and Paper Canada 78(5):69-78.

[3] Brinker, R.W., D. Miller, B.J. Stokes, and B.L. Lanford. 1989. Machine rates for selected forest harvesting machines. Ala. Agric. Exp. Stn. Circular 296.

[4] Kurelek, J. 1984. The feller-forwarder concept and its application. Proceeding of COFE/IUFRO Conference, Orono, Maine, pp.191-194.

[5] Legault, R. and L.H. Powell. 1975. Evaluation of FMC 200 BG grapple skidder. Forest Engineering Research Institute of Canada Technical Report TR-1. 27p.

[6] McMorland, B.A. 1977. Evaluation of Volvo BM 971 bunk skidder. Forest Engineering Research Institute of Canada Technical Report TR-16. 49p.

[7] Mellgren, P.G. and E. Heidersdorf. 1984. The use of high flotation tires for skidding in wet and/or steep terrain. Forest Engineering Research Institute of Canada Techincal Report TR-57. 50p.

[8] Miyata, E.S. 1980. Determining fixed and operating costs of logging equipment. USDA Forest Service General Technical Report NC-55.

[9] Powell, L.H. 1978. Production and performance studies of FMC 200 series skidder. Forest Engineering Research Institute of Canada Technical Report TR-29. 37p.

[10] Sander, B.J. 1984. Skidders using high flotation tires. Proceeding of COFE/IUFRO Conference, Orono, Maine, pp. 109-114.

[11] Stokes, B.J. 1988. Wetland logger survey summary and production and costs of selected wetland logging systems. Technical Paper 88-A-10. American Pulpwood Association, Inc. Washington, DC.