POTENTIAL FOR SHARED LOG TRANSPORT SERVICES

Tim McDonald, Research Engineer
Bob Rummer, Project Leader
USDA Forest Service, 520 DeVall Drive
Auburn, AL 36849-5418

Steve Taylor, Associate Professor
BioSystems Engineering Dept., Auburn University
Auburn University, AL 36849

Jorge Valenzuela, Assistant Professor
Industrial Engineering Dept., Auburn University
Auburn University, AL 36849

ABSTRACT – A simulation model of a log transport logistics network was developed. The model could be structured to either share truck capacity among a group of loggers, or to assign a fixed number of trucks to individual loggers. Another variation of the model allowed the use of a staging yard to set out loaded trailers and deliver them to destinations using dedicated shuttle trucks that operated continuously. Pooling trucks among loggers provided more flexibility in dealing with driver shift length constraints, and consequently delivered more wood to mills than did individual ownership. The magnitude of the difference was related to dispatch method. Accounting for logger status when dispatching trucks increased wood volume moved and reduced average trailer waiting times for all loggers. Staging yards were effective in maintaining delivered volume of wood when severe delays were probable at destination mills.

INTRODUCTION

Application of information and planning technologies are potentially of primary importance in increasing the efficiency of timber harvesting. Greene and others (2001) reported, for the period 1987 to 1997, an increase in labor productivity of 78 percent for Georgia loggers, while capital productivity remained constant. Given nearly flat logging rates over the same period, marginal returns most likely did not increase while investment risk more than doubled. In a business environment with an oversupply of harvesting capacity, loggers have no incentive to further invest in expensive equipment to increase unit productivity. Efficiency gains in timber harvesting, therefore, are more likely to come about as a result of applying knowledge capital, rather than financial – loggers will have to work smarter to stay in business. Traditional approaches to logging can potentially be redesigned to benefit from the application of information technology, resulting in efficiency gains with a relatively low price tag.

Log transport, representing nearly half the delivered cost of wood fiber, is a particularly good candidate for investigation of the benefits of applying information technology. Tree-length logging contractors in the South typically transport their own product to consumption points. They tend to use a fixed number of trucks to haul wood regardless of the distance from the logging job to the consuming mill, and this leads to inefficiencies. When tracts are far from the mill, overall logging system productivity may suffer because of insufficient truck capacity. And conversely with tracts close to the mill, the logger must accept trucks idling at the deck awaiting a load to haul. Sharing a pool of trucks among a group of loggers could potentially decrease the number of rigs required to haul a fixed amount of wood to the mill, thereby reducing costs. There are problems associated with this approach that must be solved before it is implemented. Some central agency would be required to dispatch trucks among loggers, and do so in a fair and efficient manner. Communication and planning technology would need to be developed to ensure that best use was made of available trucking capacity to serve loggers equitably and move the maximum possible amount of wood.

This study was done to investigate, using a simulation approach, the potential for sharing log transport resources among a group of loggers. Factors important in evaluating such a shared transport system were identified as the ability to serve loggers equally, move the greatest amount of wood with a given number of trucks, and be relatively immune to external influences, particularly changes in woodyard configuration or operation characteristics. Specific objectives of the study were:

1. Develop a realistic simulation model of a log transport logistics network that pooled truck resources among a group of loggers.
2. Investigate alternative methods of dispatching trucks given a shared logistics system.
3. Determine the relative influence of woodyard operating characteristics on log transport logistics performance, and evaluate the effectiveness of using a 'staging yard' in minimizing the influence of woodyard operations on transport efficiency.

MATERIALS AND METHODS

The transport simulation model was constructed assuming that a central dispatch agent was available to direct trucks to one of a group of loggers, who in turn represented some portion of a procurement system supplying a set of consuming mills. For this study, tracts consisted of a mix of up to three products and each product was to be transported to a single destination. A group of 10 loggers was to be served. Each was assigned parameters that represented a rate at which trailers could be loaded, a location that corresponded to the amount of time necessary to haul a load to a specific mill, and a set of probabilities that defined the amount of each product type on the tract being logged. Loggers did not move between tracts during the simulations.

The three destination mills were identical in their model behavior, but differed in the amount of time needed to process a truck through the woodyard, and in the number of trucks arriving during the day. One mill in particular was assumed to be the predominant destination for wood (nominally a 'pulp' mill). About 400 trucks per day were processed through its woodyard, with about 100 per day sent to the other two destinations. This made it simpler to investigate the effect of changing woodyard performance characteristics on overall transport system efficiency. Arrival intervals between trucks other than those being explicitly modeled was assumed to be exponentially distributed, with the mean inter-arrival time a function of time of day. Truck arrivals over a 24-hour period were as shown in Figure 1.

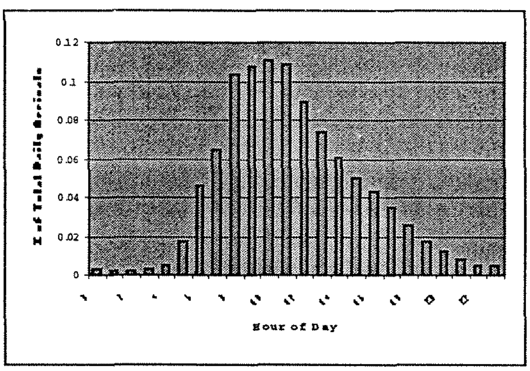

Figure 1. Truck arrival distribution as a function of time of day.

Woodyards were modeled as three server processes in series, nominally an inbound scale, a crane, and an outbound scale. Asynchronous delays were imposed between the servers to represent the amount of time needed for travel within the yard, and for various other necessary functions (e.g. unbinding). Server processing times were defined as being triangularly distributed with an assigned mean and range. Delay times were assumed uniformly distributed, with mean of 8 minutes, and range of 4 minutes.

Trucks were assigned a logger destination as they left the woodyard. Trucks hauled an empty trailer to the appropriate logger, dropped it into a queue for loading, then the next available loaded trailer was picked up and hauled to the mill corresponding to the load type (i.e., no mill destination assignment was made). If no loaded trailer was available, the truck waited until either one was, or the end of the shift was reached. Trucks were allowed to operate for 10 hours per day, with a variable starting time. Truck shift length was evaluated at the time logger assignments were made. If the truck could not make a complete turn (travel empty, travel loaded) in the time remaining on the shift, it was sent home.

Loggers were single-server processes that loaded empty trailers and assigned a load type based on stand characteristics. Loggers worked 9-hour shifts each day, also with a variable starting time.

Trucks were assigned destinations by a dispatch agent that used one of four algorithms to pick loggers: a completely random assignment; a fixed assignment; a 'uniform' assignment in which each logger 'owned' (nearly) the same number of trucks; and an 'informed' assignment. The fixed assignment algorithm used a weighted distance scheme to assign trucks from the pool to a specific logger, and this assignment did not vary over the course of the simulation. The weights used in assigning trucks were the sum of distances from the logger to each mill, scaled by the relative abundance of products of the particular type in the stand. Informed assignment was based on the minimum difference in time between when a logger would run out of trailers (in the queue at the deck plus those in transit) and when the truck being assigned would arrive if sent to that logger.

The simulation was built using a software product known as AnyLogic, version 4.0. Dispatch algorithms were evaluated using five runs of the model for each assignment method, with variations in the number of trucks available in the pool and in pulp mill processing times. Each simulation run modeled 30 working days.

The model assumed that trucks delivered their loads directly to the woodyard at the appropriate mill. Another model was developed that simulated the situation in which road trucks delivered loads to a remote yard facility, picked up an empty trailer, and were assigned another logger destination. Shuttle trucks carried the full trailers from the remote yard to their final destinations. Shuttle trucks were assumed to work continuously.

Simulations based on this model were run using the same number of trucks as in the previous model, but with the trucks divided into over-the-road and shuttle contingents. Simulation runs were made using a single remote yard located near the pulp mill, and with two remote yards, each yard on opposite sides of the mill. Figure 2 shows relative positions of the simulated components used in the models.

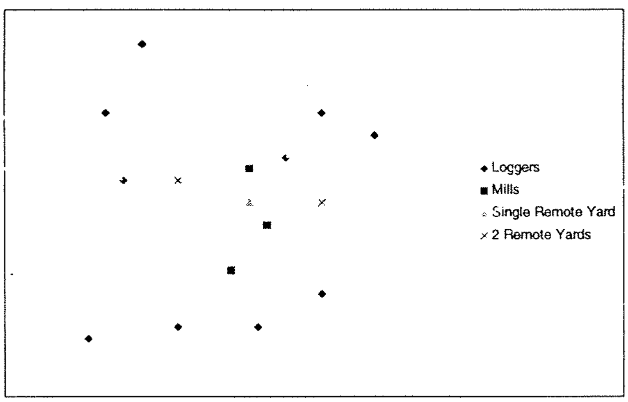

Figure 2. Map showing relative positions of loggers, mills, and remote yards.

RESULTS AND DISCUSSION

Simulation parameters were based strictly on conjecture, and therefore were not necessarily reflective of an actual situation. Values were, however, selected to at least resemble typical operations. In general, the simulations were set up such that about 65 trucks could haul all wood produced by the 10 loggers if no delays at the mill were experienced. The theoretical maximum amount of wood that could be produced was about 490 tons/logger/day.

Dispatch method influenced the amount of wood produced (Table 1). Fixed assignment was the worst performer, moving only about 70 percent of the wood as the best method regardless of the number of trucks available. This was likely a result of the shift-length constraints. There was no flexibility to send a truck to a different logger if the turn could be made in the time remaining on the shift. This was not true for the random and informed dispatch methods, where destinations were prioritized and the truck sent to the logger with the highest priority. Uniform assignment hauled more wood than the fixed dispatch method, probably because it favored loggers closer to the mill, whereas fixed assignment attempted to statically balance idle time among loggers. Informed dispatch moved the greatest amount of wood, about 12 percent higher than random assignment for both levels of truck capacity. This result confirmed the value of logger state information in maximizing the volume of wood moved.

Table 1. Summary of amount of wood hauled by dispatch assignment method.

# of Trucks	Tons Hauled (tons/logger/day)			
	Uniform	Fixed	Random	Informed
60	254	225	281	324
75	295	273	315	359

Although 20 percent more wood was moved, there was not as big a difference in performance of the pooled system versus the uniform assignment as was expected. If uniform assignment is roughly equivalent to the logistics network currently in place, then these results did not indicate a substantial benefit from pooling transport resources strictly from the standpoint of maximizing delivered amounts. There was, however, a significant difference between the assignment methods in the amount of time loggers spent waiting on a trailer to load. Table 2 summarizes waiting time results for the four dispatch methods using 75 trucks. Uniform assignment had both the highest mean and variance in logger waiting time, over twice the mean for the informed method, and the standard deviation was over three times higher.

Table 2. Summary of variation in logger idle time as a function of dispatch assignment method. Situation modeled was: 75 trucks; in-bound scale, crane, and out-bound scale mean process times were 1.5 min, 1.7 min, 1.5 min, respectively.

Assignment Method	Average percent logger idle time			
	Mean	Std Dev	Min	Max
Uniform	26	20	0	58
Fixed	30	14	15	45
Random	21	12	7	34
Informed	11	6	1	19

These results reinforced the idea that distance to the mill is the single most influential variable affecting truck transport efficiency. No dispatch method can change the fact that a tract is 90 minutes form the mill, but using an effective dispatch method can, however, minimize the potential for disparity in logger productivity associated with working at longer haul distances. From that standpoint, pooling truck resources would probably be beneficial. There was also evidence that pooled trucking could haul more wood with the same number of trucks as the current transport system.

Truck time in the woodyard has a large impact on overall transport efficiency. There are two critical factors involved in determining woodyard turn times: number of trucks arriving over a given interval, and woodyard server (scales and crane) processing times. Of these two factors, the most easily influenced is the arrival distribution pattern of trucks. Most log transport trucks operate during normal working hours and consequently the woodyard is most heavily burdened during that time. A remote yard operating continuously shuttling trailers to their destination points uncouples the effect of woodyard loading from log transport. Table 3 summarizes simulation results when using 0, 1, and 2 remote yards to stage trailers before hauling to the woodyard. Variations in the model included using 55, 65, and 75 total trucks, and 3 levels of mean processing time for woodyard servers at the 'pulp' mill (representing about 85 percent of the total wood being hauled). The processing time levels represented low, moderate, and high delay probabilities for trucks going through the woodyard. Figure 3 shows the distribution of queue lengths for the inbound scale when modeling 65 trucks.

There was no improvement shown in total wood hauled when using a remote yard system when the woodyard was not a bottleneck. This was the case regardless of the number of trucks being modeled in the simulations. Increasing the server process times by 15 percent (scales 1.3 to 1.5 minutes, crane 1.4 to 1.5 minutes) dropped the total amount of wood hauled with no remote yard by an average of about 9 percent. When either one or two remote yards were used, total delivered wood amounts were only about 1 percent less on average, and the remote yard transport systems both delivered more wood than using over-the-road trucks only.

When the woodyard was a severe bottleneck, the remote yards delivered about 24 percent more wood than the equivalent number of trucks without the yard. Further, the amount of wood delivered under high delay probability was only about 4 percent less than the situation where the woodyard was not a significant delay. Use of remote yards to stage wood had significant benefits when delays at the woodyard were long and highly probable. Costs for the staging system, however, would be higher because of the added drivers needed to run the yards continuously.

All of these results indicated that there were potential benefits to using a pooled transport system to deliver wood from multiple loggers. The magnitude of the benefits, however, was dependent on numerous factors, particularly trailer unloading times. Woodyard operational parameters used in these simulations were, at best, educated guesses, and the true benefits of using a pooled transport logistics system need to be confirmed using a verified simulation model with accurately estimated parameters.

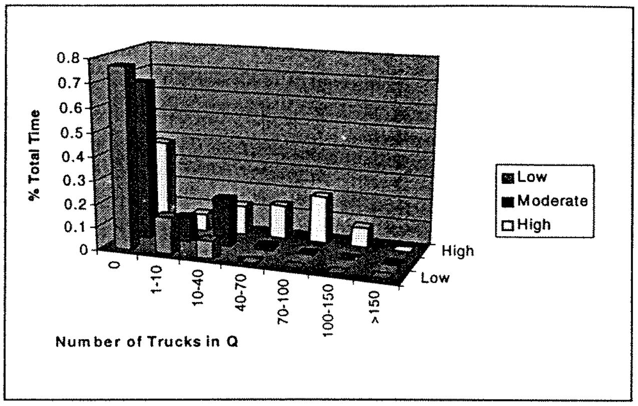

Figure 3. Graph of the percent of time for various categories of number of trucks waiting in the pulp mill woodyard inbound scale processing queue over the course of the simulation. Low, moderate, and high refer to scale processing mean times (1.3, 1.5, and 2.3 minutes, respectively). These results are for the case of 65 total trucks being modeled.

CONCLUSIONS

Simulation results comparing pooled versus contractor-owned trucking networks indicated that more wood could be hauled using equivalent numbers of trucks under the shared transport system. Delivered wood volume was limited by the number of available trucks. Sharing trucks and using a simple dispatch algorithm that accounted for logger status was shown to move 12 percent more wood than random dispatch, and 20 to 30 percent more wood than when ownership of trucks was constrained to a single logger. Advantages of the pooled methods were at least partially related to flexibility in dealing with driver shift length constraints. Pooled dispatch was also much more effective at balancing trailer waiting times among loggers regardless of haul distance.

Table 3. Wood hauled (tons/logger/day) using remote concentration yards. Mill parameters are: in-bound scale, crane, and out-bound scale mean process times. Numbers (in parentheses) show distribution of total trucks to road/yard.

# Remote Yards	# Trucks		
	75	65	55
		Mill Params: 1.3 , 1.4 , 1.3	
0	390	354	305
1	388 (67/8)	349 (58/7)	301 (49/6)
2	392 (55/10/10)	365 (47/9/9)	293 (37/9/9)
		Mill Params: 1.5 , 1.7 , 1.5	
0	359	323	276
1	387 (66/9)	345 (57/8)	297 (48/7)
2	389 (53/11/11)	356 (45/10/10)	312 (39/8/8)
		Mill Params: 2.3 , 2.5 , 2.3	

0	302	271	232
1	376 (62/13)	330 (54/11)	285 (46/9)
2	378 (49/13/13)	342 (43/11/11)	293 (37/9/9)

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