Information Needs for Increasing Log Transport Efficiency

Timothy P. McDonald, Steven E. Taylor, Robert B. Rummer, Jorge Valenzuela

Timothy P. McDonald
Research Engineer
USDA Forest Service
520 Devall Drive
Auburn, AL 36849-5418
tpmcdonald@fs.fed.us
334 821 0037

Steven E. Taylor
Associate Professor
Biosystems Engineering Department
Auburn University
Auburn, AL 36849
staylor@eng.auburn.edu

Robert B. Rummer
Project Leader, Forest Operations
Research Unit
USDA Forest Service
520 Devall Drive
Auburn, AL 36849-5418
rbrummer@fs.fed.us

Jorge Valenzuela
Assistant Professor
Industrial Engineering Department
Auburn University
Auburn, AL 36849
jvalenz@eng.auburn.edu

Information Needs for Increasing Log Transport Efficiency

ABSTRACT

Three methods of dispatching trucks to loggers were tested using a log transport simulation model: random allocation, fixed assignment of trucks to loggers, and dispatch based on knowledge of the current status of trucks and loggers within the system. This 'informed' dispatch algorithm attempted to minimize the difference in time between when a logger would use up available empty trailers and when a new empty would arrive. Simulations modeled a situation in which trucking capacity was limited relative to logger production capacity. The fixed assignment of trucks to loggers produced the highest amount of delivered wood, followed closely by the informed dispatch method. The difference seemed to be a result of the fixed assignment method favoring loggers close to mills over those further removed, while the informed method dispatched trucks more evenly among loggers regardless of transport distance. Results also demonstrated the need to balance trucking capacity with logging production to maximize the amount of delivered wood.

INTRODUCTION

About 80 percent of pulpwood delivered to US mills in 1996 (nearly 200 MM tons) arrived by truck (APA 1997). Transportation of wood fiber accounts for about 25 to 50 percent of delivered costs, depending on haul distance, and increasing fuel prices will likely cause that portion to drift upward. Optimizing the transport efficiency of these large quantities of raw material should benefit wood consuming industries. Applying information technology to log transport has the potential to increase its efficiency, as it has in many other industries.

The wood transport network is somewhat different from most other logistics systems, where a commodity is delivered from a central location to scattered distribution points. The opposite is true for wood delivery: a commodity is collected from independent contracting agents that are widely distributed across the landscape. These contractors are normally individually responsible for delivery of their product to consuming mills. Each logger maintains, or contracts for, a fleet of tractors to haul loads of wood. The number of trucks used is typically fixed and is sufficient to keep a steady flow of empty trailers at the logger's deck for the in-woods crew to load. Too few delivered empty trailers, and the logging deck will become clogged and utilization of expensive in-woods equipment will suffer. When trucks are in oversupply, the logger is paying for transport capacity that is unused. The optimal number of trucks should be related to at least two controllable factors: distance to the consuming mill, and production rate of the logging system. Of these two factors, production of the logging system should always be maximized to achieve optimal financial returns, implying that elasticity in the overall supply logistics should be maintained in trucking capacity.

Loggers, however, do not typically have the option of varying trucking capacity to match distance to consumption points. Although data are scarce concerning transport capacity (Greene and others, 2001 report an average of 2 drivers plus 2 contract haulers per crew in Georgia), it would make sense to assume that loggers retain enough trucking capacity to handle an average haul distance. Loggers live with reduced utilization of in-woods equipment at stands far removed from the mill, and with idle trucks when working at stands close to the mill. If this scenario is correct, pooling trucking capacity among a group of loggers should increase log transport efficiency. With pooled transport trucks could be rationally dispatched to the logger at which they are most needed and eliminate the tradeoff between utilization of trucking and logging equipment caused by haul distance variations. Daniels (1994) discussed the development of a truck dispatching system that was credited with increasing overall efficiency, resulting in cost savings to the company implementing the system. Shen and Sessions (1989) presented a truck scheduling system that was said to minimize costs of transporting wood from several loggers to a single destination.

This is also an example of how real-time information is of potential benefit to the wood consuming industry. To work effectively, the transport network would have to be managed to balance utilization of all loggers being served, and to maximize the amount of wood moved. Implementing the dispatch system should require feedback on the disposition of trucks and status of loggers, perhaps information on queue lengths at receiving mills. All this data would have to be collected and analyzed in real time in order to respond to dynamic changes in system status. Although there is no true spatial precision involved, the dispatch system requires a higher level of information resolution and temporal necessity than currently employed, placing this problem into the category of 'precision forestry'.

The objective of this study was to evaluate the utility of real-time information in enhancing effectiveness of truck dispatch to loggers. 'Effectiveness', in this case, was assumed to be one approach to dispatching trucks moving more wood compared to another with the same number of vehicles. A transport network simulation was used to compare dispatch methods. Methods evaluated were a fixed allocation of trucks to individual loggers, dispatch to randomly selected loggers, and an 'informed' approach that attempted to use data regarding transport network status to dispatch trucks to the 'best' destination.

METHODS

A simulation of a transport network was constructed that included 3 destinations, 5 loggers, 30 trucks, and a dispatch agent. The destinations were intended to simulate wood consuming mills and consisted of in- and out-bound scales, with a crane in between. In between the crane and scales, trucks were subjected to asynchronous delays that simulated travel and unbinding functions inside the mill gates. Processing times were based on information obtained from local mills, and each was assumed to be a triangularly distributed random variable. Truck arrivals at the mill gates included those explicitly modeled as part of the simulation (i.e. the 30 mentioned previously), as well as others representing the rest of the procurement system. Distributions of arrival times of these additional trucks were exponential, and means were assigned using total daily wood consumption data from local pulp and saw mills.

Loggers were modeled simply as loaders that processed empty trailers. Loading times were assumed to be triangularly distributed with a fixed mean and range of variation. Processing queues for each logger could be charged with an initial number of empty trailers at the start of the simulation. Loaded trailers were assigned a weight that was a random variable uniformly distributed between 25 and 29 tons. The trailer was also assigned a product code that corresponded to a destination mill. The logger was assigned product sort information at the beginning of the simulation. Each product was assigned a probability of occurrence that represented the percent of that product included in the stand being harvested. Distances to each mill were also assigned at startup. Each mill had a fixed x-y location, as did each logger. Mean travel times between the logger and mills were related to Euclidean distance, and an assumed (fixed) average travel speed for all trucks (45 miles per hour). Actual travel time was triangularly distributed, with range equal to 40 percent of the mean travel time.

Trucks cycled between loggers and mills. The dispatcher made logger assignments at the time the truck exited a mill. Trucks added an empty trailer to the logger's processing queue upon arrival, then either picked up a loaded trailer, or waited for the next loaded trailer if none were available. The load was hauled to the receiving mill and the cycle repeated. There was no attempt made to optimize or prioritize which loaded trailer to haul to a mill among those available at the logger. Trucks simply grabbed the first available in the queue and hauled it to the mill corresponding to the product type of the load.

The dispatch agent waited for assignment requests from trucks, then used one of three different algorithms to select a destination logger:

1. Randomly assigned. Probability of assignment among loggers was the same.
2. Fixed (static) assignment. A truck was assigned an 'owner' logger at startup.
3. 'Informed' (dynamic) assignment. This method calculated the time in the future that all loggers would exhaust the available supply of trailers either in transit or waiting at the deck. The truck was then assigned to the logger such that the difference between the arrival time and the time trailer supply was exhausted would be minimized. A further check was applied such that the 'best' assignment would be dropped in favor of the logger that was furthest 'behind', i.e. the logger that had been waiting for a trailer the longest, if that waiting time was large.

Overall, the simulation was designed to model a transportation network that was truck-limited. It was assumed that situation would favor a truck assignment that was informed, rather than fixed or random. The scenario modeled assumed all loggers produced loaded trailers at the same rate, varying only in the distance to the mills. Model parameters were assigned such that, over long periods of time, trucks were available to haul about 75 percent of the trailers that loggers were capable of producing.

Model parameters used in the simulations are shown in Table 1. A travel index value, T_i from Equation [1] for logger i, was calculated as the sum of the products of the transit time means and associated probability of occurrence for each mill destination, where M was the number of mills. Numbers of trucks assigned in the static allocation simulations were based on the proportion of the travel index for an individual logger relative to the total for all loggers.

$$T_i \; ? \; \overset{M}{\underset{j\,?\,0}{?}} \; t_{ij} \; ?s_{ij} \qquad [1]$$

Simulations were run for a total of 300 model hours, 5 replications for each assignment type. Output variables measured included vehicle and logger utilization, plus total number of truck cycles and tons moved of each product type.

Table 1. Model parameters used in the simulations.

Logger	Product Probabilities, s_{ij}			Mean Travel Time, t_{ij} (min)			Travel Index, T_i	# of Trucks Assigned
	V[a]	C	P	V	C	P		
1	0.1	0.2	0.7	68	91	57	65	4
2	0.0	0.1	0.9	114	156	149	150	8
3	0.0	0.4	0.6	132	112	137	127	7
4	0.0	0.0	1.0	78	27	42	42	3
5	0.05	0.15	0.8	149	109	142	137	8

[a] – V,C, and P designate the three mill destinations (nominally a veneer, chipnsaw, and pulp mill)

RESULTS AND DISCUSSION

Simulation results showed no advantage gained using dynamic dispatch information. Although more wood was transported than using random assignment, matching trucks to the expected emptying time of loader queues moved 1.3 percent less wood than the static assignment of trucks to loggers. Overall, there was 1 more turn per truck over the 300-hour simulation using static assignment.

Table 2. Mean simulation output values by truck assignment method.

Model Result	Assignment Type		
	Random	Informed	Fixed
% Logger Idle Time	28.5^{a}	25.9^{b}	25.0^{b}
Tons Hauled	57772^{a}	59689^{b}	60490^{c}
Truck Cycles	2141^{a}	2213^{b}	2243^{c}

[a] – Values with the same superscript are statistically equal, P = 0.05.

This finding was counter to our original hypothesis, but other simulation results indicated that the advantage for the static assignment was gained by slightly favoring loggers closest to the consuming mills. In the scenario used for these tests, trucking capacity was about 25 percent below that needed to match the output capacity of the loggers. This effectively capped the advantage that could be gained by any allocation method unless some structural change to the transport network was implemented, e.g. changing the number of loggers, or their production rates. In the informed assignment, there was a check used in the assignment algorithm that made sure no logger was ignored. Without this check, the algorithm consistently stopped dispatches to one logger altogether, and wound up moving about 4.8 percent more wood than when serving all 5 loggers. Similarly, the fixed assignment strategy allocated trucks based on an expected turn time, but the assignment was not exact because only integer numbers of trucks could be allocated to each logger. Rounding the number of trucks upward for loggers closer to the mill gave them an advantage in truck response time over those further away, which netted more wood to the mill by trading off idle time at remotely placed loggers for work time at closer loggers. The informed dispatch method balanced idle time among all loggers more effectively. Standard deviation and range of logger idle time for the informed assignment was 2.3 percent and 7.6 percent, respectively. For the fixed assignment, the same values were 3.8 percent and 8.7 percent.

The overall improvement in tons hauled when dropping 1 logger was also seen in the static allocation of trucks, but to a lesser extent (2.6 percent improvement). This result emphasized the significance of matching trucking capacity to logging systems to maximize delivered wood amounts. Although the static allocation of trucks was superior to a dynamic approach in these simulations, this does not necessarily imply that real-time information flow has no use in truck dispatching. These results were based on steady-state conditions. Random perturbations in the system would perhaps occur often enough that a static allocation of trucks, even repeated when the transport network changed, would not be best, or even feasible. Future work will be done to examine the relative importance of random perturbations on wood delivery schemes.

Any simulation is only a model of reality and there were a number of idealizations incorporated in this study. Shift lengths of drivers, for example, were not considered, neither were dynamic fluctuations in arrival times at mills. Truck arrival intervals change significantly over the course of a day, but this was not considered in the model. In fact, no mill information was used in the truck dispatch algorithm at all, but could be incorporated and perhaps provide additional efficiencies over a static allocation. This would most likely be of benefit if there were alternative destinations available for a single product class. Distributions of various processing times used in the simulation were selected for simplicity rather than based on solid information. Measuring these input parameters might improve the overall realism of the simulations.

A single method of dynamically allocating trucks was tested in this study. There are almost assuredly better methods than the approach taken here, but further research will be needed to define what the important state variables and decision criteria would be to improve dispatch efficiency.

The simulations underscored the nearly linear relationship between number of trucks needed to haul for a logger and travel distance to mills. This indicated that pooled allocation of trucks among a group of loggers would likely haul the same amount of wood with fewer trucks, lowering delivered costs. Other structural changes in the transport network, e.g. use of surge yards to distribute truck arrivals at mills more evenly, could also provide transport efficiency advantages. Dynamic allocation of trucks, at least for the conditions tested in this study, did not improve transport efficiency, but did provide other benefits. The algorithm was very effective at equalizing logger productivity by balancing empty trailer deliveries, an important consideration for loggers if they were considering turning their trucking systems over to a central dispatching system.

LITERATURE CITED

1. APA. 1997. Annual pulpwood statistics summary report. Forest Resources Association, 600 Jefferson Plaza, Suite 350, Rockville, MD. APA Report 97-A-12. 20 p.
2. Daniels, T. 1994. Transport systems today and tomorrow. P. 202-208 *in* Proceedings of the 17th Annual Meeting of the Council on Forest Engineering; Advanced Technology in Forest Operations: Applied Ecology in Action, Sessions and Kellogg (eds.). Oregon State University: Corvallis, OR.
3. Greene, W.D., B.D. Jackson, and J.D. Culpepper. 2001. Georgia's logging businesses, 1987 to 1997. Forest Products Journal. 51(1):25-28.
4. Shen, Z., and J. Sessions. 1989. Log truck scheduling by network programming. Forest Products Journal. 39(10):47-50.

University of Washington - College of Forest Resources

First International Precision Forestry Symposium

Welcome to the CD ROM containing information about the First International Precision Forestry Symposium University of Washington Seattle, Washington, USA June 17 - 20, 2001

Presented by
University of Washington College of Forest Resources'
Precision Forestry Cooperative

and
University of Washington College of Engineering

With support from
American Society for Photogrammetry and Remote Sensing

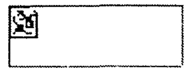
and
USDA Forest Service

For more information about precision forestry please conatct:

Doug St. John, Executive Director
Precision Forestry Cooperative
University of Washington
Box 352100
Seattle, WA 98195
Phone 206.685.3073
E-mail: stjohnd@u.washington.edu
web page: http://www.cfr.washington.edu/research.pfc/

Please use the following list to navigate through the CD. Many documents are present in .PDF format to be used with the

Adobe Acrobat Reader software. If needed, you may obtain a free copy of this software by clicking on the icon below and following instructions at the Adobe web site.



Call for papers - October, 2000

Symposium announcement

Oral presenters and their papers

Attendee List

Precision Forestry Cooperative

Evaluation Form

Precision Forestry Symposium
[web page with post conference updates]