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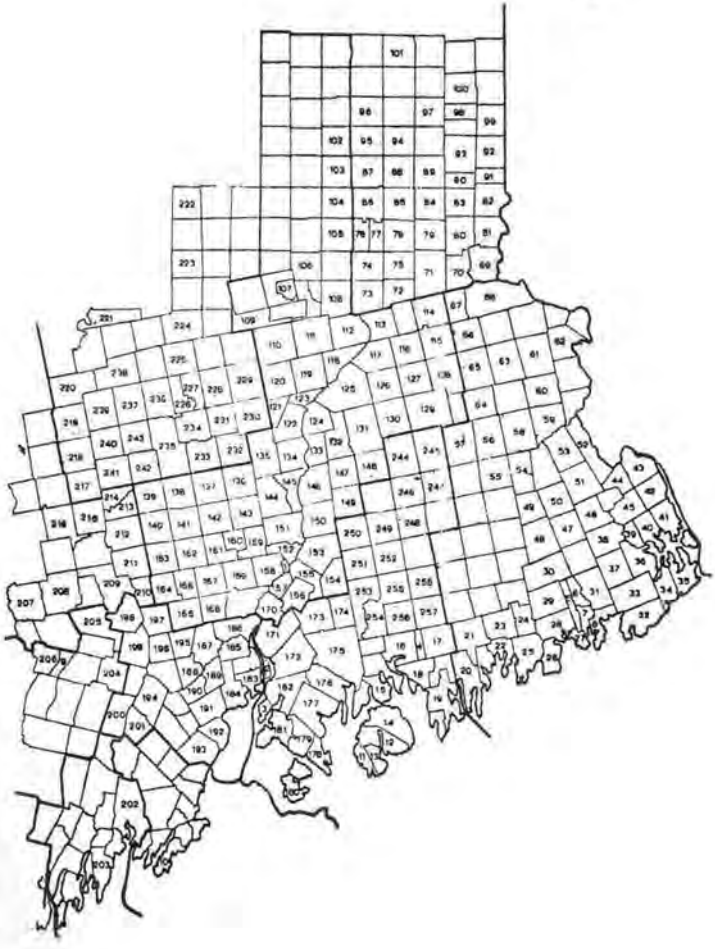
FOREWORD

The map, opposite page, depicts the townships (numbered) in east-central Maine that participated in the 1963 supply of pulpwood trucked from woodlands to delivery stations in this area. The numbered townships are identified in the appendix.

Questions have been advanced in recent years concerning the practice of cross-hauling and its effect on a pulpwood distribution system. This study attempts to place a measure on the cross-hauling and other seemingly costly hauling practices. The fact that the study was undertaken and presented herein does in no way mean to imply that these so-called problems can or should be overcome.

The authors wish to extend their appreciation to the many firms that engaged in trucking pulpwood in east-central Maine during 1963 for the direct or indirect cooperation in this and a prior study. Special acknowledgment is due to Gerald F. Dube of the University of Maine's Computer Center for his assistance in connection with the computational portions of this study.



AN EVALUATION OF THE DISTRIBUTION OF TRUCKED PULPWOOD IN EAST-CENTRAL MAINE

(a linear programming application)

Thomas J. Corcoran[1] - Daniel I. Schroeder - David B. Thompson

Introduction

The movement of pulpwood from forest to market can be a critical and costly activity. Many factors influence this movement and contribute to its complexity. In 1963, a study was undertaken to quantitatively describe the distribution patterns of trucked pulpwood for a representative area of the state of Maine.

Nearly all of the pulpwood harvested in the area is transported at one point or another by truck. A large part of it was transported by truck, exclusively. The published results of the 1963 study[2] provided breakdowns of information on trucked pulpwood based upon woodland origins and the ownerships of these origins, hauling seasons, type of hauling agencies, load compositions, hauling distances, and other categories.

During the progress of the study, it was noted that truckloads of pulpwood were frequently transported from their woodland origins[3] to markets which were more distant than other available markets in the area.[4] Some of these loads pass by one potential purchasing

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[2]Schroeder, Daniel I. and Thomas J. Corcoran. 1965. Distribution patterns of trucked pulpwood in east-central Maine. Maine Agr. Exp. Sta. Bul. 630.

[3]Woodland origin is defined for purposes of the study as the township in which a woodland was located.

[4]An available market is defined for purposes of this study as a purchasing point or delivery point (e. g., pulp mill or rail head) which will accept a specified type of pulpwood. Type refers to species or species group and its condition, peeled or rough.

point on their way to another purchasing point.[5] It was further noted that pulpwood of a specific type from some woodland origins was marketed at as many as three different purchasing points. One of these points normally could be expected to have a location advantage in respect to a particular woodland origin.

These occurrences suggest higher-than-necessary transportation charges to the firms directly involved in the pulpwood movements. Naturally, factors other than transportation costs influence the decision to move pulpwood from a specific woodland origin to a specific delivery point. In general, some apparent reasons which prompt pulpwood suppliers to incur the increased costs of transportation in these situations may be:

1. Differences in net returns to pulpwood shipments because of variation between available markets in the basic price of delivered wood, payment of mileage differentials, determination of load scales, or methods of making payment to pulpwood suppliers.
2. Arrangements that result from contracts, traditions, or direct business integration between the pulpwood supplying agency and the firm receiving delivery of the pulpwood.

Even though an individual pulpwood supplier[6] may tend to react in his best interest in regard to decisions among available markets at a given time and facing a given set of conditions, it does not necessarily follow that the aggregate actions of all pulpwood suppliers produce the most advantageous results to the pulpwood industry as a whole. In the light of the aforementioned occurrences involving increased hauling distances, it would seem to be desirable to establish for a specified period of time the degree of influence these practices have on transportation costs for east-central Maine's pulpwood industry. It was for this purpose that the present investigation was initiated.

[5]This practice has been termed "cross-hauling".

[6]A pulpwood supplier may be a pulp and paper firm, pulpwood jobber or producer, or any agency engaged in supplying available markets with pulpwood.

Analysis Methods and Results

This evaluation of the 1963 pulpwood distribution system is based upon a comparison between the 1963 system and a "hypothetically ideal system". Basically, it contrasts but one aspect of these two systems or the total mileage traveled in truck deliveries of all pulpwood loads in the geographic area. Table 1 provides for this contrast by species-condition classes and for all species in aggregate.[7]

Information in the table indicates for each pulpwood type:

A. The total pulpwood volume in cords trucked during 1963 in the east-central Maine area (see map) and identification of townships in appendix II).

B. The total number of truckloads of pulpwood that make up the total volume.

C. The average size in cords of a truckload of pulpwood.

D. The number of different townships from which one or more truckloads originated.

E. The number of different delivery or purchasing points at which one or more truckloads was accepted.

F. The total one-way[8] miles required to make all of the actual 1963 truckload deliveries.

H. The total one-way miles that might have been traveled in making all deliveries under the hypothetical (optimal) system.

I. The difference between the total hypothetical miles and total actual miles traveled by all truckloads.

J. The average distance in one-way miles that might have been traveled under the hypothetical system.

K. The difference between the average hypothetical and average 1963 load trip (one-way) distances.

L. The difference in total trucking costs between the 1963 system and the hypothetical system under the assumptions that the operating cost of a non-descriptive truck is 30 cents per mile and that round trip distances are equal to twice the load trip (one-way) distance.

M. The total trucking cost differential on a per cord basis.

[7] In table I the term "actual" refers to the 1963 system and the term "optimal" to the hypothetical system.

[8] From woodland origin to delivery destination.

Table 1 - Aggregate information by species-condition classes for actual and optimal deliveries of all trucked pulpwood in east-central Maine during 1963

Species (condition)	Total volume A	Total truckloads B	Average load size C=(A/B)	Township origins D	Delivery or purchasing points E	Total actual load trip distance F	Average actual load trip distance G=(F/B)
	(cords)	(no.)	(cords)	(no.)	(no.)	(miles)	(miles)
Spruce-fir (rough)	153,943	29,100	5.3	183	7	796,417	27.4
Spruce-fir (peeled)	56,633	8,429	6.7	122	5	545,579	64.7
Hardwoods (rough)	140,851	29,785	4.7	179	3	1,124,611	37.8
Hardwoods (peeled)	7,796	1,608	4.8	76	4	82,944	51.6
Hemlock (rough)	17,007	3,066	5.5	82	4	87,216	28.4
Hemlock (peeled)	61,782	8,543	7.2	125	6	471,271	55.2
All species	438,012	80,531	5.4	258	8	3,108,038	38.6

Species (condition)	Total optimal load trip distance H	Total load trip distance differential I=(F-H)	Average optimal load trip distance J=(H/B)	Average load trip distance differential K=(C-J)	Total round trip differential cost* L=(1) (2) (30¢)	Round trip differential cost per cord* M=(L/A)
	(miles)	(miles)	(miles)	(miles)	($)	($)
Spruce-fir (rough)	713,729	82,688	24.5	2.9	49,613	0.32
Spruce-fir (peeled)	499,854	45,725	59.3	5.4	27,435	0.48
Hardwoods (rough)	1,025,892	98,719	34.4	3.4	59,231	0.42
Hardwoods (peeled)	69,454	13,490	43.2	8.4	8,094	1.04
Hemlock (rough)	84,781	2,435	27.7	0.7	1,461	0.09
Hemlock (peeled)	416,531	54,740	48.8	6.4	32,844	0.53
All species	2,810,241	297,797	34.9	3.7	178,678	0.41

*Based upon an estimated cost of 30 cents per mile and under the assumption that return trip distances are equal to the load trip distances.

The actual figures presented (A-G) were established from purchasing point records or from expansion of a 9.35% sample[9] of all truckloads participating in the 1963 supply.

Optimal total mileages were determined through a linear programming technique, the transportation model (appendix 1)[10]. Actual figures were related to or contrasted with optimal figures where appropriate. In establishing actual figures, whenever loads of mixed species-condition types were encountered, loads and mileages were applied on a proportionate basis.

The transportation model provides for the movement of pulpwood by truckload units of each species-condition type so that the total mileage expended in the delivery of the year's supply of that species type would be a minimum. It should be noted that the model does not necessarily eliminate cross-hauling, but would tend to reduce excessive occurrences of cross-hauling.

In the model each woodland origin's capacity to participate in the supply was defined by the total number of truckloads of a pulpwood type delivered during the year from that woodland to purchasing points in the area. The requirements of each delivery destination were established by the total number of truckloads of a pulpwood type received during the year at that destination from woodlands in the area. A truckload could be considered as of average load size. Since capacities were what was actually delivered from the origins, and requirements were what was actually received at the destinations, total capacity for any given pulpwood type equaled the total requirement for the type. The model does not provide for movements of pulpwood at specified times during the year, only for the year as a whole. Mileages between the various combinations of origins and destinations were the actual trip mileages encountered or were determined by scaling road map distances by the most direct reasonable route.

Conclusions

It is not the intent of the authors to justify or even suggest actions that might be undertaken by the pulpwood trucking industry to achieve some form of optimality in the truck delivery of pulpwood. As

[9]Total number of truckloads sampled that had application to this analysis was 7,700.

[10]Computations accomplished on IBM-1620 computer under library program 1620-LM-017, Modification No. 2, Version I, entitled: Transportation Program with Indirect Addressing".

stated earlier, the study objective was merely to establish the influence sub-optimal trucking practices have on the total transportation cost structure facing the industry in east-central Maine and thereby provide a measure of the potential worth of subsequent actions. This influence has been quantified by the comparison between optimal and actual miles or the costs applied to these mileages in the table.

On a relative basis for the all-species category the dollar savings attributed to the optimal situation represents about 1.5 to 2.5% of the total value of the delivered product and up to 10% of the total delivery cost. Percentages for some specific pulpwood types would be higher or lower than the percentages above, e. g., peeled hardwoods and rough hemlock. Furthermore, while the cost differential refers to a particular year, in any year in which a trucking system similar to the 1963 system was active, a differential of the same order could be expected.

It will be left to the concern and judgment of the pulpwood trucking industry whether the magnitude of the figures provided warrant serious attention. However, it should be recognized that it is unlikely that savings in the full amount of $178,678 could be realistically achieved as the hypothetical distribution suggests. This would have required full planning and control of the distribution system. Even if legalistic and practical problems were avoidable, planning and control themselves represent costs to the system.

APPENDIX I

Transportation Model for each species-condition type

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$$\text{Minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} \quad x_{ij}$$

$$\text{Subject to: } \sum_{i=1}^{m} x_{ij} = b_j \text{...for all j's}$$

$$\sum_{j=1}^{n} x_{ij} = a_i \text{...for all i's}$$

$$\text{when, } x_{ij} \geq 0 \text{ .... for all i's and j's}$$

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

m = the total number of woodland origins from which pulpwood was delivered in 1963 for each species-condition type.

n = the total number of delivery or purchasing destinations to which pulpwood was delivered in 1963 for each species-condition type.

i = denotes the identity of the woodland origin

j = denotes the identity of the destination

c_{ij} = the one-way miles between the ith origin and the jth destination

x_{ij} = the number of truckloads moved from the ith origin to the jth destination

b_j = the total number of truckloads of pulpwood accepted at the jth destination in 1963

a_i = the total number of truckloads of pulpwood moved from the ith origin in 1963

APPENDIX II

The numbered townships illustrated inside front cover are identified below:

1 Veazie
2 Verona
3 Castine
4 T9 S. D.
5 Whitneyville
6 Marshfield
7 Machias
8 Machiasport
9 Waterville
10 St. George
11 Tremont
12 Mount Desert
13 Southwest Harbor
14 Bar Harbor
15 Lamoine
16 Franklin
17 T10 S. D.
18 Sullivan
19 Gouldsboro
20 Steuben
21 Cherryfield
22 Harrington
23 Columbia
24 Columbia Falls
25 Addison
26 Jonesport
27 Roque Bluffs
28 Jonesboro
29 Centerville
30 Northfield
31 East Machias
32 Cutler
33 Whiting
34 Trescott Twp.
35 Lubec
36 Edmunds Twp.
37 Marion Twp.
38 No. 14 Plt.
39 Dennysville
40 Pembroke
41 Perry
42 Robbinston
43 Calais
44 Baring Twp.
45 Charlotte
46 Cooper
47 T19 E. D.
48 Wesley
49 T26 E. D.
50 Crawford
51 Alexander
52 Baileyville
53 Princeton
54 T27 E. D.
55 T43 M. D.
56 T6 N. D.
57 T5 N. D.
58 Grand Lake Stream Plt.
59 Indian Twp.
60 Waite
61 Codyville Plt.
62 Lambert Lake, T1R3
63 Topsfield
64 T6R1
65 Kossuth
66 T8R3
67 T8R4
68 Danforth
69 Weston
70 Bancroft
71 Reed Plt.
72 Macwahoc Plt.
73 Molunkus, TAR5
74 T1R5
75 T1R4
76 Benedicta
77 Silver Ridge Twp.
78 T2R4
79 Glenwood Plt.
80 Haynesville

81 Orient
82 Amity
83 Forkstown, T3R2
84 T3R3
85 T3R4
86 Sherman
87 Crystal
88 Island Falls
89 T4R3
90 TAR2
91 Cary Plt.
92 Hodgdon
93 Linneus
94 Dyer Brook
95 Hersey
96 Moro Plt.
97 Smyrna
98 Ludlow
99 Houlton
100 Hammond Plt.
101 St. Croix, T8R4
102 Mt. Chase Plt.
103 Patten
104 Stacyville
105 Herseytown, T2R6
106 Grindstone, T1R7
107 Millinocket
108 Medway
109 Long A, TAR8, & 9
110 T3R9
111 T2R9
112 Woodville
113 Mattawamkeag
114 Drew Plt.
115 Prentiss Plt.
116 Webster Plt.
117 Winn
118 Chester
119 T2R8
120 Seboeis Plt.
121 Maxfield
122 Howland
123 Mattamiscontis, T1R7
124 Enfield
125 Lincoln
126 Lee
127 Springfield
128 Carroll Plt.
129 Lakeville Plt.
130 T3R1
131 Burlington
132 Lowell
133 Passadumkeag
134 Edinburg
135 Lagrange
136 Bradford
137 Charleston
138 Garland
139 Dexter
140 Corinna
141 Exeter
142 Corinth
143 Hudson
144 Alton
145 Argyle Twp.
146 Greenbush
147 Summit, T1ND
148 Grand Fall Plt.
149 Greenfield
150 Milford
151 Old Town City
152 Orono
153 Bradley
154 Clifton
155 Eddington
156 Holden
157 Brewer City
158 Bangor City
159 Glenburn
160 Kenduskeag

161 Levant
162 Stetson
163 Newport
164 Plymouth
165 Dixmont
166 Etna
167 Carmel
168 Newburg
169 Hermon
170 Orrington
171 Bucksport
172 Orland
173 Dedham
174 Otis
175 Ellsworth City
176 Surry
177 Blue Hill
178 Brooklin
179 Sedgwick
180 Deer Isle
181 Brooksville
182 Penobscot
183 Stockton Springs
184 Searsport
185 Frankfort
186 Winterport
187 Monroe
188 Brooks
189 Swanville
190 Waldo
191 Belfast City
192 Northport
193 Lincolnville
194 Montville
195 Jackson
196 Thorndike
197 Troy
198 Burnham
199 Unity
200 Palermo
201 Liberty
202 Waldoboro
203 Bristol
204 Albion
205 Clinton
206 Oakland
207 Norridgewock
208 Skowhegan
209 Pittsfield
210 Detroit
211 Palmyra
212 St. Albans
213 Ripley
214 Cambridge
215 Harmony
216 Athens
217 Wellington
218 Kengsbury Plt.
219 Blanchard Plt.
220 Shirley
221 TA2-R13 & 14
222 T3R11
223 T1R11
224 TB R11
225 Katahdin Iron Works
226 Barnard Plt.
227 Williamsburg, T6R8
228 Brownville
229 Lake View Plt.
230 Medford Twp.
231 Milo
232 Orneville Twp.
233 Atkinson
234 Sebec
235 Dover-Foxcroft
236 Bowerbank
237 Williamantic
238 Elliottsville Plt.
239 Monson
240 Abbot

241 Parkman
242 Sangerville
243 Guilford
244 T3 N. D.
245 T4 N. D.
246 T40 M. D.
247 T41 M. D.
248 T34 M. D.
249 No. 33 Plt.
250 T32 M. D.
251 Amherst
252 Aurora
253 Mariaville
254 Waltham
255 Osborn Plt.
256 Eastbrook
257 T16 M. D.
258 T22 M. D.