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BULK CONTAINERS FOR DECIDUOUS FRUITS:

Costs and Efficiency in Local Assembly Operations

John F. Stollsteimer

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GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

In Cooperation With
Marketing Economics Research Division
Agricultural Marketing Service, U.S.D.A.

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FOREWORD AND ACKNOWLEDGMENTS

This report presents estimates of the effect the introduction of bulk containers may have on costs and efficiency in the orchard-to-plant transportation of deciduous fruits. Costs for these operations with the new type container are compared with costs when lug boxes are used. The comparisons emphasize the effects of handling method, rate of output, hauling distance, and container costs with the two types of containers. The results indicate that a shift from an efficient lug-handling method to an efficient bin-handling method will have little effect on handling costs at the lower rates of output and shorter hauling distances. As hauling distance is increased, the cost advantage of the bulk methods increases. If both handling and container costs are considered, the efficient bulk-handling methods are lowest in cost at all rates of output and hauling distances. A detailed summary of the finding of this study is given on pages 39 through 42.

This study was conducted cooperatively by the Agricultural Experiment Station, University of California, and the Market Economics Research Division of the Agricultural Marketing Service, U. S. Department of Agriculture.

The author is indebted to many members of the industry for cooperation in the field studies and to Mr. Richard E. Coutchie, of the Giannini Foundation of Agricultural Economics, who assisted in the field work. Bin-handling photographs are through the courtesy of Western Fruit Grower, San Francisco, California, and Blackwelder Manufacturing Co., Rio Vista, California.

Special thanks are due to L. L. Sammet, Professor of Agricultural Economics, University of California, Berkeley, who made available the details of earlier analyses which form the basis for parts of this report and who was consulted frequently during the planning and conduct of the study and during the preparation of this report.

TABLE OF CONTENTS

List of Tables

List of Tables

BULK CONTAINERS FOR DECIDUOUS FRUITS: COSTS AND EFFICIENCY IN LOCAL ASSEMBLY OPERATIONS

by

John F. Stollsteimer[1/]

Transportation from orchard to packing house is the first of many steps in the movement of California tree fruits to consumers. The basic operations consist of collecting and loading filled containers in the orchard and their transportation to the packing house, as well as the return of empty containers and their distribution in the orchard. The containers ordinarily used consist of lug boxes designed for manual handling. While not of completely standardized dimensions, they usually hold about 42 pounds of fruit. In some areas, however, there is a growing interest in the use of larger containers that are handled with power-lift equipment. The new-type containers are constructed in the form of a pallet bin. Their dimensions vary, but capacities of bins used with tree fruits usually range from 925 to 1,150 pounds net weight per bin.

The apparent reduction in labor requirements and increased convenience in handling bins as compared with lugs make the possibility of their adoption of great interest to fruit growers and handlers. The likelihood of reduced container costs and some evidence that, with certain fruits, the use of bins creates no additional difficulties in regard to fruit quality also contribute to this interest.[2/] A change to bins, however, involves additional costs for equipment, and this also must be considered in evaluating the possible economies with the new container.

1/ Agricultural Economist, Agricultural Marketing Service, U. S. Department of Agriculture and Associate in Agricultural Economics, University of California, Berkeley, California.

2/ For example, see R. D. Langmo, Influence of Bulk Bins on Winter Pear Damage, Oregon Agricultural Experiment Station Misc. Paper No. 82 (Corvallis, 1959), 16p.; and S. W. McBirney and A. Van Doren, Pallet Bins for Harvesting and Handling Apples, Washington Agricultural Experiment Station Circ. 355 (Pullman, 1959), 11p.

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by

John F. [illegible]1/

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Hand loading lugs on a pallet in the orchard.

Picking up a full bin with a tractor-fork lift.

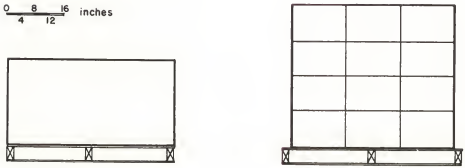

Figure 1 – Comparisons of the two containers. A 24-lug bin occupies 36 cubic feet and weighs approximately 135 pounds while 24 lugs and the accompanying pallet occupy 57 cubic feet and weigh approximately 250 pounds. These differences in space requirements result in the use of bins increasing the net quantity of fruit that can be hauled on any given transport vehicle by approximately 33 per cent.

The objective of this report is to show how costs and efficiency in orchard-to-plant transportation are affected by the introduction of bin-type containers.[1] This requires consideration of certain characteristics of individual orchards, such as rate of harvest, orchard layout, and distance to plant. These are considered in detailed studies of the following variations in type of container and handling method:

BINS:

- Orchard handling with fork lift[2]
  - Transport to plant on flat-bed trucks (Method B-1)
  - Transport to plant on low-bed trailers (Method B-2)
- Orchard handling with utility carrier[3] (Method B-3)
- Direct filling of bins on trailer (Method B-4)

LUGS:

- Hand loading in the orchard
  - Direct haul to plant on low-bed trailers (Method L-1)
  - Direct haul to plant on flat-bed trucks (Method L-2)
  - Transfer to flat-bed truck at roadside
    - Trailers hand loaded in orchard; hand transfer at roadside (Method L-3)
    - Trailers hand loaded in orchard; fork-lift transfer at roadside (Method L-4)
- Orchard handling with fork lift
  - Transport to plant on flat-bed trucks (Method L-5)

1/ For an earlier analysis of relative costs with different methods of orchard-to-plant transportation in California, see L. L. Sammet, Efficiency in Fruit Marketing: Orchard-to-Plant Transportation, University of California, Giannini Foundation Mimeographed Report No. 131 (Berkeley, 1952), 29p.

2/ Normally, a fork-lift attachment for a farm tractor.

3/ A lift which is attached to the three-point hitch system of certain farm tractors.

METHOD OF ANALYSIS

To compare the alternative handling methods, labor and equipment requirements and costs have been estimated for each handling method at various rates of output and hauling distances. Crew and equipment requirements for each of the handling methods were determined primarily by means of time and production studies of actual orchard operations. Costs are estimated by applying current cost and wage rates to the estimated input requirements.

Sources of Data

Bin-handling operations were studied in 13 California apple orchards and 1 California pear orchard. The data on lug handling come from three different sources.[1/] Supplemental handling information was obtained through grower interviews, manufacturers' equipment specifications, analysis of accounting record data, and production studies of handling operations with other commodities where the methods employed are essentially the same as those used in deciduous fruit orchards.

Production Standards

Production standards for individual workers and equipment units are the basis for estimating crew and equipment requirements at different levels of output. These standards represent the rate of performance that can be sustained regularly by average workers in efficiently organized operations. The production standard for a specified unit is built up from the unit time requirements for elements of such operations. These elements are the basic operations involved in handling containers, such as picking up a bin with a fork lift or transfering a lug from stacks to a low-bed trailer. Given approximately equal weight per container, differences in type of fruit handled should not materially affect the time requirements for these elemental handling operations. This allows the time requirements observed in handling operations with one kind of fruit to be used to estimate the time requirements of performing these same operations with other fruits.

1/ Sammet, 29p.; B. C. French, L. L. Sammet, and R. G. Bressler, Jr., "Economic Efficiency in Plant Operations With Special Reference to the Marketing of California Pears," Hilgardia, vol. 24, no. 19, July, 1956; and unpublished material made available by Sammet on handling operations in five California vineyards.

Use of unit time standards can be illustrated by estimating the time requirements for loading a highway truck. In this operation a fork lift (tractor attachment) is used to pick up full bins, transport them to and position them on the truck. It is assumed that the bins are double stacked at a point 65 feet from the truck. The work elements and unit times (taken from Appendix A) are given below.

(a)	Engage bin	.172
(b)	Move bins to truck	.380
(c)	Release bins on truck	.442
(d)	Move fork lift back to point where bins are stacked	.380
(e)	Maneuver	.425
	Total net time	1.798

The total net time given above does not provide for the unavoidable delays or personal time of the lift operator that would be encountered under actual operating conditions. To do so an allowance of 20 per cent of the total time requirement is added to the estimated net working time. This 20 per cent allowance for unavoidable delay and personal time has been built into all of the production standards used in this analysis. Including this percentage, the estimated time required to load two bins is 2.247 minutes or 1.123 minutes per bin.

Bin Handling at Orchard

A number of alternative procedures may be followed in moving bins between transportation vehicles parked in the transfer area and the orchard. As the method used affects cost comparisons with alternative handling methods and containers, this phase of the operation was standardized by using the least-cost procedure in any given handling situation. The basis of selection is summarized in Table 1, which indicates the gross handling time per bin and capacity output rate per hour of fork-lift operation with four alternative in-orchard handling procedures. Gross handling time per bin is based upon the unit times shown in Appendix Table A-3 and specified orchard conditions.[1/] Capacity output rates are expressed in terms of bins and lug equivalents to facilitate comparisons of the new container and the more familiar lug box.

1/ Element time requirements for the operations involved in using the four different procedures are given in Appendix Table A-2.

Orchard-handling procedure C provides the maximum output rate per hour of fork-lift operation. However, this handling procedure requires a particular type of integration for the orchard-handling and highway transportation operations; that is, a transport vehicle must be in the transfer area at all times.

In many handling situations, this type of integration increases the required investment in transportation equipment above that required for less perfect integration. The cost estimates in the following sections are based on the orchard-handling procedure with which the combined cost of orchard handling and highway transportation is lowest at each level of output considered.

The information contained in Table 1, along with assumptions as to rate of highway travel and time spent at the plant, provides the basis for determining the capacity output rate per hour for alternative crew and equipment organizations at any given hauling distance.

Estimation of crew capacity is illustrated in the following example which assumes use of fork-lift equipment to handle the bins on the ranch and highway trucks to transport the containers to and from the plant.[1/] With this method one man working with one truck and one tractor fork lift could use ranch-handling procedure C. The estimated time required to move 12 empty bins from the truck to the orchard and 12 full bins from the orchard onto the truck then is 68.88 minutes--(12 x 5.74). If the total time required at the plant is 24 minutes, and if the one-way hauling distance is 1 mile, the total time spent in highway travel is 6 minutes with travel at an assumed speed of 20 miles per hour. Thus, the total number of man-minutes expended in moving a load of full containers from the orchard to the plant and a load of empty containers from the plant to the orchard is 98.88 minutes. The capacity output rate per hour in lug equivalents is determined by dividing the number of man-minutes available per hour by the number of man-minutes required per load and multiplying the result by 288 (the lug equivalent of a 12-bin load). In the example, 60 man-minutes are available per hour and this divided by 98.88--the total man-minutes required--yields .6068. Multiplying .6068 by 288, we obtain 175 lugs per hour as the capacity output rate in lug equivalents per hour. Capacity output rates for other crew and equipment organizations are determined in a similar fashion. Appropriate cost rates applied to these quantities yield estimates of total handling costs.

1/ This is the procedure used with handling Method B-1, described in detail on page 12.

TABLE 1

Time Required Per Bin and Capacity Output Rates Per Hour With Alternative In-Orchard Handling Procedures[a]

Procedure	Description	Gross handling time per bin	Capacity output rate per hour	
			Bins	Lug equivalent[b]
		minutes		
A	Empty bins unloaded two at a time. Bins transported to and from the orchard one at a time with alternate full bins released, double stacked, in the transfer area for later loading. Full bins loaded two at a time.	8.15	7.36	177
B	Empty bins unloaded two at a time. Bins transported to and from the orchard one at a time. Full bins released directly on the highway transportation equipment used.	7.12	8.43	202
C	Empty bins unloaded two at a time. Bins transported to and from the orchard two at a time. Full bins released directly on the highway transportation equipment being used.	5.74	10.45	251
D	Empty bins unloaded two at a time. Bins transported to and from the orchard two at a time. Full bins released in transfer area for later loading. Full bins loaded two at a time.	6.69	8.97	215

a/ For a detailed breakdown of the time requirements with alternative in-orchard handling procedures, see Appendix Table A-3.

b/ Computed at the rate of 24 lugs per bin.

Cost Estimation

Comparison of costs with the different handling methods must take into account the level of both fixed and variable costs. Fixed equipment costs include depreciation, interest on investment, fixed repair charges, license fees, and insurance. These are costs which are incurred on an annual basis and in this study are taken as constant over the range of output rates considered with any given set of equipment. Variable costs include the operating costs of the equipment and labor charges, both of which are directly related to the level of output attained during any given time period.

Fixed Cost Rates

Table 2 indicates the replacement costs and annual fixed charges allocated to fruit handling for the various equipment items used in orchard-to-plant transportation operations. Replacement costs are based on 1959 delivered prices for northern California. Annual fixed charges are computed by allocating replacement costs over a representative length of life for the various equipment items to obtain annual depreciation charges and adding to this an allowance for interest, fixed repair costs, insurance, and other fixed charges. Fifty per cent of the annual fixed costs for trucks and tractors and 100 per cent of the annual fixed costs for other equipment items have been allocated to the fruit handling operation. The partial allocation of the fixed costs of tractors and trucks is to take account of their use in other ranch operations. The correct allocation to fruit handling would be one which reflected the proportion of total machine service in this use. This is likely to vary among different ranches and so the allocation chosen may not be strictly appropriate in individual situations. Use of alternative allocation rates would shift the estimated level of costs with each handling method but would not alter the relative cost position of the various methods at most output rates and hauling distances.[1] A useful basis for comparison is, therefore, provided.

1/ This is due to the combined effect of two factors. First, the allocation rate affects only part of the total fixed cost for each method. While the proportion of costs affected is not equal for all methods, it is similar and so changes in fixed cost accompanying a change in allocation rate would generally not be sufficient to appreciably affect the relative total cost of alternative methods. Second, the basis for differences in allocation rates presumably is differences in total annual use. As hours of use in handling are more or less fixed by the length of the harvest season, variations in orchard handling, as a proportion of total annual use reflect variations in hours of use in other jobs and variations in total hours of use. If estimated use life and fixed repair charges are adjusted to reflect intensity of use, the percentage change in annual fixed cost charged to handling associated with a change in allocation rate will be much smaller than the percentage change in allocation rate.

TABLE 2

Replacement Costs and Annual Fixed Charges for Equipment Used in Orchard-to-Plant Transportation California, 1959

Item	Estimated use life	Replacement cost	Allocation to fruit handling				
			Proportion of total equipment use	Depreciation	Interest on investment[a]	Repairs[b] and miscellaneous expenses[c]	Total annual cost
	years	dollars	per cent	dollars			
Tractor[d]	10	2,700	50	135	40	75	250
Truck[e]	10	3,800	50	190	57	68	315
Fork-lift attachment[f]	15	1,600	100	107	48	28	183
Trailer[g]	15	345	100	23	10	20	53
Utility carrier[h]	15	160	100	11	5	5	21

a/ Interest on investment computed at 3.0 per cent of replacement cost. This is approximately equal to 5.5 per cent interest on the undepreciated balance.

b/ Fixed repair charges computed at the rate of 2.0 per cent of replacement costs for tractors and trailers and 1.0 per cent for other equipment.

c/ Includes insurance charges at 0.75 per cent of replacement costs plus license fees for trucks, tractors, and trailers.

d/ Four-wheel pneumatic tires, 28-33 h.p.

e/ 18,000-pound gross vehicle weight, 8' x 14' flat bed body.

f/ 2,500-pound capacity, 9-foot lift.

g/ Low-bed pallet-type orchard trailer.

h/ 2,000-pound capacity, 18-inch lift.

Variable Cost Rates

A wage rate of $1.35 per hour is used for all labor. Variable equipment charges are computed at the rate of $0.29 per hour of truck or tractor operation.[1] This figure includes $0.255 per hour for gasoline, $0.015 per hour for lubricants, and $0.020 per hour for minor maintenance charges.

ESTIMATING COSTS WITH ALTERNATIVE METHODS

Production standards were used, as described above, to determine crew and equipment requirements for each of the alternative handling methods at various levels of output. These physical requirements were converted to estimates of total handling costs by applying the indicated cost rates to the quantities of each of the inputs required. To put cost estimates for different handling methods and containers on a comparable basis, certain of the operating conditions were standardized as specified in the following model.

The Model

Specifications applied to (1) orchard operations, (2) packing house operations, (3) containers, and (4) highway transportation are as follows:

1. Orchard conditions
   - (a) Trees are spaced 20 feet on center.
   - (b) Orchard drive rows are sufficiently open to allow any of the following pieces of equipment to pass through without damaging the adjoining trees.
     - (1) A 2½-ton truck with lugs stacked six high on the bed.
     - (2) A tractor-drawn orchard trailer with lugs stacked six high on the trailer.
     - (3) A tractor with a mounted fork-lift attachment carrying either a pallet on which lugs are stacked six high or two bins stacked one on top of the other.
   - (c) Picked fruit is concentrated at 40-foot, 2-tree intervals on either side of the drive row with an average stack size of 24 lugs.
   - (d) Empty containers are distributed in the drive row immediately adjacent to the one from which full containers are to be removed.

1/ Maintenance charges for trailers, fork lifts, and utility carriers are included as part of the fixed cost of these equipment items.

(e) The transfer area[1] required for certain handling methods is located 250 feet from the end of the drive row from which full containers are to be removed.

(f) When bins are used, 25 per cent of the containers have to be respotted in the orchard.[2]

(g) When lugs are used, pickers carry empty boxes from one set to another to correct for errors in box distribution.

(h) Transportation labor is used only in orchard-to-plant transportation jobs. No use on supplemental jobs is considered.

2. Packing house receiving

(a) Fork-lift equipment is available to handle palletized lugs or bins.

(b) The average time spent at the plant, both in waiting and in getting loaded and unloaded, is assumed to be 24 minutes per load.[3] A load of fruit is considered to be 216 lugs (9,072 pounds of fruit) or 12 bins (12,096 pounds of fruit).

3. Containers

(a) Lug boxes are considered to be 13½" x 18" x 9" (inside dimensions) and to hold 42 pounds of fruit.

(b) Bins are taken as 46" x 46" x 26" deep (inside dimensions) and as holding 24 lugs (1,008 pounds of fruit).

4. Highway transportation

(a) The average rate of highway travel is assumed to be:

(1) 20 miles per hour for highway trucks.

(2) 10 miles per hour for tractor-orchard trailer combinations.

The operating conditions specified are representative of the condition present in actual operations where the equipment considered is in use. Minor deviations in circumstances, likely to be present in any given orchard operation, would not alter substantially the labor and equipment requirements and costs of moving the containers between the orchard and the plant. Wide differences from the "model" would change the estimated input requirements and costs presented in the following sections, but unless these changed operating conditions are

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1/ A transfer area consists of any open area approximately 75 feet square and reasonably level. As in many of the orchards studied, more than one transfer area is provided in a large orchard.

2/ Respotting consists of moving a partially filled bin from one point in the orchard to another. It is assumed that a respotted bin is moved 100 feet.

3/ Sammet found this to be the average time spent at the plant by a sample of growers delivering fruit to California pear and apple packing houses.

particularly favorable or unfavorable to certain handling methods, the relative costs of the various methods would remain unchanged. The container specifications are sufficiently similar to those used in handling a range of deciduous fruits, for example, apples, pears, peaches, and apricots, that the results could be applied to any of these commodities, if the operating conditions are as specified.

Bin-Handling Methods

Four different bin-handling methods are considered. These include orchard handling with fork-lift equipment and transportation to plant on either flat-bed trucks or low-bed trailers; orchard handling with a utility carrier and transportation to plant on low-bed trailers; and direct filling of bins on low-bed trailers.

Method B-1: Bins-Trucks

This bin-handling method involves the use of fork-lift equipment for the on-ranch handling of the bins and highway trucks for the over-the-road hauling. Labor and equipment requirements and the costs of attaining output rates varying from zero to the equivalent of 500 lugs per hour, at hauling distances of 1 to 10 miles, with Method B-1, are shown in Table 3. The capacity output rates for the various crew and equipment organizations were determined by means of calculations similar to those given in the earlier example. For intermediate output rates, not shown in the table, the crew and equipment requirements are the same as for the next higher capacity rate shown.

The effect of an increase in the length of haul on the capacity output rate attainable with a given crew and equipment organization depends upon which operation is the limiting factor at the shorter hauling distance. For example, the capacity output rate attainable with two men, two trucks, and one tractor fork lift is 251 lugs per hour when the hauling distance is 1 mile. This is the capacity output rate of one fork lift in handling bins on the ranch when ranch handling procedure C is used. Thus, it is the ranch operation that is the limiting factor in determining the capacity output rate of this group of men and equipment. Table 3 will indicate that this crew and equipment organization has the same capacity output rate at a 5-mile haul. Further increases in hauling distance result in highway transportation becoming a limiting factor.

Crew and Equipment Requirements and Costs in Relation to Selected Bin-Handling Methods, Rate of Output, and Length of Haul from Orchard to Plant
California, 1959

Handling method and one-way hauling distance	Capacity output rate per hour	Crew required	Equipment required					Variable cost		Fixed cost per hour[2/]	Total hourly handling cost
			Tractors	Trailers	Trucks	Fork lift attachments	Utility barriers	Labor[b/]	Equipment[b/]		
	lug equivalents[a/]	men	units					dollars			
Method B-1: bins--trucks											
	175	1	1	--[c/]	1	1	0	1.35	.29	2.99	4.63
	215	2	1	--	1	1	0	2.70	.58	2.99	6.27
One mile	251	2	1	--	2	1	0	2.70	.58	4.25	7.53
	415	3	2	--	2	1	1	4.05	.87	5.34	10.26
	502	3	2	--	2	2	0	4.05	.87	5.98	10.90
	156	1	1	--	1	1	0	1.35	.29	2.99	4.63
	215	2	1	--	1	1	0	2.70	.58	2.99	6.27
Three miles	251	2	1	--	2	1	0	2.70	.58	4.25	7.53
	415	3	2	--	2	1	1	4.05	.87	5.34	10.26
	452	4	2	--	2	2	0	5.40	1.16	5.98	12.54
	502	4	2	--	3	2	0	5.40	1.16	7.24	13.80
	140	1	1	--	1	1	0	1.35	.29	2.99	4.63
	215	2	1	--	1	1	0	2.70	.58	2.99	6.27
Five miles	251	2	1	--	2	1	0	2.70	.58	4.25	7.53
	321	3	2	--	2	1	1	4.05	.87	5.34	10.26
	415	4	2	--	3	1	1	5.40	1.16	6.60	13.16
	502	4	2	--	3	2	0	5.40	1.16	7.24	13.80
	113	1	1	--	1	1	0	1.35	.29	2.99	4.63
	167	2	1	--	1	1	0	2.70	.58	2.99	6.27
	206	2	1	--	2	1	0	2.70	.58	4.25	7.53
Ten miles	251	3	1	--	3	1	0	4.05	.87	5.51	10.43
	412	4	2	--	3	1	1	5.40	1.16	6.60	13.16
	468	5	2	--	3	2	0	6.75	1.45	7.45	15.44
	502	5	2	--	4	2	0	6.75	1.45	8.51	16.71
Method B-2: bins--trailers											
	165	1	2	3	--	1	0	1.35	.29	3.37	5.01
One mile	215	2	2	3	--	1	0	2.70	.58	3.37	6.65
	251	2	2	6	--	1	0	2.70	.58	4.01	7.29
	415	3	3	6	--	1	1	4.05	.87	5.09	10.01
	134	1	2	3	--	1	0	1.35	.29	3.37	5.01
	215	2	2	3	--	1	0	2.70	.58	3.37	6.65
Three miles	251	2	2	6	--	1	0	2.70	.58	4.01	7.29
	288	3	3	6	--	1	1	4.05	.87	5.09	10.01
	415	4	3	9	--	1	1	5.40	1.16	6.73	13.29
	113	1	2	3	--	1	0	1.35	.29	3.37	5.01
	167	2	2	3	--	1	0	2.70	.58	3.37	6.65
Five miles	206	2	2	6	--	1	0	2.70	.58	4.01	7.29
	251	3	3	9	--	1	0	4.05	.87	5.64	10.56
	412	4	3	9	--	1	1	5.40	1.16	6.73	13.29
	81	1	2	3	--	1	0	1.35	.29	3.37	5.01
	105	2	2	3	--	1	0	2.70	.58	3.37	6.65
Ten miles	129	2	2	6	--	1	0	2.70	.58	4.01	7.29
	244	3	3	9	--	1	0	4.05	.87	5.64	10.56
	360	5	5	12	--	1	1	6.75	1.45	8.36	16.56
Method B-3: bins handled with a utility carrier											
	103	1	2	3	--	0	1	1.35	.29	2.72	4.36
	144	2	2	3	--	0	1	2.70	.58	2.72	6.00
One mile	179	2	2	6	--	0	1	2.70	.58	3.36	6.64
	241	3	3	6	--	0	2	4.05	.87	4.44	9.36
	289	4	4	6	--	0	2	5.40	1.16	5.44	12.00
	357	4	4	9	--	0	2	5.40	1.16	6.08	12.64
	80	1	2	3	--	0	1	1.35	.29	2.72	4.36
	108	2	2	3	--	0	1	2.70	.58	2.72	6.00
Three miles	144	2	2	6	--	0	1	2.70	.58	3.36	6.64
	179	3	3	9	--	0	1	4.05	.87	4.99	9.74
	288	4	4	9	--	0	2	5.40	1.16	6.08	12.64
	357	5	5	9	--	0	2	6.75	1.45	7.08	15.28
	65	1	2	3	--	0	1	1.35	.29	2.72	4.36
	103	2	2	6	--	0	1	2.70	.58	3.36	6.64
Five miles	125	3	3	9	--	0	1	4.05	.87	4.36	9.28
	179	3	3	9	--	0	1	4.05	.87	4.99	9.74
	206	4	4	9	--	0	2	5.40	1.16	6.08	12.64
	309	5	5	9	--	0	2	6.75	1.45	7.08	15.28
	85	3	3	6	--	0	1	4.05	.87	4.36	9.28
	120	3	3	9	--	0	1	4.05	.87	4.99	9.91
Ten miles	179	4	4	9	--	0	1	5.40	1.16	5.99	12.55
	240	6	6	15	--	0	2	8.10	1.74	8.95	18.79
	300	7	7	18	--	0	2	11.48	2.03	10.98	22.46

a/ Based on a wage rate of $1.35 per hour.

b/ Includes $0.27 for fuel and oil and $0.02 for minor repairs per hour of truck or tractor operation.

c/ Based on the annual fixed charges per equipment unit shown in Table 2, a 250-hour operating season, and the number of units specified in this Table.

d/ Bins converted to lug equivalent at the rate of 24 lugs per bin.

e/ Dashes indicate this equipment not used with this method.

When the length of haul is 10 miles, the capacity output rate for this crew and equipment organization is 206 lugs per hour or 45 lugs per hour less than at 5 miles.

The hourly costs shown in the right-hand columns of Table 3 are based on the cost rates given in the previous section and the indicated crew and equipment requirements. The labor costs shown assume that labor used in orchard-to-plant transportation operations works only in these jobs and is not assigned supplemental duties.[1/] This means that in some situations certain workers may be partially idle due to imperfect integration of the orchard and transportation operations.

Method B-2: Bins-Trailers

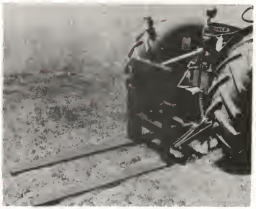
This bin-handling method differs from Method B-1 only to the extent that containers are moved to and from the plant on tractor-drawn trailers rather than highway trucks. The trailers used are low-bed orchard trailers, each of which will hold four bins or the equivalent of 96 lugs when the bins are double stacked. By hauling three of these trailers intandem, it is possible to haul 12 bins or the equivalent of 288 lugs per trip to the packing house. The ranch operations are the same as with Method B-1--that is, the bins are handled with fork-lift equipment.

The tractor-drawn trailers provide more flexibility in the highway transportation operation than can be attained with trucks, as one tractor can provide power for more than one set of trailers. This means that in some instances it is possible to meet the requirements of the most efficient ranch-handling procedure--that is, have a transportation vehicle in the transfer area at all times--with a lower investment in transportation equipment. However, the highway speed of the tractor-trailer combinations is lower than with trucks and so transportation equipment requirements for any given rate of output increase more rapidly with increases in hauling distance with Method B-2 than with Method B-1.

Table 3 contains the estimated labor and equipment requirements and the costs of attaining various rates of output over 1, 3, 5, and 10-mile hauls when bins are handled by means of Method B-2.

1/ In some orchards, swampers are used as pickers when not working in orchard-to-plant transportation jobs. In this analysis, we have assumed use of the more common practice of not assigning supplemental duties to workers used in transportation operations.

A front mounted fork-lift attachment.



A utility carrier mounted on the three-point hitch system.

Loading bins on a highway truck

Loading bins on a low-bed trailer.

Picking directly into bins on a low-bed trailer.

Figure 2 -- Alternative bin handling methods and equipment. A highway truck normally hauls 12 bins (the equivalent of 288 lugs) while a low-bed trailer will hold 4 bins if they are stacked two high.

The limitation of the highway transportation operation with this method can be seen by the rapidity with which the capacity output rate attainable with a given crew and equipment organization declines as the length of haul is increased. In terms of costs, this means that the cost of attaining a given rate of output rises rather rapidly with increases in the hauling distance.

Method B-3: Bins Handled With A Utility Carrier

This method uses the same highway transportation equipment as is used with bin-handling Method B-2, but on the ranch the bins are handled with a tractor equipped with a utility carrier. This change in ranch-handling equipment results in a reduction in the capacity output rate attainable with a given crew and equipment organization because: (a) bins can only be loaded one high on the trailers, thus reducing the effective hauling capacity of the trailers by one-half; and (b) the utility carrier is of lower capacity, as compared with fork-lift equipment, in handling bins on the ranch.

Table 3 contains the estimated crew and equipment requirements and the costs of attaining various rates of output over hauling distances of 1, 3, 5, and 10 miles when handling Method B-3 is used.

Table 3 indicates that the capacity output rate attainable with a given crew and equipment organization falls off very rapidly as the hauling distance is increased. This reflects the decreased hauling capacity of the trailers. Likewise, the cost of attaining a given rate of output increases even more rapidly as length of haul is increased with this method than with Method B-2.

Method B-4: Bins Filled On Trailers

With this method, the bins are left on orchard trailers while being filled by the pickers. When full, the bin-trailer units are pulled to the plant with farm tractors, where the bins are unloaded and the trailers reloaded with empty bins. The trailers are hauled in tandem to the end of the orchard drive row, where they are to be distributed. At this point, they are disconnected and pulled into the orchard one at a time. Trailers with full bins are hauled to this same point one at a time, where they are connected together in preparation for hauling to the plant. The estimated time spent per bin in the various orchard operations and at the plant is shown in Table 4.

The interdependence of the picking and hauling operations when this bin-handling method is used makes the rate of picking the output rate that determines equipment requirements. With the handling methods previously considered,

Table 4

Man-Minutes Required per Bin in Orchard and At-Plant Operations with Method B-4 (Bins Filled on Orchard Trailers) in Relation to the Number of Trailers Hauled per Trip to the Plant, California, 1959

Operation	Man-minutes per bin Number of trailers hauled per trip to the plant		
	1	2	3
Move trailers between transfer area and orchard	3.92	3.22	2.99
Hook and unhook trailers	1.00	1.25	1.33
Unavoidable delay and wait	1.25	1.12	1.08
Cross orchard time per bin	6.17	5.59	5.40
Gross plant time per bin	8.57	5.34	3.99

Table 5

Crew and Equipment Requirements and Costs in Relation to Rate of Output and Length of Haul when Bins Are Handled by Means of Method B-4 (Bins Filled Directly on Orchard Trailers) California, 1959

One-way hauling distance	Picking rate per hour	Crew required	Equipment required		Variable cost		Fixed cost per hour[c]	Total hourly handling cost
	lug equivalents[d]	men	Tractors	Trailers	Labor[a]	Equipment[b]		
			units		dollars			
	64	1	1	3	1.35	.29	1.64	3.28
	96	1	1	4	1.35	.29	1.85	3.49
	128	2	2	6	2.70	.58	3.27	6.55
One mile	160	2	2	8	2.70	.58	3.70	6.98
	208	2	2	10	2.70	.58	4.12	7.40
	240	2	2	12	2.70	.58	4.54	7.82
	288	3	3	14	4.05	.87	5.97	10.89
	320	3	3	15	4.05	.87	6.18	11.10
	72	1	1	5	1.35	.29	2.06	3.70
	128	2	2	6	2.70	.58	3.27	6.55
	160	2	2	11	2.70	.58	4.33	7.61
Three miles	208	3	3	13	4.05	.87	5.76	10.68
	240	3	3	15	4.05	.87	6.18	11.10
	288	4	4	18	5.40	1.16	7.82	14.38
	304	4	4	20	5.40	1.16	8.24	14.80
	64	1	1	6	1.35	.29	2.27	3.91
	128	2	2	10	2.70	.58	4.12	7.40
	160	3	3	11	4.05	.87	5.35	10.27
Five miles	208	3	3	13	4.05	.87	5.76	10.68
	240	4	4	16	5.40	1.16	7.39	13.95
	288	4	4	20	5.40	1.16	8.24	14.80
	304	5	5	21	6.75	1.45	9.45	17.65
	72	2	2	7	2.70	.58	3.48	6.76
	104	3	3	9	4.05	.87	4.91	9.83
	160	4	4	15	5.40	1.16	7.18	13.74
Ten miles	208	5	5	20	6.75	1.45	9.24	17.44
	240	5	5	23	6.75	1.45	9.88	18.08
	272	6	6	26	8.10	1.74	11.51	21.35
	304	7	7	29	9.45	2.03	13.15	24.63

a/ Based on a wage rate of $1.35 per hour.

b/ Includes $0.27 for fuel and oil and $0.02 for minor repairs per hour of truck or tractor operation.

c/ Based on the annual fixed charges per equipment unit shown in Table 2, a 250-hour operating season, and the number of units specified in this Table.

d/ Bins converted to lug equivalent at the rate of 24 lugs per bin.

some flexibility in hauling as compared with picking rates is possible, as extra bins are easily made available in the picking area. This kind of arrangement, however, is not practicable when bins are loaded directly on trailers, and so hauling capacity must be closely related to the rate of picking. The estimated labor and equipment requirements and the costs shown in Table 5 are based on the time requirements shown in Table 4, an assumed picking rate of eight lugs per hour per picker,[1] and the assumption that no more than eight pickers pick into the bins on a single trailer.[2] Because of these additional assumptions, the estimated labor and equipment requirements and costs shown in Table 5 are less generally applicable than those given for other bin-handling methods. Alternative assumptions with respect to the picking operations would alter the estimated labor and equipment needed for orchard-to-plant transportation operations.

Table 5 indicates that for low picking rates and short hauling distances, the equipment requirements and costs with this method are relatively low, but that increases in either the picking rate or the hauling distance result in rapid increases in equipment requirements (particularly the number of trailers) and costs. The change in equipment requirements as the rate of output is increased is a result both of the increased need for highway transportation equipment and the need for more stationary trailers in the orchard.

Lug-Handling Methods

Five alternative lug-handling methods are considered. These include: hand loading of low-bed trailers and flat-bed trucks in the orchard for direct haul to the plant; hand loading of low-bed trailers in the orchard with subsequent hand or fork-lift transfer to highway trucks; and handling of the lugs at the orchard with fork-lift equipment, with haul to the plant by truck. Unit times for the different lug-handling operations and production standards for the different lug-handling methods are shown in the appendix. In the same manner as illustrated for bins, lug-handling standards can be used to estimate the labor and equipment requirements necessary for any given level of output. Total handling costs are calculated by applying appropriate cost rates to these estimated requirements.

1/ This is equal to the mean rate of picking found in time and production studies in 47 California deciduous fruit orchards.

2/ This assumption is based on the common practice of assigning no more than one picker per tree.

Method L-1: Lugs-Trailers

The equipment used with this handling method consist of low-bed trailers pulled by farm tractors. These trailers are loaded and unloaded in the orchard by hand. The low-bed construction of the trailers used makes it possible for a loader-stacker to remain on the ground while placing a full lug in place on the trailer. Thus, it is possible to operate with a one-man loading crew. This is illustrated in Figure 3.

Table 6 indicates the input requirements and the costs of attaining various rates of output over hauling distances of 1, 3, 5, and 10 miles when lug-handling Method L-1 is used. The hourly costs are based on the indicated labor and equipment requirements and the cost rates given in an earlier section.

With Method L-1, and with other lug-handling methods, increases in the rate of output can often be achieved by either increasing the number of workers working with a given set of equipment or by increasing the amount of equipment available to a given crew. This means that particular output rates frequently can be achieved with a number of different crew and equipment organizations. The crew and equipment organizations shown were selected to obtain the indicated outputs at the minimum cost possible with a given method and the cost rates used in this analysis. The worker assignments assumed with multiple-man crews are as efficient as practicable, given the equipment available. For example, with a three-man crew working with two tractor-trailer units, it is assumed that two men work at loading one set of trailers while the third is delivering a load of fruit to the packing house and possibly distributing empty lugs depending upon the time required for road travel.

Method L-2: Lugs-Trucks

When this handling method is used, the orchard-to-plant haul is by means of highway trucks which are loaded directly in the orchard by hand. Usually, the minimum loading crew is two men--a driver, who at each orchard set also transfers the lugs to the truck bed, and a helper, who stacks the lugs on the truck. The lugs are stacked on pallets, with 36 lugs per pallet and 6 pallets, or 216 lugs, per truck load. The loading operation with this method is shown in Figure 3.

The input requirements and the costs of attaining various rates of output over one-way hauling distances of 1, 3, 5, and 10 miles are shown in Table 6.

Hand loading lugs on a low-bed trailer.

Hand loading lugs on a highway truck.

Flat-bed truck receiving lugs at transfer point.

Loading a pallet on a fork-lift attachment in the orchard.

Figure 3 – Alternative lug handling methods and equipment.

Table 6

Crew and Equipment Requirements and Costs in Relation to Selected Lug-Handling Methods, Rate of Output, and Length of Haul from Orchard to Plant
California, 1959

Handling method and one-way hauling distance	Capacity output rate per hour	Crew required	Equipment required			Variable cost		Fixed cost per hour[c]	Total hourly handling cost
			Tractors	Trailers	Trucks	Labor[a]	Equipment[b]		
	lugs	men	units			dollars			
Method L-1: lugs--trailers									
One mile	124	1	1	3	--[d]	1.35	.29	1.64	3.28
	166	2	1	3	--	2.70	.29	1.64	4.63
	183	3	1	3	--	4.05	.29	1.64	5.98
	247	2	2	6	--	2.70	.58	3.27	6.55
	308	3	2	6	--	4.05	.58	3.27	7.90
Three miles	101	1	1	3	--	1.35	.29	1.64	3.28
	127	2	1	3	--	2.70	.29	1.64	4.63
	137	3	1	3	--	4.05	.29	1.64	5.98
	201	2	2	6	--	2.70	.58	3.27	6.55
	254	3	2	6	--	4.05	.58	3.27	7.90
	273	4	2	9	--	5.40	.58	3.27	9.25
	285	5	2	6	--	6.75	.58	3.27	10.60
	308	4	3	9	--	5.40	.87	4.91	11.18
Five miles	85	1	1	3	--	1.35	.29	1.64	3.28
	103	2	1	3	--	2.70	.29	1.64	4.63
	170	2	2	6	--	2.70	.58	3.27	6.55
	206	3	2	6	--	4.04	.58	3.27	7.90
	229	5	2	6	--	6.75	.58	3.27	10.60
	308	4	3	9	--	5.40	.87	4.91	11.18
Ten miles	61	1	1	3	--	1.35	.29	1.64	3.28
	122	2	2	6	--	2.70	.58	3.27	6.55
	138	3	2	6	--	4.05	.58	3.27	7.90
	145	4	2	6	--	5.40	.58	3.27	9.25
	227	4	3	9	--	5.40	.87	4.91	11.18
	243	5	3	9	--	6.75	.87	4.91	12.53
	288	5	4	12	--	6.75	1.16	6.54	14.45
Method L-2: lugs--trucks									
One mile	134	2	--	--	1	2.70	.29	1.26	4.25
	156	3	--	--	1	4.05	.29	1.26	5.60
	173	4	--	--	1	5.40	.29	1.26	6.95
	195	3	--	--	2	4.05	.58	2.52	7.15
	269	4	--	--	2	5.40	.58	2.52	8.50
	269	5	--	--	2	6.75	.58	2.52	9.85
	325	6	--	--	2	8.10	.58	2.52	11.20
Three miles	119	2	--	--	1	2.70	.29	1.26	4.25
	136	3	--	--	1	4.05	.29	1.26	5.60
	149	4	--	--	1	5.40	.29	1.26	6.95
	195	3	--	--	2	4.05	.58	2.52	7.15
	244	4	--	--	2	5.40	.58	2.52	8.50
	289	5	--	--	2	6.75	.58	2.52	9.85
	317	6	--	--	2	8.10	.58	2.52	11.20
Five miles	108	2	--	--	1	2.70	.29	1.26	4.25
	121	3	--	--	1	4.05	.29	1.26	5.60
	131	4	--	--	1	5.40	.29	1.26	6.95
	195	3	--	--	2	4.05	.58	2.52	7.15
	242	4	--	--	2	5.40	.58	2.52	8.50
	263	5	--	--	2	6.75	.58	2.52	9.85
	289	6	--	--	3	8.10	.87	3.78	12.75
	325	7	--	--	3	9.45	.87	3.78	14.10
Ten miles	86	2	--	--	1	2.70	.29	1.26	4.25
	94	3	--	--	1	4.05	.29	1.26	5.60
	172	3	--	--	2	4.05	.58	2.52	7.15
	189	4	--	--	2	5.40	.58	2.52	8.10
	201	5	--	--	2	6.75	.58	2.52	9.85
	244	5	--	--	3	6.75	.87	3.78	11.40
	289	6	--	--	3	8.10	.87	3.78	12.75
	318	7	--	--	3	9.45	.87	3.78	14.10

a/ Based on a wage rate of $1.35 per hour.

b/ Includes $0.27 for fuel and oil and $0.02 for minor repairs per hour of truck or tractor operation.

c/ Based on the annual fixed charges per equipment unit shown in Table 2, a 250-hour operating season, and the number of units specified in this Table.

d/ Dashes indicate this equipment not used with this method.

An examination of this table will indicate that with Method L-2 increases in the rate of output, at a given hauling distance, result in rather large increases in the labor requirements, while increases in the hauling distance result in relatively small decreases in the capacity output rate attainable with a given crew and equipment organization.

Method L-3: Lugs Transferred by Hand

This lug-handling method combines Methods L-1 and L-2. Orchard trailers are used to move the lugs between the orchard and a transfer area where they are transferred by hand to and from highway trucks that are used for over-the-road haul. The hand-transfer operation requires a minimum crew of two men.

Estimated input requirements and costs of attaining various rates of output over hauling distances of 1, 3, 5, and 10 miles with lug-handling Method L-3 are shown in Table 7. This lug-handling method has relatively high labor requirements, due to the additional handling of the containers at the transfer point, and relatively high equipment requirements because both trucks and tractor-trailer combinations are needed.

Method L-4: Lugs Transferred With a Fork Lift

This lug-handling method is identical to Method L-3, with the exception that the transfer operation is accomplished with fork-lift equipement rather than by hand. The lugs are stacked on pallets, 36 per pallet, as they are loaded on the trailers in the orchard. At the transfer point, pallet loads of lugs are transferred by fork lift from the trailers to the trucks that are used for highway transportation.

The estimated input requirements and the costs of attaining various rates of output over 1, 3, 5, and 10-mile hauls with Method L-4 are shown in Table 7. While having somewhat lower labor requirements than Method L-3, Method L-4 requires additional equipment, in the form of a tractor and fork-lift attachment, at all output rates.

Method L-5: Lugs-Fork Lift

With this lug-handling method, fork-lift equipment is used to move pallets of lugs between the orchard and a transfer area and highway trucks are employed for over-the-road hauling. A pallet will hold 36 lugs if the containers are

Crew and Equipment Requirements and Costs in Relation to Selected Lug-Handling Methods, Rate of Output, and Length of Haul from Orchard to Plant
California, 1959

Handling method and one-way hauling distance	Capacity output rate per hour	Crew required	Equipment required				Variable cost		Fixed cost per hour c/	Total hourly handling cost
			Tractors	Trailers	Trucks	Fork lift attachments	Labor a/	Equipment b/		
	1/	nos.	units				dollars			
Method L-3: lugs transfered by hand										
One mile	108	2	1	3	1	--d/	2.70	.58	2.90	6.18
	127	2	1	6	1	--	2.70	.58	3.53	6.81
	179	3	1	6	1	--	4.05	.58	3.53	8.16
	203	4	1	6	1	--	5.40	.58	3.53	9.51
	308	7	1	6	2	--	9.45	.87	4.79	15.11
Three miles	98	2	1	3	1	--	2.70	.58	2.90	6.18
	121	2	1	6	1	--	2.70	.58	3.53	6.81
	143	3	1	6	1	--	4.05	.58	3.35	8.16
	267	5	1	6	2	--	6.75	.87	4.79	12.41
	308	7	1	6	2	--	9.45	.87	4.79	15.11
Five miles	90	2	1	3	1	--	2.70	.58	2.90	6.18
	116	2	1	6	1	--	2.70	.58	3.53	6.81
	127	3	1	6	1	--	4.05	.58	3.53	8.16
	156	4	1	6	1	--	5.40	.58	3.53	9.51
	240	5	1	6	2	--	6.75	.87	4.79	12.41
	308	8	1	6	3	--	10.80	1.16	6.05	18.01
Ten miles	74	2	1	3	1	--	2.70	.58	2.90	6.18
	98	2	1	6	1	--	2.70	.58	3.53	6.81
	143	3	1	6	2	--	4.05	.87	4.79	9.71
	154	4	1	6	2	--	5.40	.87	4.79	11.06
	267	6	1	6	3	--	8.10	1.16	6.05	15.31
	308	8	1	6	3	--	10.80	1.16	6.05	18.01
Method L-4: lugs transfered with a fork lift										
One mile	102	1	2	3	1	1	1.35	.29	4.63	6.27
	188	2	2	6	1	1	2.70	.58	5.27	8.55
	214	3	2	6	1	1	4.05	.87	5.27	10.19
	308	4	2	6	2	1	5.40	1.16	6.53	13.09
Three miles	92	1	2	3	1	1	1.35	.29	4.63	6.27
	188	2	2	6	1	1	2.70	.58	5.27	8.55
	199	3	2	6	1	1	4.05	.87	5.27	10.19
	241	3	2	6	2	1	4.05	.87	6.53	11.45
	308	4	2	6	2	1	5.40	1.16	6.53	13.09
Five miles	84	1	2	3	1	1	1.35	.29	4.63	6.27
	160	2	2	6	1	1	2.70	.58	5.27	8.55
	241	3	2	6	2	1	4.05	.87	6.53	11.45
	306	4	2	6	2	1	5.40	1.16	6.53	13.09
Ten miles	71	1	2	3	1	1	1.35	.29	4.63	6.27
	117	2	2	6	1	1	2.70	.58	5.27	8.55
	135	2	2	6	2	1	2.70	.58	6.53	9.81
	178	4	2	6	2	1	5.40	1.16	6.53	13.09
	228	5	2	6	2	1	6.75	1.16	6.53	14.44
	308	5	2	6	3	1	6.75	1.16	7.79	15.70
Method L-5: lugs--fork lift										
One mile	108	1	1	--	1	1	1.35	.29	2.99	4.63
	121	2	1	--	1	1	2.70	.58	2.99	6.27
	145	2	1	--	2	1	2.70	.58	4.25	7.53
	209	3	2	--	2	2	4.05	.87	5.99	10.91
	433	4	3	--	2	3	5.40	1.16	7.72	14.28
Three miles	99	1	1	--	1	1	1.35	.29	2.99	4.63
	123	2	1	--	1	1	2.70	.58	2.99	6.27
	145	2	1	--	2	1	2.70	.58	4.25	7.53
	289	3	2	--	2	2	4.05	.87	5.99	10.91
	309	4	3	--	2	3	5.40	1.16	7.72	14.28
Five miles	90	1	1	--	1	1	1.35	.29	2.99	4.63
	123	2	1	--	1	1	2.70	.58	2.99	6.27
	145	2	1	--	2	1	2.70	.58	4.25	7.53
	240	3	2	--	2	2	4.05	.87	5.99	10.91
	257	4	2	--	2	2	5.40	1.16	5.99	12.55
	276	4	2	--	3	2	5.40	1.16	7.25	13.81
Ten miles	75	1	1	--	1	1	1.35	.29	2.99	4.63
	123	2	1	--	1	1	2.70	.58	2.99	6.27
	145	2	1	--	2	1	2.70	.58	4.25	7.53
	201	4	2	--	2	2	5.40	1.16	5.99	12.55
	276	4	2	--	3	2	5.40	1.16	7.25	13.81
	309	5	3	--	3	3	6.75	1.45	8.98	17.18

a/ Based on a wage rate of $1.35 per hour.

b/ Includes $0.27 for fuel and oil and $0.02 for minor repairs per hour of truck or tractor operation.

c/ Based on the annual fixed charges per equipment unit shown in Table 2, a 250-hour operating season, and the number of units specified in this Table.

d/ Dashes indicate this equipment not used with this method.

stacked 6 high, or 42 lugs if they are stacked 7 high. The more common practice is to stack the containers six high, and the crew and equipment requirements shown in the lower portion of Table 7 are based on the assumption that this is the practice followed.

The loading and unloading of the pallets in the orchard is a task normally shared by the fork-lift driver and the picking crew. The fork-lift driver generally distributes part of the empty lugs on a pallet and then releases the pallet containing the remainder at a point where the lugs will be needed by the picking crew. The pickers stack the full lugs on pallet load when this is convenient, and the fork-lift driver completes the pallets from other picker stacks. In this analysis, it has been assumed that 50 per cent of the empty lugs are distributed by the fork-lift driver and that 50 per cent of the full lugs are placed on pallets by the pickers.

Table 7 indicates that the attainment of high rates of output requires the use of two or three tractor-fork lifts when Method L-5 is used. As a result the fixed equipment costs of this handling method is relatively high in relation to output rate as compared with other lug-handling methods.

COST COMPARISONS AND MINIMUM COST HANDLING METHODS

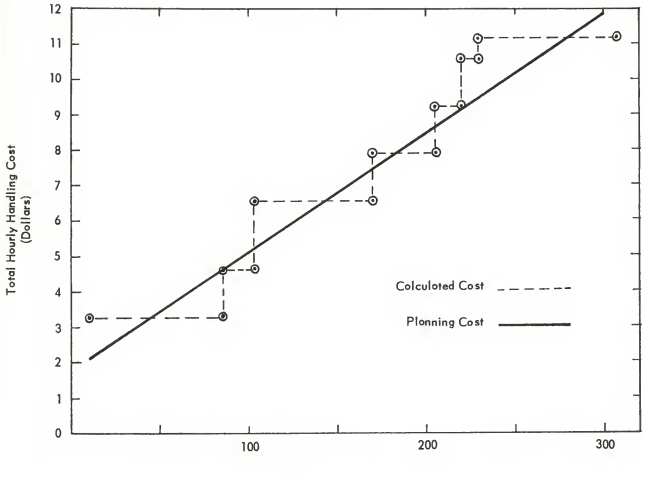
All of the handling cost comparisons made in this analysis are in terms of total handling costs--a sum of the direct cost of the labor required to achieve the output rate being considered and the variable and fixed cost of the equipment needed. The preceding sections present estimates of total hourly handling costs for a number of different rates of output at selected hauling distances for each of the handling methods considered. However, these cost estimates are rather cumbersome to use for comparing the costs of the alternative handling methods, as only in rare instances are the same output rates considered with different handling methods.

Planning Costs With Alternative Handling Methods

For convenience in comparing different methods, the estimated costs given previously have been used to develop a "planning cost" relationship for each of the handling methods. Figure 4 illustrates how this was accomplished. The

Figure 4

Total Hourly Handling Cost in Providing Orchard-To-Plant Transportation with Method L-1 – Lugs Hand-Loaded on Low-Bed Trailers – In Relation to Rate of Output when the Hauling Distance is Five Miles. California 1959.



circled points in this diagram represent the calculated costs for capacity rates of output for a number of crew and equipment organizations when lug-handling Method L-1--lugs-trailers--is used and the hauling distance is 5 miles. The line representing the planning cost relationship is drawn to show how costs, on the average, vary with output rate at the distance specified. Planning cost relationships were developed for each handling method from the estimated costs points at output rates ranging from 0 to 500 lugs per hour and hauling distances of 1, 2, 3, 4, 5, 10, and 15 miles.[1/] These relationships can be used to estimate total hourly handling costs for any given rate of output at any selected hauling distance and are used to compare the costs of the alternative handling methods.

The primary interest is in comparing total hourly handling costs of providing orchard-to-plant transportation with bins and total hourly handling costs of providing this same service with lugs. To facilitate this comparison, total hourly handling costs with alternative bin-handling methods are examined and least-cost bin-handling methods specified for rates of output between 25 and 300 lugs per hour at hauling distances of 1, 3, 5, and 10 miles. Total hourly handling costs of attaining these same output rates with five alternative lug-handling methods are considered and compared with the least-cost bin-handling methods.

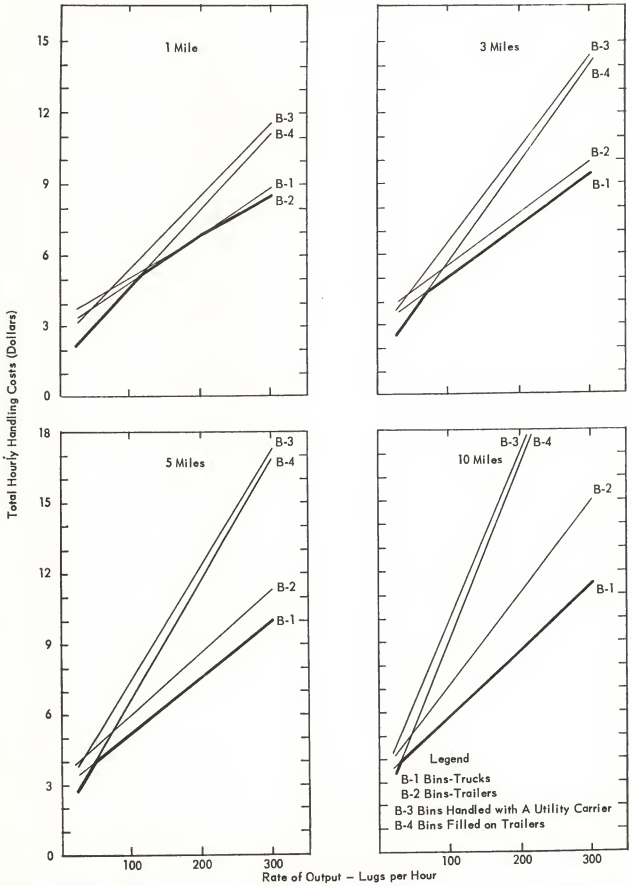
Total Hourly Handling Costs With Alternative Bin-Handling Methods

The four diagrams in Figure 5 show the total hourly handling costs, estimated in terms of "planning costs," of providing orchard-to-plant transportation with four alternative bin-handling methods at output rates of 25 to 300 lugs per hour and hauling distances of 1, 3, 5, and 10 miles. The cost curves shown in these diagrams reflect the differences and similarities in the labor and equipment requirements of the different handling methods.

1/ These relationships were obtained by fitting equations of the form: $TC = a + b_1D + B_2R + b_3RD$, where TC = total hourly handling cost per hour in dollars, D = one-way hauling distance in miles, and R = rate of output in lugs per hour, to the estimated cost points. The smoothed line in Figure 4 is a cross section of the cost surface for Method L-1 represented by $TC = 1.39 + .0221R + .0757D + .0023RD$, with D equal to 5. The cost surface equations for other handling methods are shown on page 52 of the appendix. The smoothed lines correspond fairly closely to the calculated cost points. However, they eliminate discontinuities in the total hourly cost function in both the rate and distance dimensions and thus represent an average rather than an exact relationship between estimated total hourly handling costs and these two variables.

Figure 5

Total Hourly Handling Costs With Alternative Bin Handling Methods
In Relation To Rate of Output and One-Way Hauling Distance. California 1959



Methods B-1 and B-2 require investment in fork-lift equipment for the at-orchard handling of the bins, and so these methods have relatively high total hourly handling costs at the lower rates of output. However, because of the high capacity of the equipment used, increases in the rate of output result in only moderate increases in handling cost. Methods B-1 and B-2 have total hourly handling costs which are essentially equal at all rates of output when the hauling distance is 1 mile. At greater hauling distances, B-1 is the more economical handling method, with the advantage of B-1 over B-2 increasing as the length of haul is increased because of the greater hourly hauling capacity of the higher speed highway trucks used with Method B-1.

Method B-4 has lower total hourly handling costs than Methods B-1 and B-2 at the lower rates of output and lower costs than B-3 at all rates of output. This is because no investment in bin-handling equipment is required with Method B-4 and--except for tractor drivers--no handling labor is required on the ranch. The cost advantage of Method B-4 over Methods B-1 and B-2 is gradually lost as the rate of output is increased as a result of the larger increases in the amount of equipment required to achieve high output rates when Method B-4 is used.

Minimum Cost Bin-Handling Methods

The heavy line in each of the diagrams indicates the minimum total handling costs of obtaining output rates between 25 and 300 lugs per hour when bins are the container used as well as specifying the least-cost bin-handling method for any particular rate of output within this range.

For example, if the one-way hauling distance is 1 mile, Method B-4--bins filled directly on trailers--is of least-cost for output rates less than 100 lugs per hour; B-1--bins-trucks--for output rates between 100 and 200 lugs per hour; and Method B-2--bins-trailers--for output rates greater than 200 lugs per hour.

With a length of haul of 3 miles, B-4 is the least-cost bin-handling method for output rates of less than 70 lugs per hour; for high rates of output, B-1 is the least-cost method. Method B-2 is not the least-cost bin-handling method at any rate of output when the one-way hauling distance is 3 miles or more.

Further increases in the length of haul result in further reductions in the range of output rates within which Method B-4 is the least-cost bin-handling method. When the one-way hauling distance is 5 miles, Method B-1 is the least-cost method for all output rates greater than 50 lugs per hour, while at 10 miles, B-1 is of minimum cost for all but very low rates of output.

Total Hourly Handling Costs With Alternative Lug-Handling Methods

The diagrams in Figure 6 show estimated total hourly handling costs of providing orchard-to-plant transportation at output rates ranging from 25 to 300 lugs per hour with each of five alternative lug-handling methods at one-way hauling distances of 1, 3, 5, and 10 miles. The heavy line in each of the diagrams indicates the minimum total handling cost attainable with lugs for any given rate of output within the range considered.

Method L-1--lugs-trailers--is the least-cost lug-handling method for all rates of output at hauling distances of 5 miles or less. This is primarily due to the low orchard-handling costs that are possible with this method.

For hauling distances longer than 5 miles, Method L-2--lugs-trucks--is the least-cost lug-handling method for the higher rates of output and becomes the least-cost method for a greater range of output rates as the hauling distance is increased. This is because the lower transportation costs, achieved with Method L-2, more than offset the lower orchard-handling costs of Method L-1, at the longer hauling distances.

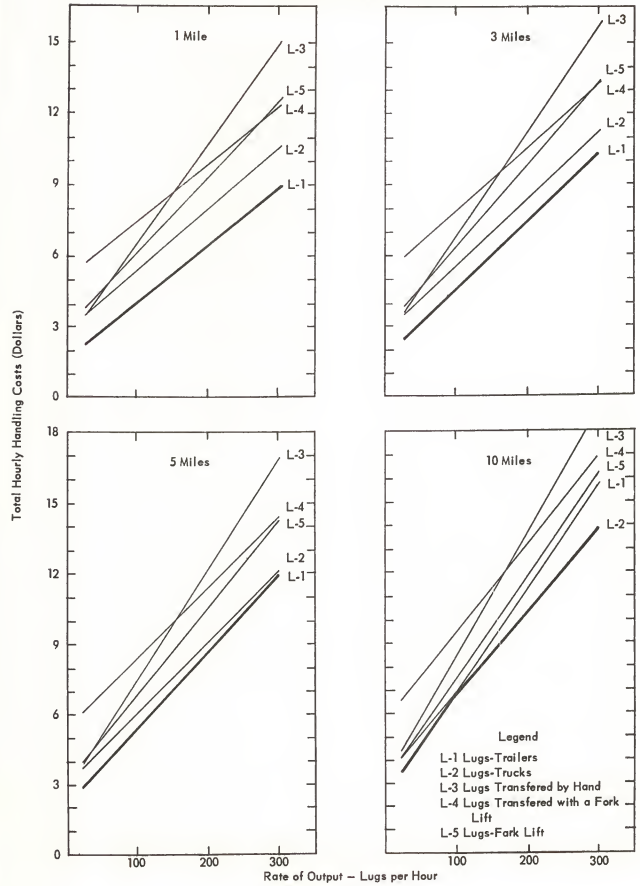
The estimated total hourly handling costs of Method L-3--lugs transferred by hand--are higher than those of Methods L-1 and L-2 at the lower rates of output and increase much more rapidly with increases in output rate. The rapid increase in costs, as output rate is increased, is due to the large amounts of labor required for the hand transfer of the lugs when Method L-3 is used.

At low output rates, Method L-4--lugs transferred with a fork lift--has higher total handling costs than any other handling method considered, a consequence of the relatively high fixed cost of the equipment needed with this handling method. However, because of its relatively high capacity, increases in rate of output are achieved with less rapidly rising costs than is the case with Method L-3.

The estimated total hourly handling costs for Method L-5--lugs-fork lift--are below those of Methods L-3 and L-4 at most rates of output but higher than those of Methods L-1 and L-2 at all output rates. Increases in output rate result in rather sharp increases in handling costs with this method because to achieve the higher rates of output, two to three tractor-fork lift combinations are required.

Figure 6

Total Haurly Handling Casts With Alternative Lug Handling Methads In Relation To Rate af Output and One-Way Hauling Distance. California 1959.



Alternative Lug-Handling Methods Compared With Least-Cost Bin-Handling Methods

Since the handling method used affects costs with either bins or lug boxes, cost comparisons must include a specification of the particular handling methods employed. Such comparisons--in terms of estimated differences in total seasons handling costs[1/] with alternative lug-handling methods as compared with least-cost bin-handling methods for output rates of 100, 200, and 300 lugs per hour at hauling distances of 1, 3, 5, and 10 miles--are shown in Table 8. The cost differences are computed by subtracting the estimated cost of achieving a particular rate of output with the least-cost bin method from the comparable figure for the lug-handling method considered. Therefore, a minus value results if the lug-handling method has the lower costs, while the difference is positive if the bin-handling method has the lower cost.

Figure 7 shows lug-handling Method L-1--lugs trailers--to have total handling costs which are less than those which can be achieved with the least-cost bin-handling methods for all rates of output less than 250 lugs per hour at 1 mile, 160 lugs per hour at 3 miles, and 105 lugs per hour at 5 miles. Thus, the entries in Table 8 for Method L-1 are negative for output rates of 100 and 200 lugs per hour at 1 mile and at 100 lugs per hour at 3 and 5 miles.

For any particular lug-handling method, the cost differences increase as the rate of output is increased. For example, when the hauling distance is 1 mile, the estimated differences in total seasons costs for Method L-2--lugs-trucks--and the least-cost bin-handling methods are $146 when the output rate is 100 lugs per hour, $286 when the rate of output is 200 lugs per hour, and $508 when the output rate is 300 lugs per hour.

It is also true that for any given rate of output the cost differences increase as the hauling distance is increased. For example, when the output rate is 300 lugs per hour, the estimated differences in total seasons handling costs for Method L-1--lugs-trailers--and the least-cost bin-handling methods are $ 77 at 1 mile, $250 at 3 miles, $429 at 5 miles, and $1,065 at 10 miles.

These cost differences are strictly applicable only when the operating conditions, variable cost rates, equipment investment, and allocation rates are as specified. However, considerable changes in these variables would be possible without important shifts in the relative cost position of the various methods.

1/ Based on a 250-hour operating season.

TABLE 8

Estimated Differences in Total Seasons Costs With Least-Cost Bin-Handling Methods as Compared With Five Alternative Lug-Handling Methods in Relation to Rate of Output and Hauling Distance, 250-Hour Season California, 1959

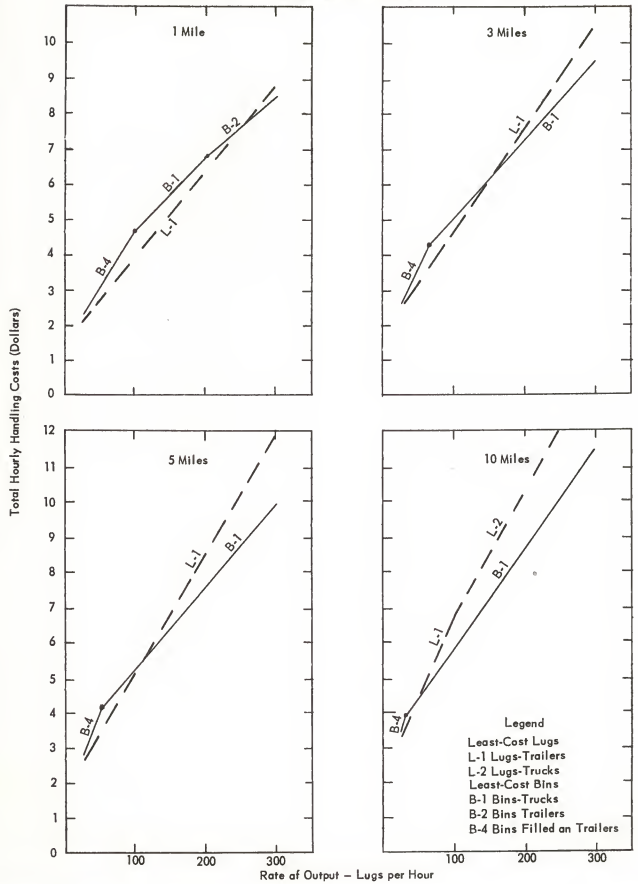
One-way hauling distance	Rate of output	Least-cost bin method[a]	Lug-handling methods[b] and cost differences				
			L-1	L-2	L-3	L-4	L-5
miles	lugs per hour		dollars				
1	100	B-4	- 183	146	461	690	365
	200	B-1	- 94	286	995	774	648
	300	B-2	77	508	1,612	940	1,014
3	100	B-1	- 112	146	485	714	352
	200	B-1	69	315	1,054	852	681
	300	B-1	250	485	1,624	990	1,010
5	100	B-1	- 17	170	532	762	362
	200	B-1	232	344	1,113	931	714
	300	B-1	429	521	1,694	1,100	1,067
10	100	B-1	218	221	644	880	389
	200	B-1	642	417	1,260	1,127	798
	300	B-1	1,065	613	1,872	1,375	1,208

a/ B-1 indicates bins-trucks; B-2, bins-trailers; and B-4, bins filled on trailers.

b/ L-1 indicates lugs-trailers; L-2, lugs-trucks; L-3, lugs transferred by hand; L-4, lugs transferred with a fork lift; and L-5, lugs-fork lift.

Figure 7

Total Hourly Handling Cost With Least-Cost Bin and Least-Cost Lug Handling Methods In Relation To Rate of Output and One-Way Hauling Distance. California 1959.



Adaption to Current Situation

The cost comparisons developed above are based on total costs with each method, which include the variable costs of crew and equipment operation and an allocated portion of the investment cost of new equipment. While this is appropriate in determining the methods that should eventually prove most economical, most growers currently face the problem of adapting existing equipment to use with improved methods. The analysis for such circumstances is similar to that already given. Variable and fixed cost of new equipment are estimated as before. The fixed cost of equipment already owned, however, is figured in terms of the decrease in its market value during the period of use, plus interest on the value of the equipment at the beginning of the period as well as taxes and insurance. The fixed cost of equipment which is common to both the current and proposed methods can be ignored in comparing the cost of the two methods.

The procedure is illustrated below for a grower whose operations extend over a 250-hour season with a hauling rate of 240 lugs per hour and a hauling distance of 3 miles. He now uses Method L-2--lugs-trucks--and wishes to compare his current costs with those he might expect if Method B-1--bins-trucks--were adopted. Using data from the preceding tables as to crew and equipment requirements and the cost of new equipment costs with these two methods might be compared as follows:

Method L-2: Lugs-Trucks

Variable cost (Table 6)		
Labor:	4 men at $1.35 per hour	$5.40
Equipment:	2 vehicles at $0.29 per hour	0.58
	Total variable cost	$5.98
Fixed cost		
Current handling equipment		
Trucks:	2 required (cost of these equipment items common to both methods thus not included in cost comparisons)	

Method B-1: Bins-Trucks

Variable cost (Table 3)		
Labor:	2 men at $1.35 per hour	$2.70
Equipment:	2 vehicles at $0.29 per hour	0.58
	Total variable cost	$3.28
Fixed cost		
Current handling equipment		
Trucks:	2 required (cost of these equipment items common to both methods thus not included in cost comparisons)	

Additional handling equipment		
Tractor:	1 required (50 per cent of annual fixed cost allocated to handling)	$250.00
Fork-lift attachment:	1 required	$183.00
Fixed cost per hour for additional equipment required with B-1, given a 250-hour operating season and 50 per cent of tractor costs allocated to handling:		$ 1.73

Given the assumptions made above, total relevant costs with Method B-1 are estimated to be $5.01 per hour as compared with total relevant (variable) cost of $5.98 per hour with Method L-2, and so the new method would be chosen.

The estimated total cost of using Method B-1 will vary with different assumptions as to the proportion of the fixed tractor cost to be allocated to handling. For example, if the use of Method B-1 required the purchase of a tractor which would be used only in fruit handling, the entire cost of owning the tractor would have to be borne by the handling operation and hourly costs for B-1 would rise. However, if the tractor were used only in fruit handling, a downward adjustment from those used in Table 2 in annual depreciation and fixed repair costs would be appropriate to reflect the less intensive use of the tractor. Thus, while this situation would result in higher costs for Method B-1, it is unlikely that the increase in cost would be sufficient to completely offset the difference in variable costs with the two methods.1/

Should the opposite situation exist, that is, a tractor currently owned be available for use during the fruit harvesting season, the estimated hourly cost for B-1 would be lower than that indicated above, and the cost savings accompanying the adoption of the new method would exceed the $0.97 per hour indicated above. Individual growers can evaluate the change in handling costs likely to accompany a shift in handling method, given their particular handling situation and equipment inventory, by carrying out calculations similar to those in this example using the wage rate, variable equipment costs, equipment replacement costs, and allocation rates applicable on their ranch.

CONTAINER COSTS

Thus far we have compared labor and equipment costs of providing orchard-to-plant transportation with various bin-handling methods as opposed to the use

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1/ If no adjustments in annual depreciation and fixed repair costs are made and 100 per cent of the cost of owning the tractor is allocated to handling the hourly cost of using, B-1 would be estimated to be $6.01 or $0.03 higher than the cost of Method L-2.

of lugs. However, this neglects the costs of the containers, which alone provide an important contrast.

At 1959 prices, container costs per unit of fruit handled are approximately 45 per cent less with bins than with lugs. The reduction in container costs made possible by the use of bins is of immediate interest only to the parties who provide the containers used in assembly operations. This is usually the packing house or cannery to which the fruit is being delivered. However, with competition among buyers for the available supply of fruit--or through direct sharing of savings in container costs by cooperative marketing organizations--an important part of the reduced container costs should ultimately be available to growers and thus should be given consideration when comparing the cost of using bins as opposed to using lugs.

The container costs used in this analysis are shown in Table 9, which gives estimates of annual and per-use costs for the two types of containers and for pallets. Annual costs are based on a ten-year life for the containers, and per-use costs are based on using the container seven times per year.[1/] The cost of pallets is included as part of the container costs for lug operations because of the necessity of palletizing the containers if they are to be handled with fork-lift equipment. Not all of the lug-handling methods would require pallets for the ranch operation, but because of the widespread use of fork-lift equipment to receive fruit at the plant it has been assumed that pallets are required for all lug-handling methods.

Combined Handling and Container Costs With Alternative Lug- and Bin-Handling Methods

The four diagrams in Figure 8 indicate the combined hourly handling and container costs for output rates ranging from 25 to 300 lugs per hour for each of the alternative lug-handling methods considered and show the least-cost bin-handling methods. The container costs for any particular rate of output is computed by multiplying the per-use cost of the container by the rate of output being considered. This figure is added to the handling costs for this rate of output to obtain the combined handling and container costs.

1/ This was found to be the mean number of times containers are used per season in a sample of California pear and apple packing houses.

TABLE 9

Replacement Costs and Annual and Per-Use Charges for Containers Used in Orchard-to-Plant Transportation of Deciduous Fruits California, 1959

Item	Replacement costs	Estimated use life	Annual cost per lug equivalent[a]			
			Depreciation	Maintenance[b] and interest[c]	Total	
					Per lug	Per use[d]
	dollars	years	dollars			
Bin[e]	14.00	10	.058	.023	.081	.0116
Lug box[f]	1.00	10	.100	.040	.140	.0200
Pallet[g]	3.25	10	.009	.004	.013	.0018

a/ Bins converted to lug equivalent basis at 24 lugs per bin; pallets at 36 lugs per pallet.

b/ Maintenance charged at the rate of 1 per cent of initial purchase price per year.

c/ Interest charges based on 3 per cent per year--approximately equal to 5.5 per cent on the undepreciated balance.

d/ Cost per use based on using the item seven times per season.

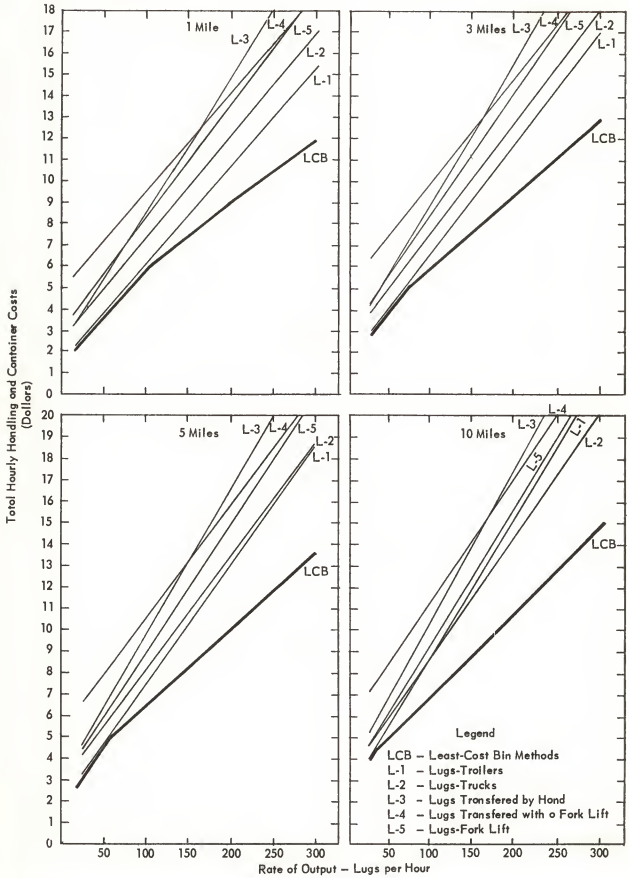
e/ Inside dimensions: 16" x 16" x 26". Volume equivalent to 24 lugs.

f/ Inside dimensions: 13½" x 18" x 9". Cost includes cost of fiber liners.

g/ Two-way entry; 47" x 47".

Figure 8

Combined Hourly Handling and Container Cost With Alternative Handling Methods In Relation to Rate of Output and Length of Haul. California 1959.



With a particular type of container, the introduction of container cost does not affect the relative position of the cost curves for the various handling methods used and, therefore, does not affect the determination of the least-cost handling method. However, the introduction of container costs does affect the break-even rates of output for the least-cost bin-handling methods and the least-cost lug-handling methods.

It will be recalled that the estimated total handling costs for Method L-1--lug-trailers--are lower than the estimated total handling costs for the least-cost bin-handling methods over a considerable range of output rates at the shorter hauling distances and that L-1 is the least-cost handling method for the low rates of output at each of the hauling distances considered. However, when both handling and container costs are considered, this is no longer true. As shown in Figure 8, the least-cost bin-handling methods have combined costs which are less than or equal to the combined costs of the least-cost lug-handling methods at all rates of output at each of the hauling distances considered.

The differences in combined total seasons handling and container costs for alternative lug-handling methods as compared with the least-cost bin-handling methods are given in Table 10.

A comparison of the figures in Tables 8 and 10 emphasizes the importance of container costs when comparing orchard-to-plant transportation costs with bins as opposed to lugs. For a particular rate of output, the reduction in container costs is the same regardless of the handling methods being used. Therefore, the relative importance of savings in container costs will depend on the lug-handling method being considered.

SUMMARY AND CONCLUSIONS

The primary objective of this report is to indicate how a shift from lugs to bulk containers will affect the input requirements and costs of providing orchard-to-plant transportation in the California deciduous fruit industry. Four alternative bin-handling methods and five different lug-handling methods were considered as follows:

BINS:

Method B-1--Orchard handling with fork-lift equipment; haul to plant on flat-bed trucks.

Method B-2--Orchard handling with fork-lift equipment; haul to plant on low-bed trailers.

with a particular type of container, the introduction of container cost does not affect the relative position of the cost curves for the various handling methods used and therefore does not affect the determination of the least-cost handling method. However, the introduction of container costs does affect the break-even rates or outputs for the least-cost bin-handling method and the least-cost bag-handling methods.

It will be recalled that the estimated total handling costs for bulked bag-fire-clay--are lower than the estimated total handling costs for the least-cost bin-handling methods over a certain range of output rates at the average handling distances and that L-1 is the least-cost handling method for the four rates of output at each of the handling distances considered. However, when bulk handling and container costs are considered, this is no longer true. As shown in figure 8, the least-cost bin-handling methods have certain output rates that are equal to the combined costs of the least-cost bag-handling methods at all rates of output at each of the handling distances considered.

The differences in combined total assembly handling and container costs for alternative bag-handling methods as compared with the least-cost bin-handling methods are given in Table 10.

A comparison of the figures in Tables 9 and 10 emphasizes the importance of container costs when comparing ordered-by-plant transportation costs with like costs imposed on bags. For a particular rate of output, the reductions or equivalents to the same magnitudes of the handling methods being used. However, the relative importance of any type in container costs will depend on the bag-handling method being considered.

SUMMARY AND CONCLUSIONS

The primary objective of this report is to indicate how a shift from bags to bulk containers will affect the plant requirements and costs of providing ordered-to-plant transportation. In the following detailed fluid analysis, four alternative bin-handling methods and five different bag-handling methods were considered as follows:

Bins:

Method L-1--Clipped handling with fork-lift equipment; load to plant on low-bed trailers.

Method L-2--Dropped handling with fork-lift equipment; load to plant on flat-bed trailers.

TABLE 10

Estimated Differences in Combined Handling and Container Costs With Least-Cost Bin-Handling Methods as Compared With Five Alternative Lug-Handling Methods in Relation to Rate of Output and Hauling Distance in Orchard-to-Plant Transportation of Deciduous Fruits, 250-Hour Season California, 1959

One-way hauling distance	Rate of output	Least-cost bin method[a/]	Lug-handling methods and cost differences[b/]				
			L-1	L-2	L-3	L-4	L-5
miles	lugs per hour		dollars				
1	100	B-4	75	404	719	947	622
	200	B-1	420	801	1,510	1,289	1,162
	300	B-2	790	1,221	2,324	1,653	1,726
3	100	B-1	146	403	742	972	609
	200	B-1	584	830	1,569	1,367	1,196
	300	B-1	1,023	1,257	2,395	1,762	1,782
5	100	B-1	240	424	790	1,019	620
	200	B-1	748	859	1,628	1,446	1,230
	300	B-1	1,255	1,294	2,467	1,873	1,839
10	100	B-1	328	478	906	1,137	646
	200	B-1	1,157	932	1,775	1,642	1,313
	300	B-1	1,837	1,385	2,644	2,147	1,980

a/ B-1 indicates bins-trucks; B-2, bins-trailers; and B-4, bins filled on trailers.

b/ L-1 indicates lugs-trailers; L-2, lugs-trucks; L-3, lugs transferred by hand; L-4, lugs transferred with a fork lift; and L-5, lugs-fork lift.

[illegible]

[illegible]

[illegible]

Method B-3--Orchard handling with a utility carrier; haul to plant on low-bed trailers.

Method B-4--Direct filling of bins on low-bed trailers, which are also used for the haul to plant.

LUGS:

Method L-1--Hand loading of low-bed trailers for direct haul to plant.

Method L-2--Hand loading of highway trucks for direct haul to plant.

Method L-3--Hand loading of orchard trailers in the orchard with subsequent hand transfer to highway trucks for the haul to plant.

Method L-4--Hand loading of orchard trailers in the orchard with subsequent transfer to highway trucks with fork-lift equipment.

Method L-5--Orchard handling of pallet loads of lugs with fork-lift equipment, haul to plant on highway trucks.

Time and production studies were used to determine the input requirements for each handling method for output rates ranging from 0 to 500 lugs per hour at hauling distances of 1 to 15 miles. Cost rates for 1959 were applied to these input requirements to obtain cost-output relationships for each of the handling methods considered.

These analyses show that for any given rate of output and hauling distance the different handling methods for each type of container have widely varying costs. This means that the change in total handling costs accompanying a shift from lugs to bins depends on how each type of container is handled. It is also true that total handling costs for the various bin- and lug-handling methods are affected differently by changes in rate of output or length of haul. The least-cost handling method for each type of container, therefore, may vary with changes in either of these two factors.

If bins are the container used and the hauling distance is 1 mile, Method B-4 is the least-cost method for output rates less than 100 lugs per hour; Method B-1, for output rates between 100 and 200 lugs per hour; and Method B-2, for output rates greater than 200 lugs per hour.

With a hauling distance of 3 miles, Method B-4 is the least-cost bin method for output rates less than 70 lugs per hour; for higher rates of output, Method B-1 is the least-cost bin-handling method. Further increases in hauling distance results in B-1 becoming the least-cost bin-handling method for an increasing range of output rates.

Method 8-1--Modern handling with a utility carrier, (Fig 31) place on low-bed trailers.

Method 9-1--Crawl. Pulling if kind on low-bed trailers, which are also used for the haul to plant.

1955:

Method 6-1--Modern loading of low-bed trailers and direct haul to plant.

Method 1-1--Hand loading of highway trucks for direct haul to plant.

Method 2-1--Hand loading of orchard trailers in the orchard with subsequent haul together to highway trucks for haul to plant.

Method 3-1--Hand loading of orchard trailers in the orchard with subsequent transfer to highway trucks with fork-lift equipment.

Method 4-1--Orchard handling of pallet loads of lugs with fork-lift equipment, haul to plant on flatbed trucks.

Time and motion-study studies were used to determine the labor requirements for each handling method for output rates ranging from 0 to 500 tons per hour and hauling distances of 5 to 25 miles. Unit costs for each method were computed from these requirements to obtain cost-output relationships for each of the handling methods considered.

Cost analysis shows that for any given rate of output and hauling distance the different handling methods for each type of operation have widely different costs. This means that the change to other handling costs necessitates a shift from one to a more efficient ... on how each type of operation is handled. It is also seen that total handling costs for the various box- and lug-handling methods are affected differently by increases in rate of output or length of haul. The least-cost handling method for each type of operation, therefore, may vary with changes in either of these two factors.

In bulk bin handling, when the hauling distance is 5 miles, Method 8-1 is the least-cost method for output rates less than 100 tons per hour, Method 9-1 for output rates between 100 and 200 tons per hour, and Method 5-1, for output rates greater than 200 tons per hour.

With a hauling distance of 5 miles, Method 1-1 is the least-cost lug method for output rates less than 75 tons per hour. For higher rates of output, Method 4-1 is the least-cost lug-handling method. Further increases in hauling distance result in ... the least-cost lug-handling method for an increasing range of output rates.

Method L-1 is the least-cost lug-handling method for all rates of output at hauling distances of 5 miles or less. For hauling distances longer than 5 miles, Method L-2 is the least-cost lug-handling method for the higher rates of output.

Any given rate of output at any particular hauling distance can be achieved at lower total handling costs with the least-cost bin-handling method than with any of the lug-handling methods considered, with the exception of Method L-1. This method--lugs-trailers--has lower total handling costs than the least-cost bin methods for a considerable range of output rates at the shorter hauling distances--up to 250 lugs per hour at 1 mile. However, this range is rapidly reduced as the length of haul is increased. At a one-way hauling distance of 10 miles, least-cost bin-handling methods have lower total handling costs than any of the lug-handling methods considered for all output rates greater than 50 lugs per hour.

If both handling and container costs are considered, least-cost bin-handling methods have lower total handling costs than any of the lug-handling methods considered at all rates of output at all hauling distances. This is because container costs, per volume of fruit handled, are approximately 45 per cent lower with bins than with lugs.

Thus, it appears that five factors must be considered in attempting to determine the effects of a shift from lugs to bins on the labor and equipment requirements and the costs of performing orchard-to-plant transportation operations. These are: (1) the lug-handling method currently being used; (2) the bin-handling method that is to be used; (3) the rate of output that is to be attained; (4) the distance the fruit is to be hauled in moving it from the orchard to the plant; and (5) the relative cost of the two types of containers. This report makes specific comparisons for conditions widely applicable in California and provides basic data for the adoption of the results to conditions of particular growers or localities.

APPENDIX A

Appendix Tables A-1 and A-2 contain brief descriptions and estimated net time requirements for the basic operations involved in handling bins and lugs. In the time studies on which the estimated unit times for bin-handling operations are based, a number of different types of fork-lift equipment were observed. These included front- and rear-mounted fork-lift attachments for farm tractors, utility carriers which mount on the three-point hitch system of certain farm tractors, and industrial-type fork lifts. Analysis of the time study data developed in these studies indicates that there are not substantial differences in the time required to perform the basic handling operation with the different types of equipment being used. Differences in the time required by different operators with the same type of equipment appeared to be as great or greater than the differences in the time associated with differences in equipment. The time requirements for the various fork-lift operations reflect conditions present in the orchard, which include uneven terrain and restricted operating space. Thus, these times are generally higher than the time required for these same operations when performed on concrete slabs.

The production standards for in-orchard operations for the various handling methods shown in Appendix Tables A-3 through A-7 are based on the unit times shown in Appendix Tables A-1 and A-2 and the orchard conditions specified in the model (page 10). These production standards contain an allowance of 20 per cent of total time for unavoidable delay and wait time.

APPENDIX TABLE A-1

General Description and Time Requirements for Each of the Basic Bin-Handling Operations

General nature of operation		Unit time
		minutes
1. Engage bin:	Engage forks of fork lift in pallet attached to bin; raise and tilt slightly in preparation for travel.	
	(a) In transfer area	.172
	(b) In orchard	.197
	(c) On truck or trailer	.173
2. Release bin:	Spot bin over release point, lower bin into position, and disengage forks.	
	(a) In transfer area	.167
	(b) In orchard	.155
	(c) On truck or trailer	.442
	(d) On top of another bin	.565
3. Maneuver:	Backing, turning, and moving forward with tractor to get into position to either pick up or release bin.[a]	
	(a) Moving bins to and from orchard	.611
	(b) Loading bins	.212
	(c) Unloading bins	.207
4. Move:	Move with tractor and fork-lift attachment over considerable distance either in going to and from orchard or in the transfer area.	
	(a) Moving to and from orchard	$T = .528 + .0026D$[b]
	(b) Moving in transfer area	$T = .266 + .0038D$[b]

a/ The unit times shown for the maneuver element are on a per-bin basis.

b/ T = time in minutes; D = total distance traveled in feet.

APPENDIX TABLE A-2

General Description and Time Requirements for Each of the Basic Lug-Handling Operations

Operation		Unit time
		man-minutes
Hand operations		
1. Load full lugs:	Transfer full lugs from picker sets to vehicle parked adjacent to set and stack on vehicle bed.	
	(a) Low-bed trailers (per lug)	.126
	(b) Flat-bed trucks (per lug)	.252
2. Unload empty lugs:	Transfer empty lugs from vehicle to stack alongside orchard drive row.	
	(a) Low-bed trailers (per lug)	.080
	(b) Flat-bed trucks (per lug)	.160
3. Transfer lugs:	Transfer lugs from orchard trailers to highway trucks or vice versa and place in stacks.	
	(a) Full lugs (per lug)	.206
	(b) Empty lugs (per lug)	.118
4. Untie load:	Remove load bindings in preparation for unloading (per load).	.990
5. Tie load:	Place load bindings in preparation for trip to plant (per load).	2.720
6. Move:	Move with truck or tractor-trailer combination in orchard lane or drive row (per load).	$T = .24 + .0046D$ [a]
		minutes
Fork-lift operations		
1. Engage pallet:	Engage forks of fork lift in pallet, lift and tilt slightly, and lower hydraulic clamp (per pallet)	.519
2. Release pallet:	Spot pallet over release area, lower into position, and disengage forks.	
	(a) In orchard or transfer area (per pallet)	.257
	(b) On truck (per pallet)	.599
3. Maneuver:	Backing, turning, and moving forward with tractor to get into position to either pick up or release pallet (per pallet).	.216
4. Move:	Move with tractor-fork lift over considerable distance either in going to and from orchard or in transfer area.	
	(a) In orchard lanes and drive rows	$T = .528 + .00257D$ [a]
	(b) In transfer area	$T = .266 + .00382D$ [a]

a/ T = total time in minutes and D = total distance traveled.

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

APPENDIX TABLE A-3

Time Requirements Per Orchard Cycle and Production Standards for Alternative On-Ranch Bin-Handling Procedures

Time	Time required per orchard cycle[a]			
	Procedure 1	Procedure 2	Procedure 3	Procedure 4
	minutes			
Total net handling time per bin, excluding travel time[b]	3.49	2.67	2.92	3.68
Travel time per bin	2.72	2.72	1.36	1.36
Total net handling time per bin	6.21	5.39	4.28	5.04
Tie and untie truck (per-bin basis)	.31	.31	.31	.31
Unavoidable delay and personal time	1.63	1.42	1.15	1.34
Total gross time per bin	8.15	7.12	5.74	6.69
Containers moved to and from the orchard per hour per fork lift:				
Bins	7.36	8.43	10.45	8.97
Lug equivalents[c]	177	202	251	215

a/ An orchard cycle is defined to be the movement of one empty bin from a highway vehicle in the transfer area to the orchard and the movement of one full bin from the orchard onto the highway vehicle. See Table 1 in the text for a description of each procedure.

b/ Includes an allowance of .33 minutes for respotting one-fourth of the bins.

c/ Computed at 24 lugs per bin.

APPENDIX TABLE A-4

Time Requirements and Production Standards for In-Orchard Operations When Lugs Are Hand Loaded Directly on Low-Bed Trailers

Operation	Labor requirements for orchard operations			
	One-man crew	Two-man crew	Three-man crew	Four-man crew
	man-minutes per 216-lug load			
Move between orchard and transfer area	2.79	5.58	8.37	11.16
Unload empty lugs	17.28	19.85	22.41	24.98
Move in orchard	4.21	8.42	12.63	16.84
Load full lugs	27.17	31.20	35.24	39.27
Tie and untie trailers	3.71	3.71	7.42	11.13
Unavoidable delay and wait	13.77	15.51	18.17	20.84
Total	68.93	84.27	104.24	124.22
Capacity output rate per hour (lugs)	188	308	373	417

APPENDIX TABLE A-5

Time Requirements and Production Standards for Orchard Operations With Method L-2--Lugs Loaded Directly on Highway Trucks

Operation	Labor requirements for orchard operations			
	two-man crew	three-man crew	four-man crew	five-man crew
	man-minutes per 216-lug load			
Move between orchard and transfer area	5.58	8.37	11.16	13.95
Unload empty lugs	34.56	39.69	42.25	44.82
Move in orchard	8.42	12.63	16.84	21.05
Load full lugs	54.34	62.41	66.44	70.48
Tie and untie load	3.71	7.42	11.13	14.84
Unavoidable delay and wait	26.62	29.28	31.94	34.61
Total	133.23	159.80	179.76	199.75
Capacity output rate per hour (lugs)	195	243	288	324

APPENDIX TABLE A-6

Time Requirements and Production Standards for Transferring Lugs Between Orchard Trailers and Highway Trucks by Hand and With Fork-Lift Equipment

Operation	Labor requirements		
	Hand transfer		Fork-lift transfer
	Two-man crew	Four-man crew	
	man-minutes per 216-lug load		
Transfer full lugs	44.50	44.50	10.97[a/]
Transfer empty lugs	25.49	25.49	8.92[a/]
Tie and untie load	7.42	14.84	3.71
Wait and unavoidable delay	19.35	21.20	5.93
Total	96.76	106.03	29.65
Capacity output rate per hour (lugs)	268	488	436

a/ Pallet moved 30 feet in transfer area.

APPENDIX TABLE A-7

Time Required Per Orchard Cycle[a] and Production Standards for Alternative Orchard-Handling Procedures When Lugs Are Moved Between the Orchard and the Transfer Area With Fork-Lift Equipment

Operation	Time required per orchard cycle	
	When pallets are released on truck	When pallets are released in transfer area for later loading
	minutes	
Handle pallets with fork lift	7.62	9.78
Set off empty lugs[b]	1.44	1.44
Set on full lugs[c]	2.26	2.26
Tie and untie truck[d]	.62	.62
Wait and unavoidable delay	2.99	3.53
Total	14.93	17.63
Capacity output rate per hour (lugs)[e]	145	123

a/ An orchard cycle consists of moving a pallet of empty lugs from a highway truck parked in the transfer area to the orchard and a pallet of full lugs from the orchard onto the highway truck.

b/ Assumes that 50 per cent of the empty lugs are distributed by the fork-lift driver and that a pallet holds 36 lugs.

c/ Assumes that 50 per cent of the full lugs are placed on the pallets by pickers and that a pallet holds 36 lugs.

d/ Per-pallet basis.

e/ Based on 36-lug pallets.

APPENDIX B

APPENDIX TABLE B-1

Total Hourly Handling Cost Equations for Alternative Containers and Handling Methods[a/]

Method	Total less container cost
Bins	
Method B-1	TC = 2.71 + .0254D + .0190R + .0009RD
Method B-2	TC = 3.26 + .0150R + .0024RD
Method B-3	TC = 2.39 + .0405D + .0260R + .0045RD
Method B-4	TC = 1.39 + .0249D + .0276R + .0047RD
Lugs	
Method L-1	TC = 1.39 + .0757D + .0221R + .0023RD
Method L-2	TC = 2.53 + .0531D + .0254R + .0011RD
Method L-3	TC = 2.17 + .0944D + .0411R + .0012RD
Method L-4	TC = 4.92 + .0573D + .0227R + .0015RD
Method L-5	TC = 2.88 + .0308R + .0014RD
	TC = total handling costs per hour measured in dollars R = rate of output measured in lugs D = one-way hauling distance measured in miles
	Total including container cost
Bins	
Method B-1	TC' = 2.71 + .0254D + .0306R + .0009RD
Method B-2	TC' = 3.26 + .0266R + .0024RD
Method B-3	TC' = 2.39 + .0405D + .0376R + .0045RD
Method B-4	TC' = 1.39 + .0250D + .0392R + .0047RD
Lugs	
Method L-1	TC' = 1.39 + .0757D + .0439R + .0023RD
Method L-2	TC' = 2.53 + .0531D + .0472R + .0011RD
Method L-3	TC' = 2.17 + .0944D + .0629R + .0012RD
Method L-4	TC' = 4.92 + .0573D + .0445R + .0015RD
Method L-5	TC' = 2.88 + .0526R + .0014RD
	TC' = total handling and container costs per hour measured in dollars R = rate of output measured in lugs D = one-way hauling distance measured in miles

a/ Based upon the model of operating conditions and cost allocations specified, 1959 cost rates in northern California, and a 250-hour operating season.

[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]