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PACKING CALIFORNIA VINE-RIPE TOMATOES

Costs and Efficiencies

PACKING CALIFORNIA VINE-RIPE TOMATOES: COSTS AND EFFICIENCIES. By Edward V. Jesse. Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 275.

ABSTRACT

Synthesized costs for three model packinghouses in California showed significant economies of size for vine-ripe tomatoes. Mechanization of the sizing process and substitution of bins for field boxes in packinghouse operations were primarily responsible for the cost savings. Under a specified season length and operating capacity, a small model packinghouse had per unit operating costs of $1.60; a medium-size model, $1.30; and a large model, $1.15. The most efficient size of packinghouse for a given area, however, was shown to depend heavily on season length.

Keywords: Tomatoes, Packing, Costs, Models, Economy of size.

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SUMMARY

Significant economies of size in California packinghouses for vine-ripe tomatoes have been demonstrated by synthesized costs in three models. Mechanization of the sizing process and substitution of bins for field boxes in packinghouse operations were primarily responsible for the cost savings.

A small model packinghouse, characterized by hand dumping of field boxes and hand sizing, showed costs per unit packed (25-pound box) of about $1.60 when operating at a seasonal average of 62 percent of potential capacity for a 300-hour season. Under the same operating conditions, a medium-size model packinghouse, using automatic dumping of field boxes and mechanical belt sizing, had per unit costs of about $1.30. Packing costs for the large model, with automatic sizing and bulk-bin dumping, were only $1.15 per unit packed.

The most efficient size of packinghouse for a given area, however, was shown to depend heavily on season length. In a long-season producing area, minimum costs could be achieved with a much smaller unit than for the same seasonal volume packed in a short-season area.

The effects of some variables influencing packing costs were considered by relaxing certain operating assumptions. Increased season length and operating levels closer to packinghouse capacity both resulted in reduced costs. However, while the cost reduction was quite dramatic for short seasons and low levels of intensity, savings were relatively small for season extensions beyond 300-hours and increases in seasonal average intensity levels above 60 percent. Changes in the culling rate showed a similar pattern. Increases in the cull rate resulted in rising costs, with increasingly larger changes at higher culling percentages.

PACKING CALIFORNIA VINE-RIPE TOMATOES

Costs and Efficiencies

Edward V. Jesse 1/

INTRODUCTION

About one-third of the fresh tomatoes sold commercially in the United States are produced in California. 2/ The California tomatoes consist of roughly equal proportions of vine-ripe and mature green tomatoes. Vine-ripes are picked after the fruit has begun to change color, while mature greens are picked and packed in the green stage.

Since the processing, packing, shipping, and wholesaling operations for these two types of tomatoes are substantially different, this report deals only with vine-ripes. A companion study will consider the packing procedures and costs for mature greens.

The bulk of California's vine-ripe tomatoes are grown and packed in three districts 3/ (table 1). The largest, in terms of production, is the coastal area near San Diego, extending from Chula Vista, near the Mexican border to Oceanside. This is a long-season district, packing vine-ripes from June through the end of the year. Growers in this district usually make two or more plantings, and packinghouses frequently shut down part of the year between seasonal harvests.

A second vine-ripe district is the coastal area around Oxnard in Ventura County. Shipments from Oxnard usually begin about 1 month later than Chula Vista Oceanside shipments and end about 1 month earlier.

1/ Agricultural economist, Commodity Economics Division, Economic Research Service, University of California, Davis.

2/ Based on 1970-73 production and marketing statistics, Statis. Rptg. Serv., U.S. Dept. of Agr. This includes only tomatoes marketed commercially. No data are available on the extent of home garden production and fruit stand sales.

3/ An additional supply of vine-ripes comes from mature green packinghouses in other regions. Colored fruit is segregated from the greens and packed separately. The mature green to vine-ripe tomato ratio in mature green packinghouses is about 90 to 10, and in many cases, vine-ripe fruit is considered largely a byproduct.

Table 1--Selected characteristics of California vine-ripe tomato districts

Item	District number and name 1/		
	1 Chula Vista-Oceanside	3 Oxnard	4 Cutler-Orosi
Counties included	San Diego Orange	Ventura Los Angeles Santa Barbara San Luis Obispo	Kern Kings Fresno Tulare
Heaviest shipping period	June-December	July-November	July
1972 shipments (carlot equivalents)	3,977	2,696	1,716
Estimated number of packinghouses (1973)	20	10	12

1/ District numbers defined by California Fresh Market Tomato Advisory Board.

The third vine-ripe district is the Cutler-Orosi district in central San Joaquin Valley. This is a short-season district, shipping from mid-June through July. High summer temperatures in this area do not permit a long growing season as in the two coastal districts. Packinghouses are, in general, larger than in the coastal districts, as seasonal packout takes place over a much shorter period.

The packinghouses in these three districts vary in size and packing techniques. Operations range in size from a maximum hourly dumping volume of less than 5 tons to more than 50 tons, with packing seasons from 5 weeks to 6 months. Some packinghouses use hand labor for conveying, dumping, sizing, and place packing. Others employ automatic equipment for these procedures.

This study focuses on how unit packing costs are affected by these differences in plant size and packing methods. Therefore, the study's major objectives are to:

1. Outline the components of packing costs and to measure costs for alternative handling and packing techniques used in 1973.

2. Compare costs in packinghouses of different size.

3. Evaluate the effect on costs of varying selected operating conditions.

A synthetic or model firm approach is used in estimating packing costs. This approach involves setting up "artificial" packinghouses by specifying required plant, equipment, labor, and packing supplies. Total and unit costs are then calculated for particular operating conditions. Costs determined in this manner are termed synthetic because they do not reflect costs actually experience

in any one plant, but rather represent a synthesis of operations observed in a number of plants. The costs are contingent upon assumptions and specifications used in setting up the model firms.

Several advantages in using the synthetic firm approach are: (1) Since replacement values are used to determine model plant and equipment investment, costs are not affected by the age of equipment nor assessments of book values; (2) Consistent equipment and labor performance is achieved by using engineering standards rather than observed performance; (3) Problems associated with primary data collection are minimized; (4) Inspection and evaluation of a large number of individual firm records are not required, since much of the necessary information can be obtained from published sources; and (5) Equipment manufacturers and supply companies can also be used to provide cost data.

Since the costs for the model plants do not necessarily reflect real-life conditions, they must be viewed as guides rather than as a summary of actual experience. Individual firms must adjust the synthetic costs to the extent their own operation differs from that of the model plants. Imposition of labor and equipment standards assumes "normal" or average operating conditions. Numerous factors can cause performance and costs to deviate from the specified standards. While attempts are made to define conditions as realistically as possible, it is not wholly feasible to consider breakdowns, slowups, and other random events. 4/

VINE-RIPE TOMATO PACKING

Figure 1 illustrates schematically the sequence of operations involved in packing vine-ripe tomatoes. Solid circles represent standard operations in the packing process, while broken circles indicate operations which may or may not apply to individual packinghouses. Arrows indicate direction of flow.

Only those operations which are performed at the packinghouse are considered in this report. Operations involved in producing and procuring fruit (growing, picking, and hauling) are excluded. Transportation of packed containers and operations at receiving points, such as wholesale terminal markets and chainstore warehouses, are also excluded.

The initial packinghouse operation shown in figure 1 is dumping. Fruit may be received at the packinghouse either in field boxes containing 20 to 40 pounds or in bulk half-bins holding about 600 pounds. Field boxes are either individually handled and unloaded by hand truck or palletized and unloaded by forklift. Half-bins must be handled with forklifts.

Three methods are used to dump field boxes in vine-ripe tomato packinghouses: (1) Boxes are picked up individually from a stack or pallet and dumped

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4/ Performance standards for labor do make allowances for fatigue and rest periods. Also, machine breakdowns are reflected in season capacity restrictions. However, realistic consideration of the timing of random occurrences would require defining probability density functions and the use of simulation techniques, which are beyond the scope of this report.

SEQUENCE OF OPERATIONS IN PACKING CALIFORNIA VINE-RIPE TOMATOES

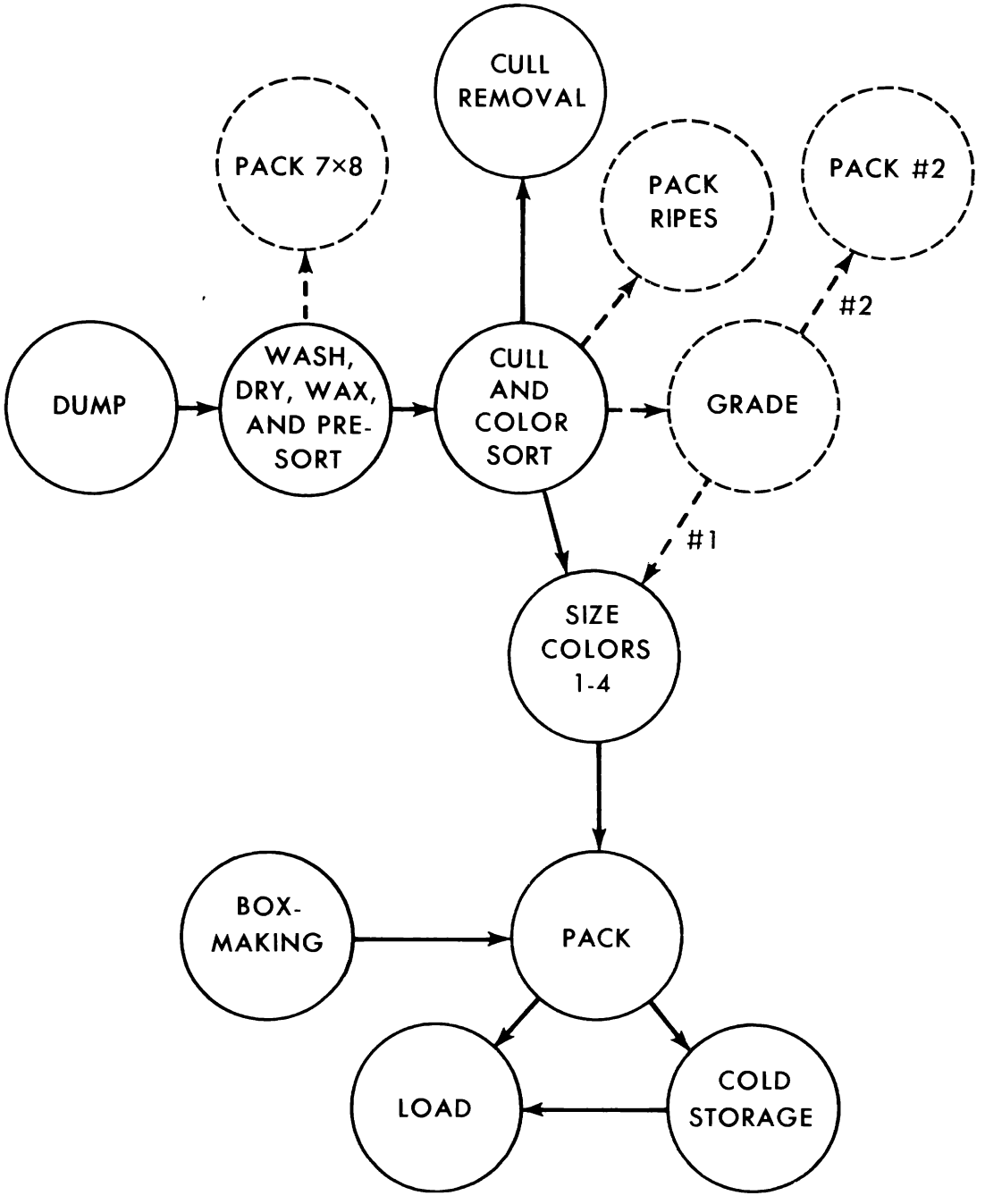

Figure 1

by hand; (2) Boxes are placed on a powered conveyor and moved to the dumping area where they are manually dumped; or (3) Boxes are placed on a conveyor which leads to an automatic dumping device. In all cases, a wet or dry dump may be used. Empty field boxes are either stacked by the dumper or conveyed out of the dumping area and then stacked or palletized by other workers.

Half-bins are usually placed on a chain conveyor by forklift, either individually or in stacks of four if a destacker is used. The conveyor moves the bins to a hydraulic bin dumper which empties the bins and places them back on the conveyor. Empty bins are lifted off the conveyor by forklift and carried to temporary storage or reloaded on trucks. (Prior to being lifted off the conveyor, the bins may be automatically restacked.)

After being dumped, the tomatoes pass through washing, drying, waxing, and presizing stages which, except for the equipment capacity, are practically identical in sheds of any size. The fruit is washed by an overhead spray of chlorinated water. 5/ Drying is accomplished by passing the fruit over revolving foam-rubber drying donuts. The fruit is generally waxed by revolving brushes over which liquid wax is dripped. Either before or after waxing, 7 x 8 and smaller sizes are removed by a belt sizer. 6/ When markets for tomatoes are strong, size 7 x 8 fruit may be packed in some sheds.

Culling and color sorting are hand operations. Sorters along an inspection belt segregate colors and remove unusable fruit. In some packinghouses, the cull and color-sort operation may be carried on simultaneously with hand sizing. In this case, each sorter is assigned one color (with four colors generally packed) and two or three sizes. The sorters pick off their assigned fruit and place them in designated bins on the opposite side of the inspection belt. Where machine sizing is used, the inspection conveyor is divided into two or three sections, and additional belts are positioned above the main sorting table. The separate colors are placed on the appropriate belt section and moved to mechanical sizers.

Sizers are either belt or weight type, with belt sizing the most common. Fruit either drops directly into packing bins from the sizer or falls into conveyors and is distributed into the bins.

Figure 1 indicates two operations which may precede sizing in certain pink-tomato packinghouses. Provisions might be made for packing ripes -- tomatoes which are too mature and soft to be shipped any distance but which could be sold immediately in local markets. In cases where ripes are not packed, they are culled. Some packinghouses may sort for grade, size, and color, and pack a second or even third grade on lines separate from the first or best grade.

5/ If a wet dump is employed, the washing operation may be omitted.

6/ The size designation used here and elsewhere refers to fruit configuration in a standard Los Angeles lug. Size 7 x 8, for example, refers to tomatoes of such a size that 56 fit in a single layer of a lug, arranged in 7 rows of 8 fruit each.

The container-filling operation is the same in all vine-ripe packinghouses. 7/ Packers stationed beside the bins place-pack fruit in two-layer or three-layer containers positioned on packing stands. Flats (two-layer boxes) are used for fruit 6 x 6 and larger, while 6 x 6 and smaller is packed in lugs (three-layer boxes). 8/ Packers usually stamp containers to designate size and place a numbered ticket on top of the filled box to identify their output.

The packers remove filled containers to a conveyor which collects containers from each packing line and moves them to a central area for tallying, lidding, and USDA inspection, if used. From this point, the containers are either stacked or palletized and loaded or moved to storage to await shipment. Storage may or may not be refrigerated. Both rail and truck shipping is used for vine-ripes, although truck shipment is dominant.

Two operations supplementary to actual fruit movement -- cull removal and boxmaking -- are shown in figure 1. The cull network consists of conveyors from the point culls are removed, a main cull conveyor, an elevator to the exterior of the packinghouse, and in some cases, an elevated holding bin. Culls drop from the elevator or holding bin into trucks for removal to landfills or fields.

Containers are either made at the packinghouse or at another location. Several types of material are used -- wood, fiberboard, corrugated paper, and plastic in various combinations. Except for all-corrugated containers, which are usually folded together by hand, boxes are built with nailing machines. Other machines attach lids following the tallying operation.

The most common method of distributing empty containers to packers is by overhead monorail. Workers in the boxmaking location place boxes on hooks fastened to a continuous chain which moves past the packing stations. An alternative box distribution method used in smaller sheds involves using an overhead roller conveyor.

The Three Model Packinghouses

To define representative vine-ripe tomato packinghouses, in terms of both size and packing techniques, a survey of California packinghouses was conducted during the summer of 1973. A mail questionnaire was distributed to packinghouse managers in which they were asked to specify several indicators of capacity (such as season length, dump capacity, and total crew). Following tabulation of the responses, visits were made to several packinghouses in each of the districts defined earlier. Operations were observed and interviews were conducted with packinghouse personnel.

7/ The use of volume or jumble filling for pinks is increasing in California, but at the time of this writing, this practice is limited to mature green sheds that pack pinks largely as a byproduct.

8/ Size 6 x 6 can be packed in either container, depending on buyer specification.

Size (where size refers to dumping capacity) and packing techniques were highly correlated. Three models -- small, medium, and large -- which are reasonably typical of the range in size observed in California vine-ripe packinghouses emerged. The combinations of packing methods employed in the models correspond to methods typically used in packinghouses of the size indicated. Characteristics of the models are discussed below and outlined in table 2.

Small Packinghouse

The smallest of the three model packinghouses might be described generally as labor intensive, for compared with the larger models, little use of labor-saving equipment is made. Maximum hourly dumping capacity is 5 tons per hour, or, at an assumed 25 pounds net weight per container and a 25-percent cull rate, 300 packed boxes per hour. The small model utilizes field boxes handled with hand trucks and dumped without mechanical aids. Following washing, drying, waxing, and presizing, the fruit is simultaneously culled, color sorted, and sized by hand. Packers receive containers from an overhead roller conveyor and place filled containers on a belt conveyor leading to a tallying point. Filled containers are removed from the conveyor, stacked, and then moved to cold storage or loaded with hand trucks. Culls are conveyed to an elevator where they are loaded directly into a dump truck.

Medium Packinghouse

Maximum capacity of the medium-size model is 13.3 tons dumped per hour, or, alternatively, 800 lugs and flats per hour at peak operation. As in the small model, field boxes are used, but the boxes are palletized prior to loading in the field, and a mechanical dump is used. Belt sizing is used, and packed boxes are palletized upon removal from the collection conveyor. Other techniques differing from the small model are use of a monorail conveyor for container distribution and an elevated bin for temporary holding of culls.

Large Packinghouse

The model defined as large has a peak capacity of 1,500 packed boxes per hour. Other than in size and capacity of equipment, packing techniques in the model beyond the dumping operation do not differ from those used in the medium-size model. Half-bins (600 pounds) are employed in field-to-packinghouse handling. The bins are transported by forklift, and a hydraulic tilt-table is used for dumping.

Model Packinghouse Operating Conditions

Several assumptions concerning operating conditions apply to all three models. In most cases, these explicitly define seasonal average conditions as observed in California packinghouses. The assumptions are imposed because point values are required to estimate costs, even though ranges more accurately reflect actual conditions. Assumptions include:

1. Culling rate. A seasonal average culling rate of 25 percent is used for the models. The cull rate varies substantially over the

Table 2--Description of techniques used in 3 sizes of model California vine-ripe packinghouses

Item	Packinghouse model size		
	Small	Medium	Large
Hourly capacity (Maximum):			
Tons dumped	5	13-1/3	25
Boxes packed 1/	300	800	1,500
Field-to-packinghouse handling	30-pound field boxes individually handled with hand trucks	Palletized field boxes with forklift handling	Half-bins, forklift handling
Dump	Dry dump, hand dumping	Dry dump, revolving drum-type automatic dumper	Dry dump, hydraulic bin dumper
Wash, dry, presize, and wax	Chlorine spray wash, foam-rubber drying donuts, belt presizing of 7 x 8 and smaller roller brush wax application	Same as small	Same as medium
Cull	- -	Hand, culls placed in chutes along sorting belts	do.
Color sort	Simultaneous hand operations along conveyer belt; sorted and sized fruit placed directly into packing bins; culls placed in chutes along sorting table	Hand, four colors separated on two divided sorting belts	do.
Size	- -	Belt sizing	do.
Pack	Place-pack in two-layer flats & three-layer lugs	Same as small	do.
Filled-container handling	Power conveyer to collection point; hand truck to precooling or loading area	Power conveyer to collection point, palletized & moved to precooling or storage by forklift	do.
Boxmaking	Purchased knocked down, hand assembled	Same as small	do.
Empty container distribution	Overhead roller conveyer	Monorail	do.
Cull removal	Belt conveyer to elevator to dump truck	Belt conveyer to elevator to cull bin to dump truck	do.

1/ Assuming average net weight of 25 pounds per box and culling percentage of 25 percent. Packout noted is surge capacity. Packinghouses are assumed to operate at average 80 percent capacity during normal packing season, and between 20 and 50 percent capacity during startup and shutdown.

season, but 25 percent seems a reasonable average over an entire season based on historical observation. The effect on costs of varying the cull rate is explored later.

2. Flat-lug distribution. Based on industry experience, an assumed ratio of two-layer flats to three-layer lugs of 75 percent to 25 percent is used. Using 23 pounds net for flats and 31 pounds net for lugs, this ratio implies an average net weight per packed container of 25 pounds. As in the case of the assumed culling rate, the flat-lug ratio and the implied net weight per box are seasonal averages.

3. Grading and inspection. While some California pink-tomato packinghouses use more than one grade, the model sheds are restricted to packing only one. It is further assumed that packed output is not USDA inspected. Since inspection charges are assessed on a basis of boxes packed, an inspection charge can easily be included in the costs derived if desired. The single grade packed is assumed to be sold as 85-percent U.S. #1.

4. Colors and sizes packed. The model packinghouses are assumed to pack breakers through pink and sizes 7 x 7 and larger. 9/ Costs involved in packing ripes and 7 x 8 and smaller are not summarized.

5. Seasonal operating pattern. Packinghouses do not operate at the same rate throughout the season. During the early and latter parts of the season, partial crews are typically employed as the flow of fruit increases and declines. Even during season peaks, substantial fluctuations occur in deliveries to the packinghouses. In an attempt to capture the actual operating pattern of packinghouses, the models are assumed to operate in the manner shown in figure 2. During the first 10 percent of the season (startup period) and during the last 10 percent (shutdown), the models are assumed to operate at an average 20 percent of maximum hourly capacity. For another 20 percent of the season (season buildup and slowdown periods), the models run at an average 50-percent rate. Season peak is defined as the remaining 60 percent of the season during which the models achieve 80 percent of potential volume. 10/

The seasonal operating pattern defined above implies that, over the season, the packinghouse models pack 62 percent of their potential capacity.

9/ Colors packed are breakers, turning, and pink, using USDA grades. The actual sizes packed vary over the season, but it is assumed that no more than four sizes are packed at any one time.

10/ In some cases, full crews may be employed during season startup, shutdown, buildup, and slowdown periods, but work only a few hours. The situation described here, however, is reasonably typical of long-season and split-season areas, where daily fruit supplies are quite variable, and operation at close to hourly capacity is not feasible for part of the season.

This breaks down as 4 percent during the startup and shutdown periods, 10 percent during season buildup and slowdown, and 48 percent during peak operation.

The irregular line in figure 2 indicates one possible daily operating schedule corresponding to this seasonal average pattern. Daily percent of capacity (daily output divided by the number of hours operated) varies about the solid average line, but these averages represent the pattern of operation for the season as a whole.

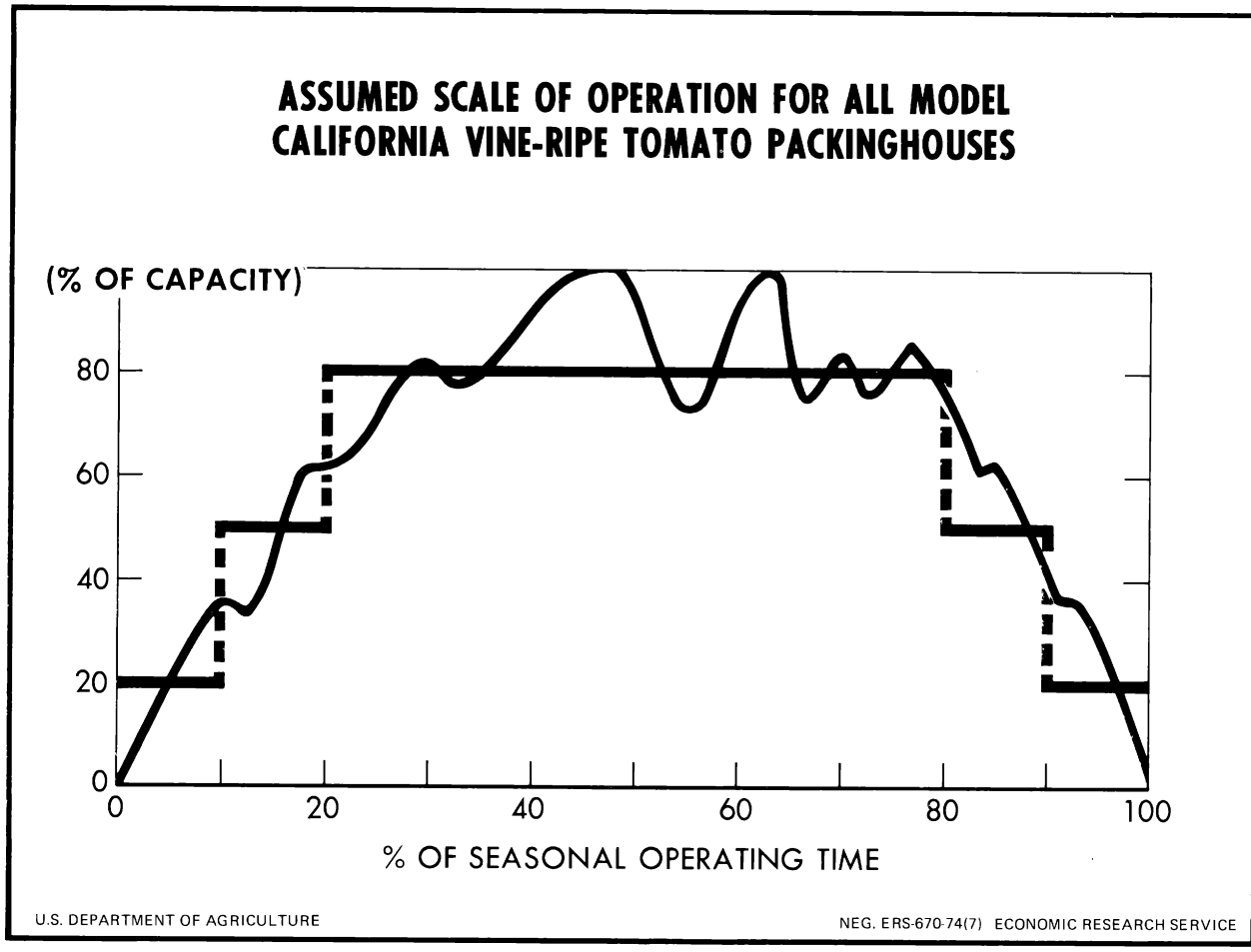

Figure 2

Certain other assumptions are made to simplify derivation of costs. These are described where they are encountered in the presentation of costs.

MODEL PACKINGHOUSE INVESTMENT AND OPERATING COSTS

Several sources were utilized in obtaining plant and equipment specifications and costs and variable packinghouse operating costs. Construction cost guides, especially Godfrey (3), were used in developing building costs. Plant layouts and footage requirements were based on observed packinghouses and similar studies in other areas (1) and (2).

Most equipment specifications and costs were obtained through interviews with machinery manufacturers and designers. Packinghouse operators provided additional information. In most cases, labor performance standards were taken from tomato packinghouse studies conducted in other States, adjusted where necessary to reflect California conditions. Extensive use was made of studies by Bohall, Farish, and Podany (1) and Brooker and Pearson (2). Container costs were averaged over costs quoted by manufacturers. Other items of cost were obtained directly from packinghouse managers.

Following complete specification of investment and cost components, further interviews with managers of California vine-ripe packinghouses were conducted to verify the data. Discrepancies were subsequently corrected and certain assumptions modified to more realistically portray operating conditions.

Specific cost components are discussed below. In all cases, costs reflect 1973 conditions.

Land and Buildings

Typical plant layouts for the three model packinghouses are shown in figures 3, 4, and 5. It should be emphasized that the layouts shown are examples. In actual practice, equipment arrangement is frequently dependent on existing building structure.

Building requirements include a main packing floor, receiving platform, loading dock, restrooms, office, and cold storage room. 11/ Footage required for each of these areas and the building site, cost per square foot, total investment, and annual ownership costs are shown in table 3.

Investment in land is based on an acquisition cost of $5,000 per acre, including site improvements. Annual costs for land assume no appreciation or depreciation. They total 9 percent of investment--8 percent for interest and 1 percent for taxes.

The model packinghouses are assumed to be of concrete and wood construction. All building components have a 25-year life, and the straight-line method of depreciation is used to calculate annual costs of ownership. In addition to depreciation, annual costs include interest on investment, repairs, taxes, and insurance. These total 11.4 percent of replacement costs, broken down as follows: 12/

11/ While not all California vine-ripe packinghouses use cold rooms, the models were assumed to provide refrigerated storage to maintain consistency for cost comparison. Cold storage capacity was specified at 10 hours pack under peak operating conditions.

12/ Fixed percentage charge for repairs, taxes, and insurance based on (1) and information provided by packinghouse managers.

	Annual percentage	
Depreciation	4.0	
Interest on investment	4.0	(8 on 1/2 replacement cost)
Repairs	1.8	
Taxes	1.0	
Insurance	0.6	
Total	11.4	

Total land and building investment ranges from about $60,000 for the small model to $155,000 for the large model. The comparable range in annual costs is from $6,600 to $17,000. Expressing land and building investment in terms of cost per unit of hourly capacity shows substantial economies of size in packinghouses. Investment per box per hour is $198, $122, and $103 for the small, medium, and large shed, respectively.

Equipment

Equipment requirements and other depreciable assets for the model packinghouses are outlined in appendix tables 1-3. Information on equipment specifications, replacement costs, useful life, and energy requirements was obtained through equipment manufacturers, and in some cases, from packinghouse operators. Quoted replacement costs for stationary equipment were increased by 17.5 percent to cover installation and shakedown costs.

Initial equipment investment, variable operating costs, and annual ownership costs are summarized in table 4 by stages in the packing process. Variable operating costs per hour were calculated as 3 cents per unit of horsepower plus .005 percent of replacement costs for repairs associated with hours of use. (An additional repair charge is included in annual fixed cost to account for repairs and maintenance not necessarily affected by operation time.)

Annual fixed costs are the sum of depreciation, interest on investment, taxes, insurance, and maintenance. Depreciation is charged using the straight-line method and the equipment life shown in appendix tables 1-3. Other costs are expressed as a percentage of initial investment, based on (1), as follows:

	Annual percentage	
Interest on investment	4.0	(8 on 1/2 of replacement cost)
Repairs	1.5	
Insurance	1.0	
Taxes	1.0	
Total	7.5	

Equipment investment for the small model is relatively low--$23,000--due to the labor-intensive nature of the operation. For the more mechanized medium-size model, equipment replacement costs are $85,000 -- 3.7 times the investment in the small model, but hourly capacity is only 2.7 times larger. The equipment cost per unit of additional capacity for the large model is substantially less than for the medium-size model. In fact, the cost per unit of capacity in the large model is less than in the small model, demonstrating significant economies of size.

Table 3--Land and building requirements, 3 sizes of model California vine-ripe packinghouses

Area	Square feet required			Cost per sq. ft.	Total initial investment			Annual fixed cost 1/		
	Small	Medium	Large		Small	Medium	Large	Small	Medium	Large
						Dollars				
Land & improvements 2/.....	50,000	150,000	250,000	.11	5,500	16,500	27,500	495.00	1,485.00	2,475.00
Buildings:										
Receiving platform.....	200	275	300	2.30	460	632	690	52.44	72.04	78.66
Cold storage 3/.....	1,000	1,900	3,000	17.00	17,000	32,300	51,000	1,938.00	3,682.20	5,814.00
Restrooms.....	150	150	300	15.40	3,080	3,080	4,620	351.12	351.12	526.68
Office.....	200	300	600	7.00	1,400	2,100	4,200	159.60	239.40	478.80
Loading dock.....	200	500	1,000	5.20	1,040	2,600	5,200	118.56	296.40	592.80
Packing floor.....	5,000	6,500	10,000	6.20	31,000	40,300	62,000	3,534.00	4,594.20	7,068.00
Total buildings	6,750	9,625	15,200		53,980	81,012	127,710	6,153.72	9,235.36	14,558.94
Total investment & annual fixed cost, land and buildings....					59,480	47,512	155,210	6,648.72	10,720.36	17,033.94
Investment & cost per box per hour at peak capacity.....					198.27	121.89	103.47	22.16	13.40	11.36

1/ Calculated as 9.0 percent of initial investment for land and 11.4 percent of initial investment for buildings. (See text for breakdown of annual cost components.)

2/ Site preparation, grading, paving, water, and sewer.

3/ Sufficient capacity for holding 10 hours pack at peak operation.

SMALL MODEL
CALIFORNIA VINE-RIPE TOMATO
PACKINGHOUSE LAYOUT

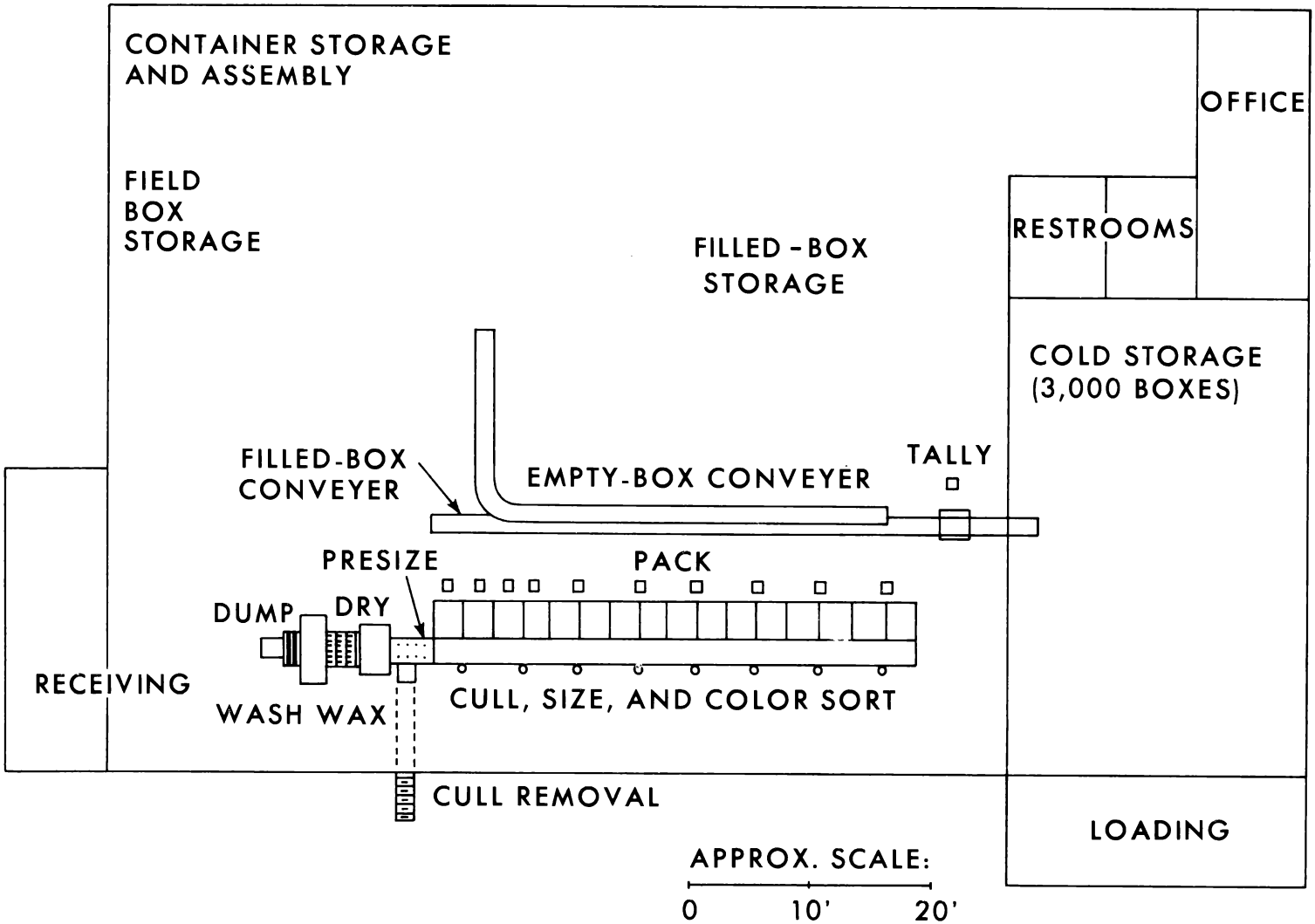

Figure 3

MEDIUM-SIZE MODEL
CALIFORNIA VINE-RIPE TOMATO
PACKINGHOUSE LAYOUT

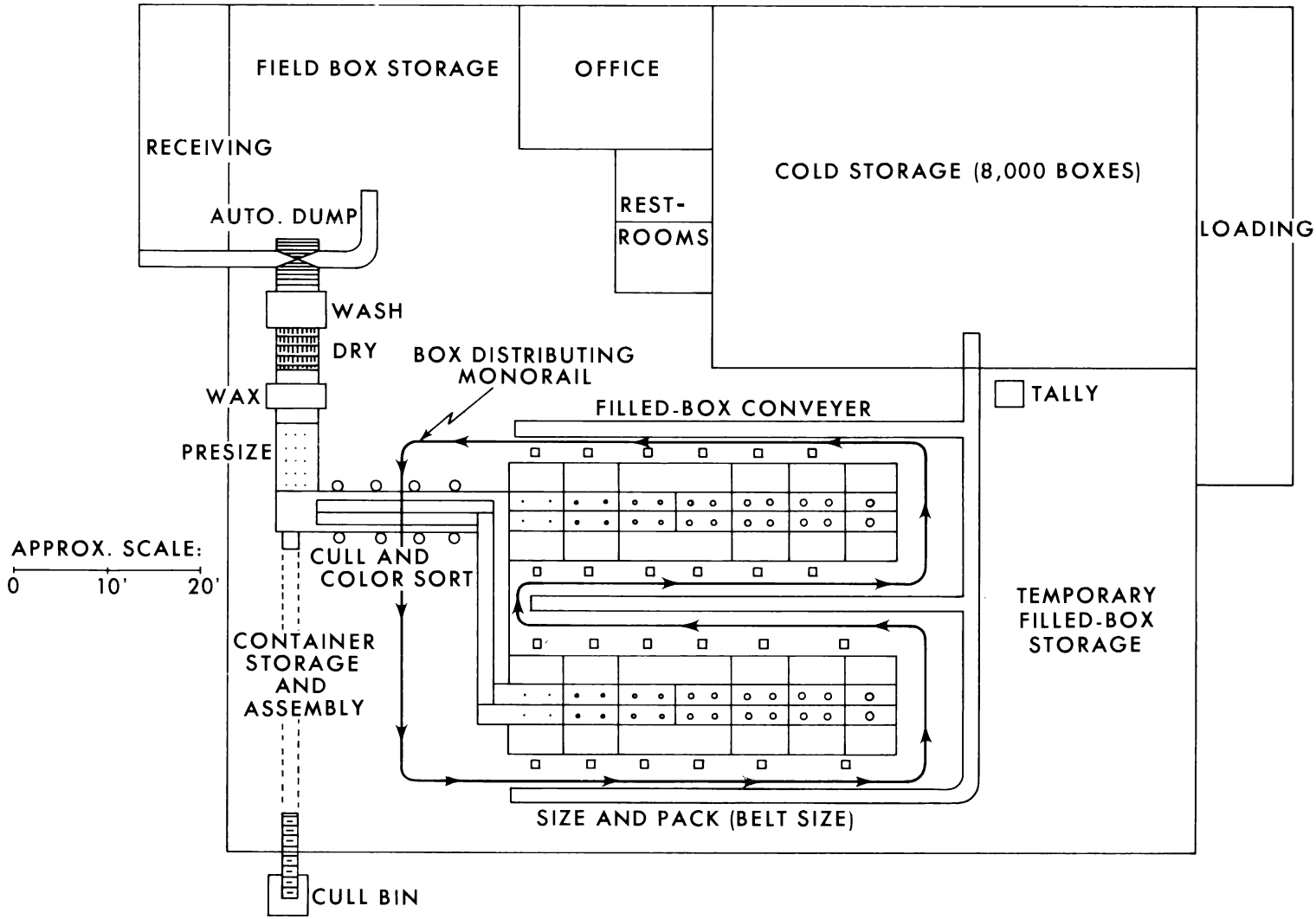

Figure 4

LARGE MODEL
CALIFORNIA VINE-RIPE TOMATO
PACKINGHOUSE LAYOUT

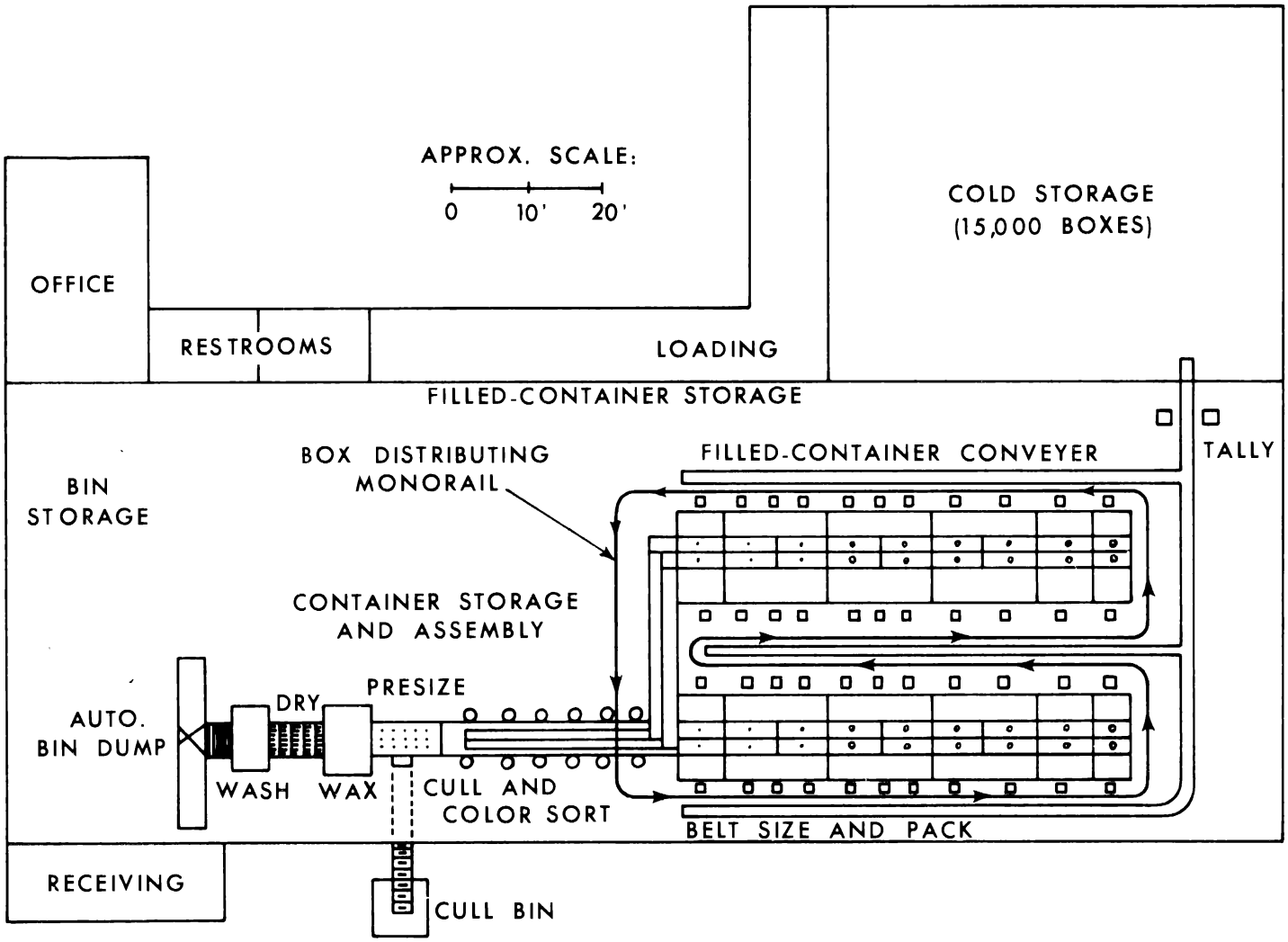

Figure 5

Table 4--Equipment investment and variable and fixed operating costs, 3 sizes of model California vine-ripe packinghouses 1/

Stage	Initial investment			Variable costs per hour			Annual fixed cost		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
					Dollars				
Dump	11,475	33,288	43,495	.59	1.73	2.32	4,341.45	12,358.73	11,361.63
Presize	1,057	1,762	2,250	.07	.12	.14	184.98	308.35	393.75
Cull & color sort 2/	3,880	8,342	12,500	.24	.51	.79	679.00	1,459.85	2,187.50
Size & pack		23,740	33,380		1.31	1.85		4,154.50	5,841.50
Filled-container handling	1,550	6,540	7,475	.11	.49	.57	100.10	411.25	616.88
Cull removal	2,617	6,292	7,750	.16	.37	.45	457.97	1,101.10	1,356.25
Overhead	2,000	3,000	3,500	.10	.15	.18	350.00	525.00	612.50
Total	23,151	85,314	113,875	1.30	4.86	6.57	6,384.75	21,463.28	23,678.13
Investment & annual fixed cost per box per hour at peak operation	77.17	106.64	75.91				21.28	26.82	15.78

1/ See text for formulas used in calculating variable and fixed charges.

2/ In the small model packinghouse, the sorting and sizing operations occur simultaneously.

Source: App. tables 1, 2, and 3.

Table 3 and appendix tables 2 and 3 show particularly large equipment cost savings with the use of bulk bins for field-to-plant handling and dumping. The large model actually incurs lower annual fixed costs than the medium-size model at the dumping stage (table 3). This occurs mainly because the total investment in field boxes for the medium-size model is only about $10,000 less than the bin investment for the large model, and the boxes only have a useful life of 3 years, compared with 5 years for bins. Hence, the annual container depreciation charge is greater for the medium-size model using field boxes. In addition, the replacement costs for dumping equipment are about the same for both models, even though the hourly capacity of the large model is nearly twice that of the medium-size model.

Other Fixed Costs

In addition to plant and equipment costs, there are other types of packinghouse costs not directly dependent on output. Salaried employees (those not paid an hourly wage), for example, represent another fixed cost component. Required jobs and seasonal salary expense for the three model packinghouses are outlined in table 5.

Assignment of salaried employees is confounded by wide variability in season length throughout the State. For example, salaried personnel may only be needed for 6 weeks in the Cutler-Orosi district, while similar sized packinghouses in the San Diego district may require such employees for 6 months. Table 5 uses a maximum employment period of 6 months to calculate salary expense. Hence, where months required for a particular job exceed 6, more than one employee is needed.

Table 6 summarizes other fixed costs in the model packinghouses. These include printing, paper forms and other expendable office supplies, advertising and promotion expense, and a miscellaneous fixed cost category.

Labor

Labor standards for packing-line personnel and crew requirements are given in appendix table 4. The labor standards specify the output in packed boxes per man-hour for the various jobs.

Three crew requirements are given for each model: 50 percent, 75 percent and 100 percent. It is assumed that the 50-percent crew is required for operation at an average rate less than 20 percent of maximum capacity. The 75-percent crew is applicable between 20 and 50 percent of maximum capacity. At average rates of operation above 50 percent, the 100-percent crew is needed. Given the seasonal average operation pattern shown in figure 2, the 50-percent crew would be used during season startup and shutdown; the 75-percent crew would be used during buildup and slowdown; and the full or 100-percent crew would be used during peak operation.

Hourly labor costs, using a wage rate of $3.05 including fringe benefits, are summarized in table 7. 13/ Wages for packers are not included. Since

13/ The model packinghouses are assumed not to incur overtime wage payments.

Table 5--Salaried employees, 3 sizes of model California vine-ripe packinghouses

Job description	Months required			Monthly salary 1/	Salary expense		
	Small	Medium	Large		Small	Medium	Large
				Dollars			
General manager	6	6	6	1,100	6,600	6,600	6,600
Assistant manager	0	4	4	990	0	3,960	3,960
Foreman	6	6	12	880	5,280	5,280	10,560
Mechanic	0	6	12	825	0	4,950	9,900
Sales manager	0	6	12	1,100	0	6,600	13,200
Secretary-clerk	6	12	20	550	3,300	6,600	11,000
					15,180	33,990	55,220

1/ Includes 10 percent for fringe benefits.

Table 6--Miscellaneous fixed costs per season, 3 sizes of model California vine-ripe packinghouses

Item	Cost per season		
	Small	Medium	Large
	Dollars per season		
Office supplies	300	600	1,000
Advertising	0	400	1,500
Other 1/	700	1,600	3,000
Total	1,000	2,600	5,500

1/ Dues, subscriptions, donations, legal and audit fees, and other miscellaneous expenses.

Table 7--Hourly labor cost by stage, 3 sizes of model California vine-ripe packinghouses 1/

Stage	Small house with crew size of--			Medium house with crew size of--			Large house with crew size of--		
	50%	75%	100%	50%	75%	100%	50%	75%	100%
Dump	$6.10	$12.20	$12.20	$9.15	$15.25	$15.25	$9.15	$9.15	$9.15
Cull, size, & color sort	24.40	36.60	48.80	18.30	27.45	36.60	36.60	54.90	73.20
Filled-container handling	15.25	15.25	15.25	15.25	15.25	21.35	21.35	30.50	36.60
Boxmaking & distribution	6.10	6.10	9.15	12.20	15.25	21.35	18.30	27.45	36.60
Nonspecific	3.05	3.05	3.05	6.10	6.10	9.15	9.15	12.20	15.25
Total	54.90	73.20	88.45	61.00	82.35	103.70	94.55	134.20	170.80
Weighted 2/ hourly cost			78.69			90.89			148.23
Hourly labor cost per packed container 3/			.42			.18			.16

1/ Assumes hourly wage rate of $2.75 + 11 percent for fringe benefits, or $3.05 per hour. Costs do not include packing labor, which is paid on a piece-rate basis.

2/ Hourly cost of volumes at 50, 75, and 100 percent of capacity weighted by proportion of time firm operates at these rates under assumed seasonal average operating conditions.

3/ At average hourly rate per season (186, 496, and 930 containers per hour, respectively, for the small, medium, and large models).

Source: App. table 4.

packers are normally paid on a piecework basis, their wage costs are included in variable costs per packed container. Hourly labor cost, exclusive of compensation to packers, ranges from $55 for the 50-percent crew to $88 for the full crew in the labor-intensive small model, averaging $79 when the crew costs are weighted by the proportion of the time the three crews are employed. The comparable weighted average cost in the medium-size model -- $91 -- is $12 higher, reflecting the substitution of equipment for labor between the small and medium-size models. Seasonal average hourly labor cost in the large model is about $150. On a packed container basis, seasonal average hourly labor costs for the small, medium, and large models are 42, 18, and 16 cents per container, respectively. The high labor cost for the small model reflects its labor-intensive nature.

Other Variable Costs

In addition to wages, two types of variable costs can be identified in the model packinghouses. Some variable costs vary with hours of operation, irrespective of containers packed, while others depend solely on volume.

Variable Costs Per Operating Hour

Table 8 summarizes packinghouse costs which vary with hours of operation. Unlike labor costs, these are not influenced by changes in the level of output per hour. Utilities expense consists of electrical power for lighting, cold storage refrigeration, and miscellaneous electrical equipment. Power cost for packing-line equipment is included in equipment costs. Electrical requirements are assumed to be 1 kilowatt hour per 100 square feet of floor space. Charge per kilowatt hour is specified as 3 cents for all three models. Other utility costs include charges for water, sewer, and fuel (for forklifts and cull truck).

The medium-size and large packinghouses are assumed to rent forklifts on a monthly basis. This results in lower costs per hour than ownership or annual lease because of only part-year use. 14/ Since the minimum rental period is 1 month, specification of forklift rental cost on an hourly basis is not entirely appropriate but would closely approximate actual expenditure.

Telephone and telegraph charges are primarily selling expenses. Communications costs depend heavily on market conditions, and the cost specified necessarily assumes a "normal" season.

Variable Costs Per Packed Container

Costs which vary with number of containers packed include box and pallet costs; chlorine, wax, and washing and waxing equipment; and the California fresh market tomato marketing order assessment, currently set at 2.5 cents per

14/ In real-life operations, forklift ownership could be economically feasible if the equipment is used during packing of other items. This possibility is not considered here.

Table 8--Miscellaneous variable costs per operating hour, 3 sizes of model California vine-ripe packinghouses

Item	Cost per hour by house size		
	Small	Medium	Large
	Dollars		
Utilities:			
Electricity 1/	2.02	2.89	4.56
Other	.40	.90	1.60
Forklift rental 2/	0	3.80	7.60
Telephone & telegraph	2.00	4.00	6.00
Total	4.42	11.59	19.76

1/ Does not include energy required for equipment operation, which is included in equipment costs.

2/ Based on monthly rental charge of $380 per month for 200 hours use. Two forklifts are required in the medium house and four in the large house.

hundredweight, or 0.625 cent per packed 25-pound container. 15/ These variable costs are summarized in table 9.

There is wide diversity among vine-ripe packinghouses with respect to the type of container used. Container types included all wood, wood side and top with fiberboard ends, wood with corrugated overlay, corrugated sides with wood ends, all-corrugated, and plastic. Since it is not possible to consider all of these containers in estimating costs, the decision was made to use an all-corrugated box for all three models. The use of corrugated containers is increasing, due largely to rapid lumber price rises in recent years. The models are based on practices of new vine-ripe packinghouses (1973), and there would be an incentive to use corrugated rather than wood containers in such cases.

The corrugated container used in the models is a one-piece interlocking unit which is hand-assembled. The lid locks to the body, and no fastening material or equipment is required. Boxes are purchased knocked-down. Based

15/ The entire marketing order assessment is charged to the packing operation. In some cases, this charge may be shared by growers and packers.

Table 9--Miscellaneous variable costs per packed container, 3 sizes of model California vine-ripe packinghouses

Cost item	Model and container								
	Flats	Lugs	Wgt. avg. 1/	Flats	Lugs	Wgt. avg. 1/	Flats	Lugs	Wgt. avg. 1/
	Cents per container								
Container	42.00	47.3	43.32	39.50	43.60	40.52	37.00	41.50	38.12
Disposable pallets	2/	2/	2/	3.333	3.333	3.333	3.333	3.333	3.333
Washing-waxing equipment, lease and supplies	5.00	5.00	5.00	4.25	4.25	4.25	3.25	3.25	3.25
Marketing order 3/ assessment	.575	.775	.625	.575	.775	.625	.525	.775	.625
Total	47.575	53.075	48.945	47.658	51.958	48.728	44.108	48.858	45.328
Packing labor	13.0	19.5	14.6	13.0	19.5	14.6	13.0	19.5	14.6

1/ Cost per packed container assuming 75-percent flat and 25-percent lug seasonal distribution.

2/ Pallets not used in small model.

3/ Costs assume 23-pound flats and 31-pound lugs.

on industry experience, the small packinghouse is assumed to buy in lots of 5,000, the medium-size house in lots of 10,000, and the large house in carlots (15,000). Material costs for two-layer flats are 42, 39.5, and 37 cents, respectively, for the small, medium, and large houses. The comparable costs for lugs are 47.3, 43.6, and 41.5 cents. Using a 75-percent flat, 25-percent lug distrubution, costs of 43.32, 40.52, and 38.12 cents for the small, medium, and large models are obtained.

The medium-size and large packinghouses ship tomatoes on disposable pallet (unstrapped). 16/ At 60 containers per pallet, palletizing adds 3-1/3 cents per container to variable costs.

Equipment for washing, drying, and waxing is commonly leased by vine-ripe tomato packers in California. The lease rate includes equipment, maintenance, and expendable supplies (chlorine and wax). Suppliers charge a variable rate depending on total seasonal volume. The rates used in the model houses are 5 cents for the small, 4.25 cents for the medium, and 3.25 cents for the large.

In addition to the miscellaneous costs noted in table 9, piece-rate payments to packers represent a variable cost per packed container. The rate used is 6.5 cents per layer, or 13 cents for flats and 19.5 cents for lugs. Using the assumed flat/lug ratio of 75 to 25, a container packing charge of 14.6 cents is obtained.

UNIT PACKING COSTS UNDER ALTERNATIVE OPERATING CONDITIONS

The preceding section outlined the cost components making up total seasonal packing costs in the model packinghouses. These costs are summarized in table 10. Three categories are identified -- (1) fixed costs, which are inflexible with seasonal packout or hours operated, (2) costs which depend on the number of hours operated, and (3) costs which depend on containers packed. For each cost item within the three categories, the table reference indicates the table in the preceding section where the item is derived.

Seasonal average unit packing costs (cost per packed box) can be derived from the total costs in table 10 by specifying hours operated for the season and average ouptut in packed boxes per hour. The formula for calculating unit cost is:

$$\left.\begin{matrix}\text{Packing cost} \\ \text{per container}\end{matrix}\right\} = \frac{\text{Fixed costs} + (\text{hours operated} \times \text{variable costs per hour})}{\text{Total boxes per season}}$$

$$+ \text{ variable costs per container}$$

Fixed, variable, and total costs per packed box by stage of operation are shown in table 11 for a 300-hour season (300 operating hours). Total unit costs for this season length are $1.61 (flats, $1.58; lugs, $1.70), $1.31 (flats, $1.28; lugs, $1.39), and $1.15 (flats, $1.12; lugs, $1.24) for the

16/ The cost of strapping pallets, if strapping is used, is usually incurred by buyers.

Table 10--Summary of packing costs, 3 sizes of model California vine-ripe packinghouses

Cost component	Table Reference	Cost by house size: Small	Medium	Large
		------Dollars per season--------		
Fixed costs:				
Land and buildings	3	6,648.78	10,720.36	17,033.94
Equipment, annual fixed cost	4	6,384.75	21,463.28	23,678.13
Salaried employees	5	15,180.00	33,990.00	55,220.00
Miscellaneous fixed costs	6	1,000.00	2,600.00	5,500.00
Total		29,213.53	68,773.64	101,432.07
Variable costs per hour:		-------Dollars per hour---------		
Labor 1/	7	78.69	90.89	148.23
Equipment, variable costs per hour	4	1.30	4.86	6.57
Miscellaneous	8	4.42	11.59	19.76
Total		84.41	107.34	174.56
Variable costs per container: 2/		-----Dollars per container------		
Packing labor 3/	9	.146	.146	.146
Other	9	.489	.487	.453
Total		.635	.633	.599

1/ Weighted hourly cost from table 6.

2/ Weighted average cost for flats and lugs from table 9.

3/ Number of packers employed shown in app. table 4.

Table 11--Unit packing costs (25-pound equivalent) by stage, 3 sizes of model California vine-ripe packinghouses 1/

Model and type of cost	Dump	Wash, dry, wax, and presize	Cull and color sort 2/	Size 2/	Pack	Filled-container handling	Boxmaking and distribution	Cull removal	Nonspecific	Total unit cost	Total cost per season
	Cents per 25# equivalent										Dollars
Small (55,800 boxes):											
Fixed cost per season	7.87	.33		1.21	0	4.17	.18	.82	37.76	52.3	29,213.53
Variable cost per hour	6.22	.03		22.42	0	8.24	4.28	.09	4.06	45.4	25,323.00
Variable cost per container	0	5.00		0	14.60	0	43.32	0	.62	63.5	35,433.00
Total	14.09	5.36		23.63 2/	14.60	12.41	47.78	.91	42.44	161.2	89,969.53
Flats										158.3	
Lugs										170.3	
Medium (148,800 boxes):											
Fixed cost per season	8.36	.21	.98	2.79	0	3.44	.28	.74	29.42	46.2	68,773.64
Variable cost per hour	3.56	.02	6.38	.26	0	4.40	3.73	.07	3.20	21.6	32,202.00
Variable cost per container	0	4.25	0	0	14.60	3.33	40.52	0	.62	63.3	94,190.40
Total	11.92	4.48	7.36	3.05	14.60	11.17	44.53	.81	33.24	131.1	195,166.04
Flats										128.5	
Lugs										139.3	
Large (279,000 boxes):											
Fixed cost per season	4.10	.14	.78	2.09	0	2.76	.22	.48	25.77	36.3	101,432.07
Variable cost per hour	1.64	.02	6.77	.20	0	3.95	3.37	.05	2.77	18.8	52,368.00
Variable cost per container	0	3.25	0	0	14.60	3.33	38.12	0	.62	59.9	167,121.00
Total	5.74	3.41	7.55	2.29	14.60	10.04	41.71	.53	29.16	115.0	320,921.07
Flats										112.2	
Lugs										123.5	

1/ 300-hour season.
2/ Culling, color sorting, and sizing are simultaneous hand procedures in the small model.

small, medium, and large models, respectively. These costs are calculated using the formula above and the set of operating assumptions defined earlier. In particular, the costs reflect the seasonal operating pattern illustrated in figure 2, which implies that seasonal output is 62 percent of maximum potential output (small = 55,800 boxes, medium = 148,800, and large = 279,000).

The breakdown by stage indicates where the major differences in costs among the three models occur. Almost half of the 30-cent cost difference between the small and medium-size models is attributable to the difference in the cost of sizing. The cull, color-sort, and sizing operations in the small model, using wholly hand procedures, add almost 24 cents to unit packing costs. The same operations using mechanical sizing in the medium-size model are performed at less than half this cost. Hence, from the standpoint of reducing packing costs, there would seem to be a strong incentive to utilize mechanical sizing. 17/

The 16-cent difference in total unit costs between the medium-size and large models is due in large part to the cost savings inherent in bulk handling. Nearly 40 percent of this difference is accounted for in the dumping stage. As shown previously, annual fixed cost for equipment at this stage is actually less for the large model. This results largely because bins have a longer useful life than field boxes, and the replacement cost ratio of bins to field boxes (9:1) is less than the substitution ratio (one half-bin substitutes for 20 field boxes).

The apparent economic incentive for adopting bin dumping must be tempered by the unknown difference in fruit damage between bins and field boxes. Specifically, it is conceivable that the use of bins could result in fruit losses which might more than outweigh the cost savings. Further, replacement of an existing field box system with bins requires a large initial investment which might be difficult to secure, particularly in the case of smaller operations.

The most expensive stage in all three models is boxmaking and distribution, which includes container costs. The cost of box materials, which increases with the size of firm (27 percent for the small, 31 percent for the medium, and 33 percent for the large model), contributes a large share to total unit costs. Given the magnitude of container cost, it would appear that technical research efforts directed at changing packaging methods could yield a high payoff.

The costs cited above reflect a strict set of operating assumptions for the model packinghouses. The remainder of this section examines how costs change when certain of these assumptions are relaxed.

Packing Costs Related to Season Length

The effect of season length on packing costs is illustrated in figure 6. For all three models, costs rise sharply when operating hours fall below 300

17/ This report does not consider possible differences in fruit damage attributable to the two sizing methods.

hours per season. On the other hand, there is a gradual leveling of costs beyond 300 hours. The nature of this cost function is emphasized in table 12. In the medium-size model, for example, packing costs decline 93 cents, or 41.5 percent when the season is increased from 100 to 300 hours. Between 300 and 900 hours, the decrease in unit cost is only 31 cents, or 23.7 percent. The other models show comparable changes.

The shape of the cost curves in figure 6 explains, to some extent, the large variability in season length observed among California packinghouses. Specifically, much of the efficiency attributable to extending the packing season is achieved at 300 hours, which represents about a 6-week season at 48 hours per week. The short-season districts can apparently compete favorably on the basis of unit costs with those districts having seasons two or three times as long.

Packing Costs Related to Level of Intensity

Fresh fruit and vegetable packinghouses are usually planned and constructed such that given expected fruit supplies, they can operate as close to capacity as possible during the packing season. However, seasonal variation in supplies, machinery, breakdowns, and other unpredictable occurrences seldom permit full capacity operation, even under the most favorable conditions. Furthermore, seasonal fruit supplies after plant construction may be substantially different from what were anticipated during construction planning. This brings up the question of the cost of excess capacity. For example, construction and operation of a packinghouse larger than required to pack current seasonal supplies permits future expansion. But how are unit packing costs affected by operating at levels well below capacity? 18/

Figure 7 shows how the model packinghouse costs are influenced by how close to maximum hourly capacity the packinghouses are being operated. The cost curves shown in figure 7 exhibit a pattern similar to those in figure 6. While costs decline rapidly when the level of intensity is increased from 0 to 50 percent, the decline beyond 50-percent intensity level is much slower. Table 13 shows that for an increase in intensity from 30 to 62 percent (62 percent is the overall season intensity level assumed by the operating pattern illustrated in figure 2), the reduction in unit cost is 84, 58, and 47 cents, respectively, for the small, medium, and large models. These compare with changes from 62 percent to 90 percent of only 37, 29, and 22 cents.

The discontinuities in the cost curves in figure 7 are due to a changing hourly labor crew mix. Given the assumptions previously defined concerning crew sizes and the operating conditions under which each crew applies, hourly labor costs change abruptly when certain values are reached.

18/ In years of short supplies, it is possible to approach capacity operation by operating the packinghouse for fewer hours per day -- that is, shorten the packing season. However, two problems are encountered with this policy: (1) decreasing season length results in unit cost increases (see preceding section), and (2) satisfactory labor relations may be difficult to maintain as daily hours drop. (See French, Sammet, and Bressler (4, p. 27)).

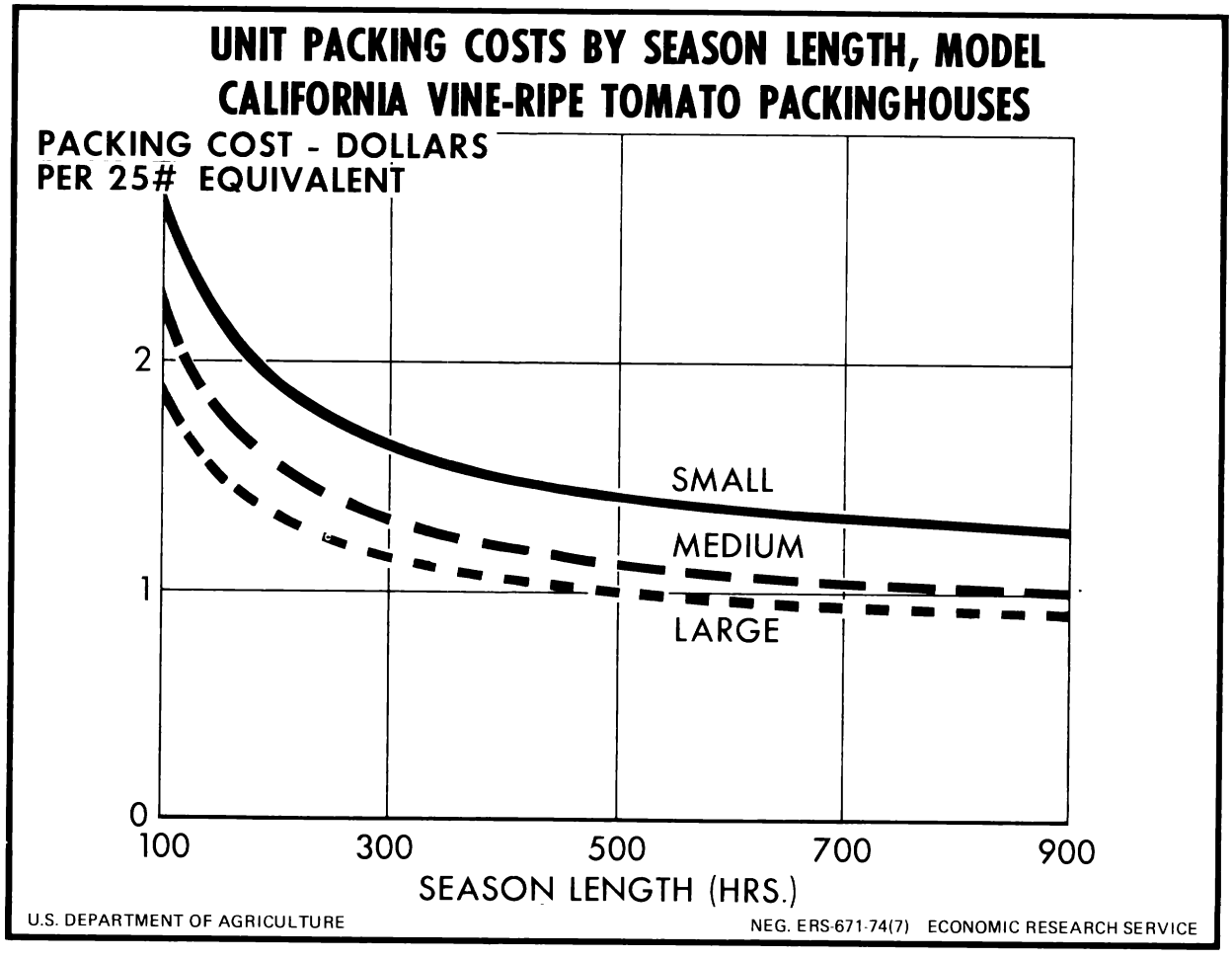

Figure 6

Table 12--Changes in unit packing costs with changes in season length, 3 sizes of model California vine-ripe packinghouses

Packinghouse size	Season length (hours)			Change in cost by extending season--			
	100	300	900	100-300 hours		300-900 hours	
	---Dol./25 lb.---			Dol.	Pct.	Dol.	Pct.
Small.....	2.66	1.61	1.26	-1.05	-39.5	-.35	-21.7
Medium.....	2.24	1.31	1.00	-.93	-41.5	-.31	-23.7
Large.....	1.88	1.15	.91	-.73	-38.8	-.24	-20.9

Source: Figure 6.

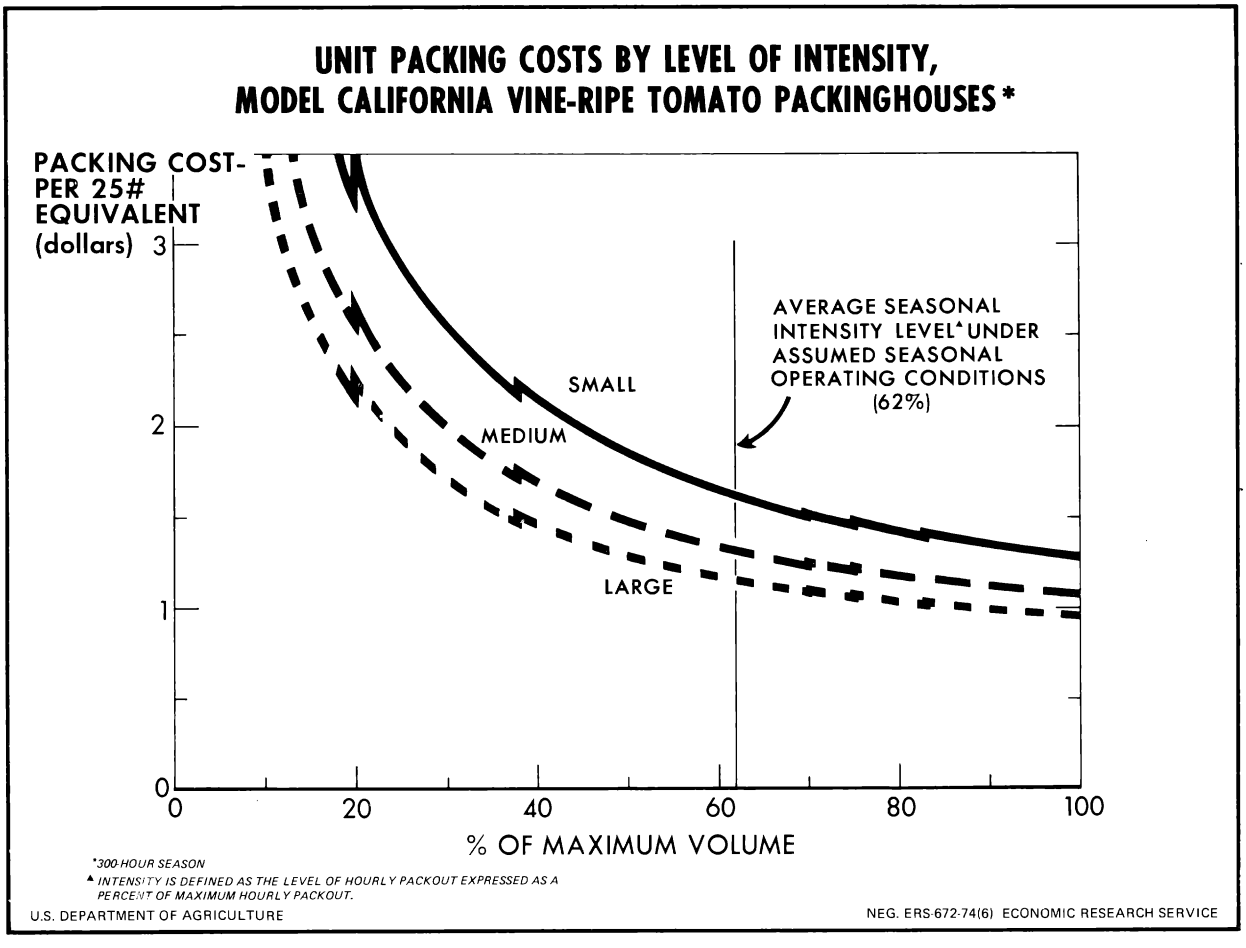

Figure 7

Table 13--Changes in unit packing costs with changes in intensity level, 3 sizes of model California vine-ripe packinghouses

Model	Unit packing cost, intensity level at--			Change in unit packing cost between --			
	30%	62%	90%	30 - 62%		62 - 90%	
	Dollars			Dol.	Pct.	Dol.	Pct.
Small....	2.553	1.717	1.344	-.836	-32.7	-.373	-21.7
Medium...	1.982	1.404	1.118	-.578	-29.1	-.286	-20.3
Large....	1.689	1.223	.995	-.466	-27.5	-.228	-18.6

Changes in packing costs with changing levels of intensity show that relatively low unit costs can be achieved at seasonal average volumes substantially below peak capacities. In effect, this correlation implies that a limited amount of excess capacity is not extremely costly. This is important since prolonged operation at maximum hourly capacity would be difficult, and, in fact, may entail expenses (such as equipment breakdowns and overtime pay) which are not included in the synthetic costs developed in this study. Furthermore, the results suggest that limited season-to-season variability in fruit supplies would not greatly affect unit costs, even if season length was held constant.

Packing Costs Related to Culling Rate

The proportion of total tons dumped that consist of culls has an important impact on unit packing costs for pink tomatoes. At a cull rate of 50 percent, 100 pounds dumped yields two packed containers. At a 25-percent cull rate, the same 100 pounds yields three containers. The costs of moving the 100 pounds through the packinghouse are about the same except for costs which vary with containers packed.

In figure 8, the seasonal average culling rate for the three model packinghouses varies from 10 percent to 60 percent for a season length of 300 hours. The quantity of tomatoes dumped is kept constant at 930 tons for the small model, 2,480 tons for the medium model, and 4,650 tons for the large model.

Costs increase rapidly as the culling percentage increases, particularly when the cull rate exceeds 30 or 40 percent. In the small model, unit costs increase over $1.00, from $1.45 to $2.47, as the culling percentage increases from 10 to 60 percent, with more than 70 cents of this increase from 35 to 60 percent. The comparable changes in unit costs for the medium-size and large models is from $1.20 to $1.91 and from $1.06 to $1.63.

Figure 8 indicates a clear incentive for keeping culling percentages low strictly from the standpoint of packing cost reduction, even without considering the cost of lost fruit. The high cost associated with high culling rates suggests that savings might be achieved by a concerted effort to prevent cull fruit from leaving the field.

Expected Seasonal Production and Packinghouse Size

A primary question in planning new or replacement packinghouses concerns the size of the planned unit. While a critical variable in this decision is anticipated seasonal fruit supplies, the length of the packing season is of equal or greater importance. This is shown clearly in figure 9, which shows costs for the three models related to seasonal production. 19/ The curves are drawn assuming the seasonal operating pattern presented in figure 2 (seasonal

19/ This analysis considers only the packing technique combinations represented by the models. That is, nothing is implied with respect to the optimal combination of techniques, and, indeed, combinations other than those evaluated may yield lower costs in the packinghouse sizes considered.

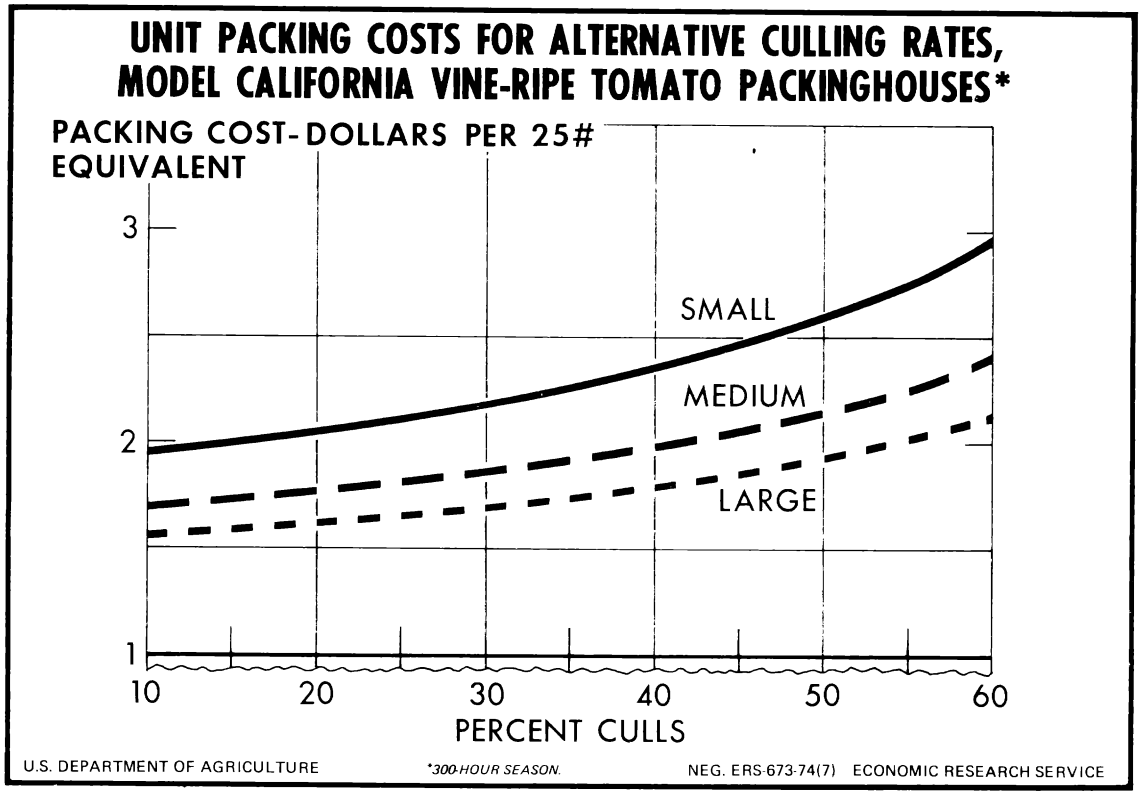

Figure 8

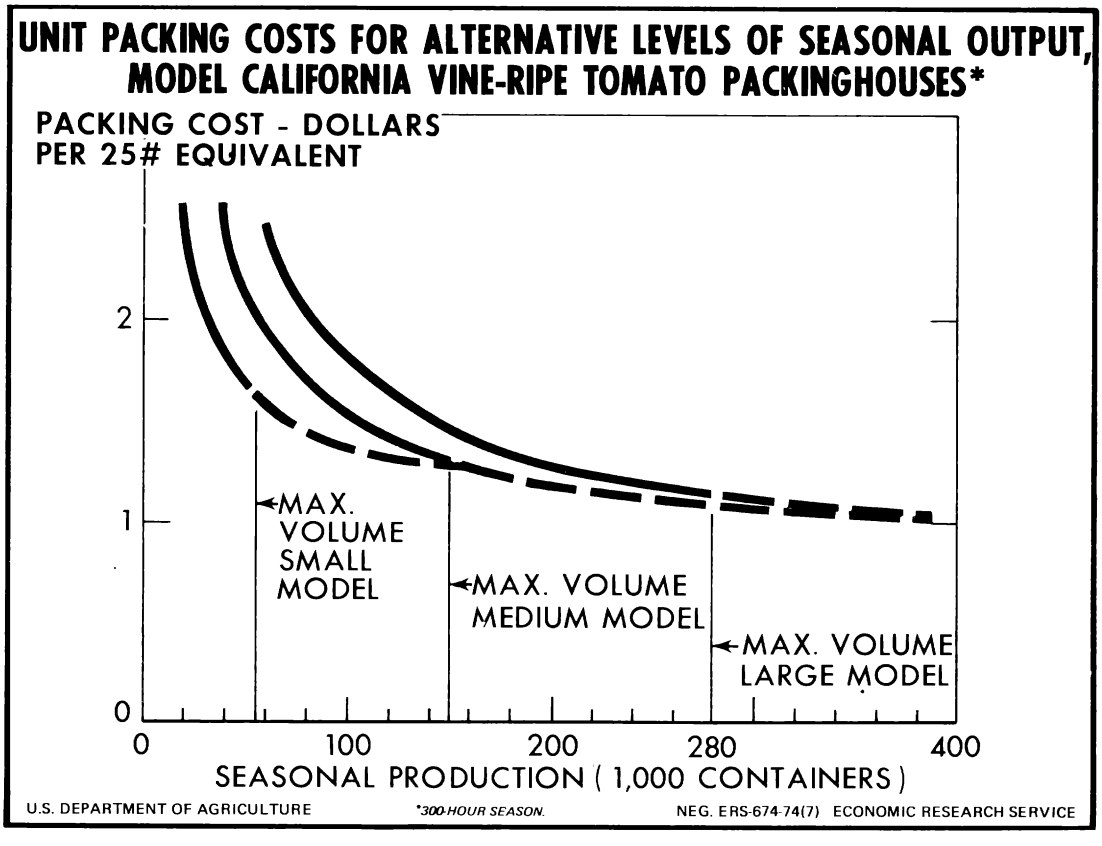

Figure 9

average hourly volume = 62 percent of potential) and an average culling rate of 25 percent.

With no restrictions on length of packing season, the small model yields the lowest unit cost for production up to about 160,000 boxes. Beyond this level, unit cost for the large model never falls below cost for the medium-size model. At first glance, it would appear that construction of a plant comparable to the small model would be the most practical if seasonal volume was not expected to exceed 160,000 boxes, and that construction of a plant similar to the large model would not be feasible under any conditions. However, to pack 160,000 boxes in the small model, a season length of almost 900 hours would be required. The same packout could be produced in the medium-size model operating only about 325 hours. Similarly, while the unit cost for a seasonal pack of 300,000 boxes is shown in figure 9 to be about 4 cents less in the medium-size than in the large model, the season length required to pack this volume in the medium-size model would be nearly twice that necessary in the large model.

When a maximum season length of 300 hours is imposed on the cost curves in figure 9, quite a different picture appears. In this case, the small model is applicable only up to a seasonal volume of about 56,000 boxes, at which maximum capacity under the assumed capacity conditions is reached. The medium-size model demonstrates the lowest cost between 56,000 and 150,000 boxes when a 300-hour capacity is reached.

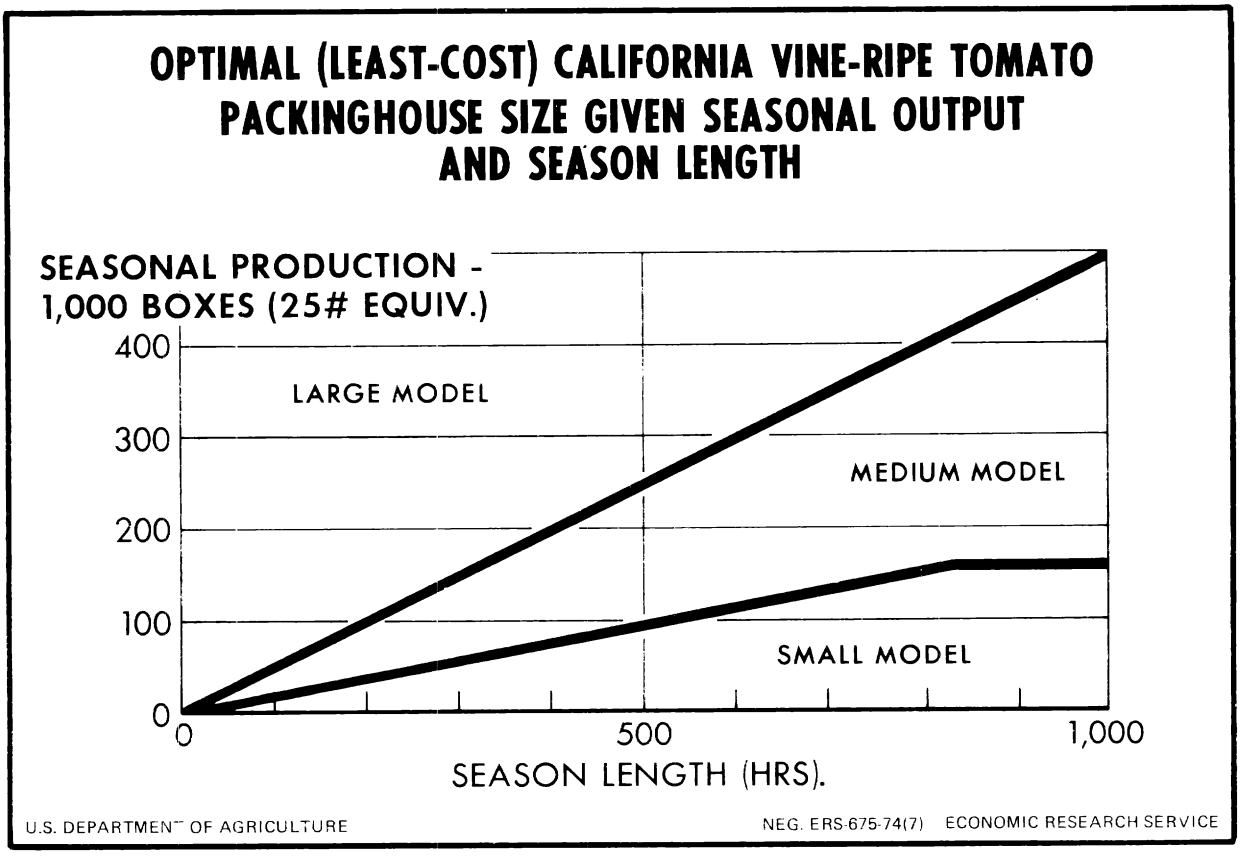

Figure 10

In figure 10, the least-cost model with combinations of season lengths from 0 to 1,000 hours and seasonal packouts from 0 to 500,000 boxes is explicitly identified. This diagram clearly indicates the relationship between season length and production in planning packinghouses. As an illustration, consider a situation where firm managers in two districts are planning new packinghouses. Both expect the same production -- 100,000 boxes per year. In case A, a short-season district, the ripening and packing period is 6 weeks, representing 300 hours of packinghouse operation. Case B reflects a split-season district with the 100,000 boxes divided between two 6-week periods, or 600 hours of operation. For case A, note that the intersection of 300 hours and 100,000 boxes in figure 10 falls within the medium-size model. Figure 9 shows that the output in case A could be packed at a unit cost of $1.54. For case B, the small model minimizes packing costs at $1.38 per unit.

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Appendix table 1--Packing equipment and other depreciable assets, small California model vine-ripe packinghouse

Stage	Equipment	Size & description	Units required	Replacement cost 1/ Unit	Replacement cost 1/ Total	Life	Electric h.p.	Variable cost/hr. 2/	Annual fixed cost 2/
				Dollars		Years		Cents	Dollars
Dump	Field boxes	Wood, 40# capacity	5,000	2.00	10,000	3	0	50.00	4,083.33
	Hand trucks		3	100.00	300	10	0	1.50	52.50
	Dump hopper	24" with power conveyer to washing unit	1	1,175.00	1,175	10	½	7.38	205.62
Wash, dry, & wax	3/								
Presize	Belt presizer	24" single frame	1	1,057.00	1,057	10	½	6.78	184.98
Cull, size, color sort & pack	Sorting table	24" by 40' powered belt conveyer with culls returned on bottom of belt. Includes table, attached cull chutes, belt, & padded packing bins with moveable dividers	1	3,760.00	3,760	10	1½	23.30	658.00
	Packing stands	Portable wood tables to position packing boxes	12	10.00	120	10	0	.60	21.00
Convey, tally, lid, & store filled containers	Box conveyer	12" powered conveyer	40'	32.50	1,300	10	1	9.50	227.50
	Tally stand	Wood construction	1	50.00	50	10	0	.25	8.75
	Hand trucks		2	100.00	200	10	0	1.00	35.00
Boxmaking & distribution	Empty-box conveyer	12" nonpowered roller conveyer	65'	8.80	572	10	0	2.86	100.10
Cull removal	Cull conveyer	12" powered conveyer from presizer to elevator	15'	39.50	442	10	1	2.21	77.35
	Elevator	Elevates culls from conveyer to truck, 12"	1	1,175.00	1,175	10	0	8.88	205.62
	Dump truck	Used, 5-yd. capacity	1	1,000.00	1,000	10	0	5.00	175.00
Overhead	Office & misc.		1 lot	2,000.00	2,000	10	0	10.00	350.00
Total					23,151			129.26	6,384.77

1/ Delivered price plus 17.5 percent for installation of stationary equipment.
2/ See text for formulas used to calculate variable and fixed costs.
3/ Equipment leased. Lease cost included in variable costs per packed container.

Appendix table 2--Packing equipment and other depreciable assets, medium California model vine-ripe packinghouse

Stage	Equipment	Size & description	Units required	Replacement cost 1/		Life	Electric h.p.	Variable cost/hr. 2/	Annual fixed cost 2/
				Unit	Total				
				--Dollars--		Years		Cents	Dollars
Dump	Field boxes	Wood, 40# capacity	13,400	2.00	26,800	3	0	134.00	10,943.33
	Automatic dump	Drum dumper for field boxes with full-box conveyer & empty-box conveyer/inverter	1	4,113.00	4,113	10	1½	25.06	719.78
	Pallets	Nondisposable, wood	200	6.00	1,200	3	0	6.00	490.00
	Conveyer	Roller conveyer from dump to washer	1	1,175.00	1,175	10	3/4	8.12	205.62
Wash, dry, & wax	3/								
Presize	Belt presizer	42" single frame. Includes crossbelt to cull belt	1	1,762.00	1,762	10	1	11.81	308.35
Cull & color sort	Main sorting table	52" by 20'. Main platform with cull chutes & divided belt conveyer	1	3,642.00	3,642	10	2	24.21	637.35
	Overhead table	Upper belt for color separation, 12" by 20'	2	1,469.00	2,938	10	½	16.19	514.15
	Distributing belt	24" by 20' conveyer from upper belt to sizer unit	1	1,762.00	1,762	10	3/4	11.06	308.35
Size & pack	Sizers	36" by 40'. 5 sizes plus overflow, 6 frames. Includes padded packing bins on both sides with movable dividers	2	11,750.00	23,500	10	4	129.50	4,112.50
	Packing stands	Portable wood tables to position packing boxes	24	10.00	240	10	0	1.20	42.00
Convey, tally, lid, & store filled containers	Filled-container conveyer	12" powered conveyer	220'	29.50	6,490	10	5½	48.95	1,135.75
	Tally stand	Wood construction	1	50.00	50	10	0	.25	8.75
Boxmaking & distribution	Monorail box conveyer	Continuous chain with hooks for empty containers	200'	11.75	2,350	10	2	17.75	411.25
Cull removal	Cull belt	12" powered conveyer	40'	29.50	1,180	10	2	11.90	206.50
	Elevator	24" to cull bin	1	1,762.00	1,762	10		8.81	308.35
	Cull bin	10-ton capacity, elevated holding bin for culls	1	2,350.00	2,350	10	0	11.75	411.25
	Dump truck	Used, 5-yd. capacity	1	1,000.00	1,000	10	0	5.00	175.00
Nonspecific	Office & misc.		1 lot	3,000.00	3,000	10	0	15.00	525.00
Total					85,314			486.56	21,463.28

1/ Delivered price plus 17.5 percent for installation of stationary equipment.

2/ See text for formulas used to calculate variable and fixed costs.

3/ Equipment leased. Lease cost included in variable costs per packed container.

Appendix table 3--Packing equipment and other depreciable assets, large California model vine-ripe packinghouse

Stage	Equipment	Size & description	Units required	Replacement cost 1/ Unit	Replacement cost 1/ Total	Life	Electric h.p.	Variable cost/hr 2/	Annual fixed cost 2/
				-Dollars-		Years		Cents	Dollars
Dump	Half-bins	Wood construction, 16" by 4' by 4'	1,250	30.00	37,500	5	0	187.50	10,312.50
	Automatic dump	Hydraulic bin dumper with hopper and roller conveyer to washing unit	1	3,525.00	3,525	10	5	17.62	616.88
	Bin conveyer	Powered conveyer through dump	1	2,470.00	2,470	10	5	27.35	432.25
Wash, dry, and wax	3/								
Presize	Belt presizer	60" single-frame with cross-conveyer for culls	1	2,250.00	2,250	10	1	14.25	393.75
Cull and color sort	Main sorting table	60" by 30' platform with cull chutes and raised worker platform. Divided conveyer belt with culls returned on bottom side	1	6,450.00	6,450	10	3	41.25	1,128.75
	Overhead table	Upper belt for separating colors, 12" by 30'	2	1,900.00	3,800	10	1½	23.50	665.00
	Cross belt	Conveyer belt to sizer, 20" by 30'	1	2,250.00	2,250	10	1	14.25	393.75
Size and pack	Belt sizer	48" by 52', 5 sizes plus overflow, 8 frames. Includes padded packing bins with movable dividers	2	16,450.00	32,900	10	6	182.50	5,757.50
	Packing stands	Portable, wood	48	10.00	480	10	0	2.40	84.00
Convey, tally, and lid	Filled-box conveyer	12" powered conveyer	250'	29.00	7,375	10	6½	56.38	1,290.62
	Tally stand	Wood, portable	2	50.00	100	10	0	.50	17.50
Boxmaking and distribution	Monorail conveyer	Endless chain with hooks for boxes	300'	11.75	3,525	10	3	26.62	616.88
Cull removal	Cull belt	20" conveyer	25'	35.00	875	10	1	7.38	153.12
	Elevator	From conveyer to cull bin	1	2,350.00	2,350	10	1	14.75	411.25
	Cull bin	Elevated holding bin	1	3,525.00	3,525	10	0	17.62	66.88
	Dump truck	Used, 5-yd. capacity	1	1,000.00	1,000	10	0	5.00	175.00
Nonspecific	Office equipment		1 lot	3,500.00	3,500	10	0	17.50	612.50
Total					112,700			656.37	23,678.13

1/ Delivered price plus 17.5 percent for installation of stationary equipment.
2/ See text for formulas used to calculate variable and fixed costs.
3/ Equipment leased. Lease cost included in variable costs per packed container.

Appendix table 4--Assumed labor standards and crew requirements under alternative operating conditions, 3 sizes of model California vine-ripe packinghouses

Stage	Job description	Packed boxes per man-hour [1]	Crew requirement for house sizes								
			Small			Medium			Large		
			50%	75%	100%	50%	75%	100%	50%	75%	100%
Dump	Hand truck field boxes from truck to dump station, return with empty boxes	186	1	2	2						
	Lift boxes from stack, dump into dump hopper	238	1	1	1						
	Stack empty boxes	523		1	[2]/1						
	Forklift palletized field boxes from truck or temporary storage to dump station, return palletized empty boxes to loading or storage area	[3]/800+				1	1	1			
	Place full boxes on dump conveyer	533				1	2	[4]/2			
	Remove and palletize empty boxes	523				1	2	2			
	Forklift half-bins from truck or temporary storage to dump station	1500+							1	1	1
	Remove empty half-bins with forklift, stack on truck or in storage area	1500+							1	1	1
	Operate automatic dump	1500+							1	1	1
Cull & color sort	Inspect fruit, remove culls, separate colors and sizes by manually placing into packing bins	[5]/15-25	8	12	16						
	Inspect fruit, remove culls, separate colors by placing on appropriate conveyer on or above sorting table	[5]/50-75				6	9	12	12	18	24
Pack	Remove container from distributing conveyer or monorail, place-pack fruit from packing bins in 2-layer flats & 3-layer lugs, stamp size, place filled container on take-away conveyer	[5]/25-35	6	8	10	16	20	24	30	38	45
Tally & lid	Record size, color & packer; inspect; & fasten lid	400	1	1	1	1	2	2	2	3	4

See footnotes at end of table.

Continued

Appendix table 4--Assumed labor standards and crew requirements under alternative operating conditions, 3 sizes of model California vine-ripe packinghouses--Continued

Stage	Job description	Packed boxes per man-hour 1/	Crew requirement for plant sizes								
			Small			Medium			Large		
			50%	75%	100%	50%	75%	100%	50%	75%	100%
Store & load	Remove filled containers from conveyer, stack or palletize by color & size	310	1	1	1	2	2	3	3	4	5
	Hand truck to precooling or temporary storage	400	1	1	1						
	Forklift pallets to precooling or temporary storage	1500+				1	1	1	1	1	1
	Transport to load by handtruck	400	1	1	6/ 1						
	Load truck by hand	225	1	1	1						
	Transport & load with forklift	925				1	1	1	1	2	2
Box assembly & distribution	Assemble boxes	125	2	2	3	4	5	7	6	9	12
	Place containers on roller conveyer or monorail	800	7/	1	1	7/	1	7/	1	1	2
Misc. labor	Assist in bottleneck locations, remove culls to field or landfill, minor repairs, cleanup, other assorted duties	300	1	1	1	2	2	3	3	4	5
	Total crew requirement		24	33	40	36	48	58	62	83	103
	Crew less packers		18	25	30	20	28	34	32	45	58

1/ Assumptions: 25-percent culling rate, 25 pounds net weight per packed container (75-percent 2-layer flats at 23 pounds net; 25-percent 3-layer lugs at 33 pounds net). Standards assume 30-pound field boxes and 500-pound half-bins, or .9 packed boxes per field box and 18 packed boxes per half-bin.

2/ Stacker assists dumper during peak operating conditions.

3/ A plus sign following labor standards means that the potential output per man-hour is greater than the indicated figure, but additional capacity is not needed.

4/ One dumper responsible for supervising automatic dump unit. Empty box handlers can assist dumpers during peak conditions.

5/ Point estimates not given because of particularly large variability in worker standards for these operations due to varying fruit quality, worker skill, and other factors. The ranges provided are believed to reflect worker performance under most operating conditions.

6/ Hand truck operator assists loader.

7/ Job handled by workers assembling boxes.