USE OF PHOTOGRAPHY
AND OTHER OBJECTIVE YIELD PROCEDURES
FOR CITRUS FRUIT

1968 TEXAS RESEARCH

by

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SUMMARY

Possibility of using ground photography in an objective yield survey for Texas citrus was demonstrated in a 1968 research project of the Statistical Reporting Service, USDA. Color slides of selected citrus trees were taken during the growing season. Other aspects of the survey were counting of fruit by limbs, measuring of fruit size each month, and recording the number of fruit dropped each month. Preliminary conclusions based on the 1968 work include:

A. Photography of citrus trees in late July or early August can be used with limb counts of fruit to estimate "fruit set" per tree. Relationship of number of fruit and limb size will allow improved estimates of total fruit for a tree based on limb counts of a small number of limbs selected by probability sampling methods.

B. Size distribution of fruit at harvest can be predicted from August or September measurements. Average fruit size is a linear function of time so additional size increase due to delay in harvesting can be predicted.

C. Fruit droppage can be estimated from a sample of limbs but with less reliability than size of fruit. Droppage is essentially linear over time. Thus, average number of fruit expected at a specific harvest date can be determined from total set estimate and projected droppage.

D. Number of fruit required to fill a standard size box can be determined from harvest size or weight per fruit.

PROJECT OUTLINE

Ground photography and other objective yield procedures for forecasting citrus production were studied in the Rio Grande Valley of Texas during 1968. Research and Development Branch, Statistical Reporting Service (SRS) conducted the study in cooperation with the Texas Citrus Mutual and the Agricultural Research Service (ARS) Remote Sensing Laboratory at Weslaco, Texas.

Citrus production is an important industry in the Valley area, although not a major portion of total Texas agriculture. Texas Citrus Mutual is interested in reliable forecasts of fruit production and fruit size in order to market the crop more efficiently and profitably.

Texas Citrus Mutual provided student help from Pan American College in Edinburg, Texas for the fieldwork. ARS provided motor vehicles, photo developing, aerial photography and some field help. Research and Development Branch planned the survey procedures and directed the fieldwork with help of part-time enumerators of the Texas SRS State Statistical Office (SSO).

Principal procedure under study was the possibility of using ground photography of sample trees to reduce work and cost required for making production estimates using probability survey procedures. This approach has been explored for other types of fruit in Virginia, California and Michigan.

Information on number of limbs, size of limbs and fruit per limb was gathered. These and similar factors would enable estimates of fruit numbers to be made from a sample of limbs. This approach is currently used in estimating citrus production in Florida and is referred to as an objective yield survey.

Selected fruit were measured monthly to study growth patterns. Also, the number of fruit on selected limbs was counted monthly to determine fruit droppage. These factors are components necessary to forecast fruit numbers and fruit size at the time of harvest.

Aerial photography of sample blocks was taken by the ARS laboratory. This was analyzed to determine whether aerial photos could be used in stratification and tree selection and to study the possibility of detecting fruit.

SAMPLE

Four types of citrus fruit were included in the 1968 study: Marrs oranges, other early orange varieties, Valencia oranges, and grapefruit. Two blocks of each fruit type were selected—one block near Monte Alto, Texas and the other near Mission, Texas.

Principal consideration in the selection of sample blocks was obtaining grower cooperation. Blocks were to be revisited monthly and block production figures were desired so complete cooperation was vital. Blocks selected for the survey were under control of only three management companies.

After selection of sample blocks, cross sectional area (CSA) of tree trunks was measured. Approximately 150 trees were measured in each block. In large blocks, a subsample of rows was selected and each tree in the selected rows was measured. Trees were listed by trunk area, in ascending order, for selecting a subsample of trees for detailed counts and measurements.

A systematic sample of four trees was selected from the ranked listing using a random start. This method insured some variation in tree size within a block.

Replacement trees were excluded from this study since they were not representative of the majority of the trees in the block. In addition, those replacement trees (trunk area less than 10 square inches) have very few fruit and it would be faster and more efficient to count all fruit rather than selecting sample limbs.

SURVEY PROCEDURES

Selection of blocks and measurement of trees was done in early July. Photography and counting of early oranges started about August 1 with Valencia and grapefruit work beginning about September 1. Blocks were then revisited at monthly intervals until harvest.

The total number of fruit on each selected tree was counted. To facilitate counting and to provide information on fruit location, the tree was "mapped." Each primary division of the trunk, or primary limb, was sketched and labeled with an identifying letter designation. Each primary was then further divided until terminal or "count" limbs were reached and each terminal was numbered. CSA was measured and recorded for all primaries and terminals. Limbs were marked on the trees using plastic flagging tape with the appropriate letter or number.

Fruit counts were made for each terminal limb. Fruit growing from a primary limb at a position below a terminal were designated as "path fruit" and recorded for the corresponding primary.

Enumerator instructions for the mapping and counting survey are presented as Appendix A.

At the time of the mapping and counting work all selected trees were photographed from the ground. Aluminum poles were used to divide the side of a tree into four quarters. Both sides of the tree were photographed with the photos taken from a distance of 13 to 18 feet from the sample tree. Complete photography instructions are included as Appendix B.

After all fruit were counted, subsamples of limbs were selected for fruit size and fruit droppage studies. Earlier work had indicated final fruit size might be related to fruit per square inch. The terminal limb fruit count was divided by terminal CSA to give an equivalent fruit count per square inch ratio. These ratios were ranked from smallest to largest with a systematic sample selected for the intensive size and drop study. Since a sample size of about 20 fruit was desired for each sample limb, limbs with small fruit counts and similar fruit count divided by CSA ratios were combined into quasi-limbs of about 20-25 fruit before selection. Two quasi-limbs were selected from each tree for the sizing survey and two for the drop study.

All fruit on the selected limbs were tagged and numbered with a white tag. Fruit size measurements were made with a device obtained from the Florida SSO. It is constructed from spring type barbecue tongs. A section of steel measuring tape is attached and looped such that after squeezing the tong to open the loop and placing the loop around a fruit, releasing hand pressure will draw the loop tightly about the fruit. Circumference reading can be made directly from the steel tape. Measurement recorded was circumference around middle of the fruit at a right angle to the stem.

After the initial survey period, trees were revisited monthly to check the fruit sizing and drop for sample limbs. Size measurement for each fruit was entered next to previous measurement. This provided a check against errors in measuring and permitted correlation of fruit size with earlier size. The numbers of any dropped fruit were recorded.

Each month additional ground photography was taken. This photography was taken to study change in photo count—fruit count relationship from month to month. In alternate months only one side of each tree was photographed.

Sample trees were harvested limb by limb. Individual fruit weights were obtained for all fruit on sizing limbs. Fruit on each drop limb were weighed together.

FRUIT COUNTS

Fruit on sample trees were counted by teams of two or three members. Limbs were counted in numerical order. Most limbs were counted only once with two members of a team counting at the same time. Limbs were entangled and it was often necessary to hold one or more limbs out of the way of the limb being counted. Each limb was counted from the base of the limb out with fruit number being called out as the fruit was touched.

Tagging of fruit on the fruit size and fruit droppage limbs gave a quality control indication of original counting accuracy. In general, additional fruit were found on the return visit to the early oranges which indicated undercounting in original counts. Number of additional fruit found was small with a maximum of an additional 1.9 percent found in the block of Jaffa oranges. Reasons for original undercounting included:

A. Foliage on citrus trees is very dense and many fruit are located in a cluster of leaves.

B. Many citrus limbs have several small branches which contain several fruit.

C. Two or four small limbs were combined to form a count limb in some cases. Combining limbs increased the chances for counting errors since one of the limbs might be overlooked.

D. Very few limbs were subsectioned and marked before counting. Counts per limb were small (largest average count per limb was 24.6) and counters did not feel subsectioning was necessary.

These quality check results from early oranges were available before fieldwork was started on Valencia oranges and grapefruit. Counting procedures used the second month were the same as the month earlier but more care was taken to obtain correct counts. Less than 1 percent difference in counts were found in two blocks but considerably fewer fruit (2.2 to 3.5 percent) were found in the return visit to the other blocks. This might mean that some fruit were dislodged during the original counting process. In both of these blocks the sample for sizing and drop work was drawn in the field. Thus, there was no time lag, between counting and recounting, for wind or other factors to have knocked fruit off. Fruit from another limb may have been counted in cases where limbs overlapped.

Table 1 lists the average fruit count per tree by blocks and results of the quality control work.

Table 1.--Fruit counts per tree and quality check of accuracy
1968 Texas Citrus Project

Fruit	Average original count per tree	Quality control count ÷ original	Quality control sample size		
			Total fruit	Total limbs	Nonzero limbs
	Number	Percent	Percent	Percent	Percent
August 1					
Marrs I......	437.0	101.4	19.8	23.1	25.8
Marrs II.....	700.0	101.6	17.5	23.9	23.9
Pineapple....	680.2	100.3	13.2	12.3	12.7
Jaffa........	1,169.5	101.9	9.0	9.1	9.6
September 1					
Valencia I...	492.2	100.8	18.8	19.0	19.3
Valencia II..	1,146.2	96.5	8.2	7.1	7.2
Grapefruit I.	262.8	97.8	25.6	23.4	32.0
Grapefruit II	220.8	100.9	38.6	29.7	32.8

Table 1 illustrates that a fairly large sample was selected in each block for the size and drop surveys. Sample should have been large enough to provide a good estimate of actual counting precision.

Experience with other types of fruit has indicated that counting accuracy within 2 percent is quite good. All but the two blocks which indicate overcounts fall within this 2 percent tolerance.

Even though the accuracy of counting seemed quite acceptable in the 1968 work, changes would be recommended for any later surveys. A limb to be counted should be checked visually before counting to determine any branchings which overlap other limbs or which might be missed. Limbs with many branchings should be divided into subsections with each subsection counted separately.

Counting fruit limb by limb allowed comparison of various measures of size with number of fruit. It was found that the sum of areas of original primary branchings was better correlated with number of fruit per tree than area of the trunk itself. This is shown by Table 2.

Table 2.--Correlation of tree size and total fruit
1968 Texas Citrus Project

	Average number of fruit per tree	Average trunk area (CSA)	Average original primary area	Correlation fruit and trunk area	Correlation fruit and primary area
	Number	Inches	Inches	r value	r value
Marrs I...........	437.0	40.8	38.1	.636	.661
Marrs II..........	700.0	13.8	20.8	-.797	.839
(All Marrs)......	568.5	27.3	29.4	-.514	-.385
Jaffa.............	1,169.5	87.1	75.8	-.377	.600
Pineapple.........	680.2	21.1	32.4	-.470	.333
(All other early)	924.8	54.2	54.2	.787*	.912**
Valencia I........	492.2	34.0	38.0	-.148	.033
Valencia II.......	1,146.2	122.7	111.6	-.758	.968*
(All Valencias)..	819.2	78.2	74.8	.587	.949**
Grapefruit I......	262.8	51.0	44.8	.142	.030
Grapefruit II.....	220.8	17.6	26.4	-.738	-.892
(All Grapefruit).	241.8	34.3	35.6	.173	.080

* Indicates correlation differs from zero with probability = 95 percent.
** Indicates correlation differs from zero with probability = 99 percent.

Sum of original primary branchings was much better correlated with fruit count for older trees. Trees in these blocks may have been cut back and trunk size is no longer representative of tree size.

Correlation is quite high for all other early oranges and all Valencia oranges because two blocks of completely different size trees were combined in each case. This gives a false impression of the value of tree size in predicting fruit load.

Correlation of primary limb size and number of fruit on that primary was significant at the 99 percent level for all blocks. Correlation of terminal limb area and number of fruit was significant at the 99 percent level for all blocks except grapefruit block I. Over 20 percent of terminals in this block did not have fruit which explains the low correlation.

Tables 3 and 4 list correlation of primary and terminal size with number of fruit. Correlations in both tables are within block correlation rather than within tree correlation.

Table 3.—Correlation of primary limb area and fruit count 1968 Texas Citrus Project

Fruit	Total primaries	Average CSA of primaries	Average fruit per limb	Correlation coefficient
	Number	Sq. inches	Number	r value
Marrs I........	26	5.8	66.8	.742**
Marrs II.......	26	3.2	108.8	.827**
Jaffa..........	20	15.1	233.5	.845**
Pineapple......	18	7.2	151.1	.832**
Valencias I....	23	6.6	85.6	.682**
Valencias II...	39	11.5	117.6	.802**
Grapefruit I...	21	8.5	50.0	.805**
Grapefruit II..	21	5.2	42.0	.763**

** Indicates correlation is greater than zero with probability = 99 percent.

Table 4.—Correlation of terminal limb area and fruit count 1968 Texas Citrus Project

Fruit	Total terminals	Average fruit per limb	Average CSA per terminal	Correlation coefficient
	Number	Number	Sq. inches	r value
Marrs I........	169	10.1	0.78	.559**
Marrs II.......	113	24.6	0.74	.593**
Jaffa..........	286	16.0	0.94	.616**
Pineapple......	171	15.6	0.83	.589**
Valencia I.....	153	12.7	0.87	.657**
Valencia II....	337	13.2	0.86	.548**
Grapefruit I...	209	4.9	1.01	.145*
Grapefruit II..	145	5.7	0.87	.345**

* Indicates correlation is greater than zero with probability = 95 percent.
** Indicates correlation is greater than zero with probability = 99 percent.

Several methods of limb sampling could be used to estimate fruit count per tree. Estimates could be based on fruit counts per primary limb or per terminal limb or per cluster of limbs. Limb counts could be expanded to totals based on number of limbs or size of limbs.

Two methods of selecting limbs were compared. A single stage selection could be used which requires that all possible count limbs be identified before selection of a sample. More practical for citrus work is multiple stage sampling which is commonly referred to as the "random path" method. Limbs are selected by moving outward from the trunk recording number of limbs and sizes of limbs at each division point. A probability selection of a path to follow is made at each division point until a limb of desired size is selected.

Limb counts were expanded to tree totals by two methods of limb selection: (1) Equal probability (EPS)—based on number of limbs at each stage, or (2) probability proportional to size (PPS)—based on size of limb and total size of all limbs at each stage.

Variances were calculated for sampling of terminal limbs and secondary limbs. Secondary limbs designate limbs larger than terminals. A secondary is generally a major division of an original primary limb but it includes small original primary limbs which branches only into terminals.

Table 5 lists variances of sample blocks using the four possible sampling—expansion combinations for selection of secondary or terminal limbs. All variances are within tree variances based on all possible samples of the tree.

Single stage PPS method gave a lower variance than random path in most cases. This is not practical for sampling terminal limbs in citrus work since the entire tree would have to be mapped to select the sample limbs. Mapping generally takes nearly as long as counting the entire tree so this method would be quite costly. The use of secondary limbs in single stage sampling may be practical since less than half of the tree needs to be mapped and the reduction in variances may justify the costs of mapping. Bare tree photography can be taken of deciduous fruit with sample limbs selected from the photography. This cannot be done for citrus.

Table 5.—Variances of alternative limb sampling methods
1968 Texas Citrus Project

Block	Limbs per tree	Random path selection		Single stage selection	
		EPS	PPS	EPS	PPS
		Terminal sampling			
Marrs I........	42	350,900	83,501	90,789	63,748
Marrs II.......	28	642,011	156,799	180,707	120,982
Jaffa..........	72	3,628,548	855,274	1,970,001	511,089
Pineapple......	43	645,498	123,677	174,249	106,168
Valencia I.....	38	566,263	53,864	103,830	53,313
Valencia II....	84	4,569,578	803,300	625,152	309,626
Grapefruit I...	52	237,830	61,066	75,635	47,656
Grapefruit II..	36	79,283	22,599	18,862	15,921
		Sampling of secondaries 1/			
Marrs I........	10	72,724	33,739	60,790	28,046
Marrs II.......	6	199,525	79,710	166,903	45,605
Jaffa..........	14	1,306,215	467,831	475,075	341,169
Pineapple......	8.5	331,272	256,021	151,793	51,663
Valencia I.....	8.5	159,071	24,883	58,238	25,168
Valencia II....	19	1,814,296	571,891	644,039	296,883
Grapefruit I...	14	80,940	11,768	42,323	24,699
Grapefruit II..	9	21,545	8,669	15,097	8,010

1/ "Secondaries" imply sampling the last division before terminals. This means some original primaries and some secondary divisions.

Other methods of limb selection should be studied in future research and by combining 1968 limb data. The high correlation of primary CSA and fruit count suggests that multiple stage sampling with CSA of primaries used in probability of selection or in estimation might be logical. For subsequent stages of sampling (within primaries) limb selection might be based on probability proportional to CSA or equal probability.

Multiple stage sampling (especially two stage sampling) might be easier to handle under field conditions than random path sampling. Strict definitions of primaries and terminals would be needed for selection. Some additional limb measurements will be needed of trees in the 1968 survey to conform to alternative definitions.

GROUND PHOTOGRAPHY

Sample trees were photographed during the season to study the relationship of photo fruit counts to actual fruit counts. Many of the techniques used in the photo study had been developed in similar studies of deciduous fruit trees in Virginia and California. Complete photography instructions are found in Appendix B.

Trees in some blocks were planted very close together giving a "hedged" effect within a row. An aluminum pole was placed upright at each outside edge of the sample tree to indicate on the photo which fruit were to be associated with the sample tree. An upright pole was placed directly in front of the trunk and the camera position was lined up using this pole and the trunk. A crossbar was laid across the three upright poles. Distance from the camera to the edge of the frame, height of the crossbar and height of the camera were recorded.

A tripod was used for taking each month's photography. The tripod and the original measurements aided in duplicating the same camera position each month. Placing the center upright in line with the trunk of the tree did not divide the tree into equal left and right sides in some cases, but this method did aid in recreating the desired shot. Pole and camera positions were marked with wooden stakes but many of these were dislodged by irrigation water or discing.

The bright sun was a problem in the first month's photography. Some pictures tended to be too dark because of overcompensation for the sunlight. Later photography was taken using a Minolta camera with a light meter behind the lens. Using the indicated settings with this camera gave mostly good quality photos for counting purposes. It was found that omitting as much sky as possible when taking photos of upper quarters was an aid in cutting down on dark shadows on these slides. The best procedure seemed to be to take the light reading only a few feet from the tree but this is quite inconvenient using the camera mounted on the tripod. Light conditions vary considerably during the course of photographing one side of the tree because of variable cloud cover. Thus, most camera settings were based on readings from the 13' to 15' distances.

Most photos were taken using high-speed Ektachrome film which could be developed daily at the Weslaco Remote Sensing Laboratory of ARS. This was a great advantage in interpreting the quality of the photography and enabled rephotographing trees if initial shots were not adequate for counting.

Fruit Counts from Slide Photographs

Fruit counts from the slide photos were made by the clerical staff of the Research and Development Branch. Each block consisted of four trees; each with two positions (sides of the tree) and four quarters per position. A team of four counters was used to count each block. Assignments for counting four trees were based on a 4 x 4 Greco-Latin square design. Each counter would count one "diagonal" (a lower and the opposite upper quarter of the same side) of each tree on the first counting series. Then a second series of one diagonal per tree was counted. Each slide in the block was double counted. The design was such that each counter counted against each other counter on four slides and recounted his own count on two slides. Counters were not told that they would be checking their own counts. The counts against himself indicated whether a counter was counting essentially the same on both series.

Written instructions for counting fruit on the slides were prepared which were as thorough as possible. Training slides were provided which illustrated particular counting problems. To describe how to interpret fruit by written instructions alone is not possible, but the combined use of instructions and training slides aid in obtaining consistent counts. Attempts were made to analyze what was being counted on training slides and to discuss apparent differences with individual counters. Some individuals have a tendency to count higher or lower than others depending upon their subjective opinion of questionable fruit. Examples of questionable fruit are fruit partially hidden by leaves, fruit in shadows or even round leaves themselves. It does not appear possible to ever develop a completely objective method of photo interpretation using people for counting. However, consistent counts can be obtained if objective rules are established for handling questionable fruit. Written counting instructions are included as Appendix C.

Table 6 lists average percents of total fruit counted, average time per slide and average fruit count per slide for early season photography. Relationship of time required and number of fruit counted is quite consistent between blocks. Percent of total fruit counted from the early season photography seems reasonable for all blocks except the Jaffa oranges and the Valencia oranges block II. Photography of these two blocks may not have been of the same quality as the other blocks. Some mention of these blocks will be made later.

Table 6.--Average percent of fruit counted from slides 1/
1968 Texas Citrus Project

Block	Percent of total fruit counted	Average time per slide	Average fruit count per slide
	Percent	Minutes	Number
Marrs I........	29.8	6	17
Marrs II.......	32.2	7	28
Pineapple......	40.8	8	32
Jaffa..........	25.7	9	39
Valencia I.....	40.2	7	25
Valencia II....	21.7	8	31
Grapefruit I...	28.5	6	9
Grapefruit II..	36.4	5	10

1/ August or September photography.

Table 7 shows the correlation of number of fruit counted by tree to the total fruit count of that tree. The effect of the low percentage counted for the Jaffa oranges and the Valencia block II can be seen in Table 7. Correlations were computed by type of fruit giving eight trees per type. Correlation of the photography counts for the Marrs oranges and grapefruit trees was significant at the 1 percent level. The correlation of photo count and total fruit for all oranges is also highly significant since the two blocks with the lowest percentages counted have the most total fruit.

Table 7.--Correlation of photo count with tree count 1/
1968 Texas Citrus Project

Type of fruit	Correlation
Marrs oranges......................	.935**
Other early oranges................	.512
All early oranges.................	.798**
Valencia oranges..................	.546
All oranges.......................	.690**
Grapefruit........................	.915**

1/ August or September photography.
** Indicates correlation is greater than 0 with probability = 99 percent.

Interpretation of Photo Counts

Correlation results in Table 7 indicate that photography could be used in an estimating program. It would be desirable from a time and cost standpoint to photograph and count only a portion of each tree. Therefore, the distribution of photo counts within a tree is an important consideration.

Fruit counts per slide were analyzed to determine source of variation. A nested classification model was assumed:

$$Y_{ijklm} = u + t_i + p_{ij} + d_{ijk} + q_{ijkl} + e_{ijklm}.$$

Y_{ijklm} is the mth count for the lth quarter of the kth diagonal within the jth position of the ith tree. ($i = 1, 2, 3, 4$; $j = 1, 2$; $k = 1, 2$; $l = 1, 2$; $m = 1, 2$.) Thus, an analysis of variance of this assumed model tests hypotheses of no differences between (1) quarters within a diagonal, (2) diagonals within a position, (3) positions within a tree, and (4) trees.

The error component in this model contains the effect of the two counters on the same slide. It was possible to separate this counter effect from the normal residual effect by comparing results of different counters on same slide.

Table 8 lists the results of analyses of variance of photo counts for early season photography. Quarters within diagonals varied significantly in every block. More fruit were counted on lower quarters than on upper quarters of trees.

Blocks in Table 8 have been listed in rows by order counted. After the first two blocks (Marrs II and Pineapple) were counted, photo interpreters were given additional instruction. Effect of this instruction is shown by the mean squares for counters. Mean squares for counters were reduced from approximately 55 for first counts to a level of about 20 to 25 for most later blocks.

Grapefruit block I was counted by four members of the professional staff. Mean square for counters was very low for this block. Each member of this counting team had considerable field experience with fruit studies before counting photography of this block. This practical experience helped to insure more uniform identification of fruit but this was also a special assignment for the professionals. Thus, they may have been careful in their counting.

Table 8.--Analyses of variance of actual photo counts 1/
1968 Texas Citrus Project

Source	Degree of freedom	Mean squares	F ratio	Mean squares	F ratio
		Marrs II		Pineapple	
Trees	3	160.06	.52	72.38	.38
Position/trees	4	309.36	1.85	216.84	.99
Diagonal/position	8	166.80	.24	220.03	.73
Quarter/diagonal	16	693.20	16.87**	302.75	31.47**
Counter	16	55.27	1.35	53.69	5.58**
Residual	16	41.08		9.62	
Total	63				
		Marrs I		Jaffa	
Trees	3	721.31	7.63*	765.19	2.56
Position/trees	4	94.55	.72	299.41	.89
Diagonal/position	8	130.58	.85	335.84	.92
Quarter/diagonal	16	154.17	11.76**	363.22	44.19**
Counter	16	13.98	1.07	24.03	2.92*
Residual	16	13.11		8.22	
Total	63				
		Valencia I		Valencia II	
Trees	3	843.88	11.54**	541.35	3.37
Position/trees	4	73.16	.49	160.45	1.03
Diagonal/position	8	149.47	.63	155.14	.46
Quarter/diagonal	16	235.56	25.30**	336.89	14.52**
Counter	16	20.88	2.24	25.20	1.09
Residual	16	9.31		23.20	
Total	63				
		Grapefruit I		Grapefruit II	
Trees	3	520.18	3.87	66.85	.30
Position/trees	4	134.39	4.93*	225.41	2.66
Diagonal/position	8	27.23	.43	84.78	.43
Quarter/diagonal	16	63.83	34.88**	195.59	29.68**
Counter	16	5.14	2.81*	26.53	4.02**
Residual	16	1.83		6.59	
Total	63				

1/ August or September photography.
* Tabular F values at the 5 percent level are F (3,4) = 6.59, F (4,8) = 3.84, F (8,16) = 2.59, F (16,16) = 2.35.
** Tabular F values at the 1 percent level are F (3,4) = 16.69, F (4,8) = 7.01, F (8,16) = 3.89, F (16,16) 3.41.

Counter effect was significant at the 5 percent level in four of the eight blocks. Some counters tend to count higher or lower than others for the same quality of photography. However, counters may count quite differently if slides are somewhat dark or light. This interaction of counters and slide quality is a component of the residual mean square.

Results of these analysis of variance tables are encouraging. Because of the positioning of the crossbar when photographing and the actual distribution of fruit on a tree, we would expect differences between the upper and lower quarters of a diagonal. Therefore, the minimum unit that could be counted would be one diagonal on one side of a tree.

Position or side of tree was significant only for grapefruit block I. Two of the trees in this block had very few fruit and the distribution of fruit may have differed between sides. If counts from two sides of a tree do not differ, then only one side needs to be photographed. This approach could be expanded. If fruit distribution differed consistently between sides and the same side of each tree was photographed, parameters based on photos of that side would be consistent.

Diagonals within a side did not differ significantly in any of the blocks. This means that only one diagonal would be needed. It still may be advisable to photograph all four quarters. The time required to shoot the additional diagonal would be negligible and would provide some insurance against missing photography of a tree.

The differences in photography counts in Marrs block I and Valencia Block I would be expected since actual fruit counts differed. The trees in Grapefruit block I and Valencia block II differed in actual count but this was not demonstrated by photo counts. This may be due to size of tree. A larger tree is harder to photograph and a lower percent of fruit is counted. It may be desirable to stratify trees by actual fruit count in interpreting photo counts. That is, different parameters might be needed for different strata (ages or sizes) of trees.

FRUIT SIZE STUDY

During the growing season, diameter size distribution graphs were prepared from the circumference measurements and supplied to the individual citrus managers. Citrus fruit are marketed by size (number of fruit per box) which is based on fruit diameter. Oranges' diameters were distributed normally about the average.

Average sizes of fruit measured monthly are shown in Table 9. Top figure listed is the average size of all fruit measured. Figure in parenthesis is average size of fruit which remained until harvest. Measurements were taken around the first day of the month listed.

Only the fruit which remained on sample limbs all season and were measured each month were included in correlation and regression calculations. The fact that some fruit measured in early surveys will be lost during the season does not affect computations if the fruit that drop are of similar size. Table 9 illustrates that there was very little difference in size of all fruit measured and size of fruit which were retained all season.

Table 9.--Monthly average size of fruit measured 1/
1968 Texas Citrus Project

Block	Survey period (first of month)						
	August	September	October	November	December	January	March
Marrs I	2.01	2.25	2.42	2.63			
	(2.00)	(2.26)	(2.43)				
Marrs II	2.07	2.22	2.40	2.51			
	(2.08)	(2.22)	(2.40)				
Pineapple	2.22	2.36	2.43	2.57			
	(2.23)	(2.37)	(2.44)				
Jaffa	1.99	2.15	2.27	2.41	2.52		
	(2.01)	(2.16)	(2.27)	(2.41)			
Valencia I		2.23	2.36	2.47	2.58	2.63	2.74
		(2.28)	(2.38)	(2.49)	(2.59)	(2.64)	
Valencia II		2.22	2.33	2.47	2.56	2.61	2.65
		(2.24)	(2.35)	(2.48)	(2.56)	(2.61)	
Grapefruit I		3.49	3.66	3.85	4.03		
		(3.50)	(3.67)	(3.85)			
Grapefruit II		2.94	3.25	3.32			
		(2.96)	(3.25)				

1/ Top figure is average diameter in inches of all fruit measured during survey. Lower figure is average size of fruit which were measured each month and on the tree when harvested.

Fruit growth during the season is essentially linear. Block differences in fruit growth may be due to differences in irrigation or other factors during the period. Our survey dates were approximately a month apart except for January to March, but the number of days varied between measurements. To correct for the differences in survey timing, average daily growth was calculated. Table 10 lists average daily increase in fruit diameter between survey periods.

Table 10 indicates that growth rate varied considerably during the growing season. Growth rate was not constant nor did it necessarily increase or decrease throughout the season. As mentioned above, timing and amount of irrigation water applied influenced growth.

Table 10.--Average daily growth of fruit
1968 Texas Citrus Project

Block	Average daily diameter change between surveys - inches					
	August to September	September to October	October to November	November to December	December to January	January to March
Marrs I	.0075	.0065	.0075			
Marrs II	.0056	.0064	.0035			
Pineapple	.0052	.0026	.0044			
Jaffa	.0045	.0046	.0048	.0038		
Valencia I		.0054	.0042	.0033	.0013	.0021
Valencia II		.0039	.0038	.0033	.0012	.0008
Grapefruit I		.0071	.0070	.0045		
Grapefruit II		.0107	.0025			

Fruit size at time of first or second measurement is well correlated with final size. Also, the size at harvest is a very strong indicator of fruit weight. Table 11 lists the simple correlation coefficients (r) at the block level of early season size with harvest size and harvest size with harvest weight.

All simple correlations in Table 11 are significant at the 1 percent level. The square of a simple correlation coefficient indicates the percent of variation of the dependent variable explained by the independent variable. Size of fruit the first month accounts for approximately 65 to 80 percent of the variation in final size. This would indicate that other variables might be found to explain much of the additional variation.

Table 11.--Correlations of fruit sizes and weights
1968 Texas Citrus Project

Block	Correlation of size with harvest size, by survey period						Correlation harvest size with weight
	August	September	October	November	December	January	
Marrs I.......	.8464	.9305	.9673	Harvest			.9769
Marrs II......	.9077	.9544	.9752	Harvest			.9720
Pineapple.....	.8163	.8639	.9222	Harvest			.9452
Jaffa.........	.8961	.9272	.9457	Harvest			.9728
Valencia I 1/.		.8994	.9109	.9390	.9580	.9784	.9824
Valencia II 1/		.8152	.8690	.8961	.9509	.9710	.9748
Grapefruit I..		.7968	.8927	.9056	Harvest		.9371
Grapefruit II.		.9858	.9944	Harvest			.9512

1/ Valencia harvest was about March 1.

Variables used in combination with first month size to predict final size included (a) fruit count on terminal limb, (b) cross sectional area of terminal, and (c) limb fruit count divided by terminal area. None of these variables contributed significantly to a multiple regression equation for predicting harvest size.

Other possible variables for multiple regression analysis of fruit size might include trunk CSA, total CSA of original primaries, CSA of original primary on which fruit are located, and CSA of last division before the terminal. These variables were used in a multiple regression based on limb means. This analysis indicated that total primary CSA contributed the most to multiple regression. However, its contribution was less than 5 percent of the unexplained variance after using the original size measurement.

Change in fruit size from the first month to the second month was considered in a multiple regression equation with the second month's size. Correlation of this change with final size is high for some blocks but correlation of the second month's size itself is quite high and little gain is accomplished.

Regression and correlation results from the 1968 research on fruit size are presented in Appendix D. Data listed are analyses at the block level only. Calculations at the tree level gave similar regression results for applicable comparisons.

FRUIT DROPPAGE STUDY

Selection of a sample of limbs to check fruit droppage had three objectives: (1) To estimate percent of fruit dropped in block, (2) to study pattern of droppage during growing season, and (3) to determine if techniques used in the size measurement study dislodged fruit. Fruit were tagged and numbered as were the fruit in the sizing study but fruit were handled as little as possible. Limbs for the droppage study on each tree were checked at the same time as the fruit size measurement. Tag numbers of any dropped fruit were recorded.

Table 12 displays results of the study of objectives (1) and (3) above. Original average tree figures are as counted; adjustments for quality control results was not made. Therefore, results of sizing and drop studies are listed as percent of original limb counts not percents of number of fruit tagged.

Table 12.--Fruit droppage indications: Percent of original counts 1968 Texas Citrus Project

Block	Total tree results			Droppage on sample limbs		
	Original average	Harvest average	Fruit dropped	Sizing study	Droppage study	Both studies 1/
	Number	Number	Percent	Percent	Percent	Percent
Marrs I	437.0	387.5	11.3	11.2	18.3	15.0
Marrs II	700.0	626.5	10.5	6.2	9.1	7.3
Pineapple	680.2	672.0	1.2	9.5	10.0	9.8
Jaffa	1,169.5	1,085.2	7.2	10.9	6.3	8.8
Valencia I	492.2	333.0	32.3	26.5	37.1	31.5
Valencia II	1,146.2	921.0	19.6	16.9	25.5	21.4
Grapefruit I	262.8	249.2	5.2	17.2	4.5	11.9
Grapefruit II	220.8	220.8	0.0	6.5	-0.6	2.9

1/ Percentages are total number of fruit at harvest divided by total original count, not straight average of sizing and droppage percents.

Fruit size measurement procedures did not increase the amount of fruit dislodged from sample limbs. Percentage of fruit lost from droppage limbs was higher than for sizing limbs in five of the eight blocks included in the study. Fruit were handled more in the fruit size study but the fruit were handled with extra care. Differences between percentages from sizing study and droppage study within a block may have been due to sample variation in limb selection. The most reasonable estimate of fruit dropped is the data combined from both studies.

Drop indication from the combined studies exceeds the total tree droppage percent in six of the eight blocks. This suggests the possibility that some fruit may be dislodged from the limbs during the surveys, and droppage rates may be slightly less than indicated by sample limbs. The sample results provided a good estimate of total drop in most blocks. Very low drop indications for Pineapple oranges and grapefruit block II are a result of the early season counts being too low.

Comparisons in Table 12 did not consider effect of errors in original limb or tree counts. A more valid indication of amount of citrus fruit droppage is shown in Table 13. In this table original counts are adjusted by the results of the quality control work and sample droppage percents are based on number of fruit tagged.

Table 13.--Fruit droppage indications: Adjusted for quality control 1968 Texas Citrus Project

Block	Total tree results			Droppage on sample limbs		
	Adjusted original	Harvest average	Fruit dropped	Sizing study	Droppage study	Both studies 1/
	Number	Number	Percent	Percent	Percent	Percent
Marrs I	443.1	387.5	12.5	13.9	18.3	16.2
Marrs II	711.2	626.5	11.9	9.3	8.2	8.8
Pineapple	682.2	672.0	1.5	8.6	12.2	10.2
Jaffa	1,184.8	1,085.2	8.4	9.3	8.7	9.0
Valencia I	496.1	333.0	32.9	32.0	46.0	39.0
Valencia II	1,106.1	921.0	16.7	14.0	17.0	16.0
Grapefruit I	257.0	249.2	3.0	16.1	6.1	11.9
Grapefruit II	222.8	220.8	0.9	6.5	1.7	4.1

1/ Percentages are total number of fruit at harvest divided by total original count, not straight average of sizing and droppage percents.

Calculations for Table 13 did not change the general relationship between sample indications and total tree results. Shifts were made in some relationships between sizing and drop percentages. Differences between sizing indications and drop study indications were reduced in six of the eight blocks. Comparing the number of fruit harvested with number tagged removed the variation which had been due to differences in original counts.

Indicated droppage percents for fruit types in Table 13 seem quite reasonable. Droppage estimates would be 11.05 percent for all early oranges, 27.50 percent for Valencia oranges, and 8.00 percent for grapefruit. Droppage percents of these magnitudes would be expected for the respectable fruit types, from historic droppage figures for Florida citrus. Excluding the block of Pineapple oranges, total tree results of the other three early blocks would average 10.93 percent fruit lost.

It is obvious from Table 13 that the recheck of enumerator counting did not accurately estimate the undercounting in the Pineapple orange block and grapefruit block II. The adjusted original count is only 41 fruit more than harvest count for the Pineapple oranges and only 8 fruit more for the grapefruit block. A total of 36 fruit dropped from the Pineapple drop and size limbs during the season and 13 fruit dropped from the grapefruit sample limbs. Several path fruit were harvested in the grapefruit block that were not counted originally.

Distribution of fruit dropped by months during the growing season is shown in Table 14. Data listed are cumulative percentages lost between tagging and survey date.

Table 14 illustrates that fruit dropped is essentially linear over time. Interpretation of 1968 results is limited by the fact that sample trees in all blocks except the Valencias were harvested quite early. Most trees in sample blocks were harvested considerably later than sample trees. Trees in some blocks were ring-picked about the time of our harvest with final harvest much later. Survey procedures did not estimate droppage for the other trees in the block because of our early harvest.

Table 14.--Seasonal distribution of fruit droppage
1968 Texas Citrus Project

Block	Fruit dropped between tagging and survey date					
	September	October	November	December	January	March
	Percent	Percent	Percent	Percent	Percent	Percent
Marrs I	2.0	9.4	16.2			
Marrs II	0.8	6.1	8.8			
Pineapple	0.6	1.9	10.2			
Jaffa	1.4	4.3	9.0			
Valencia I		4.5	17.6	22.2	32.1	39.0
Valencia II		1.2	6.4	10.2	14.3	16.0
Grapefruit I		4.8	6.7	11.9		
Grapefruit II		1.7	4.1			

AERIAL PHOTOGRAPHY

Aerial photography of sample citrus blocks was taken by the ARS Remote Sensing Laboratory at Weslaco, Texas. Both regular color and color infrared film were used.

Three types of relationships were studied from the aerial photography: (1) Possibility of counting fruit from aerial shots, (2) relationship of tree canopy area and fruit on tree, and (3) relationship of reflectance of citrus trees to fruit counts.

Oblique photography was taken for the fruit counting study. It was not possible to detect fruit on any of the 1968 photography. Most photography was taken with a Hasselblad camera with a maximum shutter speed of 1/500th of a second. All photography of trees in 1968 seemed blurred, indicating a camera with a faster shutter speed was needed.

It was hoped that a Ziess camera, or a 35mm camera with a telephoto lens could be used for late season aerial photography of individual trees. This was not possible; a K-17 camera was used instead which did not remove the motion or blurring effect.

Truco photography was taken approximately 35 feet above ground level for overhead shots. Oblique shots were approximately 25-30 feet above ground and 30 feet from edge of tree. Shots in this study were made into 70mm slides which were projected on an Itek reader-printer screen. Fruit on these slides were counted by an interpreter experienced in both aerial photography and fruit counting. Results of these counts are shown in Table 15. Counts from overhead shots are included in this table.

As expected, percent of fruit counted from oblique photography was greater than that from overhead photography. Fruit counts from infrared photography were lower than counts of same tree from Ektachrome color slides.

Correlation of these counts with total fruit on trees was perhaps better than would be expected since such a small percent of the total fruit on the tree was visible. If comparable aerial photography could be obtained (by use of faster film or camera, telephoto lens, different airplane) it might be used in a double sampling procedure.

Additional Truco photography would be beneficial in later studies. It will be an aid in interpreting results of aerial photography. Because of damp field conditions at time of the Truco study only a few sample trees could be reached in the 1968 work. It might also be possible in further studies to extend the Truco boom to a much greater height, giving even more of an aerial effect.

Table 15.--Fruit counts from Truco photography
1968 Texas Citrus Project

Trees	Color film		IR film		Correlation of counts	
	Slides	Fruit	Slides	Fruit	Color film	IR film
	Number	Percent	Number	Percent	r value	r value
			Oblique photography			
Oranges......	9	5.26	12	4.43	.758**	.601*
Grapefruit I.	4	1.63	2	2.72	-	-
			Overhead photography			
Oranges......	6	2.71	-	-	.555	-
Grapefruit I.	2	0.54	-	-	-	-

* Indicates correlation is greater than zero with probability = 95 percent.
** Indicates correlation is greater than zero with probability = 99 percent.

Truco photography was also used for measuring canopy area. A 4 foot by 4 foot plywood marker had been mounted on a tripod at the edge of each tree. This identified sample trees for aerial photography and provided a known base for calibrating canopy measurements.

The 70mm slides of individual trees were large enough to allow use of several methods of measurements. First, tree area was planimetered on a light table but this did not prove very accurate. This method also could not be used for aerial photography since individual trees would be too small.

Each slide was projected on the screen of the Itek Reader-Printer. Area was estimated from a square grid on the Itek screen and by measuring a series of diagonals of the image on the screen. Then the tree canopy was traced on a sheet of acetate. This tracing of the canopy (and the 4 by 4 marker) was planimetered by eights, quarters and as a whole.

Planimetering of the entire canopy sketched on acetate seemed to be a reasonable method. It is the most appropriate method for estimating canopy area from aerial photography since individual trees will be much smaller.

Canopy areas of the trees included in the Truco study were not significantly related to fruit counts of the trees. Canopy area seemed better related to trunk areas of trees in this small sample.

Aerial photography from the 1968 project could not be used for measuring accurate canopy areas. Precision was very limited since the images were so small the planimeter recorded only in the range of the three smallest readings. Photography was not of high enough resolution to blow up images for measurement.

Aerial photography did indicate that trees within a block could be stratified into broad size categories based on canopy area. For example, replanted trees could be separated from regular trees. Sample selection could be made from an aerial photo and an enumerator could use this photo to locate sample trees.

Relative reflectance of sample trees were measured by a Densichron, which gives one reading for the entire canopy. These readings were not satisfactory for studying relationship of reflectance to fruit count.

Differences in shadowed areas within a tree canopy may limit the analysis of reflectance. Results of two scans per tree with an Isodensitracer for one block indicated as much variance between scans of the same tree as between trees.

TIME COSTS

Times were recorded for most work operations during the 1968 project. Times for many of the operations are not closely related to times necessary for an operational survey. Mapping and counting times in an operational survey would be reduced to the time required to select and count a portion of the tree. Photography times might be reduced by using a wide angle lens, taking fewer measurements and using fewer poles for dividing the tree.

Average times from the 1968 project are listed in Table 16. All times are in minutes per crew of workers.

Block selection and measurement of approximately 150 tree trunks in each of the 8 blocks required 8 man days. Harvest of each sample tree required about 2 hours for teams of 2 to 4 men. This harvest time included individual measurement and weighing of fruit on size limbs.

Table 16.--Average times per tree for various citrus study field operations 1/
1968 Texas Citrus Project

Block	Mapping time 2/	Counting time 3/	Photography 4/		Sizing & drop 5/	
			Original visit	Later visit	Original visit	Later visit
Marrs I	98	65	22	22	44	22
Marrs II	56	73	17	21	54	48
Pineapple	73	98	12	8	29	24
Jaffa	118	219	48	18	30	42
Valencia I	69	64	20	18	36	37
Valencia II	156	217	21	15	44	38
Grapefruit I	76	46	42	20	33	25
Grapefruit II	77	34	17	10	34	28

1/ All work was done with crews of 2 or more men. Time reported is crew time in minutes.

2/ Most mapping was done by a two man crew of one Washington Statistician and a student or enumerator.

3/ About half of counting was done with a two man crew; half with three men.

4/ Most photography was taken with a three or four man crew. One person took photography with other members setting poles and taking measurements. Some photography was taken by shooting both morning and afternoon to avoid shooting shady side of tree. Photography of grapefruit block I required two camera positions on each side of a tree.

5/ Most original sizing and drop work, when fruit was tagged, was done with three or four member crews. Later work was mostly done by two member teams.

Estimates of times for counting sample limbs would depend on method of sampling used. Times required for tagging and measuring fruit in sizing and drop studies are quite realistic if a similar limb selection scheme would be followed.

Photography time could be cut in perhaps half if one side or less of the tree was photographed. A figure of 10 minutes per tree should allow sufficient time for taking good quality photographs and recording necessary information.

RECOMMENDATIONS

Research during 1968 indicated that the potential for incorporating a variety of new techniques for making objective yield survey estimates for citrus did exist. More research is needed before the question, "What is the most efficient way to conduct an objective yield survey?" can be answered.

More information is needed on variances of various limb counting procedures. Trees in the 1968 survey provided good within tree variance information and provided some between tree variance information. Not enough blocks were included to provide between block variance estimates.

Blocks of trees in the 1968 sample were not chosen at random and may have represented above average management. Therefore, to gather necessary variance information for between tree and between block components, a random sample of blocks should be studied. A sample of about 20 blocks should be sufficient to collect information for a single fruit type (early oranges, Valencia oranges or grapefruit). A sample of trees could be selected in each block with a sample of limbs counted to estimate the fruit per tree. A survey of this type should take only about four days for 20 blocks if three experienced crews of workers could be used and if the exact location of each block of trees were known.

If additional blocks are sampled, photography should be taken of sampled trees. A wide-angle lens should be used where possible to cut photography down to one or two shots per side. Photography of these trees would compare photo counts to estimated fruit. It is hoped that correlation of photo counts with these estimated fruit counts will be nearly as good as with actual counts. The amount of correlation will have to be known before an operational survey can be recommended using photography.

In addition to the limb counts and photography, fruit size information should be gathered for these additional blocks. A sample of fruit per tree should be tagged and measured at the time of limb counting. Then fruit should be measured again at harvest. This will provide more information on the relationship of early season fruit size and final size and on the relationship of fruit droppage. For Valencias or grapefruit an additional measurement between tagging and harvest would be useful.

Work with the eight blocks in the 1968 survey should be continued. Limb counts, sizing and droppage studies and photography should be conducted again during the 1969 growing season. Photography can be reduced considerably by use of the wide-angle lens. Shots of two sides of each tree should be taken again for these blocks. It is important to test once again the hypothesis of no differences between sides of a tree.

Additional measurements of limb size should be made during the fruit counting work. It may be possible to divide the trees into somewhat more homogeneous sized units. Count limbs may have been slightly too small in the 1968 work. That is, it might be possible to define limbs of cross sectional area about 1.2 to 1.5 inches as count limbs instead of limbs 1.0 inches.

If this is possible, the new measurements should be made but counts should also be made for 1968 limb divisions. This will be no problem since more emphasis will be placed on sectioning limbs before counting. Retaining the 1968 limbs for counting purposes will allow direct comparisons of year-to-year fruiting changes.

Work with the blocks from 1968 should be started before any work with additional blocks. Any changes in limb definition can then be incorporated into the new research. In addition, researchers can gain experience with the wide-angle lens before starting the extra research.

Work in additional blocks as recommended above will allow calculation of reliable cost estimates for an objective yield survey. Procedures to be used in tree selection, limb selection, and photography should be kept on times for each aspect of the project and all other costs.

Additional work needs to be done to study the possibility of using remote sensing methods such as aerial photography for citrus. Flights should again be made of the eight sample blocks by using a better camera, perhaps with a telephoto lens. Additional photography should be taken with the Truco boom truck. Different methods of measuring the optical density of reflectance of citrus photography should be tried.

In addition to the aerial photography of the regular sample blocks, some intensive research should be conducted in a few blocks. Best procedure might be to scan all trees in some blocks. If there are differences in reflectance indicated from these scans, some trees which differ can be selected. Samples of limbs should be counted to provide reliable estimates of fruit per tree.

Scientists working on other citrus projects at the Weslaco research center should be contacted. Someone else may have research results or recommendations which will provide clues to the fruit count-reflectance relationship.

APPENDIXES

Appendix A. Suggested Procedure for Counting Citrus Fruit 1968 Texas Citrus Project

All oranges and grapefruit on selected trees in the Rio Grande Valley will be counted. These trees will be photographed during the same period with ground and aerial photography. Thus, we will be investigating the possibility of estimating fruit load from ground or aerial photography. Counts will be made and recorded limb by limb to provide information about fruiting patterns within trees and within varieties.

Mapping

In order to gain the maximum information from the counting procedure each tree will be "mapped" (a sketch drawn with all limbs labeled) before counting. Each tree will be divided into primary and terminal branches. Primary branches will be basically those arising from the main trunk which will have smaller fruit-bearing terminal branches.

Sketching the tree is important but artistic quality is not. A sketch should show the primary branches arising from the trunk and the general shape of the tree. Each primary branch should be drawn showing position of all terminals arising from it. Some trees will require partial sketches from two or more positions to show location of all limbs. Each limb should be labeled both on the tree and on the sketch. See Figure 1 at the end of these instructions for an example of a tree map.

Marking of the limbs will be done with flagging tape. Each primary will be marked with red flagging tape and the branch will be designated by a letter. Terminal branches will be marked with blue flagging tape and will be numbered consecutively starting with "1" on each tree. Limb number or letter can be written on the flagging tape using a magic marker.

As the tree is mapped and marked, the cross-sectional area (CSA) of each limb will be measured and recorded on Form I, Path Fruit Form, (Figure 2). Steel tapes which convert circumference to CSA will be used for the measurement. CSA measurement is taken just above the junction with the primary limb or trunk. Avoid measuring over any nontypically large portions of the limb.

Also on Form I is a column for entering path fruit counts. Most fruit will be on terminal branches and will be entered on Form II, Limb Fruit Counts, (Figure 3). However, some fruit may be growing on a small branch or twig from the primary branch which is too small to be considered a terminal limb. These fruit will be called path fruit associated with the primary limb. The best procedure is to count path fruit as the tree is mapped to insure that they are not missed later when terminal branches are counted.

It is difficult to give rules for mapping a tree which will hold for all trees. If a primary branch divides into other large branches or CSA reduces from one end to the other it is desirable to divide it with red tape, measure CSA and label with additional letter(s).

As a general rule, a terminal branch will have area about 1.0 square inches in CSA. It may be often possible to combine several smaller branches close together as one terminal branch. In this case the combined branches should be clearly marked on the sketch, the CSA of each branch recorded and all branches joined together with flagging tape marked with the terminal number.

Fruit Counting

Counting will be done by two member teams. Each member will count a limb individually with the other member recording the count. If there is a disagreement between the two counts the difference is to be reconciled by recounting together. Best procedure for counting is to start at the base of a limb and count outwards touching each fruit as it is mentally counted. Keeping one hand on the terminal and moving outwards as the limb is counted is a help for remembering how much of the limb had been counted.

Limbs which fork or which have a large number of fruit should be subdivided into sections. It has been found with other types of fruit that counting sections of no more than 20 fruit is helpful for accuracy. Sections on a limb can be marked with yellow plastic tags or the white tags on strings. Tagging sections eliminates confusion for the second counter and simplifies reconciliation of differences.

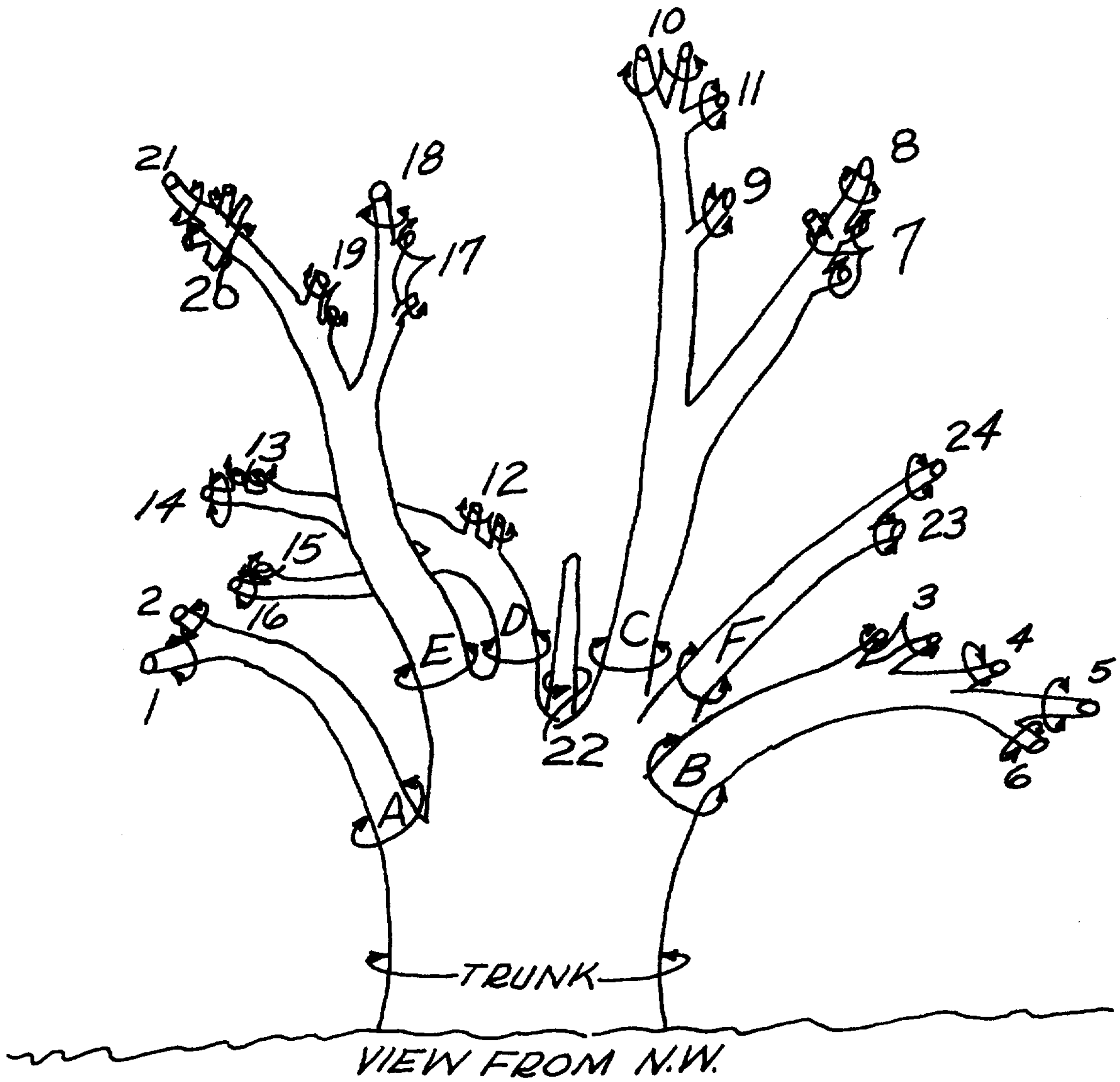
If any fruit falls off during the counting process it is recorded on Form II in the drop column. The total number of fruit on the limb when counting started is to be entered in the first count column with second column plus drop column equalling the first.

Ladders will be used for the counting process. A 9-foot step-ladder should be sufficient for reaching most limbs. It will not be possible to climb up or count from within the tree as is the case for some deciduous fruit trees.

If a limb is encountered in the counting process which seems to have been missed during the mapping it should be marked with the next limb number not previously used and counted. One of the supervisors should be informed and the limb should be clearly indicated on the original sketch.

This suggested procedure will be amended or modified as needed during the fieldwork. Proposals are based mainly on experience with noncitrus fruit so changes may be necessary.

Appendix A - Figure 1



Tree Mapping Example

Appendix A - Figure 2

PATH FRUIT FORMS

Trunk C.S.A.______________ Counter______________

Variety______________ Recorder______________

Block______________ Date______________

Tree No.______________ Time: Start__________
Finish__________

Limb	C.S.A.	Fruit Count (If Path)	Limb	C.S.A.	Fruit Count (If Path)

Appendix A - Figure 3

TERMINAL WORKSHEET
Form II

Fruit Type____________________ Counter____________________

Variety____________________ Recorder____________________

Block____________________ Date____________________

Tree No.____________________ Time: Start____________________
Finish____________________

Limb No.____________________

Section	Count 1/	Recount	Drop	Count 1/	Recount	Drop	Count 1/	Recount	Drop
	Limb____			Limb____			Limb____		
1									
2									
3									
4									
5									
	Limb____			Limb____			Limb____		
1									
2									
3									
4									
5									
	Limb____			Limb____			Limb____		
1									
2									
3									
4									
5									

1/ Include all fruit on limb when count begins

Appendix B. Instructions for Photographing Citrus Trees 1968 Texas Citrus Project

Each tree selected for the 1968 research will be photographed from the ground in addition to aerial photography. Photographs will normally be taken before fruit are counted so the natural state of the tree will not be disturbed.

Two considerations are the most important in ground photography: (1) Individual count units must be uniquely identified and (2) photographs should have as much detail as possibly. An aluminum frame will be used to divide each side into four quarters before photographing. Photographs will be taken as close to the tree as possible.

Shots will be taken of two opposite sides of each tree. Camera position will be determined in most blocks by row direction. If trees are planted wide enough apart that they can be photographed from any angle, shoot the east and west sides to avoid shooting directly into the sun.

A tripod will be used for all photographs. This will cut down on camera motion, will insure that each series of photos is taken at the same height and will allow the photographer to wait for an instance with no wind before snapping a shot. Camera height and crossbar of frame should be approximately five feet high.

First step in setting up to photograph a tree will be to position a center upright pole. This pole should be placed at the edge of the tree directly in front of the trunk, as the camera would look at the tree. Placing the upright by this rule may not evenly divide the tree foliage but it will insure that we can reproduce the same shot in later months.

Upright poles should be placed at the outside edge of the tree. If trees are close together, these poles should mark which fruit to count on the finished photo. If limbs from other trees overlap the limbs from the sample tree, separate them if possible. It may be possible to hold limbs out of the way, stand in front of limbs from other trees or use some other device.

To complete the frame, a crossbar will be placed across the uprights. Metal hooks will be provided for attaching the crossbar to the uprights. If these don't work or if uprights cannot be pushed into the ground, the crossbar can be held in place or tied to uprights and the tree with plastic flagging ribbon.

Frame will be constructed of 6-foot sections of $\frac{1}{2}$ inch aluminum pipe joined by 2-foot sections of 3/4 inch aluminum pipe. Screws about a foot from the end of the long poles will hold the connectors. A center upright of 18 feet and outside uprights of 12 feet should be sufficient for most trees. If the frame is tied together it may be possible to move the entire frame to the other side of a tree without dismantling.

After setting up the aluminum frame, tripod position should be determined. It is expected most shots will be taken from about 15 feet from the tree. Tripod should be set as close to tree as possible by lining up the largest quarter of the side in the lens finder. If distance between rows is too narrow to get the proper distance, half of each side should be photographed from a position across from the edge of the outside frame poles. Mark tripod and center pole locations with a wooden stake in the ground.

When the tripod has been set, measure the distance from camera to edge of tree and trunk of tree. Record these measurements on Form IV (Figure 4) along with camera height and height of the crossbar.

The first side to be photographed will be designated as position A; the other side will be position B. Shots should be taken in a clockwise manner starting with the lower left and listed as LL, UL, UR, and LR. Film roll number should be listed for the first shot of each tree and shot number on the roll listed for each shot. Lens setting and shutter speed should be recorded for each shot.

Each kit envelope contains a sheet of white paper with tree number in bold black letters. Mount this sheet on a clipboard and include it in the picture of the lower left and lower right sections. Using this sign and the clockwise pattern will insure that all developed frames can be identified. Knock down any grass or weeds that may obscure a portion of the tree.

Most pictures will be taken with a Minolta single lens reflex camera with a light meter behind the lens. This camera is focused by adjusting the lens setting and speed until the circle and arrow visible in the lens match up. Best procedure will be to take light meter readings at the edge of the tree before mounting the camera on the tripod. This will give the best pictures but it will not be practical to take the camera on and off the tripod for each side of the tree.

Camera settings indicated from the tripod should give good results. One aid will be to include as little sky as possible when shooting upper quarters. Sky areas will affect settings indicated by the light meter and shots will be underdeveloped if too much sky is included.

Use as slow a speed as possible for citrus photographs. This should give fairly good depth of field on finished photos. Most fruit are towards the edges of citrus trees, but many are in shadowed areas within the tree. Wind will affect light meter readings so wait for calm if possible.

Equipment needed includes:

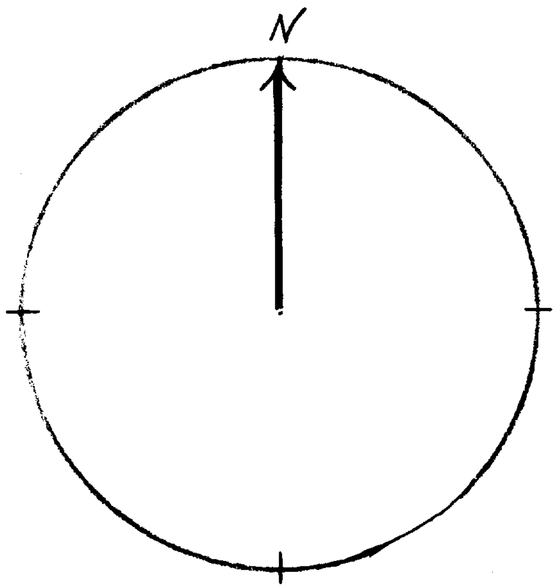
Milolta single lens reflex camera
High-speed Ektachrome or Kodachrome II film
Tripod
Aluminum poles
Form IV's
Tree identification sheets
50 foot steel measuring tape
Wooden stakes

APPENDIX B - FIGURE 4
FORM IV - PHOTOGRAPHY DATA

1. Date ____________ Time ____________ Fruit Type ____________ Variety ____________
2. Date ____________ Time ____________
3. Date ____________ Time ____________ Block ________________ Tree No. ____________

			CAMERA DATA				
Pos. A or B	Por. Tree	Camera Height	Roll-Shot	Film Type	Lens	Lens Setting	Speed

Distance - A ________________ Feet
Distance - B ________________ Feet
Crossbar Height - A __________ Feet
Crossbar Height - B __________ Feet



Notes:

Area to be counted will be bounded by the center pole and crossbar. Best procedure may be to start at the intersection of the poles and count in one direction away from the intersection. It seems most natural for most counters to count up and down rather than across but this is not important. It is important to count in sequence so no areas of the slide are missed.

Record fruit count for each square of the grid. If a fruit is on the line between two squares it is to be counted in the square which contains more than half or in the first square if it is evenly split. Follow this same rule for fruit divided by the upright pole or the crossbar.

A zero does not need to be entered for every square without fruit. However, it is wise to enter a zero or a mark for the squares at the edge of the tree as they are counted. If there were no fruit counted for a particular row or column of the grid, this zero at the edge indicates this section has been counted.

Report any problems with the machine or any interpretation problems to the supervisor. If there are comments on the quality of a slide such as "too dark" enter them on the counting sheet. Make any suggestions which may help in this project.

Fruit types will differ greatly so some written or oral instruction will be needed for each. Some of the instructions above may need changes for special situations such as wide-angle photography or large trees.

Special Citrus Instructions

Most immature citrus fruit can be detected by (a) round shape, (b) smooth, but grainy texture, and (c) color. Color is generally a different shade of green than leaves. Many fruit reflect the sunlight. Most fruit on each slide will be quite obvious from these relationships. Slide number 1 illustrates two fruit which are almost white from reflection. Both of these can be identified as oranges from their shape and position on the limb. Leaves are smaller and tend to have a smooth surface which does not have the texture or shine of fruit. Some fruit will be present in shadows on most slides and often the complete round size of a fruit is visible in the shadow. If approximately half of the circumference of an orange can be detected, it should be counted as a fruit.

Appendix C. Instructions for Counting Fruit on Slide Photographs 1968 Texas Citrus Project

Members of the Research and Development Staff will count various types of fruit from slide photographs of bearing trees. This work is a part of continuing research in the area of objective yield sampling. Photographs of bearing trees may replace some of the more difficult and costly field counting.

During this research stage, it is important to follow instructions as written or as given orally. Any suggestions for improvements in instructions or counting procedures will be welcomed. New procedures will be tried but evaluation of current procedures will depend on following instructions.

At this time, all counts will be made from 35mm color slides. Supervisors will give instructions in operation of the Kodak Carousel 800 slide projector. Slides will be projected onto a screen of white paper on which a square grid has been outlined. Squares in this grid have been designated numerically along the side and alphabetically along the top and bottom.

Most slides will be of one quarter of one side of a fruit tree. Slide will be labeled by a letter (A or B) designating the side of the tree and letters (LL, UL, UR, LR) indicating the upper or lower portion of the left or right side. Trees were divided in the orchard by using an aluminum upright pole in the center of the side and a crossbar dividing upper and lower portions.

The supervisor will supply the slides to be counted and the order in which to count. This counting order is very important; do not change the order. Most counting assignments will be for one hour, with 4 to 8 slides assigned for that period. Do not rush to finish the assignment in the time allowed. Slides not counted can be interpreted in a later counting period.

A mimeographed counting form will be used for recording fruit counts. The counting grid is drawn and labeled on this sheet. Identification data to list are fruit type, tree number, position and quarter, date, time, and counter initials. Time is very important; it will determine efficiency of using photo counts instead of ground counts. Record the starting time and ending time for each slide.

Load all slides to be counted in the projector in order. It is a good idea to project the first slide and allow your eyes to become adjusted before starting to count. Types of fruit will vary in size of tree, amount of foliage and fruit color. Becoming adjusted on one slide before counting will help in detecting fruit.

Occasionally, only one arc of what may or may not be fruit is detected. This should not be counted as a fruit unless some other factor (shine, color, etc.) verifies identification. Some slides, particularly of upper portions of a tree, may be overexposed. It is still possible to count fruit accurately on these slides by observing the different color and shape relationships of fruit and leaves. Some fruit on these overexposed slides appear as light colored silhouettes. One other factor which may be important in interpreting overexposures is the fact that good sized fruit near the top of the tree would weight a small limb down, but a cluster of limbs with a round shape would not.

Citrus fruit often occur in groups of two or three. One fruit may be partially hidden by the other fruit in the group. These particular fruit should be counted. They normally will be the same color and have the same physical appearance as the ones nearer the camera. Slide number 2 illustrates two fruit in a cluster. The second fruit is only partly visible behind the first. Leaves are sometimes mistaken for fruit, particularly in areas which are in shadows. Observing leaves of similar color on another part of the tree is the best advice for determining whether to count as a fruit or as a leaf.

On the citrus photographs an outside pole was used in addition to the normal pole which marks the center of the tree. If fruit on the slide are located outside the extra pole but are on branches growing from the tree being counted these fruit should be included in our counts. If trees are very close together, the outside pole should mark the portion which is our sample tree. However, in some cases the outside pole is poorly placed. In counting trees which cover part of the center pole or the crossbar, the best procedure is to place a pencil on the screen where the bar should be and count up to or away from the pencil.

Trees that were photographed after August 1 may have a "flush" of growth. This means some young branches have a lot of new leaves. These leaves are mainly lighter colored and smaller than normal leaves and fruit. Slide number 3 illustrates some of this "flush" on one tree. Usually no fruit will be found amid these new leaves, but they may be hiding fruit behind them.

Some limbs on each tree have had fruit tagged with white paper tags. These tags will show up quite well on our slides. Do not automatically assume there is a fruit for each tag. Some of the tagged fruit have dropped with only the tag remaining. Use our rules above and do not count fruit unless you are positive it is visible. Slide number 4 is a close-up of a limb and the white tags.

In many slides some fruit may be on the ground below the tree. Do not count these fruit if they are not attached to a limb of the tree. If the fruit has been on the ground very long it will have turned yellow or orange. Occasionally, an orange or yellow colored fruit will be still attached to a limb. This is generally damaged fruit or fruit which was split. It still should be counted if it is attached to the limb.

Most citrus fruit on each slide will be obvious. It will be difficult or impossible to determine the nonobvious fruit consistently between slides and perhaps even within slides. Count only fruit which qualifies by the above rules.

Appendix D. Fruit Size and Weight Regression Results
1968 Texas Citrus Project

Following tables list the regression and correlation results of the fruit size study. Regression calculations were performed on those fruit which were measured each month of the survey and weighed at harvest time.

Size data in these tables are reported as circumference in inches. Data can be easily converted to diameter in inches if desired. Average size and standard deviation of average size can be converted to diameter equivalents by multiplying by .31831 (or by dividing by 3.14159). The slope of the regression line in equations predicting final size by earlier size would be unchanged by converting to diameter. However, intercept of the regression line must be multiplied by .31831 to convert to a diameter prediction equation.

Weight data are in grams. If an equation predicting final weight based on circumference were to be converted to a diameter basis, slope would be multiplied by 3.14159 and intercept would remain the same.

Table 17.--Regression of harvest size on August 1 size

Block	Harvest size		August 1 size		Correlation	Regression	
	Mean	Standard deviation	Mean	Standard deviation	(r)	Slope	Intercept
Marrs I....	8.26592	0.67455	6.29718	0.52080	0.84635	1.09621	1.36289
Marrs II...	7.87836	0.49607	6.52338	0.51175	0.90774	0.87993	2.13823
Pineapple..	8.08217	0.28705	6.99861	0.30242	0.81626	0.77477	2.65985
Jaffa......	7.58297	0.54890	6.30411	0.43612	0.89613	1.12786	0.47281

Table 18.--Regression of harvest size on September 1 size

Block	Harvest size: Mean	Harvest size: Standard deviation	September 1 size: Mean	September 1 size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Marrs I.......	8.26592	0.67455	7.09965	0.55927	0.93054	1.12234	0.29772
Marrs II......	7.87836	0.49607	6.95967	0.48972	0.95442	0.96679	1.14984
Pineapple.....	8.08217	0.28705	7.43628	0.30414	0.86386	0.81532	2.01923
Jaffa.........	7.58297	0.54890	6.78277	0.50970	0.92716	0.99848	0.81054
Valencia I....	8.59611	0.58320	7.15294	0.45353	0.89938	1.15652	0.32362
Valencia II...	8.34622	0.63784	7.03769	0.47711	0.81525	1.08991	0.67579
Grapefruit I..	12.64984	0.91660	10.98349	1.18384	0.79684	0.61696	5.87343
Grapefruit II.	10.44038	0.93325	9.28580	0.88533	0.98582	1.03918	0.79073

Table 19.--Regression of harvest size on October 1 size

Block	Harvest size: Mean	Harvest size: Standard deviation	October 1 size: Mean	October 1 size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Marrs I.......	8.26592	0.67455	7.62746	0.60217	0.96729	1.08356	0.00113
Marrs II......	7.87836	0.49607	7.54238	0.48556	0.97517	0.99627	0.36410
Pineapple.....	8.08217	0.28705	7.65300	0.29242	0.92223	0.90531	1.15380
Jaffa.........	7.58297	0.54890	7.13119	0.54454	0.94570	0.95327	0.78499
Valencia I....	8.59611	0.58320	7.47452	0.49534	0.91094	1.07251	0.57962
Valencia II...	8.34622	0.63784	7.38350	0.49118	0.86900	1.12846	0.01424
Grapefruit I..	12.64984	0.91660	11.52264	0.99757	0.89274	0.82028	3.19802
Grapefruit II.	10.44038	0.93325	10.20936	0.91168	0.99435	1.01787	0.04861

Table 20.--Regression of harvest size on November 1 size

Block	Harvest size: Mean	Harvest size: Standard deviation	November 1 size: Mean	November 1 size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Valencia I....	8.59611	0.58320	7.81809	0.51054	0.93902	1.07267	0.20987
Valencia II...	8.34622	0.63784	7.78462	0.50151	0.89614	1.13974	-0.52619
Grapefruit I..	12.64984	0.91660	12.08760	0.90556	0.94540	0.95693	1.08287

Table 21.--Regression of harvest size on December 1 size

Block	Harvest size: Mean	Harvest size: Standard deviation	December 1 size: Mean	December 1 size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Valencia I....	8.59611	0.58320	8.15230	0.54064	0.95804	1.03346	0.17104
Valencia II...	8.34622	0.63784	8.05042	0.55268	0.95093	1.09746	-0.48881

Table 22.--Regression of harvest size on January 1 size

Block	Harvest size: Mean	Harvest size: Standard deviation	January 1 size: Mean	January 1 size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Valencia I....	8.59611	0.58320	8.29929	0.56436	0.97838	1.01106	0.20506
Valencia II...	8.34622	0.63784	8.19867	0.58431	0.97104	1.06001	-0.34443

Table 23.--Regression of harvest weight on harvest size

Block	Harvest weight: Mean	Harvest weight: Standard deviation	Harvest size: Mean	Harvest size: Standard deviation	Correlation (r)	Regression: Slope	Regression: Intercept
Marrs I.......	147.45774	33.13001	8.26592	0.67455	0.97690	47.97973	-249.13865
Marrs II......	128.41635	22.18692	7.87836	0.49607	0.97202	43.47457	-214.09215
Pineapple.....	139.32777	14.25499	8.08217	0.28705	0.94522	46.93952	-240.04526
Jaffa.........	120.93068	24.20282	7.58297	0.54890	0.97276	42.89215	-204.31923
Valencia I....	173.80158	34.04043	8.59611	0.58320	0.98243	57.34251	-319.12097
Valencia II...	160.74125	34.50100	8.34622	0.63784	0.97478	52.72613	-279.32278
Grapefruit I..	425.47276	80.45527	12.64984	0.91660	0.93707	82.25225	-615.00540
Grapefruit II.	263.42032	64.42463	10.44038	0.93325	0.95116	65.66104	-422.10605

Table 24.--Regression of harvest size on September 1 size and August growth

Block	Average harvest size	Average Sept. 1 size	August growth: Mean	August growth: Standard deviation	Correlation: r_1	Correlation: r_2	Correlation: R	Multiple regression: Intercept	Multiple regression: b_1	Multiple regression: b_2
Marrs I.......	8.26592	7.09965	0.80246	0.16316	0.93054	0.48813	0.94279	0.27831	1.04876	0.67518
Marrs II......	7.87836	6.95967	0.43628	0.13629	0.95442	0.02104	0.95553	1.06842	0.96800	0.16726
Pineapple.....	8.08217	7.43628	0.43767	0.11199	0.86386	0.14181	0.86442	2.01042	0.82129	-0.08131
Jaffa.........	7.58297	6.78277	0.47866	0.20576	0.92716	0.39730	0.93429	0.45351	1.07676	-0.36342

Table 25.--Regression of harvest size on October 1 size and September growth

Block	Average harvest size	Average Oct. 1 size	September growth: Mean	September growth: Standard deviation	Correlation: r_1	Correlation: r_2	Correlation: R	Multiple regression: Intercept	Multiple regression: b_1	Multiple regression: b_2
Valencia I....	8.59611	7.47452	1.04488	0.01553	0.91094	0.22282	0.91268	2.74262	1.09366	-2.22138
Valencia II...	8.34622	7.38350	1.04942	0.02100	0.86900	0.13149	0.87066	-1.66273	1.12217	1.64226
Grapefruit I..	12.64984	11.52264	0.53915	0.31899	0.89274	-0.16538	0.94123	0.95118	0.96962	0.97586
Grapefruit II.	10.44038	10.20936	0.92357	0.14496	0.99435	0.23286	0.99467	0.13329	1.02478	-0.16816

Table 26.--Regression of harvest size on original size and number of fruit

Block	Average harvest size	Average original size	Limb fruit count: Mean	Limb fruit count: Standard deviation	Correlation: r_1	Correlation: r_2	Correlation: R	Multiple regression: Intercept	Multiple regression: b_1	Multiple regression: b_2
Marrs I.......	8.26592	6.29718	10.59859	4.51013	0.84635	-0.02089	0.84721	1.28033	1.09967	0.00573
Marrs II......	7.87836	6.52338	33.26393	10.78180	0.90774	-0.03695	0.91549	1.82430	0.89977	0.00555
Pineapple.....	8.08217	6.99861	11.36468	11.36468	0.81626	-0.06565	0.81847	2.69748	0.77439	-0.00152
Jaffa.........	7.58297	6.30411	24.52970	10.14921	0.89613	-0.29682	0.90166	0.78930	1.09918	-0.00553
Grapefruit I..	12.64984	10.98349	9.18604	5.17772	0.79684	-0.17037	0.80051	6.07652	0.60989	-0.01366
Grapefruit II.	10.44038	9.28580	9.53530	5.19433	0.98582	0.04247	0.98582	0.79082	1.03919	-0.00001

Table 27.--Regression of harvest size on original size and limb area

Block	Average harvest size	Average original size	Limb C.S.A.		Correlation			Multiple regression		
			Mean	Standard deviation	r_1	r_2	R	Intercept	b_1	b_2
Marrs I.......	8.26592	6.29718	0.77535	0.26875	0.84635	0.08367	0.85005	1.39438	1.11616	-0.20266
Marrs II......	7.87836	6.52338	0.88216	0.25608	0.90774	-0.15993	0.92246	1.45682	0.93857	0.33883
Pineapple.....	8.08217	6.99861	0.90222	0.26782	0.81626	-0.08741	0.81749	2.71889	0.77254	-0.04817
Jaffa.........	7.58297	6.30411	1.23218	0.29083	0.89613	-0.20844	0.90054	0.77732	1.11269	-0.16953
Grapefruit I..	12.64984	10.98349	1.09380	0.33254	0.79684	0.09255	0.79713	5.82420	0.61546	0.06010
Grapefruit II.	10.44038	9.28580	0.93121	0.20250	0.98582	0.13246	0.98633	0.68608	1.03575	0.14665

Table 28.--Regression of harvest size on original size and fruit density

Block	Average harvest size	Average original size	Fruit ÷ C.S.A.		Correlation			Multiple regression		
			Mean	Standard deviation	r_1	r_2	R	Intercept	b_1	b_2
Marrs I.......	8.26592	6.29718	14.40859	6.23373	0.84635	-0.14534	0.84722	1.23277	1.10717	0.00424
Marrs II......	7.87836	6.52338	39.37889	13.92255	0.90774	0.10208	0.90781	2.14514	0.88129	-0.00040
Pineapple.....	8.08217	6.99861	24.69583	6.50007	0.81626	-0.03433	0.81900	2.71516	0.77731	-0.00296
Jaffa.........	7.58297	6.30411	19.71217	6.78935	0.89613	-0.20807	0.89822	0.65285	1.11499	-0.00502
Grapefruit I..	12.64984	10.98349	9.10096	5.68803	0.79684	-0.22543	0.80025	6.10654	0.60578	-0.01212
Grapefruit II.	10.44038	9.28580	10.22372	5.05425	0.98582	0.01524	0.98586	0.80512	1.03942	-0.00168