Research Report on
Tart Cherry Objective Yield Surveys

by

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TART CHERRY OBJECTIVE YIELD

FORECASTING SURVEYS

I. NATURE OF SURVEYS

Introduction: Tart cherry objective yield studies were begun in Michigan during the 1958 season. The project was financed jointly under matching arrangements with funds provided by the Michigan Cherry Producers Association, Michigan State Department of Agriculture and the Department, including the Agricultural Marketing Act and the Statistical Reporting Service. In 1962, the program was extended to include pilot sample programs in New York, Pennsylvania, and Wisconsin, with a view to developing sampling and forecasting procedures for these States. The Great Lakes Cherry Marketing Association helped finance this extension of the program.

Procedures in 1958 and 1959 were directed especially to developing workable and efficient field sampling techniques and obtaining measures of variability for sample design. Procedures have been essentially unchanged since the 1960 study. Statistics and procedures contained in this report cover the 1960, 1961, and 1962 seasons. The principal changes effected with the 1960 program were to increase the number of orchards sampled and to reduce the amount of sampling done in each orchard.

The sampling program for tart cherry objective yield surveys was arranged as two distinct parts:

(1) Development Surveys: a series of frequent visits to a few orchards to observe major growth and development characteristics in order to determine their relationship with yield per tree.

(2) Yield Surveys: four large-sample surveys to obtain acceptably precise estimates of peak bloom date, number of fruit per tree, and weight per cherry.

Development Surveys: Observations were made two to three times weekly throughout each season in two representative orchards in each of three Michigan districts. In 1962, development observations were also made for New York, Pennsylvania, and Wisconsin in four or five orchards in each State. In each sample orchard, two adjacent trees were chosen and in each tree four branches were selected to give representation on four sides of the tree so as to take into account possible differences of exposure to the sun. These branches were marked with tags.

Samples of 24 fruited spurs (any spur possessing one or more flower buds or blossoms) were marked with numbered tags on the east and west branches of one tree, and the north and south branches of the other tree. These tags were attached during the period of bloom development, as soon as fruit buds could be distinguished from leaf buds.

Development observations were begun as soon as fruit buds opened, and continued two or three times weekly until the sample trees were harvested.

Five different aspects of tart cherry development were observed:
(1) Bloom development
(2) Fruit droppage
(3) Shuck split
(4) Cherry weight
(5) Pit hardening

The first three of these aspects was observed from the set of tagged spurs, whereby the progress of development could be seen from the same set of spurs and cherries. Cherry weight and hardness of pit were determined from samples of cherries picked from the other two selected branches of each sample tree.

Observation procedures and results are discussed later in this report.

Yield Surveys: The four yield surveys were conducted in all orchards sampled to obtain estimates with acceptable precision for use in forecasting. These surveys will be referred to throughout this report by the following names:

1. Bloom
2. Mid-June
3. July 1
4. Pre-Harvest

Results of the yield surveys provide the data for the current-year averages of peak bloom date, cherries per tree, and weight per cherry which are the bases of forecasts of yield per tree.

The Bloom Survey visit is made as closely as possible to the time of peak blooming in each orchard.

The Mid-June and July 1 Surveys are scheduled to meet forecasting deadlines. The schedule of the Crop Reporting Board includes forecasts for tart cherry production as of June 15 and July 1. The June 15 forecasting date is a departure from the usual CRB schedule of forecasts as of the 1st day of the month. This is desirable because of the extremely short development period for tart cherries, and because it is a highly perishable crop for which timely data on supply are of special value to the industry. Harvesting has begun in most years before the July 1 forecast becomes available on July 10.

The field work for these forecasting surveys is completed in as short a time as feasible - generally within a five day period. For the Mid-June Survey the average survey date is June 13, and for the July 1 Survey the average is June 28.

The Pre-Harvest Survey provides the necessary follow-up information of actual results. Observations are made in each orchard as near as possible to actual time of harvest. It is information from this survey which makes possible an evaluation of the forecasting program. Also data from this survey provide the only bases for making reliable estimates of forecasting parameters.

Sub-Sampling Procedure for Trees: The portion of the cherry tree actually chosen for counting represents about only one-twentieth of the entire tree. Cherries counted on a tree part are expanded to a "whole tree" basis by multiplying by the reciprocal of the probability of selection for the part sampled. The need for the sub-sampling procedure arises from the prohibitive cost of counting entire trees for a sufficiently large sample of trees. Although it is not possible to obtain acceptable estimates of total cherries for an individual tree, the statistical efficiency of this procedure is far greater than for counts on entire trees, for any given cost.

Tree parts are randomly selected by using measurements of limb size for probabilities of selection. Consider, for example, a tree which has three primary limbs. Each of these is measured at its base with a specially calibrated tape which converts circumference to cross-sectional area. If the limbs measured 10, 5, and 15 inches, their probabilities for selection based on cross-sectional area would be 10/30, 5/30, and 15/30, respectively. After choosing one of these limbs by a random process with probabilities based on cross-sectional area, it may be desired to choose a still smaller part of the tree for counting purposes. The selection procedure may be repeated again, by choosing from sub-limbs which branch from the previously chosen limb. This may be continued over as many stages of selection as are required to choose a sample limb of suitable size for counting purposes. The resulting probability of selection for the sample part (limb) is the product of probabilities over all selection stages. For example, if the probabilities were 15/30 for stage 1, 9/16 for stage 2, and 2/9 for stage 3, the final stage of selection, then the probability of selection for the sample part is $15/30 \times 9/16 \times 2/9 = 1/16$. The factor by which the cherry count on the sample part is then expanded to a "whole tree" basis is $1 \div 1/16 = 16$.

For the selected sample tree part all fruited spurs (i.e. sub-units) are counted on the sample part by only a sub-sample of these, one-tenth or more, is selected and marked with numbered tags. Estimates of cherries per spur are obtained entirely from the sub-sampled spurs which were tagged.

Seasonal Sampling Pattern: Throughout a given season the four yield surveys have been conducted in the same sample orchards on a set of three trees, randomly chosen, per orchard.

The sampling pattern is nearly standard throughout the period of the 4 survey visits. During the first visit, for the Bloom Survey, the sample branch of tree 1 is used, with all fruited spurs counted, and a sub-sample of these marked with numbered tags. Bloom counts are made for each tagged spur.

During the Mid-June Survey, a return visit is made to tree 1, and all fruit on tagged spurs is counted and picked, with the picked sample retained for weighing and other lab observations. Tree 2 is also observed, with fruited spurs on the sample branch counted, a sub-sample of spurs selected and tagged. Fruit counts are made for each tagged spur. Tree 3 is also visited, with fruited spurs on the sample branch counted, and a sub-sample tagged, but no fruit counts per spur are made on tree 3 at this time.

For the July 1 Survey, tree 2 is visited a second time, with fruit counted and picked from tagged spurs for weighing and other lab observations. Then tree 3 is visited a second time, with fruit counts made for tagged spurs.

During the Pre-Harvest Survey, tree 3 is visited for a 3rd time. Cherries on tagged spurs are counted, then picked for weight and other determinations. All remaining cherries on the sample limb are then picked and counted.

The foregoing procedure limits bias in sample results which might occur from excessive handling of cherries and spurs.

By use of the above schedule, trees 1 and 2 receive two visits. Tree 3 receives 3 visits but these occur later in the season when fruit is set more firmly on the tree.

II. TART CHERRY DEVELOPMENT AND ITS RELATION TO A FORECASTING PROGRAM

General Problems: The period of development for the tart cherry, from the petal-fall phase of bloom development to attainment of mature size and weight, is approximately 58 days. There are some seasonal variations for the duration of within-season stages of development, whereby a shortened period for any stage may be partially offset by an extended period for other stages.

Objective yield surveys have not adequately estimated this period, primarily because of problems in conducting the Pre-Harvest Survey. Over 10 percent of these samples are lost due to the orchard having been picked before the enumerator makes his visit to take the samples. Also, this visit has generally preceeded actual harvest by an undetermined amount of time. Finally, there is probably no constant relationship between date of maturity and date of harvest because the harvesting date is subject to variations in labor supply and other economic conditions.

The use of sample data in preparing forecasts of cherry yields requires that sample values be adjusted according to expected changes (forecasting parameters) for the period from forecasting survey to harvest.

For tart cherries, these adjustments are large and vary greatly, depending on the relative stage of cherry development or maturity. As later sections describe, the principal relative stage of maturity has been measured as time elapsed from Peak Bloom Date, which in turn is ascertained by observations in a few selected orchards and counts in a much larger probability sample of orchards. Survey observations have been made for later stages based on time of pit hardening or fruit color change. These are also subsequently discussed.

Time of forecasting surveys has been dictated by the need to make forecasts as of June 15 and July 1. During the period of this research work, the Mid-June average survey date occured as early as 13 days past bloom in the latest developing Michigan (Northwest) district, and as late as 37 days past bloom in the earliest Michigan (Southwest) district.

PEAK BLOOM DATE

Estimates of Peak Bloom Date have utilized data from both the development observations made frequently in a few representative orchards, and from major bloom surveys conducted in a probability sample of orchards.

Development surveys provide data for determining a starting date for the major bloom survey, as well as adjustments for estimates of the number of days duration between phases of bloom development. The Bloom Survey results, adjusted by development data, furnish the estimate of Peak Bloom Date.

Development Surveys:

In the Development Surveys, the sample of fruiting spurs is selected and tagged as soon as fruit buds are distinguishable from leaf buds. Return visits are made every two or three days, and tagged spurs are tallied as one of the following phases, according to the predominant phase of blooms on the spur:

(1) Flower bud not open - Fruit bud cluster has opened. Flower buds have emerged out of the fruit bud. White petals may or may not be showing. Flower may be partially open, but is still somewhat bell-shaped.

(2) Flower bud open - Petals have fallen back so that petal is separated and could be easily counted. Flower is no longer bell-shaped.
(3) Petals falling - one or more petals from individual flowers have fallen.
(4) Flower withered - All petals have fallen or are drying and the stamens are dried and browning. No green cherries are protruding beyond the shuck.
(5) Green cherries showing - Some green cherries are protruding beyond shuck. If any bloom has reached this phase, the spur is recorded as being in this phase.

For each sample (set of tagged spurs), the phase of the median spur is determined for each visit to form an estimate of days between bloom development phases.

The usual ranges of days between phases are shown in Table 1. These values are listed in the table in the same form as they are used to estimate an adjustment of the Bloom Survey Date to arrive at Peak Bloom Date. Use of the algebraic sign will be described in following paragraphs.

TABLE 1 BLOOM DEVELOPMENT - DAYS BETWEEN "PETALS FALLING" AND OTHER PHASES

Item	BLOOM DEVELOPMENT PHASE				
	Flower Bud Not Open	Flower Bud Open	Petals Falling	Flower Withered	Green Cherries Showing
Fast Development Period	4	2	0	-2	-4
Slow Development Period	6	3	0	-3	-6

Bloom Survey:

The primary purpose of the Bloom Survey is to obtain a precise estimate of Peak Bloom Date for each district or State expansion to be made.

Blooms are counted on every tagged spur, with counts recorded for each spur according to the same bloom development phases used for the Development Surveys and described above.

As Table 1 suggests, Date of Peak Bloom is defined here to be the date of the "Petals Falling" phase for the median sample spur. This phase is used because it falls within the bloom development period, permitting better utilization of the sequence of development data in making estimates. It was chosen in favor of the "Flower Bud Open" phase because it occurs later, and because fewer samples are lost due to the enumerator being late in making the Bloom Survey visit. It was chosen in favor of "Flowers Withered" because it is a more easily defined and recognized phase.

Peak Bloom Date is estimated for each sample orchard by calculating an adjustment period to be added to the Bloom Survey Date for the given orchard. The adjustment is the weighted average of days between development phases, such as appear in Table 1 above. The weights used are the number of spurs counted for each development phase. As an example, suppose that spurs were classified such that five were in "Flower Bud Open", ten in "Petals Falling", eight in "Flowers Withered", two in "Green Cherries Showing", and that interval estimates obtained from the Development Survey were as for the short development period shown in Table 1. The days to add to Bloom Survey date are then:

$$5 \times 2 + 10 \times 0 + 8 \times (-2) + 2 \times (-4) \div (5+10+8+2) = \frac{-14}{25} = -.56$$

That is, the survey date occured 0.56 days after estimated date of peak bloom. Results during the 1960-62 survey years as shown in Table 2 demonstrate that varibility of Peak Bloom Date between orchards within producing districts is relatively small. This is noteworthy from the standpoint that samples used to estimate Peak Bloom Date need not be as large as for comparable precision in estimates of cherries per tree.

TABLE 2 ESTIMATED PEAK BLOOM DATES WITH STANDARD ERRORS

Year	State and District	Peak Bloom Date	Standard Error
		(May)	(Days)
1960	Michigan-Southwest	8	0.58
	Central West	20	0.80
	Northwest	25	0.37
1961	Michigan-Southwest	23	1.07
	Central West	26	0.27
	Northwest	30	0.40
1962	Michigan-Southwest	11	0.51
	Central West	18	0.26
	Northwest	18	0.23
	New York	16	
	Pennsylvania	10	
	Wisconsin	23	

A secondary purpose of the Bloom Surveys has been to provide estimates of blooms per tree as of time of survey, thus, the need for counting blooms on all tagged spurs. Estimated blooms per tree form a ratio with mid-June Survey cherries per tree for use in estimating drop parameters. Relationships discovered which would utilize blooms per tree to forecast cherries per tree have not been precise enough to attempt a forecast as early as the Bloom

Survey. This is due to the fruit droppage rate during the first 20 days of development which is very high, and varies greatly between seasons. Bloom counts also vary according to the bloom development phase at the time the Bloom Survey is made.

HARDENING OF CHERRY PIT

A second property directly associated with the stage of cherry development is the development of the cherry stone or pit. The pit forms and develops concurrently with the fleshy part of the cherry, but shows principal development of hardness during the period beginning about 15 days after petal fall and ending 30-35 days after petal fall. During this period there is a lull in fruit size development, as is evident in weight parameter charts 1 and 3.

Use of an index of pit hardness for a biological reference date would be worthwhile from two or more standpoints.

(1) It would be useful to have a reference date later in the development period than the date of full bloom, to eliminate variation between years of fruit development during the early growth stages. This development characteristic occurs early enough to be usable in July 1 forecasts, and for a June 15 forecast in some years and districts.

(2) There is a relationship between fruit weight at time of pit hardening and time of maturity which may be valuable in projecting survey weight to harvest weight.

Results of Sampling Program

Observations of pit hardening have been made in a few development orchards each sampling season. In most cases these have been made every three to four days, on samples of ten cherries each. Each cherry is cut with a single-edge razor blade, at right angles to the stem, and is then classified according to pressure required to make the cut, as follows:

(1) Cuts with no apparent pressure.
(2) Cuts when slight pressure added.
(3) Cannot be cut with normal pressure.

The usual period required for samples to cover the range from all cherries in category 1 (above) to all cherries in category 3 is around two weeks. The sequence of observations was used to estimate this date for a pit hardness index, permitting a linear interpolation to estimate this date for each sample. Each of the three categories was assigned a different scale (category 1 = 1, Category 2 = 3, and Category 3 = 5). Each sample received a value based on the sum of scales for the ten cherries in the sample, with the range of values from 0 to 50. The value of the maturity index was arbitrarily chosen to be 40, to fall within the upper end of the range of possible values.

These averages appear in Table 3 together with Peak Bloom Dates and the time interval between these two reference points. As the foregoing description of the Development Sampling Phases points out, observations were confined to two orchards in each Michigan district, and 4 or 5 orchards in the other States. Thus the estimates in Table 3 are subject to rather large errors. As the data for 3 years indicates, there is variation resulting from differences between enumerators and even between observations of the same enumerator. The attainment of usable data will require greater objectivity and accuracy in defining and observing pit hardness. This may be done by developing a device which will standardize the cutting procedure and measure cutting pressure.

TABLE 3 AVERAGE REFERENCE DATES FROM DEVELOPMENT SAMPLES

Year	State and District	Peak Bloom Date	Date Pits Hard*	Interval - Bloom to Pits Hard
		May	Day of Month	Days
1960	Michigan-Southwest	6.5	10.5	35.0
	Central West	18.0	10.5	23.5
	Northwest	21.0	11.5	19.5
1961	Michigan-Southwest	17.0	16.0	30.0
	Central West	25.5	21.5	27.0
	Northwest	28.0	22.0	25.0
1962	Michigan-Southwest	8.9	29.5 1/	20.6
	Central West	16.7	6.7	21.0
	Northwest	17.3	8.9	22.6
	New York	16.1	13.8 6.5	28.7
	Pennsylvania	2.5	12.8	35.0
	Wisconsin	21.0		22.8

* Equivalent to 60 percent of pits hard.
1/ May

These data have been considered for use as: (1) a revised bloom date, whereby departures from the average period from bloom to pit hardening may be utilized to increase or decrease effective days past bloom in making projections to maturity of fruit per tree and weight per fruit; (2) a direct reference point at which average weight as of date of pit hardening may be expanded, by a constant, to mature weight.

As Table 4 illustrates, cherry weight at time of pit hardening is consistently about one-fifth of mature weight. Neither the estimates of days between bloom and pit hardening nor the weight ratios are sufficiently precise to supply presently usable relationships.

TABLE 4: COMPARISON OF DAYS FROM BLOOM TO PIT HARDENING, AND RATIO OF WEIGHT PER CHERRY, PIT HARDENING TO MATURITY

MICHIGAN

Year	Southwest District		Central West District		Northwest District	
	Days	Ratio	Days	Ratio	Days	Ratio
1960	35.0	.2076	23.5	.2071	19.5	.1774
1961	30.0	.1950	27.0	.2370	25.0	.2017
1962	20.6	.2168	21.0	.1848	22.6	.1927
	NEW YORK		PENNSYLVANIA		WISCONSIN	
1962	28.7	.2852	35.0	.3662	22.8	.1729

COLOR AS A MATURITY INDEX

Counts of cherries by color, (green, yellow, pink, and red), obtained from the weight samples were converted to ratios to totals for every sample. Averages are shown in Table 5. These color data have been considered as a maturity index for use in conjunction with, or in place of, estimated days past bloom.

Average ratio of red cherries to total cherries was considered for use as a relative maturity indicator, as a means of estimating the date on which cherries reach maturity. This would be a desirable alternative to the present system of letting harvest date equal maturity date.

However, sample averages support either of two assumptions:

1. Cherries in all districts and all years reach maturity at approximately 58 days.
2. Cherries are harvested at about the same stage of maturity, as determined by color.

That is, the relationships of color maturity with either harvest date or with days past bloom are not good between years, districts, or districts and years. Date of maturity has been difficult to measure. Harvest samples have sometimes been made too soon before picking. If sampling is delayed until immediately before picking, the risk of losing a sample due to harvesting is increased. Thus the average date of samples obtained is somewhat earlier than actual average harvest date but this margin is offset to some extent by not being able to include samples not obtained because harvesting had already occured. Therefore, it is to be desired to utilize color or other data to estimate the true date of maturity.

The relationship of color data with days past bloom, the other maturity index, strongest for the July 1 combined ratio of green and yellow cherries. This coefficient of determination is .902. Thus, during the 1960-62 survey period this would perform about equally well with days past bloom.

TABLE 5 DISTRIBUTION OF CHERRIES BY COLOR

Year	State	District	MID-JUNE SURVEYS: Av. Days Past Peak Bloom	Average Ratio: Green	Yellow	Pink	Red	JULY 1 SURVEYS: Av. Days Past Peak Bloom	Average Ratio: Green	Yellow	Pink	Red	HARVEST SURVEYS: Av. Days Past Peak Bloom	Average Ratio: Green	Yellow	Pink	Red
1960	Mich.	Southwest	35.5	.775	.220	.006	0	49.7	.044	.065	.543	.345	62.0	0	0	.017	.983
		Centralwest	23.6	.923	.051	.027	0	38.4	.314	.442	.228	.016	62.0	0	0	.071	.929
		Northwest	17.7	.886	.114	0	0	33.2	.691	.292	.016	.001	58.0	0	0	.128	.871
1961	Mich.	Southwest	25.0	1.000	0	0	0	38.8	.193	.481	.293	.033	61.0	0	0	.022	.978
		Centralwest	16.9	1.000	0	0	0	31.9	.795	.157	.047	0	61.0	0	.004	.070	.927
		Northwest	13.6	1.000	0	0	0	28.7	.791	.206	.003	0	59.0	0	0	.100	.900
1962	Mich.	Southwest	33.5	.039	.528	.355	.078	47.7	0	0	.181	.819	51.0	0	0	.038	.962
		Centralwest	25.5	.876	.088	.036	0	40.5	.041	.270	.391	.299	55.0	0	.002	.035	.963
		Northwest	26.8	.846	.154	0	0	40.4	.190	.380	.274	.156	58.0	0	.003	.033	.965
1962	N.Y.		27.1	.947	.053	0	0	40.5	.047	.110	.312	.430	55.0	0	0	.030	.970
1962	Penn.		35.1	.240	.205	.226	.330	46.5	.001	.008	.080	.910	57.0	0	0	.007	.993
1962	Wisc.		20.8	1.000	0	0	0	35.6	.280	.527	.193	0	56.0	0	0	0	1.000

*Average of ratios calculated for individual samples, where ratio is number of given color to number of all colors.

A weaker relationship ($r^2 = .400$) was found for green cherries and days past bloom for the June 15 surveys. Color data was poorly related for other color survey combinations.

SHUCK SPLIT

The shuck is the sepal or base of the bloom, and as the cherry grows the shuck is forced up and pulled away from the stem. During Development Surveys tagged spurs were classified in the following 4 categories:

(1) No shucks separated from stems
(2) Some, but less than half, separated
(3) Half or over half, but not all, separated
(4) All shucks separated

Results have indicated a difficulty in making objective observations. This stage occurs soon after bloom, but appears to be an inferior measure of a development stage in all respects.

III. SAMPLE FRAME FOR TREE SELECTION

The frame used to select the initial sample of 25 orchards in 1958 was a list developed by the Michigan Department of Agriculture in conjunction with a fruit fly inspection program. Although the list was not 100 percent complete it was deemed adequate for the small pilot sample survey. The primary sampling unit in 1958 and all subsequent surveys is the block, a contiguous planting of tart cherry trees, basically of a single age and variety. Blocks were arrayed by age group within county. Sample blocks were drawn systematically with selection probabilities proportional to total tree numbers.

The sampling frame for orchards drawn in 1959 and all subsequent years was obtained from area segments reporting tart cherries in a 1958 area sample survey designed to estimate fruit tree numbers in Michigan. For the selection of sample orchards the number of tart cherry trees of all ages reported for each block in each 1958 area sample segment was weighted by the segment expansion factor (reciprocal of the selection probability for the segment). Expanded block values were arrayed by age within county. The yield sample of orchards or blocks was selected systematically with replacement, with probabilities of selection proportional to the expanded number of trees in the block.

The yield sample is stratified geographically by the three principal producing districts of Michigan: Northwest, Central West, and Southwest. The counties contained in each are listed in the footnotes for Table 6.

Allocation of samples to strata has been roughly proportional to district or stratum number of trees of all ages, except for the small sample used in 1958.

Sample sizes and estimates of tree numbers, by district strata, are shown in Table 6. The 25 samples used in 1958 were again sampled in 1959, together with 40 newly chosen blocks. In 1960 an additional 95 blocks were chosen and the 1958 blocks dropped, so that the 1960 sample size was 135. For 1961, 45 more blocks were drawn bringing the total to 180. These same 180 blocks also served as the sample for 1962. Of course, the effective sample sizes are somewhat smaller due to orchards removed, growers' refusal to cooperate, of samples otherwise lost.

The inclusion of trees of all ages in the frame permits the sample to be self-adjusting for trees which are newly bearing each season until the frame becomes outdated.

The age at which a tart cherry tree begins to bear commercially varies widely due to environment and cultural practices. However, the practice here is to include all trees which have reached their fifth year after planting. Thus trees planted in 1958 prior to the fruit tree survey were included in the sampling frame and were regarded as of bearing age for the 1963 crop year. The sample is also self-adjusting for orchards which are no longer bearing. Sample orchards which are dead or removed are not replaced in the sample, but the resulting change in numbers of bearing trees must be reflected by the currently estimated number of bearing trees.

The foregoing claim for a self-adjusting sample needs some qualification in that self-adjustments for changes in bearing numbers are only as good as sample estimates of these changes would be.

TABLE 6 Michigan Objective Tart Cherry Yield Survey Sample Sizes

District	1958	1959	1960	1961	1962
Southwest 1/	7	17	34	46	46
Central West 2/	6	18	40	52	52
Northwest 3/	12	30	61	82	82
3 Districts	25	65	135	180	180

1/ Southwest District: Allegan, Berrien, Case, Kalamazoo, and Van Buren Counties

2/ Central West District: Kent, Mason, Muskegon, Newaygo, Oceana, and Ottawa Counties.

3/ Northwest District: Antrim, Benzie, Charlevoix, Cheboygan, Grand Traverse, Leelanau, and Manistee Counties

IV. CHERRIES PER TREE:

The most important component of tart cherry reproduction, the one which varies most widely over seasons and producing districts, is the number of cherries per tree.

The method of sampling trees to obtain estimates of cherries per tree has been described in this report, including the survey schedule of sampling three times during a survey season. Sample estimates of fruit per tree appear by survey in Tables 10 and 11. To obtain survey estimates for use in forecasting, combined averages are prepared from data for all trees counted within a survey. Combined averages of cherries per tree appear in Table 12. The combined average for the Mid-June Survey is the average of estimates for three trees, using directly the average for trees 1 and 2, and an estimate for tree 3 obtained as the product of fruited spurs on tree 3 and average fruit per spur from trees 1 and 2. For the July 1 survey, averages from trees 2 and 3 are combined. A comparison of Tables 9 and 10 with Table 12 shows the lower coefficients of variation, gained by using the combined averages.

The design which incorporates data from three trees to estimate Mid-June cherries per tree, and from two trees to make the July 1 estimate may be considered as a sample consisting of n orchards with m trees per sample. Variance components appearing in Table 7 are estimated as follows:

Source	Degrees of Freedom	Components Estimated
Orchards	$n - 1$	$\sigma_t^2 + m\sigma_O^2$
Trees	$n(m - 1)$	σ_t^2

TABLE 7 VARIANCE COMPONENTS - CHERRIES PER TREE

District and Year	MID-JUNE SURVEY Trees 1 and 2		JULY 1 SURVEY Trees 1 and 2	
	σ^2_t	σ^2_0	σ^2_t	σ^2_0
1961				
Southwest	148,095,064	186,350,254	139,833,170	100,038,367
Central West	329,313,994	292,573,455	76,089,476	12,866,164
Northwest	241,513,299	81,654,693	89,161,171	11,234,391
1962				
Southwest	116,207,615	48,367,657	109,927,772	63,887,123
Central West	121,674,253	18,442,780	98,619,857	15,554,252
Northwest	117,674,253	14,740,954	256,985,462	18,883,875

The variance of the sample estimate of cherries per tree is then:

$$V(\bar{x}) = \frac{\sigma^2_0}{n} + \frac{\sigma^2_t}{nm}$$

The optimum number of trees per sample orchard, per sample survey, disregarding sampling costs is:

$$m_{optimum} = \sqrt{\frac{\sigma_t^2}{\sigma_0^2}}$$

For the 12 analses given above m_{opt} varies from 1 to 3, supporting the general design of 2 trees per orchard. However, if costs were given, whereby total cost = $n\,c_0 + n\,m\,c_t$

c_0 = cost per orchard excluding costs within orchard*

c_t = cost per tree within orchard

Then, $$m_{opt} = \sqrt{\frac{\sigma_t^2}{\sigma^2_0}}\sqrt{\frac{c_0}{c_t}}$$

It is likely that the miltiplier, $\sqrt{\frac{c_0}{c_t}}$ would increase $m_{optimum}$ to between 2 and 3 trees per orchard.

Regarding the sampling and counting procedures and the accuracy with which they are accomplished, comparable data have been examined. In the Mid-June and July 1 surveys, where estimates of cherries per tree are available from two trees, the differences in means for these are compared in Table 8. For Mid-June the means for trees 1 and trees 2 have a common expected value, as do the July 1 means for trees 2 and trees 3. Therefore, the estimated difference should be entirely attributable to sampling variation. The July 1, 1961 difference in the Northwest District is greater than would normally be explained by sampling variability.

* Irrespective of number of trees sampled within the orchard - thus, the cost in wages and expenses of visiting the orchard, exclusive of sampling within the orchard.

TABLE 8 WITHIN SURVEY DIFFERENCES OF CHERRIES PER TREE

District and Year	MID-JUNE SURVEY: Average difference between Tree 1 and Tree 2	Standard error of Sample Difference	JULY 1 SURVEY: Average Difference between Tree 2 and Tree 3	Standard error of Sample Difference
1961				
Southwest	3.633	2 569	48	2,554
Central West	4.577	3,977	242	1,373
Northwest	1.184	2 454	3,056	1.453
1962				
Southwest	2,769	2,455	2,995	2,515
Central West	2,102	2,267	946	2,051
Northwest	961	1,753	2,842	2,605

The sampling procedure for tree 3 permits some evaluation of effectiveness of subsampling methods for sample limbs. During the mid-June visit fruiting spurs on the sample branch of tree 3 are counted, and a subsample selected and tagged. A return visit is made in July to obtain counts of cherries on tagged spurs. Then, during the harvest visit, cherries are picked from these spurs and counted, A comparison of these results appears in Table 9. Estimates obtained from subsampling are generally lower than for the entire limb. Small differences may be expected due to sampling variation in droppage rates per spur from Mid-June to harvest, and variation in fruit per spur. Standard deviations of 1962 sample average differences in numbers of cherries per tree were 363, 355, and 237 for South, Central, and North Districts, respectively. These confirm that the 1962 differences shown are well within reasonable limits such as a 90-percent or smaller confidence interval. The lower level, evident in subsample results is largely due to undercounting of fruited spurs at the time of tagging in Mid-June. Also, the handling of tagged spurs in mid-June and July 1 may cause enough damage to affect the droppage rates on these spurs.

TABLE 9 PRE-HARVEST SURVEY - TREE 3 - COMPARISON OF SAMPLE AVERAGES

District and Year	CHERRIES PER TREE Estimated with Tagged spurs	Estimated with all spurs	Difference
1960			
Southwest	5,684	6,048	-364
Central West	1,391	1,818	-427
Northwest	4,564	5,165	-601
1961			
Southwest	8,810	9,804	-996
Central West	5,590	5,733	-163
Northwest	3,851	4,429	-578
1962			
Southwest	10,663	10,881	-218
Central West	7,102	6,726	+476
Northwest	10,804	11,086	-282

Table 10: Cherries Per Tree - Sample Averages, with Sampling Errors and Coefficients of Variation

District and Year	Bloom Survey			Mid-June Survey						
	Tree 1			Tree 1				Tree 2		
	Sample Average	Sampling Error	Coefficient of Variation	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation	Sample Average	Sampling Error	Coefficient of Variation
1960										
Southwest	44,016	10,570	24.0	35.5	10,749	2,400	22.3	5,960	1,219	20.5
Central West	27,124	4,090	15.1	23.6	3,421	656	19.2	3,800	976	25.7
Northwest	46,352	6,734	14.5	17.7	6,986	1,103	15.8	8,319	1,252	15.0
3 Districts	40,026	4,153	10.4	23.3	6,721	769	11.4	6,441	721	11.2
1961										
Southwest	73,015	14,882	20.4	25.0	14,796	2,835	19.2	11,163	2,599	23.3
Central West	37,586	5,196	13.8	16.9	13,317	2,404	18.1	17,894	4,122	23.0
Northwest	54,092	5,559	10.3	13.6	13,832	1,774	12.8	15,016	2,205	14.7
3 Districts	53,327	4,518	8.5	17.1	13,891	1,279	9.2	15,026	1,726	11.5
1962										
Southwest	46,678	6,339	13.6	33.5	10,366	1,545	14.9	13,135	2,412	18.4
Central West	58,644	10,383	17.7	25.5	7,604	1,507	19.8	9,706	1,797	18.5
Northwest	75,997	9,027	11.9	26.8	10,978	1,359	12.4	10,017	1,265	12.6
3 Districts	64,256	5,502	8.6	27.9	9,826	862	8.8	10,616	971	9.1
New York	37,970	5,319	14.0	27.1	7,744	1,004	13.0	11,785	1,304	11.1
Pennsylvania	55,283	10,715	19.4	35.1	13,283	2,344	21.4	9,252	1,493	16.1
Wisconsin	35,721	6,791	19.0	20.8	7,210	1,747	24.2	8,590	2,370	27.6

Table 10: Cherries Per Tree - Sample Averages, with Sampling Errors and Coefficients of Variation (continued)

District and Year	July 1 Survey							Pre-Harvest Survey			
	Tree 2				Tree 3			Tree 3			
	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation	Sample Average	Sampling Error	Coefficient of Variation	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation
1960											
Southwest	49.7	5,574	1,182	21.2	6,892	1,356	19.7	62.0	5,684	1,195	21.0
Central West	38.4	2,029	445	21.9	1,596	371	23.2	62.0	1,391	471	33.9
Northwest	33.2	6,422	981	15.3	5,601	851	15.2	58.0	4,564	668	14.7
3 Districts	38.3	4,909	553	11.3	4,668	516	11.1	60.1	3,846	436	11.3
1961											
Southwest	38.8	10,312	2,464	23.9	10,360	2,158	20.8	61.0	8,810	1,589	18.1
Central West	31.9	6,882	1,340	19.5	6,640	1,271	19.1	61.0	5,590	1,384	24.8
Northwest	28.7	7,835	1,333	17.0	4,779	810	16.9	59.0	3,851	782	20.3
3 Districts	31.9	8,099	931	11.5	6,581	725	11.0	60.0	5,478	661	12.1
1962											
Southwest	47.7	13,947	2,573	18.4	10,952	1,741	15.9	51.0	10,663	1,723	16.2
Central West	40.5	8,888	1,697	19.1	7,942	1,276	16.1	55.0	7,102	1,265	17.8
Northwest	40.4	9,044	1,163	12.9	11,386	2,409	20.3	58.0	10,804	2,267	21.0
3 Districts	42.1	10,086	946	9.4	10,491	1,271	12.1	55.5	9,658	1,209	12.5
New York	40.5	11,043	1,239	11.2	12,382	1,589	12.8	55.0	12,387	1,800	14.5
Pennsylvania	46.5	8,925	1,554	17.4	11,249	2,900	25.8	57.0	11,246	2,920	26.0
Wisconsin	35.6	6,285	1,832	29.1	6,926	1,561	22.5	56.0	5,687	1,442	25.4

Table 11: Cherries Per Tree - Combined* Sample Averages, with Sampling Errors and Coefficients of Variation

District and Year	Mid-June Survey: Days Past Bloom	Mid-June Survey: Combined Average	Mid-June Survey: Sampling Error	Mid-June Survey: Coefficient of Variation	July 1 Survey: Days Past Bloom	July 1 Survey: Combined Average	July 1 Survey: Sampling Error	July 1 Survey: Coefficient of Variation
1960								
Southwest	35.5	8,079	1,339	16.6	49.7	6,233	1,134	18.2
Central West	23.6	3,416	711	20.8	38.4	1,812	377	20.8
Northwest	17.7	7,279	851	11.7	33.2	6,012	820	13.6
3 Districts	23.3	6,283	546	8.7	38.3	4,788	478	10.0
1961								
Southwest	25.0	12,641	2,095	16.8	38.8	10,336	1,943	18.8
Central West	16.9	15,830	2,758	17.4	31.9	6,761	1,053	15.6
Northwest	13.6	13,326	1,414	10.6	28.7	6,307	830	13.2
3 Districts	17.1	13,928	1,167	8.4	31.9	7,340	666	9.1
1962								
Southwest	33.5	11,407	1,420	12.4	47.7	12,450	1,756	14.1
Central West	25.5	8,243	1,021	12.4	40.5	8,415	1,169	13.9
Northwest	26.8	10,501	1,026	9.8	40.4	10,465	1,384	13.2
3 Districts	27.9	10,022	658	6.6	42.1	10,289	843	8.2
New York	27.1	10,716	918	8.6	40.5	11,712	840	7.2
Pennsylvania	35.1	11,165	1,578	14.1	46.5	10,087	1,720	17.1
Wisconsin	20.8	8,078	1,765	21.8	35.6	6,606	1,651	25.0

*Mid-June Survey: (Cherries per tree 1 + cherries per tree 2 + (spurs per tree 3 x average cherries per spur, trees 1 and 2)) ÷ 3

July 1 Survey: (Cherries per tree 2 + cherries per tree 3) ÷ 2

$$\text{Forecast Number} = \frac{\text{Sample Number}}{\text{Ratio}}$$

As the season progresses cherries per tree become increasingly easy to project. Sample averages of weight per cherry are projected to maturity by the use of weight parameter ratios such as plotted in Charts 3 and 4. The procedure is identical to that described for cherries per tree. Note however, that after about 30 days past bloom the rate of weight change becomes very great, and estimated ratio parameters are subject to relatively high error, due both to sampling and to the use of interpolation between sample points.

Trial forecasts of yield per tree appear in Tables 14 and 15. These must be evaluated by means of Pre-Harvest Survey expansions in Table 16. Projections of cherries per tree are not directly comparable between surveys since all sample averages do not contain a common set of trees, and differences are subject to sampling errors for this reason. Projections of weight per cherry are directly comparable between surveys and, as the limited results in Tables 14 to 16 show, sample projections are relatively unsuccessful. Table 15 is included to show that forecasts using a 3 year average weight are about equally effective as forecasts using projected weight per cherry, as contained in Table 14.

A comparison of trial forecasts of weight per tree with Pre-Harvest Survey weight per tree shows that at the State level, differences are within about one standard error of the Pre-Harvest weight per tree. To attribute these differences entirely to forecasting errors would require that survey samples had been much larger, so as to greatly reduce sampling errors.

Cherry Weight:

As the coefficients of variation in Table 13 show, estimates of cherry weights as of time of survey are much more precise for a given sample size than are estimates of cherries per tree.

V. FORECASTING METHODS

The two components of yield per tree, i.e. cherries per tree and weight per cherry, are forecast separately. Forecasting parameters are determined by the ratio of averages as of survey dates to averages at maturity, as measured by the Pre-Harvest Surveys. Separate models and forecasting parameters have been considered for each of the three Michigan producing districts. For estimates of cherries per tree and weight per fruit as of survey date, greatest precision is attained for the stratified estimate over all three districts or strata. However, data on peak bloom dates in Table 2 and on days past bloom in Tables 10-16 illustrate the differences between districts in relative maturity, which make the use of separate parameters by districts necessary in forecasting.

Forecasting parameters in the form of fruit droppage curves and weight development curves are shown in Charts 1 through 4. Charts 1 and 3 for the Southwest District and Charts 2 and 4 for the Northwest Districts are included as examples for early developing and late developing districts, respectively. The values plotted are the ratios of survey averages as of survey date to Pre-Harvest Survey averages.

The survey average number of cherries per tree may be projected to the number at maturity by referring to the droppage parameter chart and reading the ratio of cherries per tree, current to final, on the vertical scale opposite survey days past bloom. The sample average is divided by the ratio thus obtained to arrive at a forecast of cherries per tree.

VI. CONCLUSION:

The task of predicting fruit droppage is straightforward and relatively simple compared to that of forecasting mature weight per cherry. Moreover, accuracy of droppage forecasts may be expected to increase as the season progresses. On the other hand, weight per cherry as of June 15 represents only about one-fifth of mature weight, with four-fifths remaining to be projected. Although by July 1 the survey average weight represents around one-third to one-half of mature weight, the variability of forecasting parameters is great during this period of rapid weight change, and forecasting remains difficult.

Gains in forecasting accuracy would be possible if dates of forecasting surveys were made to comply with a common biological reference date, either days past bloom or date of pit hardening each year rather than with a calendar date. The first yield forecast should be delayed until about 25 days past bloom to obtain reasonably consistent results between years.

Based on the experience gained during the pilot surveys, a Mid-June forecast would be too early in the Northwest District of Michigan in many years to obtain reliable yield estimates based on objective yield characteristics. If fixed date surveys are necessary for the industry, a June 18 date for the South half and a June 25 date for the North half of Michigan should be used. In years of an early bloom in the Northwest, the June 18 date would serve for the whole State. If the four states are to be considered, Wisconsin should probably coincide with the June 25 date for the Northwest District of Michigan and the New York and Pennsylvania more nearly with the June 18 date.

Further research and survey work would be necessary to determine the ease and precision with which date of pit hardening can be estimated. Any future probability samples for objective yields on tart cherries should be greatly expanded to produce acceptably precise estimates of cherries per tree.

The frame which was employed from 1959 on--an area frame composed of segments reporting tart cherries in the 1958 fruit tree survey--has limited further value for two reasons:

(1) trees planted in 1959 became bearing trees in 1964 (according to our definition) and should be represented in the sample. While the age that trees come into bearing seems to vary considerably, sample averages must represent trees of the same ages as those included in the estimate of bearing trees employed in the forecasts. In any event, the frame used no longer provides for all trees coming into bearing age.

(2) The sampled portion of the frame used for the pilot studies will not be adequate for larger sample sizes. Too much clustering of "blocks" is inevitable if the sample size is increased.

Before operational yield surveys are started it is recommended that:

(1) A new sample survey of trees by ages be completed based on two-frame sample theory--a combined area frame with a list of cherry producers. This will insure that efficient sampling will be employed at the outset and completeness of the tree universe will be assured and can be updated periodically.

Based on the sampling errors encountered in the pilot studies, a sample of 900 trees would be required to obtain a standard error of 5 percent for yield per tree. While a "new frame" might indicate either larger or smaller errors, it seems likely the two-frame samples would produce a more efficient total design.

In addition to the basic yield characteristics measured in the pilot program, provision needs to be made to measure harvesting losses and economic abandonment.

A program should include a bloom survey with enough orchards to provide a reliable estimate of average bloom date for each district. This can be done with less than the full sample required for later surveys, as within district variability of bloom date is fairly small. Bloom date is the best reference point until a better one is found. It may be possible through better pit hardening data and equipment to find a more reliable reference point. For mid-June and July 1 surveys, the same sampling pattern used since 1960 with three trees sampled at mid-June and two trees on July 1 is recommended. The pre-harvest survey should continue to be a vital part of a yield program. The pre-harvest survey affords the best method so far of evaluating forecasting performance. It is also essential for updating drop and weight parameters and therefore should be continued for the full sample to give all possible precision in estimates of ratio changes of drop and weight.

Development studies should be continued in a few orchards to ascertain intervals between stages of bloom and to study pit hardening.

A desirable change in the present forecasting program would be to commence a mid-June survey no earlier than 20 days past bloom when most of the drop is completed. This is still extremely early in fruit development with cherries still to attain over 80 percent of their weight. There would be some merit to conducting only one forecasting survey, instead of two, since at our present state of technology the results from a second survey are not much better than the first except in the Michigan Northwest district. The split timing suggested earlier, June 18 and June 25, should provide the most efficient single survey results for the fewest dollars.

It is believed that sufficient background has been acquired to develop a sound objective yield program. Some of the usual problems of tooling up from a pilot level to an operational level can not be overlooked, but these problems can be corrected and minimized by adequate survey supervision and quality controls.

Table 12: Weight Per Cherry - Sample Averages, with Sampling Errors and Coefficients of Variation

District and Year	Mid-June Survey Tree 1				July 1 Survey Tree 2				Pre-harvest Survey Tree 3			
	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation
1960												
Southwest	35.5	.9140	.0361	3.9	49.7	2.8458	.1327	4.7	62.0	4.0814	.1701	4.2
Central West	23.6	.6379	.0332	5.2	38.4	1.5725	.0843	5.4	62.0	4.0430	.1635	4.0
Northwest	17.7	.7008	.0265	3.8	33.2	1.2160	.0455	3.7	58.0	3.8940	.1209	3.1
3 Districts	23.3	.7278	.0180	2.5	38.3	1.6761	.0447	2.7	60.1	3.9800	.0848	2.1
1961												
Southwest	25.0	.7329	.0224	3.1	38.8	1.5990	.0990	6.2	61.0	3.6846	.1186	3.2
Central West	16.9	.4770	.0316	6.6	31.9	.9130	.0548	6.0	61.0	3.7660	.1144	3.0
Northwest	13.6	.3030	.0200	6.6	28.7	.9179	.0290	3.2	59.0	4.1880	.0976	2.3
3 Districts	17.1	.4512	.0144	3.2	31.9	1.0683	.0164	1.5	60.0	3.9489	.0636	1.6
1962												
Southwest	33.5	1.6333	.0915	5.6	47.7	3.3937	.0898	2.6	51.0	3.5218	.0860	2.4
Central West	25.5	.8891	.0288	3.2	40.5	2.2487	.0883	3.9	55.0	3.6662	.1309	3.6
Northwest	26.8	.8942	.0221	2.5	40.4	2.1481	.0819	3.8	58.0	3.9590	.0837	2.1
3 Districts	27.9	1.0567	.0244	2.3	42.1	2.4549	.0513	2.1	55.5	3.7735	.0187	0.5
New York	27.1	1.0776	.0481	4.5	40.5	3.2059	.1677	5.2	55.0	4.0340	.1206	3.0
Pennsylvania	35.1	2.3723	.2003	8.4	46.5	4.0950	.1798	4.4	57.0	4.3940	.1755	4.0
Wisconsin	20.8	.6254	.0348	5.6	35.6	1.1908	.1093	9.2	56.0	3.5770	.1381	3.9

Table 13: Sample Forecasts, Yield Per Tree - 1960-62, Using Projected Sample Average Weight Per Cherry

District and Year	Mid-June Survey: Days Past Bloom	Mid-June: Cherries Per Tree: Sample Average	Mid-June: Cherries Per Tree: Projected to Maturity	Mid-June: Weight Per Cherry: Sample Average (grams)	Mid-June: Weight Per Cherry: Projected to Maturity (grams)	Mid-June: Projected Weight Per Tree (lbs.)	July 1 Survey: Days Past Bloom	July 1: Cherries Per Tree: Sample Average	July 1: Cherries Per Tree: Projected to Maturity	July 1: Weight Per Cherry: Sample Average (grams)	July 1: Weight Per Cherry: Projected to Matur. (grams)	July 1: Pro. Weight Per Tree (lbs.)
1960												
Southwest	35.5	8,079	7,213	.9140	2.504	39.818	49.7	6,233	5,880	2.8458	3.492	45.263
Central West	23.6	3,416	2,277	.6379	3.584	17.991	38.4	1,812	1,709	1.5725	3.342	12.931
Northwest	17.7	7,279	4,758	.7008	4.580	48.042	33.2	6,012	5,274	1.2160	3.987	46.357
3 Districts						37.166						36.002
1961												
Southwest	25.0	12,641	11,089	.7329	3.756	91.822	38.8	10,336	9,396	1.5990	3.297	68.295
Central West	16.9	15,830	4,947	.4770	3.560	38.826	31.9	6,761	6,146	.9130	3.238	43.873
Northwest	13.6	13,326	5,288	.3030	2.164	25.228	28.7	6,307	5,256	.9179	4.026	46.651
3 Districts						44.134						50.627
1962												
Southwest	33.5	11,407	10,185	1.6333	5.444	122.238	47.7	12,450	11,636	3.3937	4.555	116.848
Central West	25.5	8,243	6,757	.8891	4.513	67.228	40.5	8,415	7,939	2.2487	4.324	75.680
Northwest	26.8	10,501	8,537	.8942	4.362	82.096	40.4	10,465	9,690	2.1481	3.941	84.190
3 Districts						86.539						88.862

Table 14: Sample Forecasts, Yield Per Tree - 1960-62, Using 1960-62 Average Weight Per Cherry

District and Year	Mid-June Survey					July 1 Survey				
	Days Past Bloom	Cherries Per Tree: Sample Average	Cherries Per Tree: Projected to Maturity	Weight Per Cherry: 3-Year Average (grams)	Projected Weight Per Tree (lbs.)	Days Past Bloom	Cherries Per Tree: Sample Average	Cherries Per Tree: Projected to Maturity	Weight Per Cherry: 3-Year Average (grams)	Projected Weight Per Tree (lbs.)
1960										
Southwest	35.5	8,079	7,213	3.7626	59.832	49.7	6,233	5,880	3.7626	48.775
Central West	23.6	3,416	2,277	3.8252	19.202	38.4	1,812	1,709	3.8252	14.420
Northwest	17.7	7,279	4,758	4.0137	42.104	33.2	6,012	5,274	4.0137	46.670
3 Districts					39.211					37.361
1961										
Southwest	25.0	12,641	11,089	3.7626	91.983	38.8	10,336	9,396	3.7626	77.940
Central West	16.9	15,830	4,947	3.8252	41.718	31.9	6,761	6,146	3.8252	51.829
Northwest	13.6	13,326	5,288	4.0137	46.794	28.7	6,307	5,256	4.0137	46.510
3 Districts					55.311					55.102
1962										
Southwest	33.5	11,407	10,185	3.7626	84.485	47.7	12,450	11,636	3.7626	96.438
Central West	25.5	8,243	6,757	3.8252	56.982	40.5	8,415	7,939	3.8252	66.950
Northwest	26.8	10,501	8,537	4.0137	75.544	40.4	10,465	9,690	4.0137	85.747
3 Districts					71.941					82.480

Table 15: Sample Production Expansions - 1960-62 - Pre-harvest Surveys

District and Year	Days Past Bloom	Cherries Per Tree	Sampling Error	Coefficient of Variation	Weight Per Cherry (gram)	Sampling Error	Coefficient of Variation	Weight Per Tree (lbs.)	Sampling Error	Coefficient of Variation
<u>1960</u>										
Southwest	62.0	5,684	1,195	21.0	4.0814	.1701	4.2	51.145	10.974	21.5
Central West	62.0	1,391	471	33.9	4.0430	.1365	4.0	12.399	4.235	34.2
Northwest	58.0	4,564	668	14.7	3.8940	.1209	3.1	39.180	5.864	15.0
3 Districts	60.1	3,846	436	11.3	3.9800	.0848	2.1	33.746	3.893	11.5
<u>1961</u>										
Southwest	61.0	8,810	1,589	18.1	3.6846	.1186	3.2	71.564	13.117	18.3
Central West	61.0	5,590	1,384	24.8	3.7660	.1144	3.0	46.411	11.583	25.0
Northwest	59.0	3,851	782	20.3	4.1880	.0976	2.3	35.556	7.269	20.4
3 Districts	60.0	5,478	661	12.1	3.9489	.0636	1.6	47.690	6.248	13.1
<u>1962</u>										
Southwest	51.0	10,663	1,723	16.2	3.5218	.0860	2.4	82.789	13.534	16.3
Central West	55.0	7,102	1,265	17.8	3.6662	.1309	3.6	57.401	10.432	18.2
Northwest	58.0	10,804	2,267	21.0	3.9590	.0837	2.1	94.297	19.892	21.1
3 Districts	55.5	9,658	1,209	12.5	3.7735	.0187	0.5	80.344	10.137	12.6
New York	55.0	12,387	1,800	14.5	4.0340	.1206	3.0	110.162	16.350	14.8
Pennsylvania	57.0	11,246	2,920	26.0	4.3940	.1755	4.0	108.940	28.680	26.3
Wisconsin	56.0	5,687	1,442	25.4	3.5770	.1381	3.9	44.846	11.720	26.1

Table 16: 1963 Cherries Per Tree - Sample Averages with Sampling Errors and Coefficients of Variation

District and Survey	Number of Samples	Tree 1			Tree 2			Tree 3		
		Sample Average	Sampling Error	Coefficient of Variation	Sample Average	Sampling Error	Coefficient of Variation	Sample Average	Sampling Error	Coefficient of Variation
Bloom										
Southwest	10	11,810	3,620	30.7						
Central West	13	23,480	5,986	25.5						
Northwest	17	24,877	8,967	36.0						
3 Districts	40	21,556	4,708	21.8						
Mid-June										
Southwest	29	446	159	35.7	572	215	37.6			
Central West	36	2,271	555	24.4	1,344	422	31.4			
Northwest	57	9,477	3,369	35.5	6,641	1,360	20.5			
3 Districts	44	5,303	1,615	30.5	3,699	662	17.9			
July 1										
Southwest	18				269	122	45.3	251	85	33.9
Central West	23				1,464	599	40.9	1,408	486	32.8
Northwest	37				5,160	1,548	30.0	8,429	2,443	29.0
3 Districts	78				2,962	760	25.7	4,522	1,174	26.0
Pre-harvest										
Southwest								218	95	43.6
Central West								1,643	575	35.0
Northwest								7,666	2,469	32.2
3 Districts								4,200	1,190	28.3

Table 17: 1963 Survey Averages, Sample Forecasts and Expansions of Cherries Per Tree

District and Survey	Cherries Per Tree				
	Days Past Bloom	Sample Average	Sampling Error	Coefficient of Variation	Projected to Maturity
<u>Mid-June Survey</u> 1/					
Southwest	32	512	138	27.0	461
Central West	27	1,803	376	20.9	1,568
Northwest	20	8,903	1,842	20.7	6,499
3 Districts	25	4,903	886	18.1	3,674
<u>July 1 Survey</u> 2/					
Southwest	47	260	63	24.2	241
Central West	42	1,472	304	20.7	1,402
Northwest	35	6,795	309	4.5	6,067
3 Districts	40	3,742	174	4.6	3,369
<u>Pre-Harvest Survey</u>					
Southwest	62	218	95	43.6	218
Central West	55	1,643	575	35.0	1,643
Northwest	60	7,666	2,469	32.2	7,666
3 Districts	59	4,200	1,190	28.3	4,200

1/ Mid-June Survey: [(Cherries per tree 1 + cherries per tree 2 + (spurs per tree 3 x average cherries per spur, trees 1 and 2)] ÷ 3

2/ July 1 Survey: (Cherries per tree 2 + cherries per tree 3) ÷ 2

Table 18: 1963 Survey Averages Sample Forecasts and Sampling Errors for Weight Per Cherry

District and Survey	Weight Per Cherry				
	Sample Average	Sampling Error	Coefficient of Variation	Projected to Maturity	1960-62 Average
Mid-June Survey					
Southwest	1.160	.066	5.7	4.427	3.763
Central West	.900	.026	2.9	4.225	3.825
Northwest	.910	.028	3.1	5.031	4.014
3 Districts	.915	.007	0.8	4.654	3.901
July 1 Survey					
Southwest	2.845	.259	8.8	3.876	3.763
Central West	1.723	.145	8.4	2.935	3.825
Northwest	1.408	.090	6.4	3.922	4.014
3 Districts	1.822	.027	1.5	3.615	3.901
Pre-Harvest Survey					
Southwest	4.065	.2211	5.4	4.065	3.763
Central West	4.390	.1926	4.4	4.390	3.825
Northwest	4.112	.2309	5.6	4.112	4.014
3 Districts	4.185	.042	1.0	4.185	3.901

Table 19: 1963 Survey Averages, Forecasts and Expansions for Weight of Cherries Per Tree

District and Survey	Weight Per Tree: Using Projected Weight (Pounds)	Weight Per Tree: Using Average Weight (Pounds)	Sampling Error	Coefficient of Variation
Mid-June Survey				
Southwest	4.500	3.825	.361	9.4
Central West	14.605	13.223	.753	5.7
Northwest	72.082	57.511	3.679	6.4
3 Districts	39.778	27.433	1.789	6.5
July 1 Survey				
Southwest	2.059	2.00	.424	21.2
Central West	9.072	11.823	1.251	10.6
Northwest	52.458	53.689	1.656	3.1
3 Districts	25.022	25.610	.734	2.9
Pre-harvest Survey				
Southwest	1.953	1.808	.859	47.5
Central West	15.902	13.854	5.614	40.5
Northwest	69.496	67.838	22.755	33.5
3 Districts	38.958	36.930	10.987	29.8

CHART 1: CHERRY DROPPAGE PARAMETERS - MICHIGAN - SOUTHWEST DISTRICT

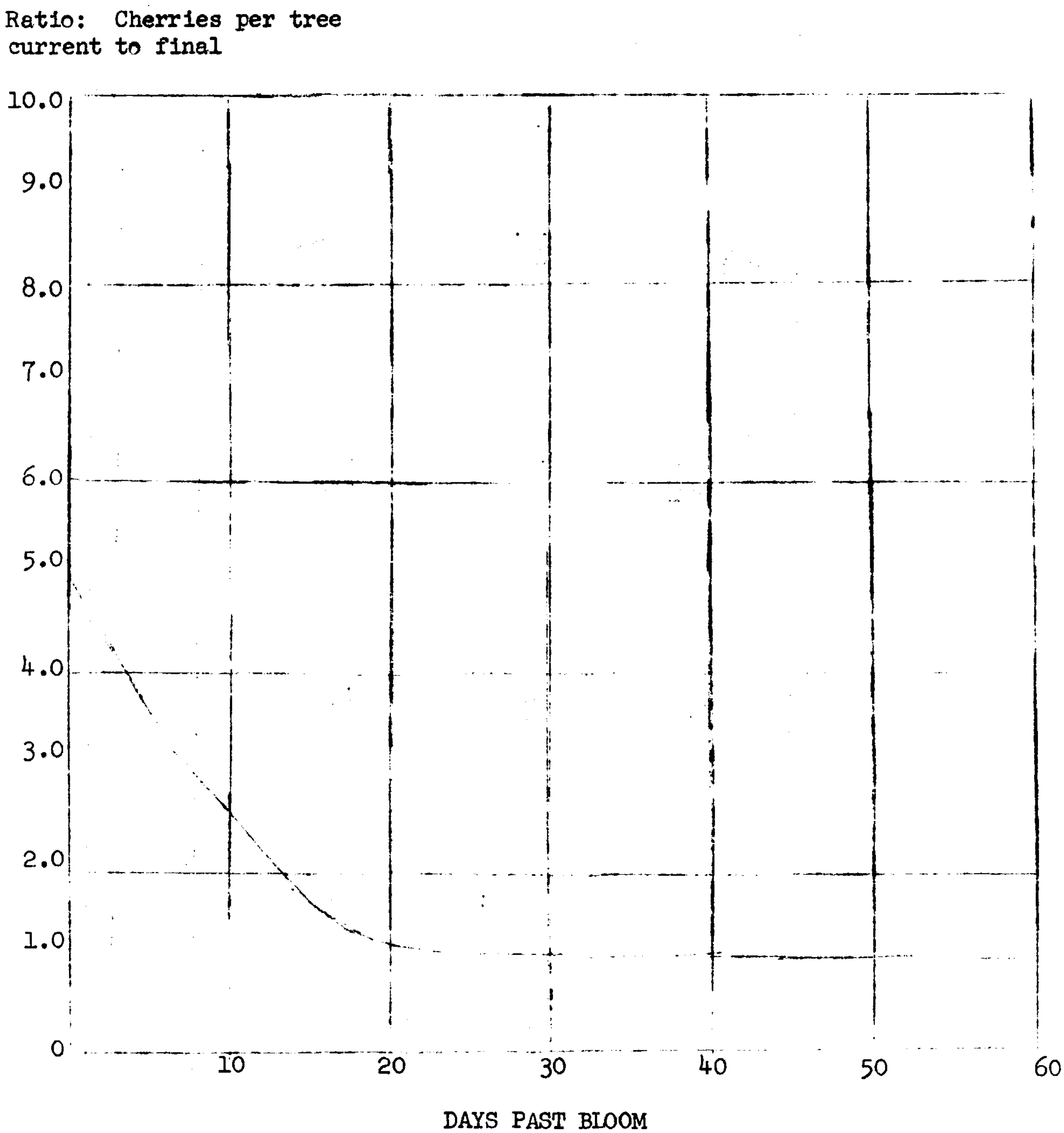

CHART 2: CHERRY DROPPAGE PARAMETERS - MICHIGAN - NORTHWEST DISTRICT

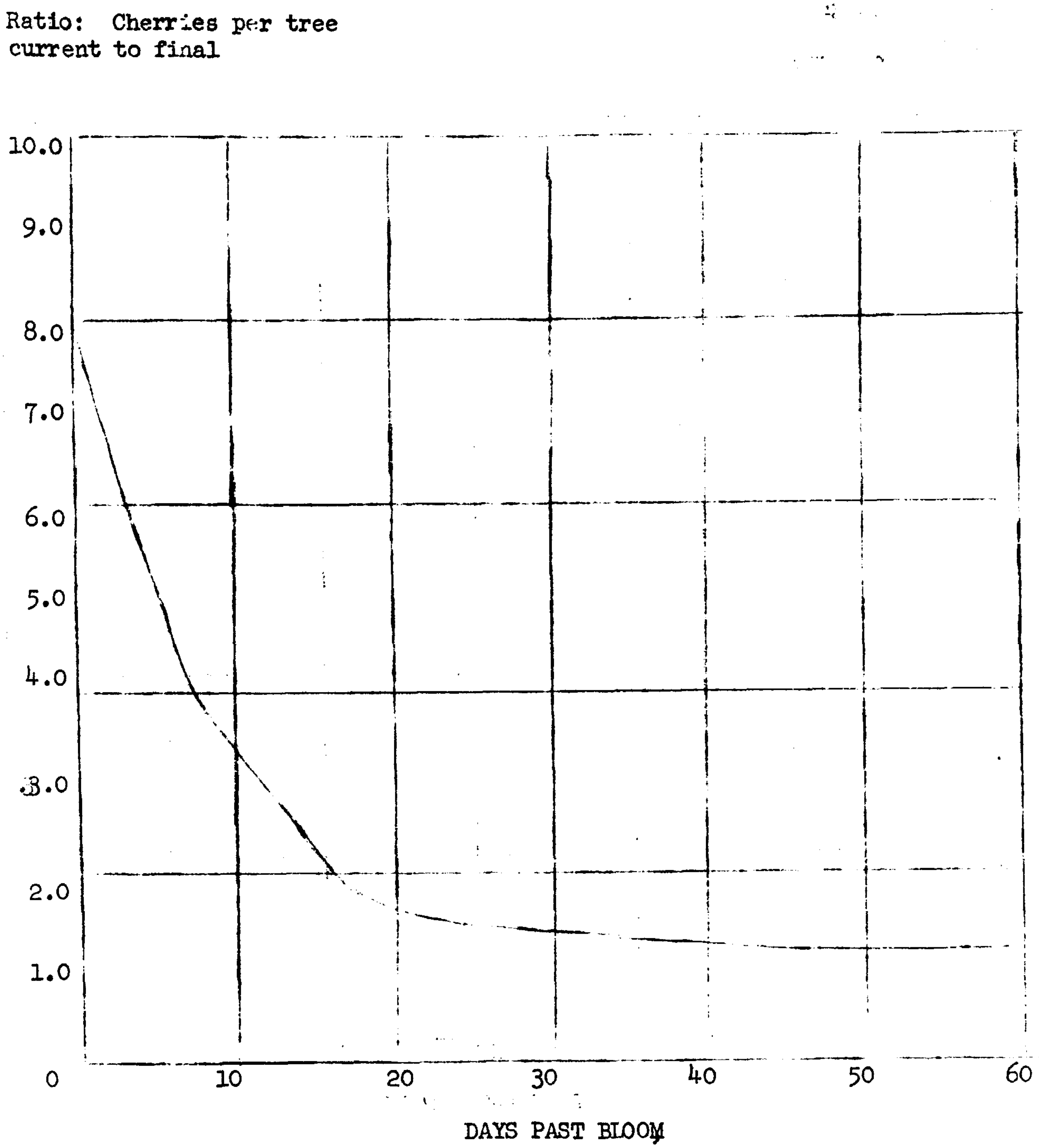

CHART 3: CHERRY WEIGHT PARAMETERS - MICHIGAN - SOUTHWEST DISTRICT

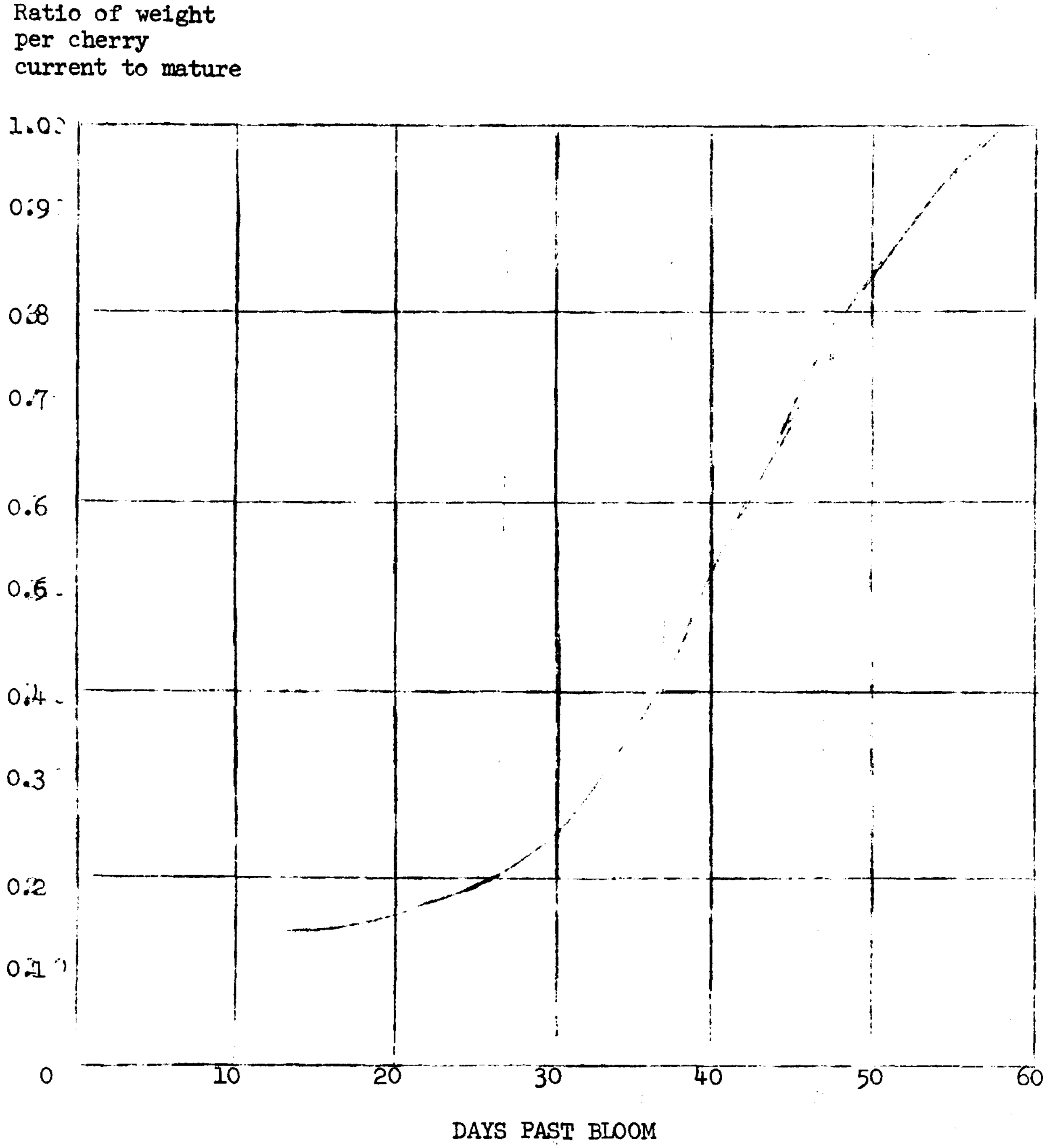

CHART 4: CHERRY WEIGHT PARAMETERS - MICHIGAN - NORTHWEST DISTRICT