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A Study of Walnut Production Forecasting

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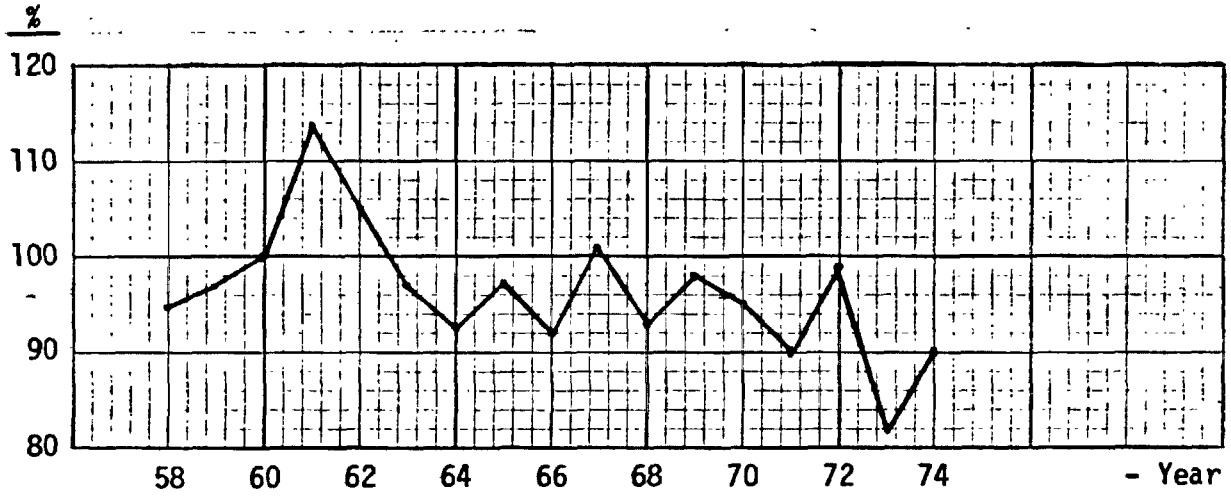
During the past twelve years the regression estimates based on data obtained from the August Walnut Objective Measurement Survey have consistently underestimated the actual California walnut production.

SRS WALNUT PREDICTION AS A PERCENT OF ACTUAL PRODUCTION



Preliminary exploratory data analysis indicated continuous changes in the target population, and in the relationship between measured variables and production. This paper will deal with the following four problems:

(1) An analysis of the changes,

(2) Possible factors causing the changes,

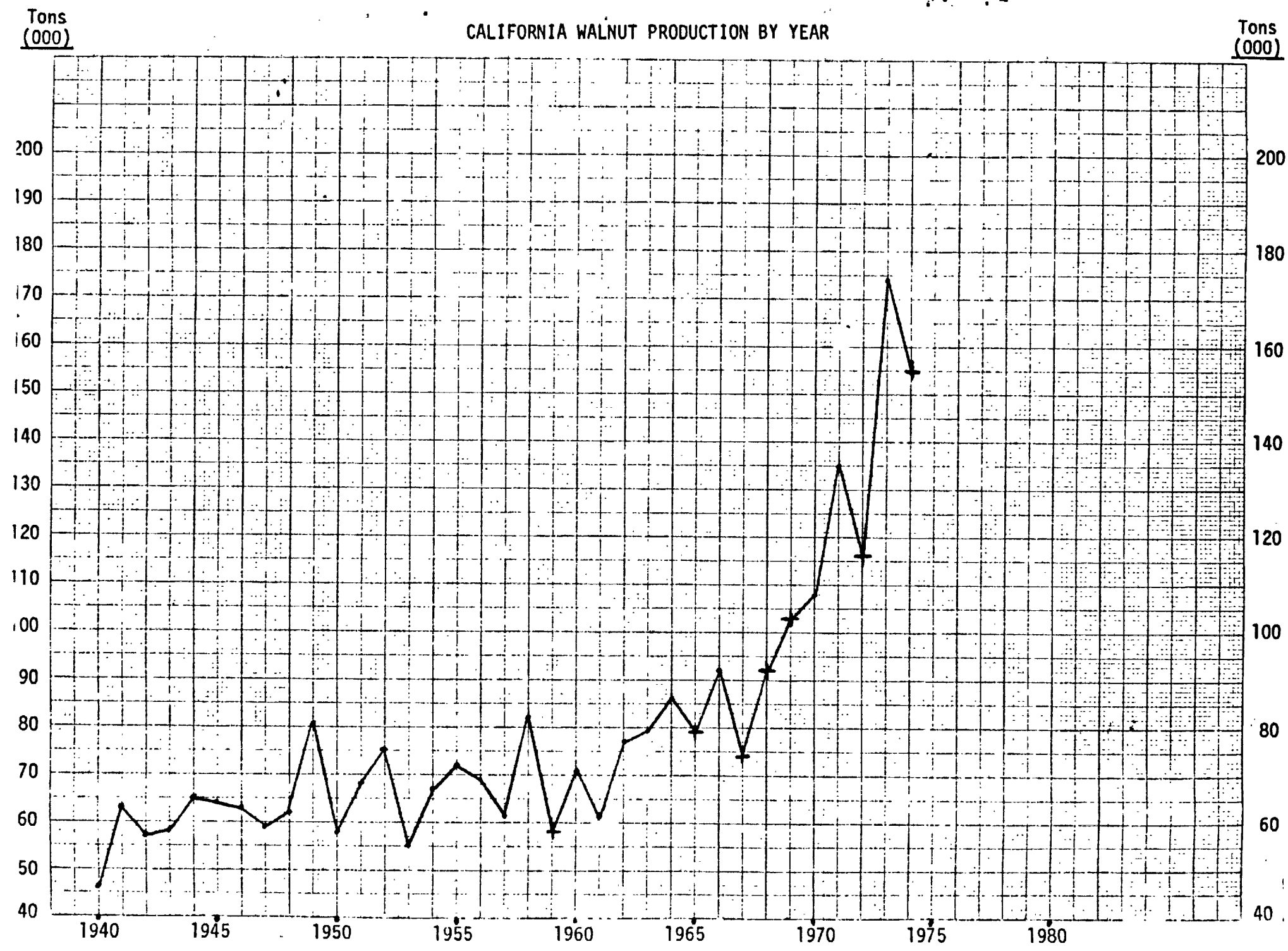
(3) New forecasting procedures, and

(4) Projections of interest to the industry.

The graph on page two visually indicates the rapidly expanding production which brought about the need for this analysis.

The Objective Measurement Survey

In 1958 a sample of California's walnut orchards was selected. The sample was stratified and chosen with probabilities proportional to county acreage, varietal acreage, and to as great an extent as possible, acreage by year


CALIFORNIA WALNUT PRODUCTION BY YEAR
Tons (000)
Tons (000)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
1940
1945
1950
1955
1960
1965
1970
1975
1980

planted. Each year random additions and deletions were made in the various strata in order to adjust the sample for acreage removed or planted and to replace blocks (sample orchards) which the owner refused to grant permission to sample. Sample blocks which have been pulled out and those which are abandoned are not sampled and are considered an estimate of the total acreage which has been removed but not recorded since the most recent fruit acreage survey.

In each orchard two trees are randomly selected. For each tree a nut count is made on an "accessible and representative" limb. A Jessen-type expansion[1/] using probabilities proportional to cross sectional area is used to estimate the total set of nuts on each tree. At the time of the count, a systematic sample of every fifth nut is chosen to be sized. If more than 20 nuts are picked, a random sample of only 20 is chosen for sizing. The following measurements are obtained for each tree and the nuts sampled from it:

(1) S_i = Estimated set on the ith tree,

(2) D_i = Number of damaged nuts in the sample from i^{th} tree,

(3) N_i = Number of nuts in the sample from i^{th} tree,

(4) $(HS)_{ij}$ = Hull suture (in-hull diameter perpendicular to the stem axis) of each nut,

(5) $(SS)_{ij}$ = Shell suture of each nut, and

(6) W_{ij} = In-hull weight (gm) of each nut.

For simplicity the subscript i will denote estimates for i^{th} tree while j will denote the jth sampled nut on that tree. Normally $i > 1000$ and $o \leq j \leq 20$. For more detailed explanation see Appendix A which contains sections of the actual samplers' manuals.

1/ Jessen, Raymond, "Determining the Fruit Count on a Tree by Randomized Branch Sampling," Biometrics, March 1955, pp. 99-109.

The summary mean statistics are computed as follows:

# of trees sampled = T

# of nuts sampled = $N = \sum_{i=1}^{T} N_i$

Set all nuts per tree = $S_A = \dfrac{\sum_{i=1}^{T} S_i}{T}$

Set sound nuts per tree = $S = S_A \left[\dfrac{\sum_{i=1}^{T} (N_i - D_i)}{\sum_{i=1}^{T} N_i} \right]$

Hull suture = $(HS) = \frac{1}{N} \sum_{i=1}^{T} \sum_{j=1}^{N_i} (HS)_{ij}$

Shell suture = $(SS) = \frac{1}{N} \sum_{i=1}^{T} \sum_{j=1}^{N_i} (SS)_{ij}$

Weight per nut = $W = \frac{1}{N} \sum_{i=1}^{T} \sum_{j=1}^{N_i} W_{ij}$

It should be remembered that T is the number of trees sampled, and is less than the number of trees chosen to be in the sample for virtually every survey. This nonresponse for the most part is attributable to wet or sprayed orchards which could not be entered and owners refusing permission to sample. An assumption was made which considered the nonresponse to be random and representative; therefore, the self-weighting properties of the sample estimates would remain unchanged. The random nonresponse assumption along with the unbiasedness of the self-weighting summary statistics are very questionable and will be discussed further in section three.

The Survey Data

Year	P Actual Board Production (tons)	A Bearing Acres	Y Yield per Acre (tons)	S_A Set All	S Set Sound	(HS) Hull Suture	(SS) Shell Suture	W In-Hull Weight
1958	82,200	120,721	0.6809	2142.4	2018.1	41.6	31.7	45.18
1959	58,500	121,796	0.4803	1414.6	1292.9	40.4	30.9	41.23
1960	70,300	123,525	0.5691	1908.3	1780.4	39.4	30.2	38.60
1961	61,200	122,775	0.4985	2075.9	1826.8	38.0	29.8	34.34
1962	77,000	123,335	0.6243	2070.1	1981.1	39.8	30.9	39.80
1963	79,300	124,460	0.6372	1963.8	1887.3	39.9	31.6	40.92
1964	86,100	128,245	0.6714	2255.7	2161.0	38.6	30.9	36.99
1965	79,000	129,380	0.6106	1701.9	1520.0	40.7	31.5	42.33
1966	92,000	135,980	0.6766	2147.4	1937.0	39.6	31.4	38.46
1967	74,000	137,550	0.5380	1532.2	1344.6	39.3	31.2	39.78
1968	92,000	139,290	0.6605	1913.4	1651.3	39.1	31.5	38.66
1969	103,000	142,630	0.7221	1629.6	1481.3	41.5	33.0	45.41
1970	108,000	146,520	0.7371	1822.8	1742.6	39.7	32.4	41.00
1971	135,000	150,430	0.8974	2068.7	1957.0	40.6	32.9	45.99
1972	116,000	154,360	0.7515	1592.0	1485.3	40.8	32.9	44.06
1973	174,000	158,066	1.1008	2294.8	2196.1	40.2	32.3	42.83
1974	155,000	161,850	0.9577	1729.8	1660.8	40.5	32.5	44.10

(1) Analysis of the Changes

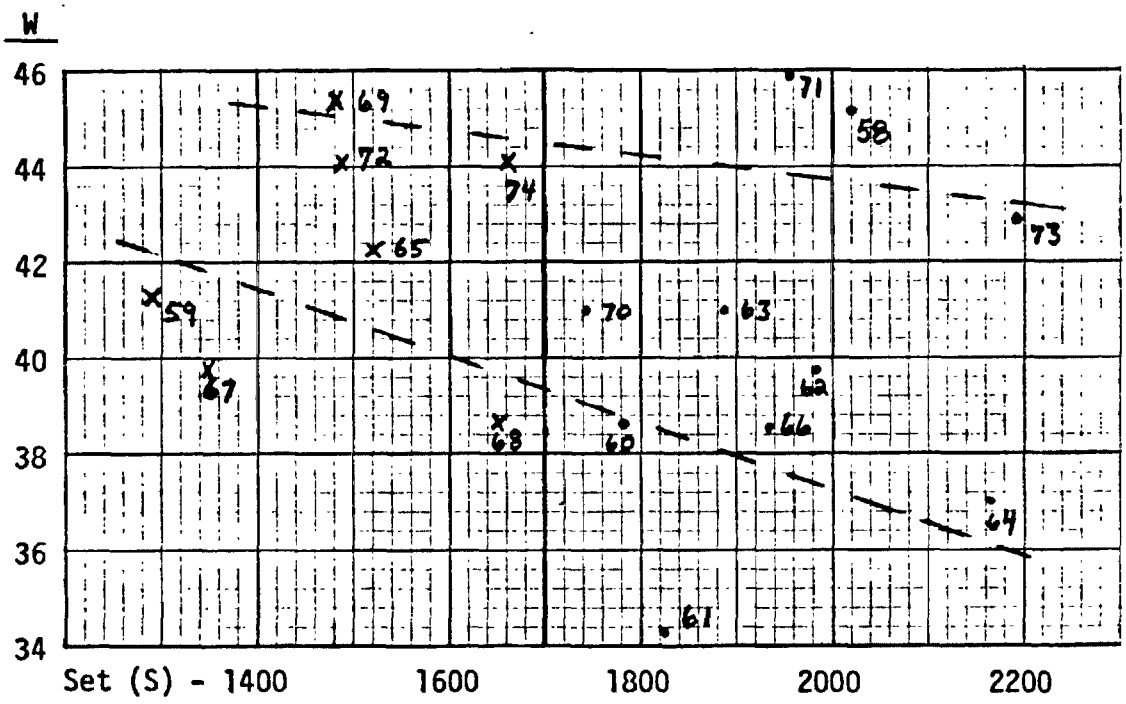
Two factors are most important to consider when trying to develop a reliable model for the prediction of walnut production. One of these factors is a trend toward increased yields--a trend which is growing at more than a linear rate with respect to time and the measured variables. The second and most significant consideration is the fact that the relationship between the independent variables and production changes with respect to the level of output per tree.

For a start some of the readily observable patterns in the data will be listed.

(a) Production and yield per acre are increasing rapidly.

(b) In general, set (S) and weight are inversely related, but the relationship has an increasing level over time. The dashed lines on the following graph indicate the level change in the relationship for pre and post 1970 data.

Weight vs. Set Sound



The solid vertical line at S = 1700 separates the data into two groups whose significance will later be discussed in relation to the second factor influencing production. The important point for now is that in each group, weight, set and year all have a tendency to increase together.

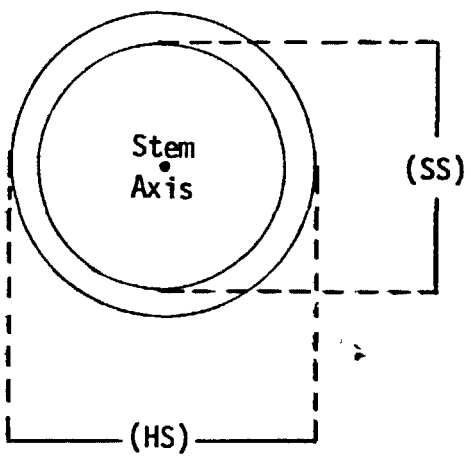
(c) Shell suture shows an increasing trend which is stronger than the upward drift for hull suture. Such a relationship implies that as time progresses, more of the Objective Measurement (O.M.) green weight W (in-hull) becomes harvested production. This being the case, use of

the variable W in a production forecasting model would tend to cause a negative bias in the production indication.

To adjust for the larger nut, the following variable will be introduced:

$$(\text{Adj}) = \frac{\text{Shell Volume}}{\text{Total Volume}} = \frac{4/3\pi(\text{Shell Radius})^3}{4/3\pi\,(\text{Hull Radius})^3} = \frac{\left(\frac{\text{Shell Suture}}{2}\right)^3}{\left(\frac{\text{Hull Suture}}{2}\right)^3} = \frac{(\text{SS})^3}{(\text{HS})^3}\,. \quad (1)$$

A "Round" Walnut



Year	(Adj)
1958	.4425
1959	.4474
1960	.4503
1961	.4823
1962	.4680
1963	.4967
1964	.5130
1965	.4636
1966	.4986
1967	.5004
1968	.5163
1969	.5028
1970	.5436
1971	.5322
1972	.5243
1973	.5187
1974	.5168

So, if (1) a walnut can effectively be considered spherical while in hull, and (2) the green in-hull weight, W, can be assumed uniformly distributed throughout the measured nut, then W* = W(Adj) can be considered a measure of the green weight of the nut which relates to the harvested amount of nut (that is, a hulled nut with lower moisture content).

The trend of the adjustment indicates that more of the measured weight now becomes harvested weight. This fact could not previously be determined by the forecasting models, thereby causing some of the negative bias.

The adjustment factor would be improved (model-wise) considerably if the true densities of green shell weight and green hull weight were determined. Such a determination could easily be made with a subsample during the regular survey. The green weight of the nut could then be expressed by:

$$W^{**} = W - (\text{density of hull in grams})(4/3\pi\frac{(HS)^3}{8} - 4/3\pi\frac{(SS)^3}{8}). \qquad (2)$$

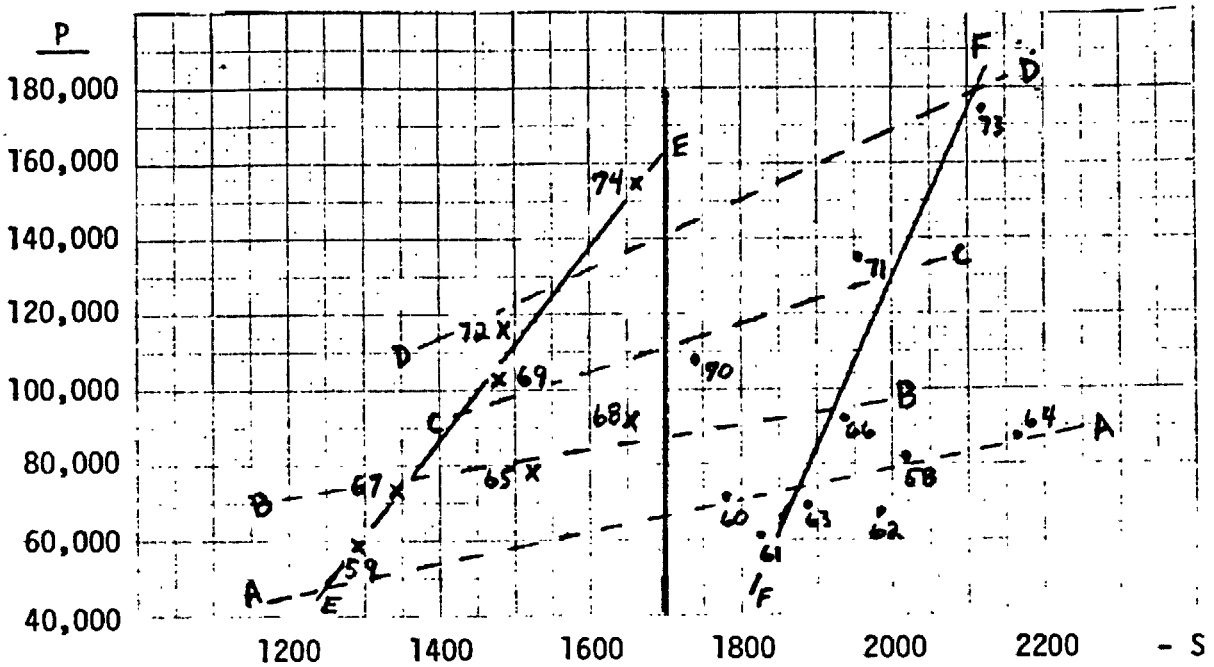
Further improvement would be attained through measurement of the axis length and modeling the walnut as an ellipsoid.

(d) A sizeable reduction in yield from one year to the next has historcally been followed by an increase in yield in the third year. The converse has not always held.

(e) Production and yield are highly correlated. It was found that models used to predict yield converted to production estimates at the same level as a corresponding production estimating model which included acreage. Since the residuals of a production model are more readily interpretable, yield models will not be considered.

Returning now to the two factors which influence production models, an example of the relationship between one of the variables, S, and production, P, will be discussed.

Set vs. Production



The lines on the graph are drawn to associate sets of years as follows:

Line	Years	Number of Years
AA	1958 through 1964	7
BB	1965 " 1968	4
CC	1969 " 1971	3
DD	1972 " 1974	3
EE	years marked X	7
FF	years marked •	10

The shifting level of the relationship between set and production is readily visible by observation of the lines AA through DD. The year 1972 may be more related to the years in group CC, but in either case, the decreasing number of years between shifts and the increasing magnitude of the shift remain clear. Similar relationships occurred when production was plotted against such variables as weight, weight per tree (W x S), sutures, bearing acres times set and various other combinations of the

measured variables. One conclusion that can be drawn from the shifting relations is that some unmeasured variable is causing the rising trend. The obvious choice for the missing variable is trees per acre, (T/A), since

P = (Bearing Acres)(Trees per Acre)(Set on Tree)(Harvest Weight per Nut). (3)

In section three a sampling procedure is developed which estimates (T/A). The variable is then effectively incorporated into a model which is not affected by the drastically changing relationships found between most variables and production.

Those with a perceptive eye have most likely already recognized the reason for the verticle line S = 1700 here again on the set vs. production graph. Yes, those values related to each of the lines EE and FF correspond to the same years which produce the reversals in the slopes of the weight vs. set graph. Here it should be noted that except for a few wild points, the approximate level of production is quite accurately indicated just on the basis of the set being high or low, which for our purposes will be above or below 1700 nuts per tree. Inspection of the production time series on page two reveals that the years in which trees produced low sets ($S < 1700$) are marked with a "+". Further, production in the marked years was somewhat lower than the level of production indicated by the trend of the peak years. 1970 may appear to be out of place, especially since its value of S is close to 1700, but the large value of W for the nuts sampled in that year cause it to be classified as a peak production year. Another hypothesis can now be stated:

> The relationship between production and the O.M. variables has two levels. For a given year the level of production is determined by individual tree production as measured by set and weight.

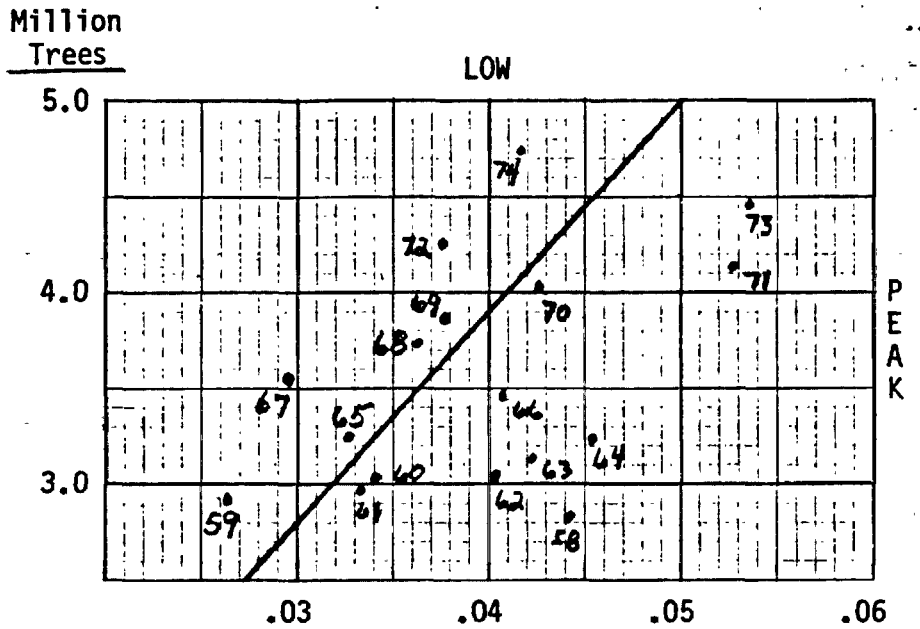
What is needed now is a method which will, prior to forecast time, classify a year as peak or low producing. Although a discriminate analysis rule will eventually be constructed, the following table based on the O. M. measurements of set and weight can be equally effective.

Classification Table for Peak and Low Production

		WEIGHT	
		Above Normal	Below Normal
SET	Above Normal	Peak	Peak
	Below Normal	Low	Low

Classification based on "normal" set and weight is presented in order to reflect the physical properties of a tree's production. Because there are natural limitations on the production of an individual tree, the sizing of the nuts on a tree is influenced by the number of nuts which set on the tree, as well as the growing conditions during the year. The word "normal" is used for the critical classification value, since the introduction of new varieties combined with other factors has caused a trend toward increased set and weight. As mentioned before, S = 1700 has worked satisfactorily to date. Inspection of the S vs. P and S vs. W relations indicates that the critical value for S should begin to increase with time. Since a classification error may occur if the critical classification values are underestimated, the following graphical discrimination based on the number of producing trees and the green production per tree should be used. Estimates for the number of producing trees are developed in section three.

Producing Trees vs. Green Production (Tons)



$$\text{Green Production} = (\text{Set/Tree})(\text{Adjusted Grams/Nut})\left(\frac{1}{454}\ \text{Lbs/Gram}\right)\left(\frac{1}{2000}\ \text{Tons/Lb}\right)$$

Here it is clear that the more recently planted trees are causally related to the increasing average production per tree. A clear division exists between the two classification groups.

(2) Possible Factors Causing the Changes

This section will discuss some of the important factors which contribute to the increasing trend of production and the varying level of yield.

Increasing Production

The most obvious factor contributing to the rise in production is the increasing number of bearing acres. In 1974, there were 34 percent more bearing acres than in 1958. Acreage alone doesn't account for the trend as indicated by the 112 percent increase in production from 1958 to 1973. Two related factors account for much of the unexplained increase. As will be shown in the next section, a nearly 25 percent increase in the average density of trees per acre causes a rapid expansion (67 percent from 1958 to 1974) in the number of bearing trees. Increasing yield per tree is the remaining factor influencing the expanding production.

Increasing Yields per Tree

Some factors contributing to increased yields are:

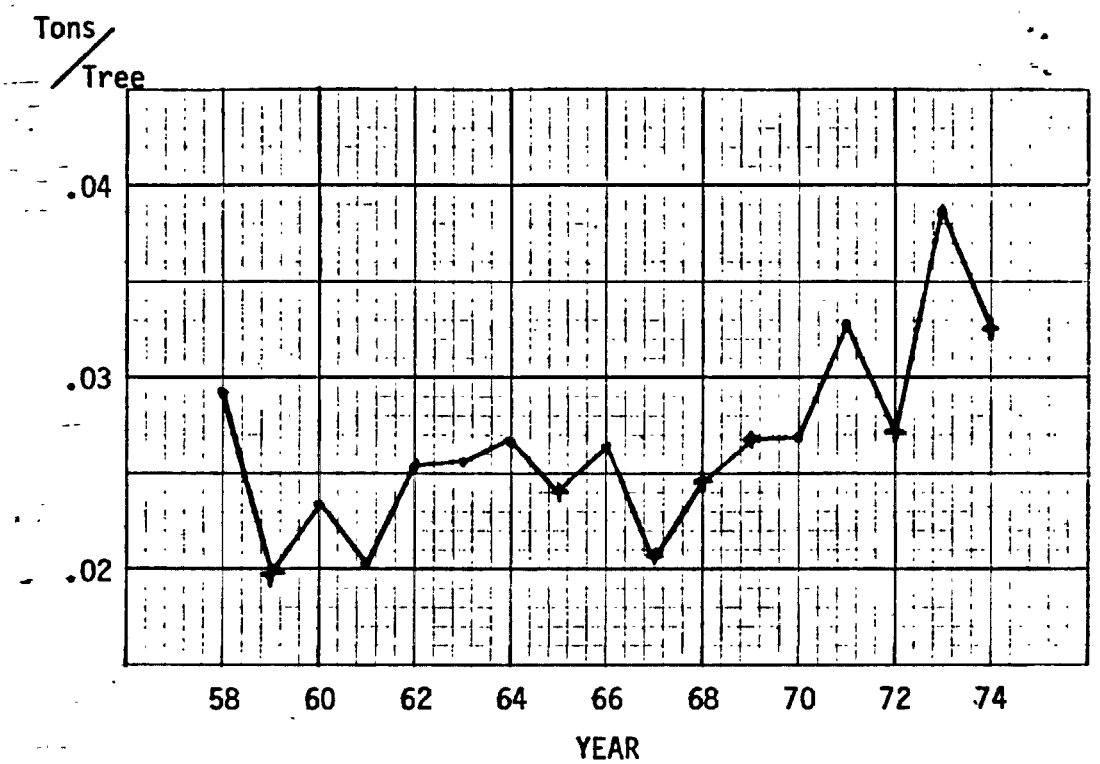
(a) Improved harvesting techniques, especially the conversion to mechanical shaking of the trees during the early 1960's. Also, mechanical sweepers may be leaving fewer nuts on the ground.

(b) Set and size on all trees are increasing, somewhat as a result of the recent spread of the trioxys wasp which is a predator of the walnut aphid.

(c) Increased planting in the higher yielding central California areas and dwindling acreage in the lower producing southern areas.

(d) The introduction of new varieties. Of particular interest are the Hartley and Ashley varieties. During the period 1964 to 1973, the bearing acreage of Hartleys had increased from 19,050 to 45,963 and that of the Ashley variety from 98 to 7,759. Their combined percent-

Yield Per Tree Time Series



age of total bearing acreage had increased from 14.9 percent to 34.0 percent with further increases expected. Any markedly different yield patterns for these varieties as compared to yields of trees prior to 1964 would make their separate estimation desirable. Further research in this direction is recommended.

(e) As a percent of bearing acreage, there has been an increasing trend toward earlier harvested varieties. Keeping in mind that the O. M. is conducted during the same period each year, this trend may explain the increase in (Adj), but also implies that more of our measured weight now results in harvested weight. Implicit in previously used regression models was an assumption that, over time, green weight as measured, had a uniform relationship with harvested weight. Therefore, the changing relationship would cause underestimation.

The Varying Level of Yield

Why should the relationship between the O. M. variables and production vary with the level of yield? The alternate bearing characteristics of many walnut varieties seems to be the most influencial factor involved. The major variety, Hartley, is an example of pronounced alternate bearing. Hartley yields show a striking high-low beat over time. The second largest variety, Franquette, has greatly varying yields, but seems to be influenced most by growing conditions, rather than a patterned output. Most varieties may in fact be alternate bearing but the planting sequence over time may have resulted with half the acreage on the low beat while the rest is having its peak year. Such a situation would result in relatively stable yields for the variety. The rapid increase of acreage can be the explanation for total yield lacking a patterned yield fluctuation over time. Still, the low yield being followed by high yields seems to be influenced by the bearing characteristics of the alternating varieties.

With more than 52 percent of the walnut acreage posessing a fluctuating yield, it is clear that the composition of the crop differs markedly from the high to the low years. During the low years we are working with the stable portion of the crop. For the peak years, a large marginal crop is added to the stable crop; the result is a larger crop, but a lower level of harvested weight in relation to the measured green nuts. The lower level will be exhibited in one of the models presented in section three and is also indicated on the "S vs. P" graph on page 9 .

(3) New Forecasting Procedures

The phrase "New Forecasting Procedures" has three possible meanings: using the existing data in a new way, new additions to the survey procedures, and more drastically, a complete change. Since a long survey history is required in order to evaluate forecasting abilities, only the first two possibilities will be considered.

Using the Existing Data

As I stressed in the first two parts, the most important consideration when using the existing data is an estimation of the number of trees in the state during a given year. Since the O. M. measurements are made on trees and not acres, the only logically related variable is trees in the state, not acres. The sampling design and estimates of the number of trees follows.

Each sample block which was chosen for the O. M. survey has an orchard record card on file. Each card lists the sample identification number, the owner, operator, variety, year planted, number of trees in the orchard, number of acres in the orchard, the year first included in the survey and the year last used in the survey. After extensive editing to verify questionable information, the sample was reconstructed year by year. For each block, the number of trees per acre (number of trees in the block/acres in the block) was computed and recorded for each year the block was to be sampled. The sample was updated each year in order to reflect the proportion of acres by variety, year planted and county; therefore, a straight average of the trees per acre recorded for a given year is a self-weighted and valid estimate of the state-wide average number of trees per acre (T/A). The data was summarized in a manner which would glean as much additional information as possible. For example, as indicated in the following table, trees per acre in the four districts was obtained.

Trees Per Acre Estimates

Year	Lower San Joaquin Valley Sample Size	Lower San Joaquin Valley T/A	Southern California Sample Size	Southern California T/A	Central Coast Sample Size	Central Coast T/A	Northern California Sample Size	Northern California T/A	STATE Sample Size	STATE T/A
1958	153	22.3	81	19.9	151	29.4	67	17.1	452	23.4
1959	174	22.8	81	19.7	168	30.4	71	17.2	494	24.1
1960	187	23.3	73	20.8	174	29.9	73	17.1	507	24.3
1961	193	23.1	63	20.8	176	30.3	76	17.2	508	24.4
1962	199	23.8	58	20.9	175	30.3	76	17.3	508	24.7
1963	209	24.4	51	20.7	175	30.6	81	17.7	516	25.1
1964	215	24.7	46	20.6	169	30.4	84	17.8	514	25.1
1965	230	25.1	45	20.7	163	30.6	89	18.1	527	25.2
1966	240	25.4	43	20.7	165	31.0	98	18.7	546	25.6
1967	249	26.0	33	22.0	164	30.9	101	19.3	547	26.0
1968	253	26.6	34	22.7	164	31.2	112	21.8	563	26.7
1969	262	26.4	33	23.4	156	31.7	114	22.1	565	26.8
1970	268	26.6	33	24.3	158	32.3	124	23.6	583	27.4
1971	251	27.0	31	24.5	133	33.1	118	22.5	533	27.4
1972	265	27.4	29	24.9	134	32.4	127	24.6	555	27.8
1973	279	28.2	30	25.1	124	32.4	131	25.4	564	28.3
1974	304	29.9	24	25.4	114	32.2	137	25.8	579	29.2

The use of irrigation, especially in the lower San Joaquin Valley, the increasing Ashley acreage (usually from 35 to above 70 trees per acre) and decreasing interplanted acreage contribute to the increasing density. In turn, the high density of the newly planted acreage makes harvesting economically feasible before the trees reach the age at which they would be included in the estimates of bearing acreage.

The first forecasting model presented will use the method of classifying a year into a high (c = 2) or low (c = 1) group. Let an estimate of green production be:

$$\tilde{P} = (B.A.)(T/A)(S)(W^*) \qquad (4)$$

and consider two relationships with final production of the form:

$$P = A_c e^{B_c \tilde{P}} \quad \text{for} \quad c = 1, 2;\ A_c,\ B_c \text{ constants.} \qquad (5)$$

An exponential model is used since there is multiplicative bias introduced into equation (1) by the possible underestimation of (B.A.), S, and W*. The values for A_c and B_c can be determined for each group by least squares linear regression of the following equivalent form:

$$\ln P = \ln A_c + B_c\tilde{P}. \qquad (6)$$

Page 19 is a graph of the relationship. It is evident that residuals are quite small and that the most recent years fit extremely well. Page 20 reconstructs the performance that use of this model would have produced.

It is evident from the comparisons between the predictions, $\hat{P}_1$, and the actual August predictions that this model gave a superior overall performance. The large overestimation in 1971 is tolerable since it is doubtful that an estimate so much higher than the previous record year would have been officially accepted. The model did give warning that a large increase in production should be expected in 1971 and proceeded to be quite accurate in the prediction of the major fluctuations of the following years.

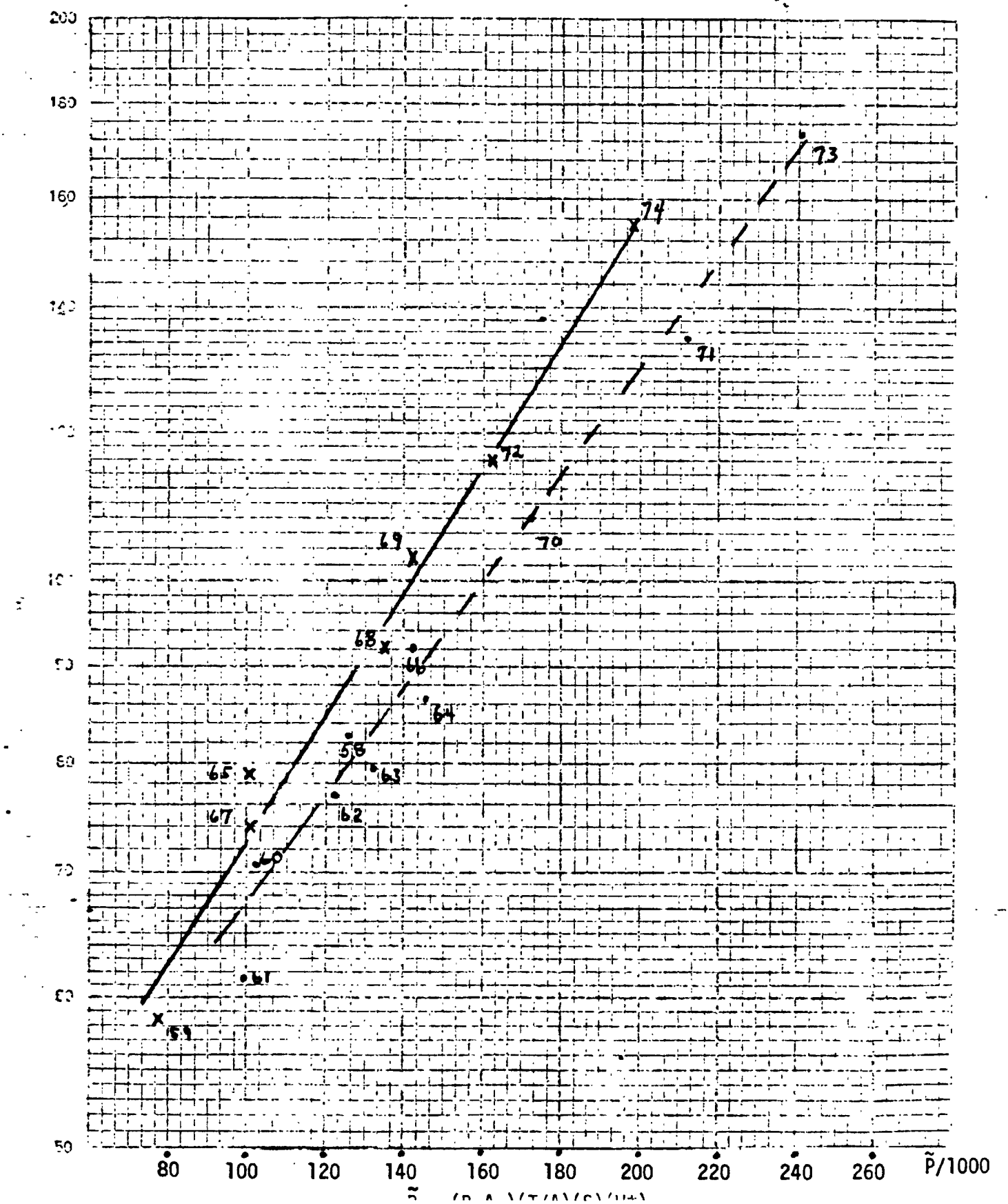
Residuals for the 1973 and 1974 Models

Year	C	P	P Estimated	Residual	% Error
1958	2	82,200	78,200	4,000	-4.9
1959	1	58,500	59,600	-1,100	1.9
1960	2	70,300	67,600	2,900	-4.1
1961	2	61,200	66,600	-5,400	8.8
1962	2	77,000	77,400	-400	0.5
1963	2	79,300	81,500	-2,200	2.8
1964	2	86,100	88,600	-2,500	2.9
1965	1	79,000	75,700	3,300	-4.2
1966	2	92,000	87,000	5,000	-5.4
1967	1	74,000	74,700	-700	0.9
1968	1	92,000	94,600	-2,600	2.8
1969	1	103,000	100,000	3,000	-2.9
1970	2	108,000	105,000	3,000	-2.8
1971	2	135,000	139,000	-4,000	3.0
1972	1	116,000	118,000	-2,000	1.7
*1973	2	174,000	161,000	13,000	-7.5
*1974	1	155,000	155,000	0	0.0

* Actual Prediction

A Classification Model

$$P = A_c e^{B_c \tilde{P}}; \quad \text{x for } c = 1, \ \text{. for } c = 2$$



A Reconstructed Performance History

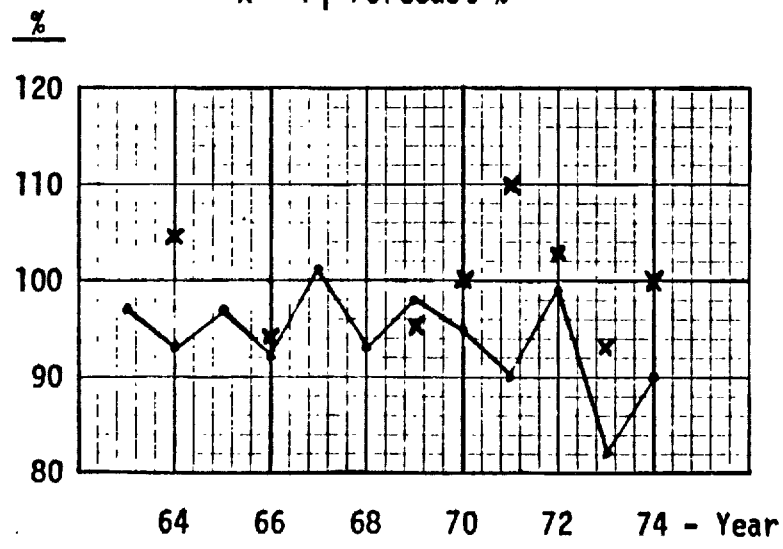
MODEL: $\ln \text{Production} = \ln P = \ln A_c + B_c \tilde{P}$

$\hat{P}_1$ = Predictions from this model

Year of Prediction	C	$B_c \times 10^6$	$\ln A_c$	R^2	P	$\hat{P}_1$	$P-\hat{P}_1$	$(P/\hat{P}_1) \times 100$
1964	2	7.27300	10.3577	.806	86,100	90,700	-4600	105
1965	1	Insufficient data history						
1966	2	6.46906	10.4468	.843	92,000	86,700	5300	94
1967	1	Insufficient data history						
1968	1	Insufficient data history						
1969	1	7.82246	10.3809	---	103,000	98,200	4800	95
1970	2	7.04713	10.3836	.867	108,000	108,000	0	100
1971	2	7.00542	10.3886	.927	135,000	149,000	-14000	110
1972	1	8.21470	10.3560	.982	116,000	120,000	-4000	103
1973	2	6.28473	10.4785	.958	174,000	161,000	13000	93
1974	1	7.98405	10.3796	.988	155,000	155,000	0	100

Prediction Comparisons

. = Actual Forecast %
x = $\hat{P}_1$ Forecast %



Since the difference in prediction from the two levels of the model is logrithmetically proportional to the value of P, the model

$$P = Ae^{B\tilde{P}}e^{D|c-2|}; \quad c = 1,2, \quad |c-2| = 1,0 \tag{7}$$

or equivalently

$$\ln P = \ln A + B\tilde{P} + D|c-2| \tag{8}$$

was developed in an attempt to construct a single forecasting relation. This model predicted 1973 within 2.3 percent, but had large errors in 1971 and 1974. Further development with this type of model may be of interest.

The forecasting model to be presented now is a two-stage procedure which takes advantage of the apparent proportional relationship between forecasting bias and the magnitude of production. A log-linear model of two independent variables will be used for the first step. The variables will be the number of trees in the state, T, and the green yield per tree, (Y/T):

$$T = (B.A.)(T/A) \tag{9}$$

$$(Y/T) = S \times W \times (Adj) = SW^{*}. \tag{10}$$

The model to be considered is:

$$P = T^{A} \times (Y/T)^{B} \times D; \quad A, B, D = e^{E}, E \text{ constants.} \tag{11}$$

The equivalent log-linear form is:

$$\ln P = A \ln T + B \ln (Y/T) + E. \tag{12}$$

The history of the model's parameters and predictions follows:

Forecast History

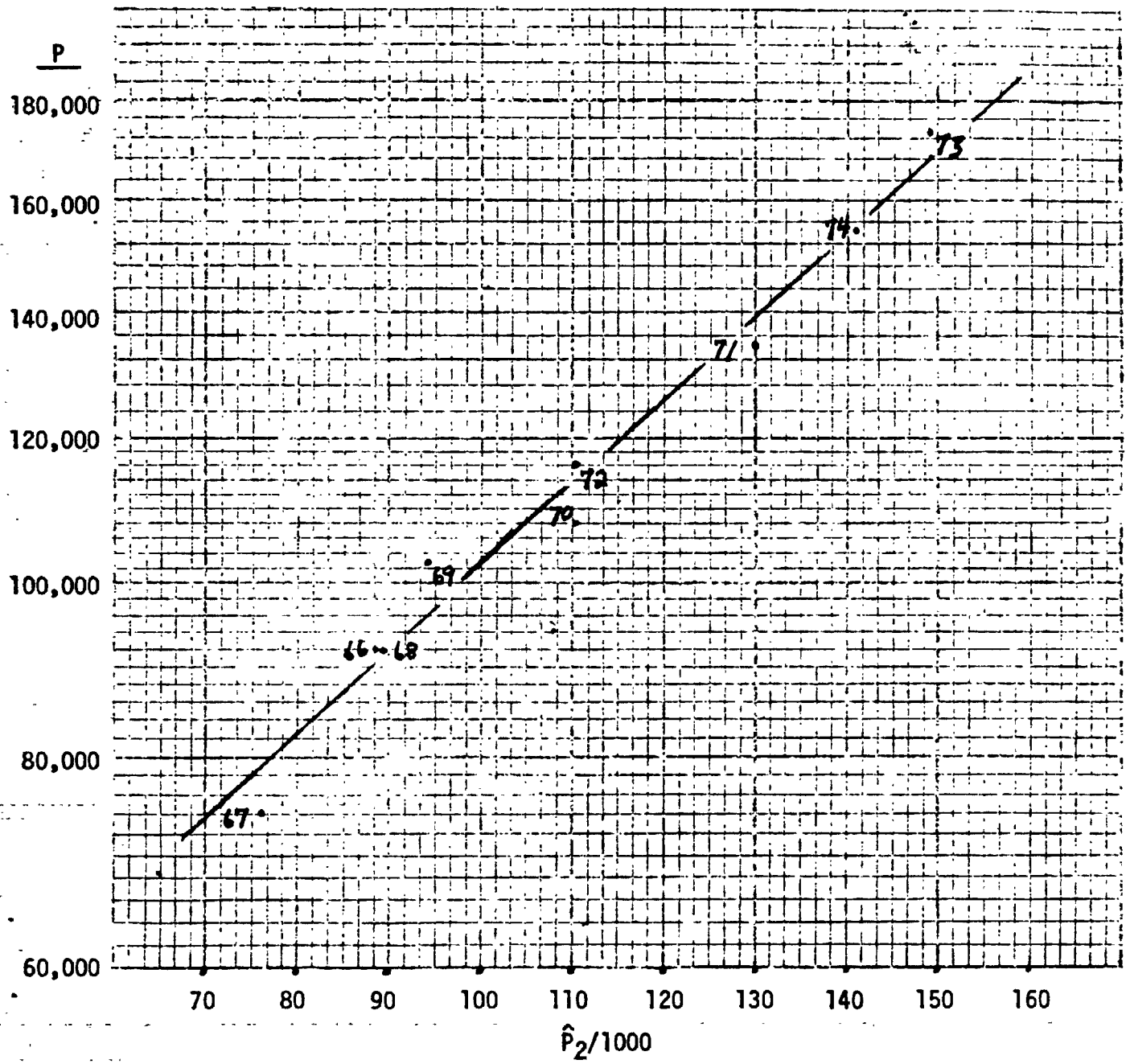
Model: ln P = A ln (Trees) + B ln (weight/tree) + E

Prediction Year	C	A	B	E	R^2	S.E.	P	$\hat{P}_2$	Error	% Error
1966	2	.90455	.60951	-.28622	.8266	.06926	92,000	88,500	3,500	3.80
1967	1	1.04886	.61217	-2.42989	.8650	.06412	74,000	76,000	-2,000	-2.70
1968	1	.97969	.62915	-1.34162	.8633	.05978	92,000	88,800	3,200	3.48
1969	1	1.05161	.63130	-2.40828	.8825	.05678	103,000	94,200	8,800	8.54
1970	2	1.19055	.64046	-4.45322	.8963	.05875	108,000	110,200	-2,200	-2.04
1971	2	1.13863	.62611	-3.72457	.9183	.05664	135,000	130,000	5,000	3.85
1972	1	1.16706	.64654	-4.08225	.9488	.05460	116,000	112,000	4,000	3.45
1973	2	1.20514	.63796	-4.68045	.9545	.05304	174,000	149,000	25,000	14.37
1974	1	1.29337	.69973	-5.79816	.9586	.06220	155,000	141,000	14,000	9.03
1975	-	1.36860	.68359	-6.97896	.9621	.06376	-	-	-	-

The second stage of the prediction process makes use of the relationship between amount of production, the amount of bias introduced into the variables and the resultant error of estimate. The graph on the following page relates the historic predictions, $\hat{P}_2$, with the log of the actual production. Notice that by adjusting the estimates to the level indicated by the drawn-in line, production is forecast to within 6,000 tons. At the current high levels of production, 6,000 tons represents an error of only 3.4 percent.

The final class of models to be discussed uses lag variables. Various lag models were tried with limited success. There are indications that the following type of lag model may be effective, but there was not enough time to test them before the preparation of this draft. Let the sequence of production values be labeled $P_{c,i}$ where the c is the previously defined 1 or 2 classification value and the i is the ith year in that c value. For example,

P vs. $\hat{P}_2$



production from 1958 thru 1962 would have the values $P_{2,1}$, $P_{1,1}$, $P_{2,2}$, $P_{2,3}$ and $P_{2,4}$. Assign the same subscripts to the value of the green production estimate for each year, $\tilde{P}_{c,i}$. Consider the following ratio to hold over time:

$$\frac{P_{c,i}}{P_{c,i-1}} = \frac{\tilde{P}_{c,i}}{\tilde{P}_{c,i-1}} . \tag{13}$$

So a model for the log-linear ratio estimate of production would be:

$$\ln P_{c,i} = A \ln P_{c,i-1} + B \ln \tilde{P}_{c,i} + C \ln \tilde{P}_{c,i-1} + D. \qquad (14)$$

New Survey Procedures

Bias in the survey statistics caused the need for the development of the models used in the previous section. Now we will be concerned with where the bias occurs and the procedures for its elimination.

The bias in the estimation of set has raised considerable concern. The "accessible" branch on which counts are made is on the lower part of the tree. A possible explanation for the separation of the data into the two classification groups is the bias in the estimate of set. It may be that the upper portions of the tree have relatively stable sets and depending on frost, heat, insects, etc., the lower branches have a variable set. This situation would cause the set per tree expansion to underestimate the actual set in years when the lower branches have a small set. Such an underestimation would be the physical justification for having two classification groups and would also explain why the group classified as "low" would give a higher level of production for a given value of S or $\tilde{P}$ (see graphs on pages 9 and 19).

Some of the factors causing a change in the population of nuts which we are sampling for sizes were discussed before. The summary statistic itself may have additional bias. In years when a variety has a large set, the sample limit of twenty nuts from each tree may often result in the sizing of a lower proportion of this type nut than the actual proportion produced. Since large sets correlate with smaller sizes, the sample size averages may be biased high in high set years because the summary statistics are straight averages and not the required weighted averages.

In order to help eliminate bias, the following procedures should be initiated.

(a) Continued use of trees per acre estimates.

(b) A study to determine production on the upper branches of the tree can be designed to relate the expansion estimates of set with actual set.

(c) The O. M. survey is a survey of trees; therefore, the size measurement statistics must be computed in a manner which will not be biased by sample limits per tree. Logical summary statistics would first obtain average sizes per tree and then weight these sizes by the set of the related tree. In this manner sample nut proportions by variety, age and county would be consistent with the actual nut population proportions. Recomputations can be made on at least the past five years of data, so a useable history could be obtained in two years.

(d) A study to determine the relationship between sample nut sizes and harvested nut sizes.

(e) Allocate the sample proportional to trees rather than acres of a variety. For some varieties, especially Ashley and Hartley, the two methods give very different allocations.

(f) Don't consider the set statistic to be self-weighting. Nonresponse has caused up to a 3 percent difference between the actual weighted and assumed self-weighted statistic.

Further detail concerning these recommendations will be included when this paper is revised.

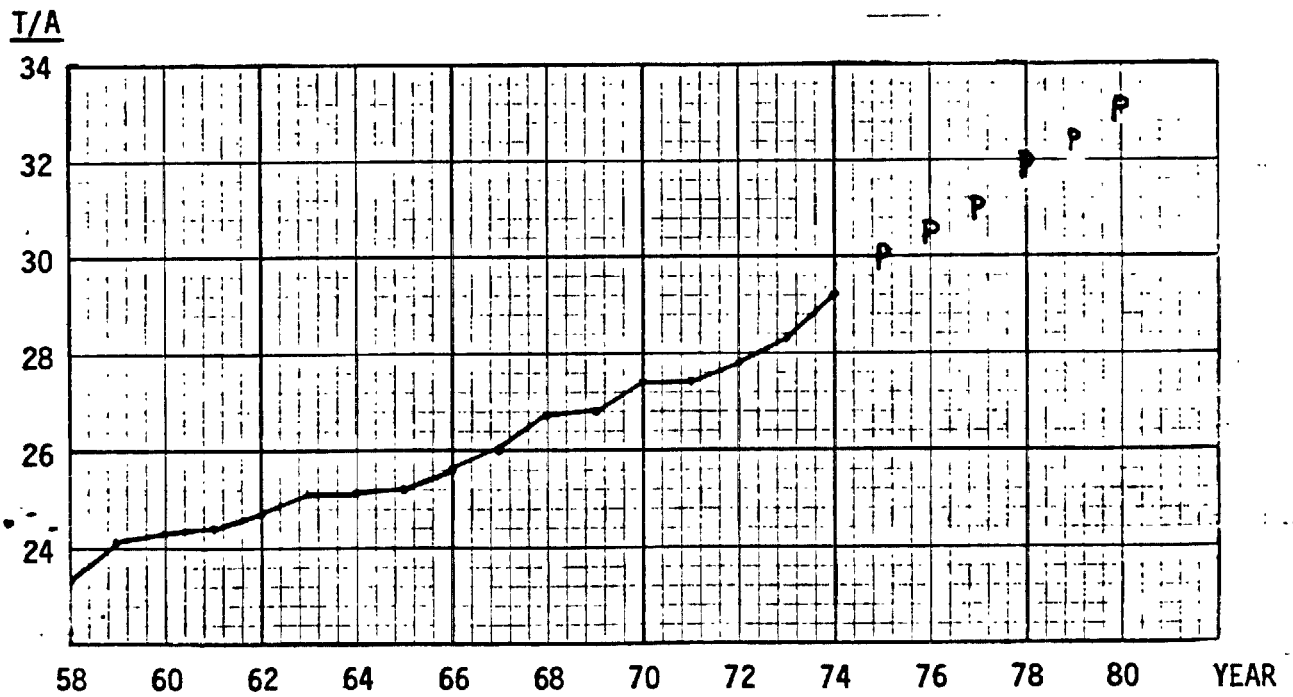
(4) Projections

This section will contain various time series and projections of interest to the walnut industry. If sufficient demand is generated, the projections will be reviewed and extended annually.

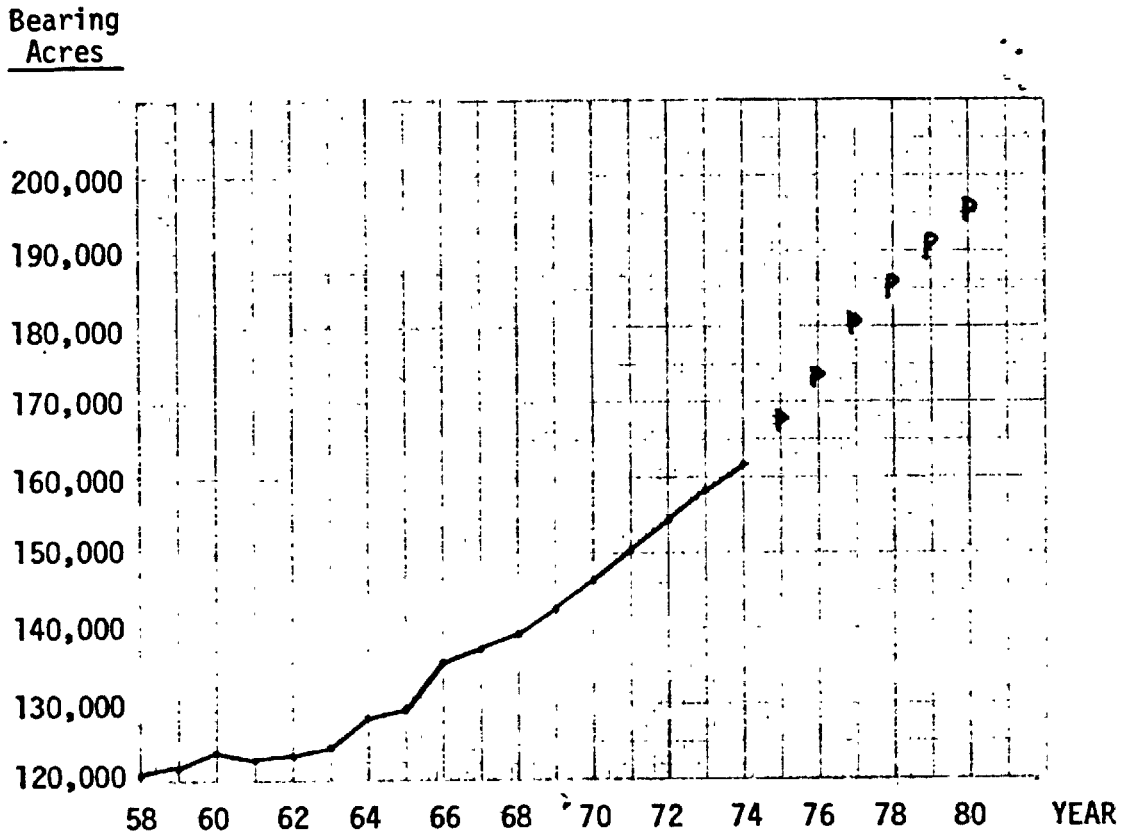
Acres, trees per acre and total bearing trees projections are based on the current trends of removals and density of planting as well as the varietal composition of nonbearing acreage. The projections through 1980 should differ from actual values only if the rates of tree removal or death change. Projections for production are based on the projected number of trees and yield per tree.

Projections are indicated on the graphs by a "P" and high and low points of ranges are designated by P_H and P_L respectively.

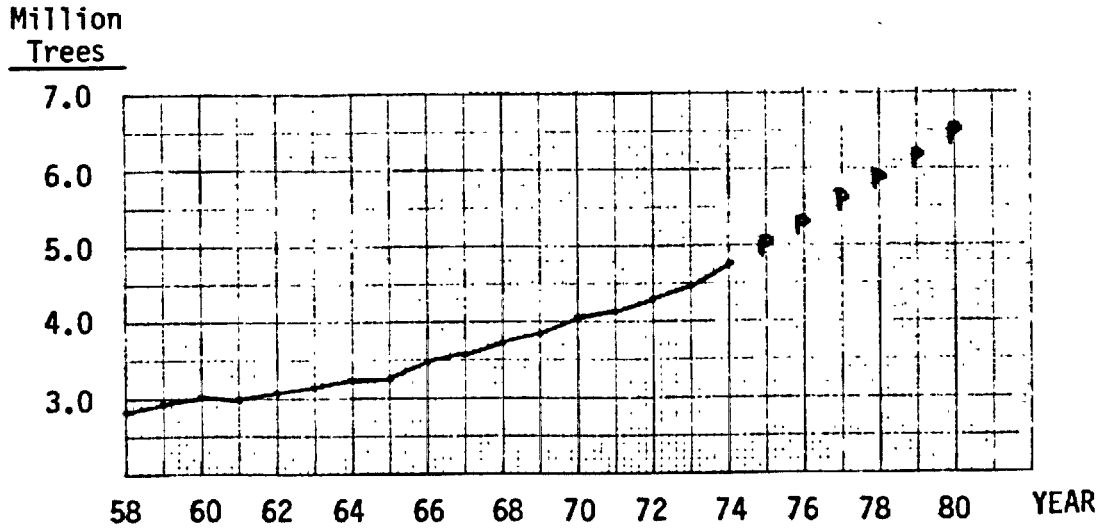
Trees Per Acre Time Series

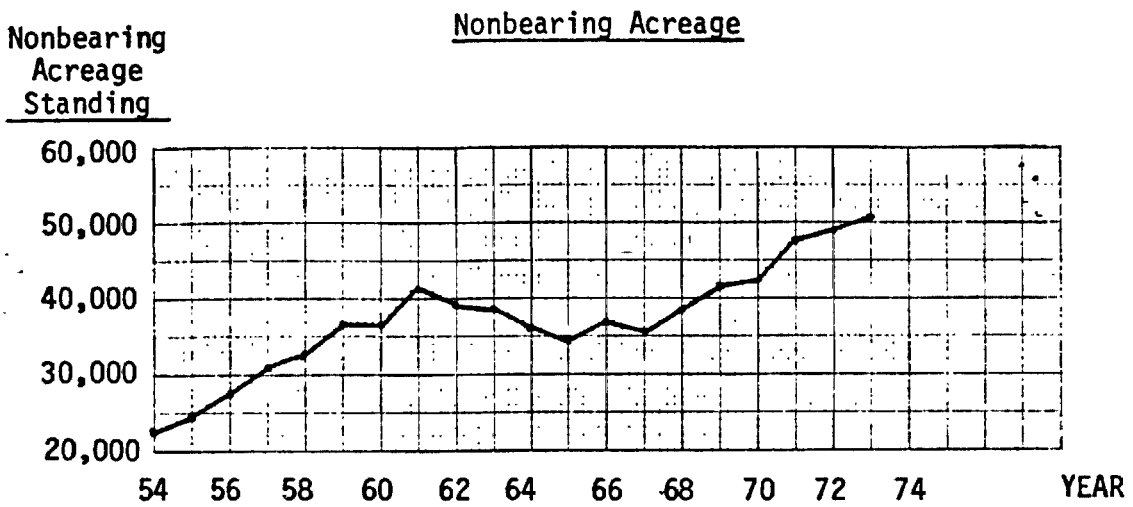


Bearing Acreage



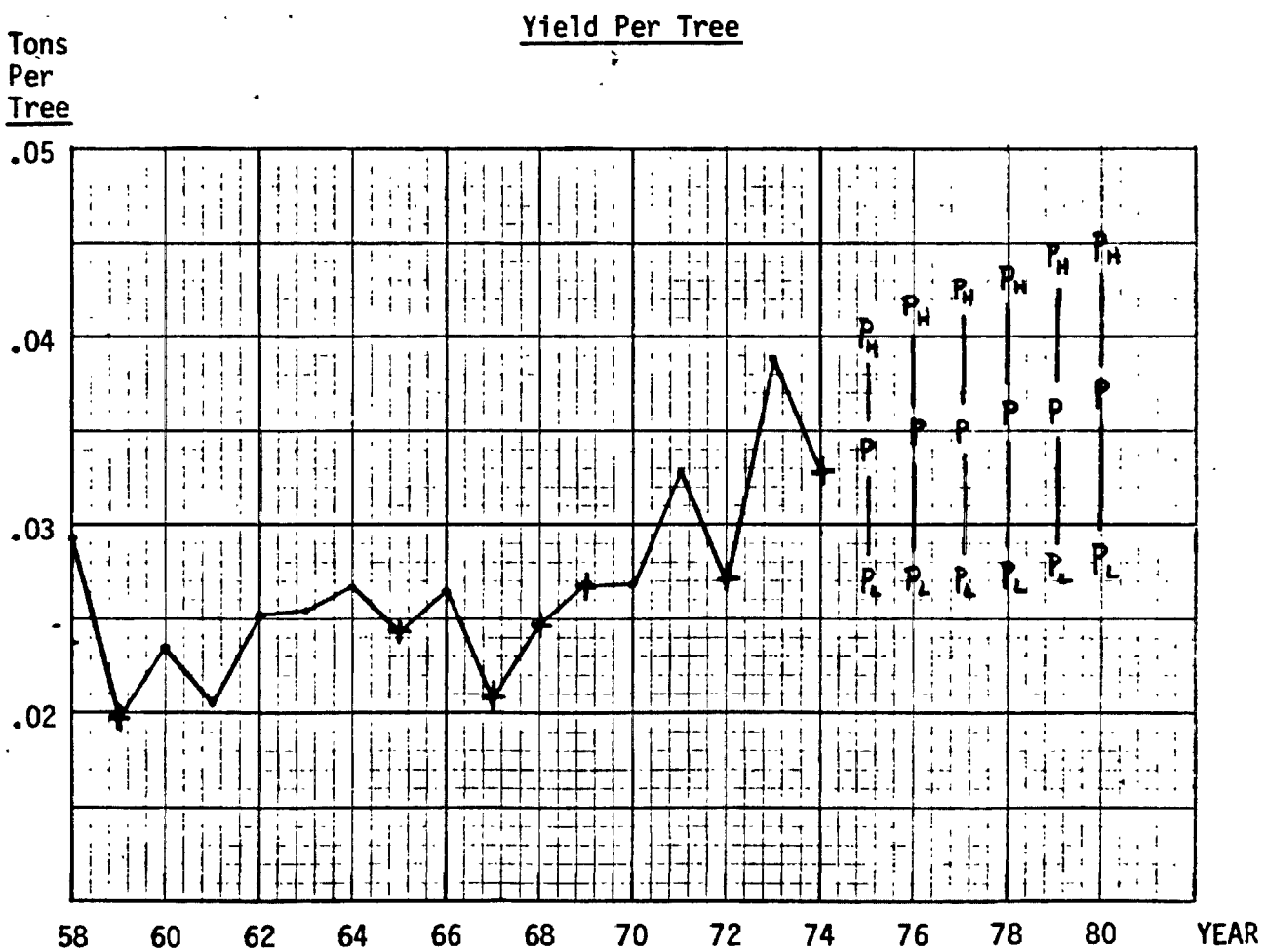
Bearing Trees

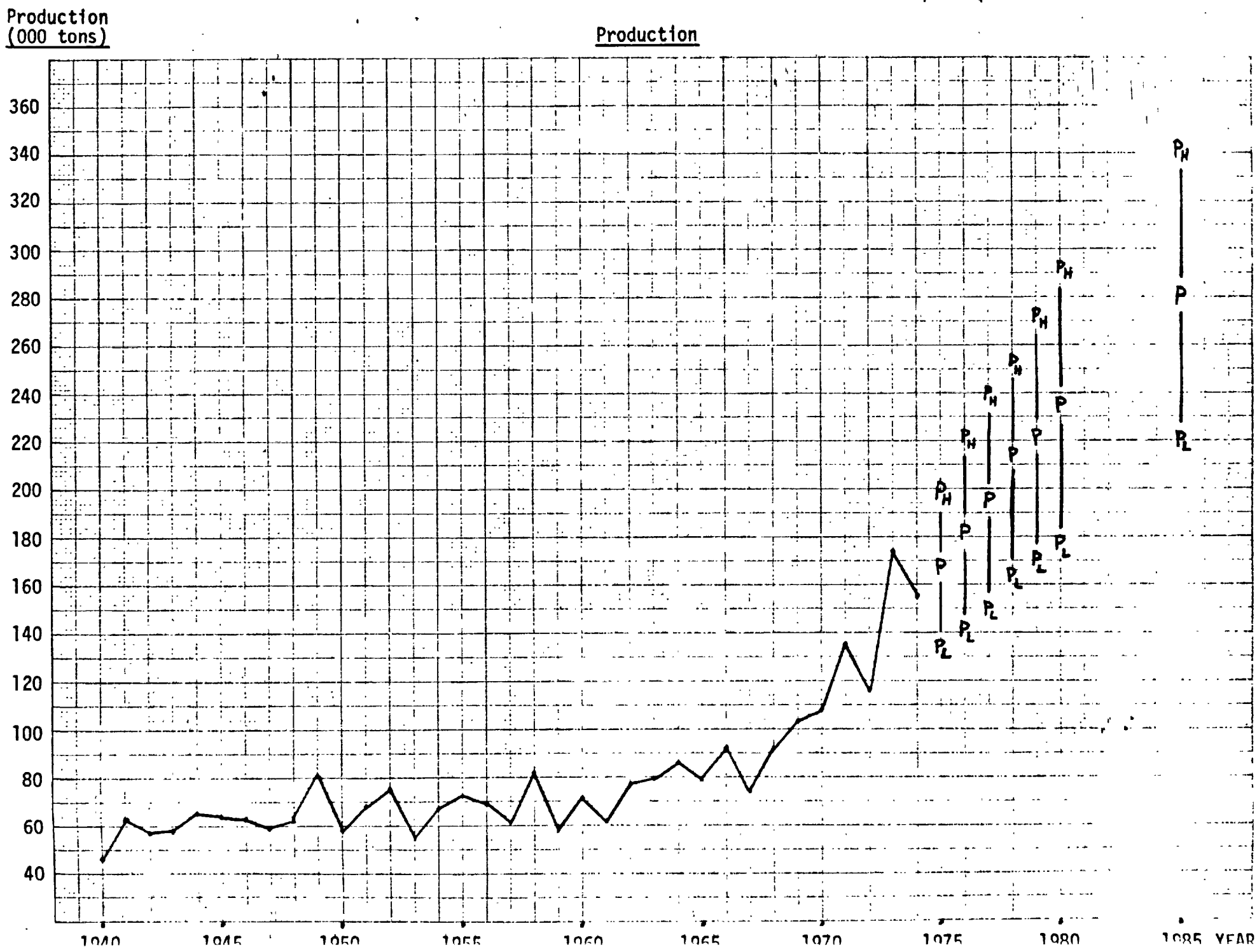




No projections will be made for nonbearing acreage, but a decline would be expected.

Yield per tree projections are based on expected increases resulting from increasing acreage of high yielding varieties.




Production
(000 tons)
Production
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
YEAR
P_H
P
P_L

Production projections are based on projections for the number of trees and projected yields per tree.

Projections

Year	T/A	Acres	Million Trees	Yield Per Tree			Production		
				Low	Median	High	Low	Median	High
1975	29.8	168,000	5.0	.027	.034	.040	135,000	168,000	200,000
1976	30.5	174,000	5.3	.027	.035	.042	143,000	183,000	223,000
1977	31.0	181,000	5.6	.027	.035	.043	151,000	196,000	241,000
1978	31.8	186,000	5.9	.028	.036	.043	165,000	215,000	254,000
1979	32.4	191,000	6.2	.028	.036	.044	172,000	223,000	273,000
1980	33.1	196,000	6.5	.029	.037	.045	179,000	236,000	293,000
1985	35.0	204,000	7.1	.031	.039	.048	221,000	282,000	343,000

ACKNOWLEDGEMENTS

Many thanks to Stephen Pavlasek, Jr. for sharing his expertise in the Walnut O. M. procedures. My ability to use the fruit acreage records for estimation and editing purposes relied heavily on the help of Jonet Stockton. The patience of Jon Field and Rick Kurosaka saved me from many hours of data summarization. The excellent typing is the work of Colleen Rosenbaum. Finally, my thanks for the information provided by other interested personnel at the California Crop Reporting Service and at Diamond Walnuts.

APPENDIX

Sections of the sampling and sizing manuals are reproduced here for those unfamiliar with the O. M. survey.

INTRODUCTION

The first and most important objective of this manual is to increase and improve your work as a sampler. A second objective is to maximize the accuracy and minimize the cost of the survey. The manual will help solve many of the problems that may develop in the field. This will allow your supervisor time to work on more important matters. The manual outlines and summarizes uniform procedures for all surveys, and informs the Stat, Supervisor, Sampler, and Sizer what is expected of each during the course of the survey.

I. PURPOSE OF SURVEYS

The Crop Reporting Service is a governmental agency designated to make the official forecasts and estimates of crop production in the United States. The Service publishes a monthly crop report during the growing season giving crop forecasts of the major maturing crops for all states. These reports are available to the public at no cost. The function of the Service is to serve as an unbiased agency in making production forecasts which are necessary in the pricing and efficient marketing of agricultural crops. For the most part, the information on which these forecasts are based is obtained through mailed inquiries from growers. The growers report their individual production conditions as a percent of full crop, expected yields, and acreage to be harvested, etc. This method provides resonably dependable forecasts and is relatively inexpensive. However, since more and more reliance is being placed on our fruit and nut crop forecasts as a basis for pricing and marketing crops, more dependable and timely production forecasts are needed. In an attempt to meet this need, the Service is using objective information obtained directly from the producing units in addition to the subjective judgment estimates described above. Such objective information includes estimates of fruit set, size, weight, percent cullage, and fruit drop or shed, etc. The Stat compiles the data to develop the forecast and sends the results to Washington, D. C. The fruit section of the California Crop Reporting Service conducts almond, grape, lemon, peach and walnut Objective Measurement Surveys.

II. IMPORTANCE OF FIELD WORK AND DATA ACCURACY

When all of the sampling and sizing field work data is completed, and all information received in the Sacramento office, the survey Stat will develop a crop forecast. The compiled data is sorted, edited, keypunched and summarized.

The importance of field work accuracy cannot be stressed enough. This importance can easily be seen in our method of deriving expanded fruit count. The fruit counts are expanded on the basis of the ratios of the selected branch cross section area (CSA) to the accumulated branch cross sectional area of each stage multiplied times the terminal count.

Example II 1

	Stage I		Stage II		Stage III		Stage IV		Fruit Count		
$\frac{\text{Accumulated CSA}}{\text{Selected Branch CSA}}$	$\frac{(58.2)}{(31.0)}$	x	$\frac{(25.2)}{(9.5)}$	x	$\frac{(4.3)}{(1.5)}$	x	$\frac{(1.7)}{(0.9)}$	x	(15)	= 405	Expanded Fruit Count

The method of expanding fruit counts using the field data figures to derive the expanded terminal count is shown in Example II 1. The ratio of the first stage is 1.88; the second stage is 2.65; the third stage is 2.87; the fourth state is 1.89; multiplying these ratios together by the terminal count gives an expanded fruit count of 405 fruits for this tree. Most surveys, except lemons use the intermediate fruit counts, which are expanded and added to the expanded terminal count. To get the expanded intermediate counts, the intermediate count is multiplied by the ratio of that stage and rounded to the nearest whole number. For this explanation intermediate counts will be assigned to each stage. The count for the trunk is 2, stage 1 is 1; stage 2 is 15; stage 3 is 0; and stage 4 is 19. The expanded count for the trunk is 2; stage 1 is 1.88 x 1 =2; stage 2 is 2.65 x 15 =40; stage 3 is 2.87 x 0 =0; and stage 4 is 1.89 x 19=36.

The expanded intermediate counts total 80. This added to the expanded terminal fruit count which gives an expanded set of 485 fruit.

You can see from the above explanation that a misplaced decimal can cause a large difference in expansions. You probably don't think about what each fruit represents when you make a fruit count. A good example is lemons where each fruit sampled is equivalent to more than a rail car of harvested fruit. This is why the need for accurate measurements and counts is very important. Small errors in sampling can cause large errors in the final results.

The individual expanded counts for each tree does not give an indication for the orchard in which they are located. However, the average set of all sample units gives an indicated set for all trees in the district the survey is conducted. In addition, a distribution of fruit sizes and weights is made. The distribution of weights and sizes is used in combination with fruit set to compute regression equations to determine the amount of crop available for harvest.

V. SUBSTITUTION OF SAMPLE BLOCKS, AND TREES OR VINES

A. Block Substitutions:

Block substitution is not to be done by the enumerator or supervisor in the field. Block susbtitutions are made only in the Sacramento office. If a sampler or supervisor believes that a block substitution is necessary, supporting facts should be attached to the block folder and returned to Sacramento, through your supervisor. Below is a list showing some examples of when block substitution may be necessary and sampling will be omitted for these blocks.

1. Refusal to cooperate by owner or operator.
2. Blocks that are pullouts. (Where 75 percent or more of the block including both sample units have been pulled out or abandoned).
3. If, by some means, the enumerator finds that the block is totally of the wrong variety, except in lemons where sampling by variety is not used.
4. Substitution is also necessary when the total orchard or a large portion including the sample trees is of the obvious wrong age. The orchard may be a replant and different from last years sample.

B. Tree or Vine Substitution:

(The word Unit will be used instead of tree or vine and orchard will be used instead of grove or vineyard).

Substitution is necessary when any one of the conditions (in #3 below) are met. Two units must be sampled in each block. In grapes you must sample 3 units.

1. There should be no substitution of sample trees unless it is absolutely necessary. Whenever a substitution is made, the designated row and space number in the chart map's heading must be changed to show the substitution sample.

2. To substitute a unit, go to the next unit in the row away from the B.I.T.
   a. Make sure that the rows run the same way the varieties run.
   b. Make sure that the substitution is the same variety and age.
   c. If there is not a sample unit away from the B.I.T. (end of row, new planting, house, different variety, etc.) then select the next unit towards the B.I.T., making sure that it is of the same variety.
3. Substitute the sample unit when selected unit space is:
   a. Blank (unit is missing).
   b. Occupied by a non-bearing unit.
   c. Occupied by a unit which has completely died.
   d. Unit is obviously the wrong variety (Franquette rather than Eureka; Thompson Seedless rather than Muscat), then complete a schedule for the old sample unit. Also select a replacement of the right variety. Prepare a new schedule and sample this unit also. In lemons, disregard this part since sampling by variety is not used.
   e. Unit is a different kind of fruit than that being sampled -- plums for peaches, oranges for lemons, etc.
   f. Impossible to locate a branch which can be counted with a 12-foot ladder (generally this applies to walnuts).
   g. Unit is operator's or other's experimental tree (this can usually be told by grafts, tag or other marketings).
4. DO NOT Substitute For A Unit For The Following Reasons:
   a. Because of size of unit or branch.
   b. Tree is of different age than other trees in block -- a replant.
   c. Tree is heavily pruned.
   d. Because tree has heavy or light set compared with other tree in block.
   e. Because the farmer says that there are better units in the orchard. Explain to him that the individual units do not give an indication for the orchard in which they are located, but for the district as a whole. Refer to section II on how the data is handled.

5. Lemons

The lemon blocks have an extra tree which is labeled as the "D" tree. The "D" tree is the substitution tree only if the original meets one of conditions in 3 above. If the "D" tree is to be sampled more than once during the year, inform your supervisor so he can select a new group.

6. Pullouts

a. In cases where 75 percent or more of the block including both sample units have been pulled out or abandoned, consider the block a pullout and do not sample.

b. In any case where more than 25 percent of the block remains, including one of the sample units, select the replacement for the missing unit based on the instruction above.

c. If part of the orchard has been pulled out, but the B.I.T. and sample units remain, continue to sample the block. Indicate the change on the map.

d. If the sample block is still in production, but a sample unit is missing, choose the next one in the row to be the sample unit.

CALIFORNIA CROP AND LIVESTOCK REPORTING SERVICE
P O BOX 1258
SACRAMENTO, CALIFORNIA 95806

WALNUT OBJECTIVE MEASUREMENT SURVEY
SAMPLING INSTRUCTIONS

1974 SURVEY

Stephen Pavlasek, Jr.
916 - 445-4478
[redacted]

I. INTRODUCTION: It is the responsibility of all personnel to read these instructions prior to attempting actual field work.

The Walnut Objective Measurement Field Survey will be conducted during the month of August as usual. The main objective of this survey is to obtain data for use in forecasting expected crop production. There are many factors that affect annual walnut production and it has been surmised in the past that most of these factors involved are measurable and can be evaluated from the Walnut O.M. Survey run in August.

The sample for this year will consist of 575 sample blocks. The sample is distributed in each county in proportion to the bearing acres in that county. In effect, we are sampling as if all the walnut trees in the State were one big orchard. It is not expected that the data collected in any one orchard will be representative of all orchards; but only that it will represent part of the population of all trees in the State. Therefore, in some blocks the sample trees will be the best trees and in others they may be the poorest. Both poor and good trees are needed to give us a representative sample to aid in forecasting the size of the total walnut production in the State.

Each sample block will have 2 sample trees which will be sampled by counting all the nuts on an accessible branch. In addition to counting the nuts on these branches, a sub-sample of nuts will be picked so that we can determine the average size, weight, and percent cullage of nuts.

II. GENERAL: These instructions contain information on the field portion of your work on the Walnut Objective Yield Survey. For information pertaining to time and mileage records and other general information about all fruit and nut objective yield surveys, you should refer to the Objective Measurement Survey Sampler's Manual.

III. EQUIPMENT AND SUPPLIES: You will be supplied with all necessary equipment and supplies to do your work. You will be asked to sign for this equipment when you receive it and it must all be returned to your supervisor when you complete your work.

IV. WORKING UNITS: Work on the survey will be done in teams of two traveling in the same vehicle. You will work directly under your area supervisor. All completed work, time and attendance sheets, supplies, etc. will be turned in to him. Your supervisor will also check a sample of your work to see if you are having any problems that you are unaware of. Any questions, problems, etc. that come up in the course of the survey should be taken up with him.

V. ORGANIZING WORK: When planning your work it is generally most efficient to begin each day with the sample furthest from where you live and then work towards your home during the day. Your work should be arranged so as to minimize mileage and travel time. Use maps where possible to ensure traveling by the shortest routes. Use the telephone where practical to cut down time, and mileage expenses.

VI. FIELD PROCEDURES:

A. Permission to Enter the Orchard: Each sample folder should have a permission agreement inside of it. Check this agreement to see if you should contact anyone prior to entering the orchard. If there is no permission agreement or if it indicates you should contact the operator first, be sure to do so prior to entering the orchard.

B. Locating the Sample Orchard: Each team will be provided a folder for each sample they are to work. Each folder will contain an Orchard Chart Map. The heading of the Orchard Chart Map will have the name, address and phone number of the owner and/or operator of the orchard.
(This information should be updated if possible).
There is also a narrative description of the orchard location in the heading of the Orchard Chart Map. The Orchard Chart Map itself will show the adjacent roads and the layout of the orchard.

Proceed to the corner of the orchard where the BIT (Block Identification Tag) is attached to the corner tree. This is identified on the Orchard Chart Map by a blacked out tree space with the letters BIT adjacent to it. Once you have located the BIT, double check the numbers on the back of it to be sure you have the proper orchard. The numbers on the BIT and the numbers on Orchard Chart Map and Random Path schedules must all agree.

You should retrace the numbers on the BIT with felt pen so they can be read next year. Replace the BIT with a newly prepared one if it is missing or damaged.

C. Locating the Sample Trees: Each sample consists of two "units" of one tree each. Each Orchard Chart Map has a small table at the upper left which lists the row number and space number for tree 1 and tree 2. Near each of these numbers is a small arrow showing which direction you should travel in counting rows and spaces. In addition each sample tree is outlined and labeled on the Orchard Chart Map. If, when you arrive at the sample tree, you find it falls into one of the categories listed below, it will be necessary to select an alternate tree to make your counts on:

1. The selected tree space is blank (no tree).
2. The selected space is occupied by a young, non-bearing tree.
3. The selected space is occupied by a dead tree.
4. The selected tree is obviously of a variety other than that specified in the heading of the Orchard Chart Map.
5. The selected tree is not a walnut tree.
6. The selected tree is being used for experimental purposes by someone else (usually can be told by tags, grafts or other markings on the tree).

D. Selecting an Alternate Tree:

1. To select the alternate tree proceed away from the BIT in the same row as the original tree until you come to the next tree that meets all of the criteria to be counted.
2. If there are no eligible trees for counting in the same row away from the BIT, then select the next eligible tree in the same row towards the BIT.
3. Be sure the alternate tree selected is the proper variety.
4. See Sampler's Manual for additional information.

E. Data Collection - Random Path:

1. When you have located tree number one, check the tree ID tag to be sure it agrees with the Random Path schedules and you have the proper tree and sample. Retrace the numbers on the tree ID tag with felt pen so they will be visible next year. Replace the tag with a new one if necessary. The tree identification tag will be found on the sample branch which we will call the accessible branch.
2. Once you are sure you have the proper tree enter the date, time started in military time, and recorder's and measurer's names on the headings of the Random Path schedule for tree 1. Also check if block, row, and tree tags, were found or if a new one was hung.

F. Sampling Procedures:

1. Sampler will measure with a CSA (Cross-Sectional Area) tape the cross-sectional area of the trunk and of each primary scaffold (0.5 CSA or larger) emanating directly from the trunk. The primaries will be numbered starting with 1 in the direction of the BIT and going clockwise around the tree and will be measured and recorded in this order. After trunk and primary CSA are recorded, continue along the primary on which the accessible branch is located. If the accessible branch is itself a primary, then measurements will be completed. However, in most cases it will be necessary to measure the secondary splits and record these. If these measurements to this point do not take in the measurement of the sample branch, then continue the procedure along the path of the accessible branch until the measurement of this branch and alternate splits are recorded. Finally, blacken in the small box which corresponds to the accessible branch after the measurement of the accessible branch and indicate the path followed on the schedule back to the trunk by blackening in the proper boxes on each stage. (See example #1). The TIT will be hung at the point where the accessible branch starts.
2. The measurements will be recorded on the accessible branch measurement schedule.
   a. For measurements of 10 CSA measurements or less, read tape to the nearest tenth, and record one decimal to the right. Example: record as 9.8; 10 record as 10.0
   b. For all limbs larger than 10 CSA measurements, read the tape to the nearest whole CSA measurement. Example: 11.8 record as 12.0; 11.4 record as 11.0.
   c. Record all measurements with one digit to the right of the decimal. Example: 300 record as 300.0; 1.2 record as 1.2.

d. In some instances, the CSA tape will not reach completely around the trunk of the tree. If this should happen, turn the tape over to the side reading inches, mark both beginning and end of tape and work around tree accumulating total inches until total circumference is measured. Record total inches <u>outside</u> trunk measurement block and label as inches. We will convert the inches to CSA measurements in the office.

4. Start the count at the base of the tree part to be counted, or on old sample blocks, from the tree identification tag that is hung. Count the laterals as they are encountered, progressing from the base of the branch to the terminal end of the branch. Feel along the main part being counted for lateral branches and at the same time use the marking crayon to mark along the main trunk as you proceed. Count each nut as it is encountered and mark it with a crayon. Pick off every 5th nut and place it in the picking bag. Using the tally sheet provided, the sampler recording the nut count will check off each nut as counted by his partner and tally every 5th nut counted in the tally column as follows:

one two three four tally or pick

Enter the odd count in the tally column and compute total count for each stage, recording this in the tally column and also on the schedule in the box provided. Label the branch stage in the left margin and draw a line across the tally columns before proceeding with the next stage.

Continue this procedure picking off every 5th fruit; thereafter, record the count and place the nuts in the picking bag. If it is necessary to move the ladder before completing the count on the sample branch, a marker tag should be hung just past the

last lateral counted, so that the starting place for the next ladder set can be easily seen from the ground. If the count ends in a number other than 5, mark the odd count lightly on the thumbnail so that you will pick up the count again after the ladder is reset. The exact off count at the end of the branch is the last count entered on the schedule. A sizer nut is not picked except when the count reaches 5. Occasionally, terminal branches will extend so high some nuts will be counted by sight only. Samplers should have with them a stick with a hook at the end to help them sight-count the nuts and to pick off the sample nuts. Include all nuts in the count except those which are totally shrivelled, totally blighted, or dwarfed; generally these will fall of when tapped lightly.

5. Count the number of sample nuts picked off. This should be the same as the number of tallies on the schedule, other than the odd count.

6. If after determining the terminal branch count you have at least 10 sizer nuts in the picking bag, no additional picking need occur.
   a. In cases where less than 10 nuts are in the picking bag at the completion of the branch count, return to the point of beginning of the count and select nut number 2 and enough successive nuts to bring the total nuts picked to ten.

7. Select Sub-Samples of Nuts
   a. From Nuts Stripped from Terminal
      (1) Place all nuts stripped from the terminal end on the counting board, spreading them in a continuous line, single file.

(2) Count the nuts and enter the total counted on the Random Path Schedule in the box which corresponds to the last stage where the terminal branch is recorded.

(3) Select 20 nuts for a sizing sample as follows:

(a) Divide the total counted by 20 and round to the next largest whole number. This is the "sampling interval".

(b) Use the third line of the Random numbers table (on the Random Path Schedule), ignoring the last digit to the right of the decimal. Choose the first number which is 01 or greater but which is not larger than the interval. The number chosen designates the first nut to choose from the line of nuts described above (see a. (1)).

(c) Select the 2nd nut by adding the "interval" to the Random number.

(d) Select the 3rd nut by adding the "interval" to the number for the 2nd nut.

(e) Select the 4th nut by adding the "interval" to the number for the 3rd nut. Proceed until 20 nuts are selected. If you reach the end of the line of nuts before the 20th nut is obtained, continue the count at the beginning of the line.

(f) If the total of nuts counted is between 10 and 20, include all nuts for your sample.

(g) Place the sample just selected in a neoprene bag. Place the Sizing Sample identification marker in the bag.

RANDOM PATH SCHEDULE
CALIF. CROP AND LIVESTOCK REPORTING SERVICE
P. O. BOX 1258, SACRAMENTO 95806
PHONE (916) 445-3214

Survey Code	Year	County	Variety	Block Number	Tree Number	Checker Code	Update Code	Form Number	Month/ Day	Block Status	Number Stages
291	74	10	15	44	1			1	7/1		3

Tags:	Block	Row	Tree	Start Time	End Time	Minutes	Team	Recorder	Measurer
Found	✓	✓	✓	0820	0905	45		K. McPEAK	D. OKUMURA
Replaced									

BLOCK STATUS CODE: 1 Sampled, 2 Wet, 3 Pulled Out, 4 Abandoned, 5 Sprayed, 6 Substitute, 7 Not Visited, 8 Refusal, 9 Not Found

	Branch	Stage: Trunk 0	Primary 1	2	3	4	5	6	7	8
1	CSA	66.0	41.0	4.3	4.1	.	.	.	.	.
2	CSA		28.0	36.0	3.9	.	.	.	.	.
	Total		69.0	40.3	8.0	.	.	.	.	.
3	CSA		.	.	32.0	.	.	.	.	.
	Total		.		40.0	.	.	.	.	.
4	CSA		.	.	.	.	.	.	.	.
	Total		.	.	.	.	.	.	.	.
5	CSA		.	.	.	.	.	.	.	.
	Total		.	.	.	.	.	.	.	.
6	CSA		.	.	.	.	.	.	.	.
	Total		.	.	.	.	.	.	.	.
7	CSA		.		000					
	Total		.		000					
					00L					
8	CSA		.							
	Total		.							
9	CSA		.							
	Total		.							
10	CSA		.							
	Total		.							
Random Number			.	.	.	.	.	.	.	.
Selected Branch			1	2	1					
Fruit Count					42					
Check										

TABLE OF RANDOM NUMBERS

316.7	66.1	64.4	94.3	16.6	91.9	3.1	6.7	3.6
041.3	54.1	55.8	34.3	63.5	35.2	3.6	1.9	0.0
184.1	72.8	48.1	18.3	47.9	98.2	3.4	0.5	6.1
192.4	18.6	19.1	36.7	41.8	61.1	7.4	5.2	4.7
159.9	74.6	27.7	37.0	75.8	31.9	0.7	1.7	2.4
179.4	32.3	92.1	97.6	36.1	19.9	6.3	3.1	4.1
408.7	78.4	64.2	25.0	11.8	62.7	0.1	3.7	4.2
089.9	62.0	95.3	67.8	70.0	44.1	8.7	1.5	9.8
186.9	12.3	02.8	07.8	33.2	62.4	8.3	0.0	2.3
234.8	76.3	78.4	16.0	56.5	96.1	0.5	0.8	6.7
340.6	05.0	41.4	98.0	72.0	28.8	0.7	4.2	8.4
459.3	46.9	78.3	54.8	25.9	36.2	8.2	4.2	4.3
434.7	47.6	65.6	43.8	29.9	78.2	8.2	3.0	2.9

COMMENTS: _____

California Crop and Livestock Reporting Service

P. O. Box 1258

Sacramento 95806

WALNUT OBJECTIVE MEASUREMENT SURVEY

SIZING INSTRUCTIONS

1974 SURVEY

Stephen Pavlasek, Jr.
445-4478
916 - [redacted]

WALNUT OBJECTIVE MEASUREMENT SURVEY

SIZING INSTRUCTIONS

1974 SURVEY

A. General

1. Be sure to read section VI, General Sizing Instructions, page 19 of your Sampler's manual.
2. A sample of nuts will be removed from the accessible branch and will be sent to one of the field sizing stations for detailed size analysis.
3. The sizing stations will be located at Modesto, Forrestville, Biggs, Atwater and Traver (southern California samplers will send the sample nuts to Traver).

B. Recording the Identification of the Sampler

1. When the sample is delivered, there will be an identification tag in the polyethelene bag.
   a. Tree #1 will use the blue tag.
   b. Tree #2 will use the pink tag.
2. The tag will contain the county number, variety code, block number, and tree number.
   a. County number is a three digit number, and must have enough zeros perceding the county number to make a three digit number.
   b. Variety code is a two digit number, a number less than 10 must be preceded with a zero.
   c. Block number is a three digit number, and must have enough zeros preceding the block number to make a three digit number.

d. Tree number is a one digit number--no zero will precede it.

3. Record your sizer code in the appropriate box. Your sizer station code is as follows:

Station	Code
Modesto	3
Forrestville	4
Biggs	5
Atwater	7
Traver	9

4. The bag I.D. tag will have the date sampled on it. Enter this under the proper column using the table below to convert to the day of the year.

5. Enter the data sized in the same manner.

Julian Date Conversion

Date	Day of Year	Date	Day of Year
July 28	209	August 10	222
29	210	11	223
30	211	12	224
31	212	13	225
August 1	213	14	226
2	214	15	227
3	215	16	228
4	216	17	229
5	217	18	230
6	218	19	231
7	219	20	232
8	220	21	233
9	221		

6. Now check to see that all boxes have the correct number of digits entered and that zeros precede the digits where necessary. Proceed to the next step.

7. You should sort the bags by county and tree before you start sizing. Also, try to do the oldest samples first.

8. It is advantageous for the sizing crew to continue with the same job until you take a break.

C. Individaul Nut Measurements

These measurements will be recorded on the white measurement cards.

1. Remove the walnuts (maximum of 20 nuts) from the neoprene bag and place in a continuous line.
2. Select the first walnut starting at the left. Measure this walnut in-hull at its widest point perpendicular to the blossom-stem axis. Record this measurement (to the nearest whole millimeter) in the two columns under the heading labeled "Width" for nut #1.
3. Make a visual determination of the in-hull grade of this nut and record the code for this grade in the column labeled "Grade" for nut #1.
4. The grades are as follows:

   SOUND = 1 (no apparent damage other than wind scarring or superficial hull damage)

   SHRIVEL = 2 (the outward appearance of the hull indicates that the nut will not mature; i.e., the hull is beginning to shrivel due to factors other than blight or sunburn)

   SUNBURN = 3 (the hull will first start to turn yellow. The area will become larger, then then the center will turn yellowish brown, then dark brown. Generally, there will be no depression. Sunburning can cause flat siding if it occurs before shell hardening, after shell hardening there will be no flat siding. Consider the nut sunburned whenever 10% or more of the surface is affected. You should cut some nuts to determine if the meat has been damaged. Meat damage will vary by district and orchard. In advance stages the meat will have turned black and will be shriveled. There will not be any wet substance inside the skin. See examples.)

   BLIGHT = 4 (there will be a depression and the hull inside the depression will be dark brown to black. Generally, the blight will start to darken the meat by the time the depression

is about 3/8" in diameter. Depressions 3/8" and larger in diameter should be coded as blight damage. In advance stages of blight the meat will be black, and shriveled. Inside the skin, there will be a wet substance. See examples.)

WORM DAMAGE = 5 (see examples for husk flies.)

DARK KERNEL = 6 (the only time you will be able to grade a nut thusly will be for those nuts which you cut to examine. Code as a dark kernel those kernels which are coffee colored or darker.)

NUTS #1 AND #2 NEED NOT BE CUT.

5. Select the next nut on the left in line, complete steps 2 and 3 and record in the proper columns for nut #2.
6. Measure the third walnut in-hull at its widest point and record as discussed in point 2.
7. Turn the walnut 90 degrees and measure the "cross width" (i.e., the narrowest point) perpendicular to the blossom-stem axis and record under the columns labeled "C Width".
8. Measure the length of the walnut (from the blossom end to the stem end) to the nearest whole millimeter and record in the columns labeled "Length".
9. Place the nut on the electronic balance and record the weight to the nearest ONE-TENTH of a gram in the columns headed "Weight".
10. Make a visual determination of the in-hull grade and record as explained in points 3 and 4.

CUT AWAY THE HULL IN THE NECESSARY PLACES AND MAKE THE FOLLOWING MEASUREMENTS.

11. Measure the width at the widest point on the suture line. Record this in the columns labeled "Width" for the in-shell portion of the data.

12. Turn the nut 90 degrees and obtain the cross suture measurement and record in the columns labeled "Cross Width".
13. Measure the length of the walnut in-shell and record.
14. Cut the nut in half at the suture and make a visual determination of the grade and record as discussed in point 4 with the following exception: Grade as "Shrivel" the nuts which have kernels that are "pulling away" from their original area -- this will be explained in detail during a visit by someone from Sacramento. See examples.
15. Complete appropriate steps for the remaining nuts as required.
16. After the last nut has been sized, make a visual check of the recorded data. The column numbers indicate the number of digits to be recorded for that particular measurement for each nut. By checking each column from top to bottom, any errors in recording the measurements can be detected before proceeding to the next sample.
17. If less than 20 nuts are in the sample, draw a line across the card through spaces provided for the next nut.
18. Caution must be exercised to keep all recording legible. Make all erasures clean and new figures clearly readable.
19. Any notes required regarding each nut or sample may be placed on the back of the card with the word "over" at the top of the front of the form.
20. A sample card has been made up which may help to answer some of the questions which may arise. Notes were put on front of the card for duplicating purposes. (See page 6, Example #1 Measurement Card)

WALNUT OBJECTIVE MEASUREMENT FIELD SURVEY 1974
(Columns 1-19 to be keyed for all 20 nuts)

BLOCK IDENTIFICATION

SURVEY CODE	BLOCK CODE			TREE NUMBER	SIZER CODE	JULIAN DATE SAMPLED	JULIAN DATE SIZED
	COUNTY	VARIETY	BLOCK				
1-[illegible]	4-6	7-8	9-11	[illegible]	13	14-16	17-19
045	020	08	044	2	7	226	227

Measurement Cards

Nut #	IN HULL MEASUREMENTS					IN SHELL			
	Width mm	Grade	C. Width mm	Length mm	Weight gr	Width mm	C. Width mm	Length	Grade
20-21	22-23	24	25-26	27-28	29-31	32-33	34-35	36-37	38
01	44	1							
02	44	1							
03	45	1	44	56	60.1	36	36	42	1
04	42	1							
05	43	3							
06	44	1							
07	46	1							
08	46	1	46	50	59.6	36	37	41	1
09	39	1							
10	46	2							
11	43	1							
12	41	1							
13									
14									
15									
16									
17									
18									
19									
20									

SCRA30