Statistical Investigation of a Sample Survey for Obtaining Farm Facts

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AMES, IOWA

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SUMMARY AND CONCLUSIONS

1. A number of the problems of sampling farm facts by means of two sample surveys taken in Iowa have been studied statistically. These were essentially problems of sampling efficiency and the detection and measurement of biases and other errors in the data.

2. A sample survey of 800 farms provided estimates for the state of Iowa which were in many cases as accurate or even more accurate than corresponding information provided by the Federal Census, Iowa State Farm Census or Federal Agricultural Marketing Service. On the other hand, it was found that some items cannot be accurately estimated from a small (800 farm) sample survey, but these items are in many cases only of minor importance.

3. The sampling methods used in these experimental surveys were found to be not only relatively free of bias but also satisfactorily efficient. Certain modifications, however, have been recommended. Some principles have been suggested for modifying size of sampling unit for maximum efficiency when certain cost situations are given. Another feature of the sampling method is that it provides a basis for making unbiased estimates of total number of farms and total land in farms in any desired area and, therefore, is independent of any other source of information.

4. It has been found that wide geographical distribution of sampling units (that is, geographical stratification into small areas) substantially reduces sampling error. Stratification by tenure group would bring only small gains if any.

5. A method has been proposed for determining the best size of sampling unit for given cost situations and for given expenditure levels. It was concluded that the quarter-section grid is an efficient sampling unit under widely varying circumstances. For investigations requiring very short interviews the half-section grid appears to have important advantages. For general inquiries (such as the census, for example), large blocks such as townships appear to be very inefficient sampling units.

6. Matching samples has proved to be an efficient method of measuring differences between years. Compared with samples taken independently each year, matched samples are from 2.5 to over 20 times as efficient, depending upon the item.

7. Matching as a special case of double sampling has been investigated. As an example of this case: A large sample is taken for a base year; in the subsequent year a small sample is taken at random from the large sample. Precise estimates of the mean of the second year are desired. If there are any correlations for items between the two years, the estimates for the second year can be somewhat improved over that obtainable from small sample considered independently. When the relative variances of these adjusted estimates were compared with the unadjusted for a selected group of items, it was found that substantial increase in sample information was gained by the matching technique.

8. Sampling errors for a 900 quarter-section sample have been found to range from 2.4 to 14.2 percent of the grid mean, depending on the item investigated. Number of sheep on farms and number of hogs bought were the most difficult to sample (having highest sampling errors). Sampling errors ranged most generally from 3 to 4 percent for these samples.

9. Biases and other errors have been detected and measured. The more important biases have been found to be chargeable to the interview method rather than to sampling method. Receipt items were seriously biased (as high as 50 percent). Failure to remember inventories of a year ago accounted for biases of 10 to 20 percent. Reports given the Iowa assessors for the annual state census were for some items quite different than those given the survey enumerators. Assessors obtain about a bushel per acre less corn yield than the sample surveys.

Since these biases are not removed by taking larger samples it indicates that improved accuracy is attainable only by improving one's knowledge on the nature and extent of this bias or by eliminating it. We believe that both methods should be tried.

10. Random variations in the reports given the assessor and sample survey enumerators were found and measured. After removing effects of farm and bias, if any, these variations (considered to be more or less random) measured as standard deviations in percentages of the means ranged from 6 to 88 percent for those farmers having some of the item. If this is really a measure of the random inaccuracies in interview data then it appears that here is an important source of error. The coefficients of variation of the farm population (stratified) from which the survey

sample was drawn ranged from 75 to 425 percent. It suggests that if attention was given to the problem of minimizing these inaccuracies the precision of sample estimates could be increased somewhat.

11. A high degree of constancy has been found in the distribution. of variance in the farm population, although certain shifts were noted. These shifts were such that the desirability of a high degree of geographical stratification was made even more evident.

12. The adoption of the method of repeated visits during the year combined with the use of some simple kind of bookkeeping system would seem to hold promise of minimizing some of the more serious errors in the economic items. Perhaps only two or three visits during the 12 months will be necessary. All pertinent information from previous visits should be available during the subsequent visits for memory aids to both interviewer and interviewee.

Statistical Investigation of a Sample Survey for Obtaining Farm Facts*

By Raymond J. Jessen†

STATEMENT OF THE PROBLEM

This study was undertaken to investigate the following questions pertinent to the problem of collecting data by the sample survey method.

(a) What is the amount and nature of error in data secured by interview?

(b) What is the best available sampling procedure?

(c) What method of "expanding" sample data will provide the best estimate of state or subdivision totals?

DESCRIPTION OF THE SURVEYS

To provide the data for the investigation, two sample surveys of Iowa farms were made during the last 2 weeks of December and the first 2 weeks of January, 1938-39 and 1939-40. The questionnaires used on these surveys carried questions designed to give general information on acreages and productions of crops; numbers of livestock bought, sold and on hand; receipts; expenditures and values of farm land and equipment; number of persons moving off and onto farm; number of cattle on feed, sow breeding plans, scale of living, etc. One of the objectives of the surveys was to test the feasibility of securing income information for a

calendar year by a single interview, consequently many of the questions were constructed for this purpose.

Since the bulk of the information from the surveys applies to the calendar years 1938 and 1939, it will be convenient to use these year numbers to identify the two surveys. The sampling procedure of the 1938 survey was as follows: The quarter-section grid (an area of about $\frac{1}{4}$ square mile or 160 acres) was selected for the sampling unit; the county was set up as the stratum.[1] Townships[2] were selected at random from each county—seven from an average size county of 16 townships, and in the same proportion for counties of other sizes[3]. Quarter-sections were selected[4] at random from each of the selected townships—one each from five, two each from the remaining two[5]. An average size county would therefore have nine quarter-sections selected for the sample. The total number of agricultural quarter-sections in Iowa is about 219,176. Of these 908 (0.4 percent of them) were selected for the sample.

The quarter-section grids merely designated the areas in which the farms to be enumerated would be found. A farm[6] was enumerated if its farmstead was situated within one of the selected grids. Farms were enumerated as complete units regardless of the location of their land area.

The 1939 survey was an integral part of the first survey. Four hundred and fifty-two (452) or approximately 50 percent of the sample grids of the 1938 survey were selected for re-enumeration. Four hundred and forty-five (445) new grids were selected at random bringing the second sample up to a total of 897 grids. Both the old and the new grids were selected in the same manner as stated above. The reason for this particular sampling design will be discussed later.

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[1] The large counties Pottawattamie and Kossuth were each divided into two parts.

[2] Survey rather than political townships.

[3] Size of county was measured by the total number of agricultural quarter-sections it contains.

[4] Only quarter-sections situated in an agricultural area were accepted. Those situated in incorporated town limits, lakes, rivers, or national parks were rejected and new selections made.

[5] The selections were made in this manner in order to assure that a sufficient number of townships would contain two sample quarter-sections with farms. This would permit of better estimates of quarter-section variance within townships. Later, however, it was found that by randomizing quarter-sections within counties (ignoring townships) would have given about the same geographical distribution and therefore the above precaution was unnecessary.

[6] A tract or tracts of land 8 acres or more under one management was considered a farm. This followed the Iowa assessor definition. See footnote 8 page 18 for elaboration on this point.
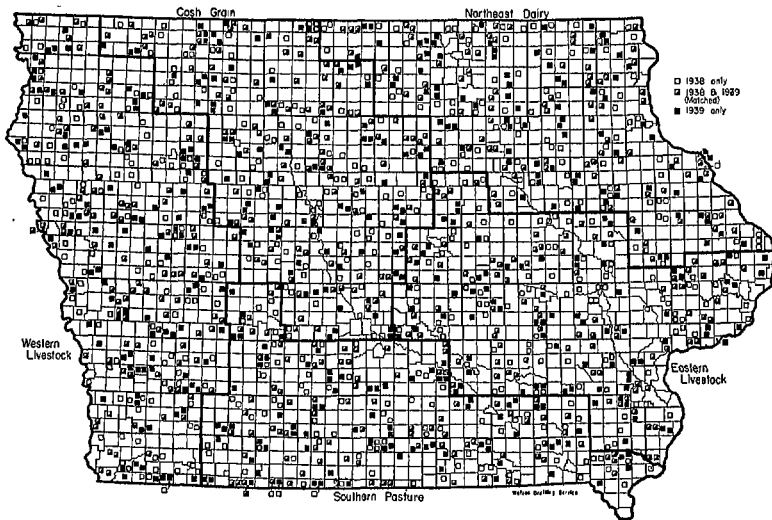
Fig. 1. Map of Iowa indicating the locations of the quarter-section grids selected for the 1938 and 1939 Iowa sample surveys. Of 1353 in all, only 456 were visited in 1938, 452 were visited both in 1938 and 1939; only 445 were visited in 1939.

ENUMERATION PROCEDURE

Enumerators were instructed to visit each farmstead situated on the selected grids to interview either the operator or whomever might be familiar with the farm's business. If no one was found at home[6a] or if non-cooperation was met, the enumerator was instructed to substitute the next nearest farm in that vicinity, a record being kept of all such cases.

Instructions for grids selected for revisitation were as follows:

(a) Change of operator and change in farm acreage were ignored.

(b) New farms (those appearing since the previous visit) were to be enumerated.

(c) Farms disappearing were recorded.

(d) If during the first visit farms were substituted these were re-enumerated instead of those for which substitution was made.

[6a]Some special cases:
   Operator does not live on selected "farm".
   a. Operator lives on some other "farm"—tract regarded as no farm.
   b. Operator lives in town—if not convenient to visit, enumerator was instructed to substitute a nearby farm.

Enumerators were in the field during the last 2 weeks of December and the first 2 weeks of January. The bulk of the enumeration, however, was accomplished during the middle of this period.

GENERAL DISCUSSION ON THE QUESTIONNAIRES AND ON FIELD OPERATIONS

The time required for enumerating the questionnaires was 32 minutes for the 1938 questionnaire and approximately 50 minutes for that of 1939. The enumerators felt that the longer questionnaire was nearing the maximum desirable for this kind of an inquiry where little was done to acquaint the farmers beforehand of what was to be asked of them. In an opinion poll of the 15 enumerators employed on the 1939 survey, it was found that they unanimously agreed that letters sent to farms selected for revisitation (matched farms) were helpful. (These letters were sent out about a week before enumeration began and contained a brief statement thanking the farmer for his cooperation last year and a statement that we intended to revisit him this year.) Most enumerators were of the opinion farmers would appreciate something in exchange for their effort—experiment station or government publications, a report on the findings of the inquiry, etc.

. Finding the designated quarter-sections in the field was not very difficult except in the northeastern section of the state and in other isolated instances. In most of the northeastern counties it was found advisable first to visit the county AAA offices where their aerial maps were used to secure information such as number of farms, if any, landmarks, etc., useful to the enumerator.

THE DATA

Usable records were obtained from 773 farms in 1938 and 782 farms in 1939. In the following tables are presented state estimates for selected items based on data from the two sample surveys compared with figures supplied by the State Farm Census (taken by the township assessor), AMS, and Federal Census.

It can be seen that for some items the sample surveys compare quite favorably with other sources of data, whereas

for others there appear to be serious differences. An investigation of this matter will be presented below under the topic "Errors". For a more complete discussion of the representativeness of the sample survey see Appendix C (pp. 83 to 94).

TABLE 1. ESTIMATES OF TOTALS FOR THE STATE OF IOWA ON 28 FARM ITEMS OBTAINED FROM THREE SOURCES: (a) SAMPLE SURVEY, (b) IOWA STATE FARM CENSUS AND (c) AMS 1938 AND 1939.

	1938 Source of data			1939 Source of data		
	Sample survey[a] (thousands)	State census[b] (thousands)	AMS.[c] (thousands)	Sample survey[a] (thousands)	State census[d] (thousands)	AMS.[e] (thousands)
Land in farms (acres)	34,080	34,403	....	34,080	34,545	....
Acreages (harvested)						
Total corn...................	10,149	10,270	10,417	9,272	9,373	9,688
Husked..................	9,557	9,709	9,844	8,832	8,943	9,261
Silage..................	210	233	240	170	179	194
Fodder.................	198	211	....	160	156	....
Hogged.................	184	116	....	110	95	....
Oats, grain..................	5,980	5,923	5,972	4,838	4,973	5,076
Wheat, grain, winter and spring.	635	581	592	426	389	390
Barley, grain	393	422	447	587	544	563
Soybeans, grain	331	306	321	572	539	487
Alfalfa, hay.................	898	814	879	845	789	879
Production of crops						
Corn, grain (bu.)....:......	455,550	449,509	452,824	481,353	467,055	481,572
Oats, grain (bu.).......	206,753	206,205	209,020	149,954	154,159	154,818
Wheat, grain, winter and spring.	9,152	9,091	9,284	6,432	6,726	6,490
Barley, grain (bu.)...........	12,266	12,831	13,634	13,540	12,533	13,794
Soybeans, grain (bu.)	6,856	6,462	6,741	11,738	11,096	10,227
Alfalfa, hay (tons)...........	1,895	1,797	1,934	1,636	1,657	1,846
Livestock (1/1/39: 1/1/40)......						
Horses, all ages (head)........	763	723	783	743	...[h]	752
Mules, all ages (head)........	55.8	47	55	45.8	...[h]	54
Cattle, all ages (head).........	4,295	4,001	4,465	4,721	...[h]	4,688
Sheep, all ages (head)........	1,303	1,229	1,710	1,105	...[h]	1,844
Swine, all ages (head)........	7,398	6,512	8,179	10,240	...[h]	9,651
Chickens (head)..............	28,661	27,377	30,172	31,736	27,846	30,930
Miscellaneous...................						
Sows bred or to be bred for						
spring farrow (head)........	1,765	1,707	1,643[f]		1,608	1,778[g]
Number of tractors...........	122	111	....		118	....
Number of autos.............	189	190	....		....	....
Number of trucks.............	20.2	19.8	....	25.1	18.8	....
Number of radios.............	158	151	....	178	....	....

[a]Estimated from sample survey data by expansion method 2 (see p. 16) for the rural (unincorporated) area of Iowa only.
[b]From the Thirty-Ninth Annual Iowa Yearbook of Agriculture. Figures rounded.
[c]Acreages and production of crops taken from Crop Report release of Dec. 12, 1929. Livestock figures taken from Livestock Report released Feb. 15, 1940.
[d]From the Fortieth Annual Iowa Yearbook of Agriculture. Figures rounded.
[e]Same source as ([c]). Preliminary.
[f]Crops and Markets, December, 1938.
[g]Livestock Report of Dec. 22, 1939.
[h]Collection of data on these items was discontinued in 1939.

TABLE 2.   YIELDS OF HARVESTED CROPS OBTAINED FROM SAMPLE SUR-
VEY, STATE CENSUS AND AMS, STATE OF IOWA, 1938 AND 1939.

Crop	1938			1939		
	Sample survey[a]	AMS prelim- inary[b]	State census[c]	Sample survey[d]	AMS prelim- inary[e]	State census[f]
Corn, bu./acre..................	47.7	45.5	46.3	54.5	52.0	52.2
Oats, bu./acre.................. ..	34.6	33.5	34.8	31.0	30.5	31.0
Wheat, all, bu./acre..............	14.4	16.4	15 7	15.1	16.6	17 3
Barley, bu./acre.................	31.3	29.0	30.4	23.1	24.5	23 0
Soybeans, bu/acre...............	20.7	19 5	21.1	20.5	21.0	20 6
Rye, bu/acre....................	....	....	....	11.5	14.5	14.1
Alfalfa hay, tons/acre...........	2.11	2.20	2.21	1.94	2.10	....
Soybean hay, tons/acre.........	....	....	....	2.06	1.50	....
Clover and timothy hay, tons/acre.	....	....	....	1.28	1.05	....

[a]Data from the 1938 survey of 778 farms.
[b]Crops and Markets, Vol. 15, No. 12, December, 1938
[c]Thirty-Ninth Annual Iowa Yearbook of Agriculture (1939).
[d]Data from the 1939 survey of 782 farms.
[e]General Crop Report, Dec. 19, 1939.
[f]Fortieth Annual Iowa Yearbook of Agriculture (1940).

TABLE 3.   ESTIMATES OF SELECTED FARM RECEIPT ITEMS[a] FOR THE STATE
OF IOWA SAMPLE SURVEYS AND AMS, 1938 AND 1939.

Item	1938		1939	
	Sample survey	AMS[b]	Sample survey	AMS[b]
	($1,000)	($1,000)	($1,000)	($1,000)
1. Government payments..............	22,769	29,719	55,214	69,444
2. Value of home-used livestock and live- stock products...................		33,550	24,040	28,365
3. Receipts from sales of:				
a. Cattle, calves, beef and veal.....	106,088	145,316	135,484	161,402
b. Hogs, pork and lard............	114,553	190,393	140,702	167,994
c. Sheep, lambs, mutton and lamb..	3,853	9,855	5,924	11,051
d. Chickens.....................		19,275	7,935	17,486
e. Eggs.........................	16,509	27,653	18,116	23,868
f. Dairy products................	48,495[c]	65,928	51,735[c]	60,789

[a]Items are not strictly comparable. AMS figures do not include inter-farm trans-
actions, whereas the sample survey figures do. The actual discrepancies there-
fore are somewhat larger than they appear in this table. Sample survey estimates
are based on the raw data—no adjustments for bias have been made.
[b]Preliminary.
· [c]A net figure. Products brought back have been deducted.

TABLE 4.   PERCENTAGE OF IOWA FARMS IN EACH TENURE GROUP; DATA
FROM THE 1939 SAMPLE SURVEY AND THE FEDERAL CENSUS.

Tenure group	Sample survey 1939	Federal census	
		1935	1940
	(%)	(%)	(%)
Owner...	37.3	39.2	41.3
Renter...	50 9	49.6	47.6
Part-owner.....................................	11.3	10.5	10.5
Manager..	0.5	0.7	0.6

ERRORS DUE TO THE VAGARIES OF SAMPLING

Estimates of the standard errors of the sample means, expressed as percent of the mean, have been computed for a selected group of items, on both an individual farm and quarter-section grid basis. These appear in table 5.

TABLE 5. ESTIMATED RELATIVE SAMPLING ERRORS OF SELECTED ITEMS ON BOTH A PER FARM AND PER QUARTER-SECTION BASIS, 1938 AND 1939 SURVEYS.

Item	Individual farm basis		Quarter section basis
	1938	1939	1939
	(%)	(%)	(%)
1. Number of swine	3.8	3.0	4.1
2. Number of horses	3.1	3.4	3.5
3. Number of sheep	14.4	9.6	15.0
4. Number of chickens	2.2	2.5	3.5
5. Number of eggs yesterday	3.8	4.3	5.0
6. Number of cattle	3.6	2.7	4.1
7. Number of cows milked yesterday	2.5	2.7	3.6
8. Number of gallons milked yesterday	3.1	3.2	
9. Receipts from dairy products	4.1		5.0
10. Farm acres	1.9	2.0	3.3
11. Corn acres	2.6	2.2	3.5
12. Oat acres	3.2	2.7	3.7
13. Corn yield	1.1	0.7	
14. Oat yield	1.3	1.6	
15. Feed expenditures, farm	8.6		6.0
16. Total expenditures, operator	5 2	3.3	
17. Total receipts, operator	5.6	3 3	4.1
18. Net cash income, operator	5.9	9.0	8.7
19. Corn sealed, operator	13.1		
20. Government payments, farm	4.9		
21. Number of hogs sold, farm		3.4	4.2
22. Number of cattle sold, farm		9.1	6.9
23. Number of hogs bought, farm		17.1	13.9
24. Number of cattle bought, farm		11.8	10.2
25. Number of cows milked during the year		2.3	
		2.5	
26. Number of hens and pullets, laying age			
27. Net income, operator			4.1
28. Number of persons on farm			3.2
29. Number of autos			3.0
30. Number of farms			2.8

It can be seen that the degree of precision by which various farm items can be sampled varies rather widely. For the items in the table, relative sampling errors range from 0.7 to 17.1 percent for the farm mean and from 2.4 to 14.2 percent for the grid mean. Most of the more important items, however, are around 3 percent or 4 percent and are slightly less on an individual farm basis.

In table 5a are shown estimated sampling errors of the 1938 survey on a type-of-farming area basis together with those for the state as a whole. Since these sampling errors have been estimated from sample data they are themselves

subject to the vagaries of sampling. In view of this, there-
fore, differences in estimated sampling errors among type-
of-farming areas may or may not be real differences and
must be interpreted with some caution. Some interesting
conclusions, however, can be drawn from these data. In the
following items: numbers of swine, horses, cattle; farm
acres, corn acres, corn yield and feed expenditures, the
Southern Pasture Area had the highest sampling errors.
For number of sheep it had the lowest. This is useful infor-
mation if type-of-farming area inquiries are to be made.
Under such circumstances samples for general inquiries in
the Southern Pasture Area should be somewhat larger than
those for other areas since many of the important items
show higher variability there.

TABLE 5a. ESTIMATED RELATIVE SAMPLING ERRORS OF SELECTED ITEMS
FROM THE 1938 SURVEY BY TYPE-OF-FARMING AREA AND FOR
THE STATE.

Item	Standard error as a percent of the mean					
	Northeast dairy area	Cash grain area	Western livestock area	Southern pasture area	Eastern livestock area	State of Iowa
(Number of farms).............	(%) (141)	(%) (158)	(%) (169)	(%) (143)	(%) (162)	(%) (773)
Number of swine...............	7.2	7.7	7.8	11.3	9.0	3.8
Number of horses..............	5.5	5.8	5.6	6.3	5.7	3.1
Number of sheep...............	31.8	40.1	30.0	17.6	24.1	14.4
Number of chickens............	5.8	4.7	4.6	5.8	4.3	2.2
Number of eggs yesterday.......	9.0	8 5	8.8	8.9	7.5	3.8
Number of cattle...............	6.6	6.7	7.8	10.6	8.9	3.6
Number of cows milked yesterday	5.5	5.2	7.6	5.6	5.5	2.5
Number of gallons milked yesterday	6.7	6.6	6.1	8.1	7.2	3.1
Receipts from dairy products.....	6.7	10.8	9.9	9.8	7.5	4.1
Farm acres....................	4.9	4.1	4.4	7.1	5.1	1.9
Corn acres....................	5.4	4.7	5.2	7.8	5.4	2.6
Oat acres.....................	5.9	4.8	9.1	9.2	5.9	3.2
Corn yield....................	2.3	1.7	2.5	2.9	2.5	1.1
Oat yield.....................	2.8	2.2	2.5	2.2	3.6	1.3
Feed expenditures, farm	13 0	11.2	12.1	26.3	22.3	8.6
Total expenditures, operator......	11.1	10.0	9.8	10.7	13.7	5.2
Total receipts, operator..........	8.3	a	9 3	10.4	11.2	5.6b
Net cash income, operator	8.8	a	15.1	12.5	11.3	5.9b
Corn sealed, operator	56.1	19.7	23.9	40.4	28.8	13.1
Government payments, operator..	13.6	8.7	11.0	10.4	8.9	4.9

aNot available.
bCash Grain Area not included in estimate of variance.

The difference between the two sets of sampling errors
is due in part to the variations of sampling and in part to
a real difference in the variabilities of items taken on the
two bases.

If $\bar{x}_g$ is the sample mean of an item on a grid basis
$\bar{x}_f$ is the sample mean of an item on a farm basis
$\hat{f}_g$ is the sample mean of number of farms on a grid basis

then
$$\bar{x}_g = \bar{x}_f \hat{f}_g \tag{1}$$

Now the variances must be the same in both cases, therefore,

$$\sigma^2_{\bar{x}_g} = \sigma^2 (\bar{x}_f \hat{f}_g) \tag{2}$$

$$\sigma^2_{\bar{x}_g} \doteq \left(\bar{x}_f \hat{f}_g\right)^2 \left(\frac{\sigma^2_{\bar{x}_f}}{\bar{x}_f^2} + \frac{\sigma^2_{\hat{f}_g}}{\hat{f}_g^2} + 2\rho \frac{\sigma_{\bar{x}_f}}{\bar{x}_f} \frac{\sigma_{\hat{f}_g}}{\hat{f}_g} \right) \tag{3}$$

or
$$V^2_{\bar{x}_g} \doteq \left(V^2_{\bar{x}_f} + V^2_{\hat{f}_g} + 2\rho V_{\bar{x}_f} V_{\hat{f}_g} \right) \tag{4}$$

where V is the relative standard error of the sample mean and ρ is true correlation of $\bar{x}_f$ and $\hat{f}_g$.

It can be seen in (4) that if ρ (that is, the correlation of item mean per farm with mean farms per grid) is zero then

$$V^2_{\hat{f}_g} \doteq V^2_{\bar{x}_f} + V^2_{\hat{f}_g} \tag{5}$$

ber of farms in the state provide the basic data for making expansions. In our case the quarter-section count can be made from a suitable set of maps (see appendix D, pp. 95 to 97) and figures on the total land in farms and total number of farms are available in the Iowa State Farm Census reports and the Federal Census. With these quantities known it is a simple operation to derive estimates of totals from a sample. For example, it has been found that there are 224,180 quarter-section grids in rural Iowa. Using this as a multiplier, item means per grid in the sample can be expanded to state totals. Similarly, expansions can be based on total farm acres or total number of farms. The three methods are presented symbolically in the following paragraphs.

If the total number of quarter-sections in the state is denoted by Q, the item mean per quarter-section (given by the sample) by $\bar{x}$ and the estimated state total of the item by $\hat{X}$, then

$$\text{(Method 1)} \qquad \hat{X} = Q\bar{x} \qquad\qquad (6)$$

If A is the total acres of land in farms, F the total number of farms in the state, $\bar{a}$ the mean acres in farms per quarter-section and $\bar{f}$ the mean number of farms per quarter-section, then also

$$\text{(Method 2)} \qquad \hat{X} = A\frac{\bar{x}}{\bar{a}} \qquad\qquad (7)$$

and

$$\text{(Method 3)} \qquad \hat{X} = F\frac{\bar{x}}{\bar{f}} \qquad\qquad (8)$$

To show the relationships that (methods 2 and 3) have to (method 1), these formulas can be written:

$$\hat{X} = Q\bar{x}\left(\frac{A/Q}{\bar{a}}\right) \qquad\qquad (7a)$$

and

$$\hat{X} = Q\bar{x}\left(\frac{F/Q}{\bar{f}}\right) \qquad\qquad (8a)$$

wherein (methods 2 and 3) become merely methods for adjusting (method 1), according to whether or not the sample deviates from the true values of the two characters, farm acres or number of farms per quarter-section. (Methods 2

and 3) require that A/Q and F/Q be known from sources other than the sample, such as a state or federal census for example. Before we can properly determine which of these methods provides the best estimate of state totals we should first consider the conditions under which each is appropriate.

TABLE 6. FARM ACRES AND NUMBER OF FARMS PER QUARTER-SECTION AS INDICATED BY STATE CENSUS AND SAMPLE SURVEY (1938 AND 1939) DATA: AND THEIR STANDARD ERRORS.

Item	State census (adjusted[a])	Sample survey	
		1938	1939
Farm acres per quarter-section..........	155 5	154.3	151 2
Standard error....	(0.23)[b]	[c]	(4.8)
Number of farms per quarter-section....	0 9159	0.8721	0.8628
Standard error........................	(0.010)[b]	[c]	(0.022)

[a]1938 report. Figures adjusted to remove incorporated areas. See appendix E, pp. 97 to 104.

[b]Estimated from the first differences of the time series including the period 1925-1937.

[c]Standard errors were not computed for 1938 data. Should be approximately the same as for 1939.

The discrepancies in the figures for farm acres per quarter-section may be due to any one or more of the following three causes:

(a) Bias; for instance, enumerators have failed to account for every farm situated on the selected quarter-sections.

(b) Quarter-sections have been selected which have fewer than average number of farms—a chance occurrence of the random sampling of quarter-sections.

(c) A variant of (b) where, although the quarters chosen were those having the average number of farms situated on them, these farms were less than average in size. This also could be the result of sampling variation.

Causes (b) and (c) are probably independent of (a) but are positively correlated with each other (correlation of total farm acres by number of farms on quarter-sections was +0.71). Both sample surveys taken individually appear to agree quite well with the state census figure for farm acres per quarter in view of the sampling error. Taken together, however, the two surveys show signs of a downward bias. The farms per quarter figures show the same

tendency. This was to be expected because of certain decisions governing enumeration procedure[7].

We have little evidence on the effects causes (b) and (c) may have had on the discrepancies under consideration. The following data may help to show the information we do have.

TABLE 7. FARM ACRES PER FARM AS GIVEN BY STATE CENSUS (1938) AND SAMPLE SURVEY (1938 AND 1939) DATA, AND STANDARD ERRORS.

Item	State census (adjusted)	Sample survey	
		1938	1939
Farm acres per farm.............................	169.7	176 9	175 2
Standard error.................................	.....	3 4	3 5

The sample survey farms appear to be larger than those reporting to the state census. Does this mean that the reverse of cause (c) has taken place—that quarters having farms larger than average farms were selected? Not necessarily. First, because for the sample survey a farm was defined so as to approximate an operating unit[8], and therefore would tend to be larger than that of the state census, and secondly, because there may be bias arising from the method of substituting farms where information on the originally selected farms were not available. However, there is no evidence of substitution bias[9] and there seems to be reason enough to believe that the sample survey farm

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[7](1) Only those quarter-sections were visited where we had some evidence that at least one farmstead was situated on them, the evidence being the information available on soils maps which were not accurate for the present situation, hence farms which might have been existing on the unvisited quarter-sections were never given the opportunity of being counted; (2) if errors are made in counting the farms on the visited quarter-sections it seems reasonable to expect that they are more likely to be the result of farms being overlooked rather than that of farms being counted which really were not situated within the confines of the selected quarter-section.

[8]Although both the state census and sample survey did not include tracts of land less than 3 acres as farms, it is not clear how state census enumerators consider tracts having complex control. For instance, during sample survey field operations cases were found where perhaps a father exercising complete control over 160 acres, had a son farming an 80-acre tract as his own but who used his father's machinery and equipment, lived with his father, and perhaps served as a hired hand on his father's farm. In such instances, if no clear-cut transactions were carried on between father and son the two tracts were considered as belonging to a single operating unit under the joint control of father and son. Frequently the control of brothers was found to be most easily handled by combining all operations into that of one "farm". Cases where tracts would be operated as farms, although no buildings were located on them, were not found although several farms were found the operators of which lived in town. Separate tracts, even if widely separated, were considered as parts of a single farm if it appeared that they were operated as part of a larger enterprise. This is merely evidence given to show why the farm defined as an operating unit would probably be larger than the farm as defined by the state census.

[9]See pp. 31 to 32.

size is really larger than that of the state census. Consequently, the sample survey figures in table 6 are not directly comparable with those of the state census. Our best estimate of average size of farm **where a farm is defined as in the sample survey** is that indicated by sample survey data. Hence, with no available check-data, we are unable to determine whether we are above or below the true value and therefore cause (c) must be rejected because of lack of evidence. Similarly, cause (b) must be rejected.

Let us again consider the discrepancies in farm acres per quarter as shown in table 6. We concluded that at least a part of this could be explained as the result of a bias. A comparison of the standard errors of these figures indicates that the state census figure is by far the more precise (it must be remembered that the use of a standard error on the state census figure is a crude one but probably useful in the sense in which we shall use it). Total land in farms in Iowa varies relatively little from year to year. It seems reasonable, then, to accept the state census figure of 155.5 as the best estimate of farm acres per quarter-section (for both years—the change is negligible). The most reasonable method of adjusting the sample survey data, then, in view of the probable bias, is to assume the total discrepancy (for both years) to be that of bias, and therefore to multiply (method 1) estimates by the factors 155.5/154.3 or 1.008 and 155.5/151.2 or 1.029 for the years 1938 and 1939, respectively (method 2). Since accurate figures on number of farms (as defined by the sample survey) are not available, we shall not attempt to estimate by (method 3). We shall later consider its potential precision, however.

COMPARATIVE PRECISION OF THE THREE METHODS OF
ESTIMATION

In the foregoing discussion we were concerned with the discrepancies between the two sample surveys and the state census ·on the quantity, number of farm acres per quarter-section, and concluded that this could well be due to a bias and with this being the case, that (method 2) was a proper method by which state estimates could be made.

We are concerned now with the problem of determining the variances associated with each of these methods. Approximations are given by the following formulas:

$$\sigma^2_{\hat{X}_{(1)}} = Q^2 \bar{x}^2 \left(v^2_{\bar{x}} \right) \tag{9}$$

$$\sigma^2_{\hat{X}_{(2)}} = Q^2 \bar{x}^2 \left(v^2_A + v^2_{\bar{x}} + v^2_{\bar{a}} - 2 v_{\bar{x}} v_{\bar{a}} r_{\bar{x}\bar{a}} \right) \tag{10}$$

$$\sigma^2_{\hat{X}_{(3)}} = Q^2 \bar{x}^2 \left(v^2_F + v^2_{\bar{x}} + v^2_{\bar{f}} - 2 v_{\bar{x}} v_{\bar{f}} r_{\bar{x}\bar{f}} \right) \tag{11}$$

where v = coefficient of variability $= \dfrac{\sigma}{m} = \dfrac{\text{standard deviation}}{\text{mean}}$.

It is apparent that when

$$r_{\bar{x}\bar{a}} > \frac{v^2_A + v^2_{\bar{a}}}{2 v_{\bar{x}} v_{\bar{a}}} \tag{12}$$

and likewise when

$$r_{\bar{x}\bar{f}} > \frac{v^2_F + v^2_{\bar{f}}}{2 v_{\bar{x}} v_{\bar{f}}} \tag{13}$$

the variances of (methods 2 and 3) will be smaller than that of (method 1).

As a first approximation, let us assume that the total number of farms and total land in farms (F and A) are known without error (that is, v^2_F and $v^2_A = 0$).

The variances of (methods 2 and 3) relative to (method 1) will be

$$\frac{\sigma^2_{\bar{X}(2)}}{\sigma^2_{\bar{X}(1)}} = 1 + \frac{v^2_{\bar{a}}}{v^2_{\bar{x}}} - 2 \frac{v_{\bar{a}}}{v_{\bar{x}}} r_{\bar{x}\bar{a}} \tag{14}$$

and

$$\frac{\sigma^2_{\bar{X}(3)}}{\sigma^2_{\bar{X}(1)}} = 1 + \frac{v^2_{\bar{f}}}{v^2_{\bar{x}}} - 2 \frac{v_{\bar{f}}}{v_{\bar{x}}} r_{\bar{x}\bar{f}} \tag{15}$$

The reciprocals of these will be a measure of relative precision. Taking (method 1) as a standard (precision = 100) the relative precisions of (methods 2 and 3) were computed for a number of items and appear in table 8.

TABLE 8. PRECISION OF EXPANSION (METHODS 2 AND 3) COMPARED WITH (METHOD 1) FOR SELECTED ITEMS OF THE 1939 SURVEY. TOTAL LAND IN FARMS AND TOTAL NUMBER OF FARMS ASSUMED TO BE KNOWN WITHOUT ERROR.

Item	(Method 2) as a percent of (method 1)	(Method 3) as a percent of (method 1)
Corn acres, harvested for grain............ ...	382	170
Number of cattle	234	140
Oat acres, harvested for grain................	220	...
Number of swine	205	148
Number of hogs sold, 1939.............	192	..
Number of persons on farms.................	181	261
Number of horses	169	..
Total receipts, operator	156	...
Net income,[a] operator......................	148	106
Number of automobiles.....................	147	702
Number of cows milked yesterday.............	137	...
Commercial feed expenditures, farm...........	129	128
Number of chickens........................	123	203
Number of cattle sold, 1939.................	120	...
Number of cattle bought, 1939...............	113	...
Number of farms...........................	113	...
Receipts from dairy products, farm...:........	112	125
Number of eggs yesterday....................	112	...
Number of sheep...........................	106	...
Net cash income, operator..	103	106
Number of hogs bought, 1939...............	102	...

[a]Includes an allowance for changes in inventory.

It is clear that if total acres in farm land is known, (method 2) is in general, the most precise method of expanding sample data. For the items: number of persons on farms, number of automobiles and number of chickens, however, (method 3) is best. Unfortunately, the total number of farms in a state at a given time is generally not known accurately. If we accept rough estimates based on time series data as measurements of the precision of these quantities, we find that $v_A^2 = 0.00000225$ and $v_F^2 = 0.00011264$. Including those elements of variation in the variances of the three methods we have the comparisons which appear in table 9.

We conclude from table 9 that variation in the total land in farms from year to year in Iowa does not greatly affect the precision of (method 2). Variation in total number of farms as found by the Iowa state census does have a notable effect on the precision of (method 3). Even after allowance has been made for error in estimating the controls, total land in farms and total number of farms, both (methods

TABLE 9. PRECISION OF EXPANSION (METHODS 2 AND 3) COMPARED WITH (METHOD 1) FOR SELECTED ITEMS OF THE 1939 SURVEY. TOTAL LAND IN FARMS AND TOTAL NUMBER OF FARMS ASSUMED ESTIMATED FROM TIME SERIES DATA.

Item	(Method 2) as a percent of (method 1)	(Method 3) as a percent of (method 1)
Corn acres harvested..........................	379	146
Number of cattle............................	234	128
Oat acres, harvested for grain.................	219	...
Number of swine............................	205	118
Number of hogs sold, 1939....................	192	...
Number of persons on farms..................	180	208
Number of horses...........................	169	...
Total receipts, operator......................	156	...
Net income,ᵃ operator.......................	148	99
Number of automobiles.......	147	367
Number of cows milked yesterday..............	137	...
Commercial feed expenditures, farm............	129	122
Number of chickens.........................	123	168
Number of cattle sold, 1939...................	120	...
Number of cattle bought, 1939................	113	...
Number of farms............................	113	...
Receipts from dairy products, farm............	112	118
Number of eggs yesterday....................	112	...
Number of sheep......	106	...
Net cash income, operator....................	103	105
Number of hogs bought, 1939................	102	...

ᵃIncludes an allowance for changes in inventory.

2 and 3) are usually more precise than (method 1), and in some cases these gains are rather substantial.

It is interesting to note that no great improvement can be made in estimating total number of farms by knowing total land in farms (the increase in efficiency is 13 percent). This suggests that increasing the number of quarters in the sample by 13 percent would give by (method 1) the same precision as the smaller sample using (method 2).

MEASURING YEAR-TO-YEAR DIFFERENCES AND PERCENTAGE CHANGES

We wish to compare the relative sampling efficiencies of two methods of measuring year-to-year differences; that is, by samples drawn independently each year and by a matched sample. Data for the matched sample were provided by those quarter-sections which were visited both years. The problem with which we are here concerned is the estimation of the sampling errors of the year differences which each of these sampling procedures propose to measure. The computations can be most conveniently carried through in the form of an analysis of variance, given in table 10.

Following the suggestions of Winsor and Clarke (25) we

TABLE 10. ANALYSIS OF VARIANCE OF SWINE INVENTORIES ON 452 MATCHED GRIDS.

(Number of Head on Hand Jan. 1, 1939, and Jan. 1, 1940.)

Source	Degrees of freedom	Mean square	Mean square an estimate of
Total................................	903		
Years......................	1	31,308	
Counties.....................	99	4,979	
Grids within counties...............	352	3,913	$\sigma^2_{YG} + 2\sigma^2_G$
Year x county..................	99	627	
Year x grids within counties.........	352	396	σ^2_{YG}

Total number of swine, Jan. 1, 1939....14,583
Total number of swine, Jan. 1, 1940....19,903

Difference (increase) = 5,320 or 11.8 swine per grid

shall assume that the number of swine situated on a given grid for a given year is composed of the components:

(a) A mean for all grids for all years.
(b) A deviation due to year, common to all grids.
(c) A deviation due to county, common to all grids within the county but varying from county to county.
(d) A deviation due to the grid, common to all years but varying from grid to grid.
(e) A residual deviation, affecting each grid independently.

Let us denote the variance of components d and e, respectively, by σ^2_G and σ^2_{YG}. Furthermore let us assume that the deviations d and e are independent and random. We wish to draw samples stratified by county which will provide estimates of the population difference between two given years.

Two methods of sampling are to be compared. First, an unmatched sample, that is, one in which grids are selected at random within each county independently in each of the 2 years. The error variance of the year difference, per grid, in this case will be given by

$$2(\sigma^2_G + \sigma^2_{YG})$$

Second, a matched sample, that is, one in which a single set of grids is selected at random within each of the counties and is used for both years. The error variance of the year difference, per grid, in this case will be given by

$$2\sigma^2_{YG}$$

The mean squares in the analysis of variance table given above are estimates of these quantities where:

Mean square of grids within counties is an estimate of

$$2\sigma_G^2 + \sigma_{YG}^2$$

Mean square of Y × G within counties is an estimate of

$$\sigma_{YG}^2$$

The comparative efficiencies of the matched versus the unmatched samples for measuring year differences (stratified by county) will be given by the ratio

$$\frac{2(\sigma_G^2 + \sigma_{YG}^2)}{2\sigma_{YG}^2} \quad \text{or,}$$

$$\frac{\text{mean square of grids within counties} + \text{mean square of Y} \times \text{G within counties}}{2(\text{mean square of Y} \times \text{G within counties})}$$

which gives the number of pairs of unmatched grids which are equivalent (give same sampling precision) to one matched grid.

For swine,

$$\frac{2(\sigma_G^2 + \sigma_{YG}^2)}{2\sigma_{YG}^2} = \frac{3,913 + 396}{2(396)} = 5.4$$

In table 11 comparative efficiencies are shown for a number of items.

It is quite evident that substantial gains are obtained by matching, although much variation exists among items.

TABLE 11. COMPARATIVE EFFICIENCIES OF MATCHED VERSUS UNMATCHED SAMPLES OF QUARTER-SECTION GRIDS. 1938-1939 DATA.

Item	Number of pairs of unmatched grids equivalent to one matched grid
1. Number of farm acres.....	18.0
2. Number of corn acres......	14.6
3. Number of oat acres	6.6
4. Number of barley acres......	3.8
5. Number of swine........	5.4
6. Number of horses.......	10.6
7. Number of cattle........	8.3
8. Number of sheep...........	12 2
9. Number of chickens...........	9.4
10. Receipts from sales of dairy products .	5 8
11. Gross expenditures, operator.... .	3.5
12. Gross income, operator........	6.2
13. Net cash income, operator[a].....	2.2
14. Number of persons on farm.....	12.3

[a]Cash grain area not included.

DISCUSSION—A DIGRESSION

The analysis of variance set forth in table 10 contains in addition to that which was just discussed, much interesting information. For instance, a simple test of statistical significance is provided by the mean squares for years and $Y \times G$ within counties. In this case $F = 31,308 \div 396 = 79.06$, which for 1 against 352 degrees of freedom is highly significant according to Snedecor's F-table. Hence it seems reasonable to believe that there has been an actual increase of swine during 1938.

The year $\times$ county interaction is statistically highly significant ($F = 627 \div 396 = 1.58$) which would suggest that in regard to swine inventories the counties did not hold the same relative positions with one another for the 2 years, indicating that components c and b are probably not independent. This does not, however, affect the conclusions reached on the comparative efficiencies, but may have some economic significance.

YEAR-TO-YEAR CHANGES AS PERCENTAGE CHANGES

Often the value of an item in 1 year is expressed as a percentage of that of the previous year or some other base year. In this case absolute values for either year are of no importance in themselves.

If the amount of an item on a sampling unit enduring through time is x_i in the initial year and y_i for some subsequent year then

$$p_i = \frac{y_i}{x_i} \times 100 \qquad (16)$$

where p_i is the percent which the subsequent year is of the initial year for the given item. For a population of N sampling units

$$P = \frac{\Sigma y_i}{\Sigma x_i} \times 100 \text{ where } i = 1, 2 \cdots N \qquad (17)$$

And for a sample of n an estimate of P is given by

$$p = \frac{\Sigma y_i}{\Sigma x_i} \times 100 \text{ where } i = 1, 2 \cdots n \qquad (18)$$

Roughly, the variance of p is given by

$$\sigma^2_p = (100)^2\left(\frac{N-n}{Nn}\right)P^2\left(\frac{\sigma^2_y}{\overline{Y}^2} + \frac{\sigma^2_x}{\overline{X}^2} - \frac{2\,\sigma_y\sigma_x\rho_{xy}}{\overline{Y}\overline{X}}\right) \quad (19)$$

which can be estimated if statistics derived from sample data are available. The square root of this variance provides a rough standard error for the estimated p's.

Estimates of changes from 1938 to 1939 have been computed for a set of items together with their corresponding standard errors, and are shown in the following table accompanied with preliminary and final estimates from AMS publications.

It can be seen from the table that the survey sample was remarkably accurate in estimating changes in the important acreage and livestock items, in fact more accurate than the preliminary estimates of the AMS (if its final estimate is taken as the better of the two). Barley acreage was difficult to measure as shown by the large standard error of its sample estimate. For sheep, chickens, and receipts from

TABLE 12. SAMPLE SURVEY ESTIMATES OF PERCENT CHANGES FROM 1938 TO 1939 FOR A NUMBER OF ITEMS TOGETHER WITH THEIR STANDARD ERRORS AND CORRESPONDING AMS PRELIMINARY AND FINAL ESTIMATES. DATA FROM 452 QUARTER-SECTION GRIDS, STATE OF IOWA.

| | 1939 as percent of 1938 | | | Standard error of sample survey estimate |
| | Sample survey | AMS | | |
		Preliminary[a]	Final[b]	
1. Acres in farms.	100 8			1 1
2. Corn acres, all harvested	91 6	93.0	91 3	1 1
3. Oat acres, grain.........................	83 4	85 0	84 0	1 5
4. Barley acres, grain....................	137 5	126 0	129 1	12 5
5. Number of swine.........................	136 5	118.0	131.0	3 2
6. Number of horses....................... ..	99 6[c]	96 0	96.0	1 5
7. Number of cattle........................	108 2	105.0	105 0	2 2
8. Number of sheep.........................	93 7[c]	108 0	104 6	5 0
9. Number of chickens.................. ...	109 9	102 5	102 5	1.7
10. Receipts from sales of dairy products.........	104.9[c]	92 2		3 0
11. Gross expenditures, operator..	117 0[d]			5.0
12. Gross receipts, operator[e]................ .. .	123 3[d]	110 9[f]		3 9
13 Net cash income, operator[e]	133 8[d]			2 5
14. Number of persons on farms.	102 6[c]			1 1

[a]From preliminary reports.
[b]Crops from December (1940) crop report. Livestock from February (1941) livestock report.
[c]Deviation from 100 not statistically significant.
[d]Not accurate because of changes in questionnaire design.
[e]Cash grain area excluded.
[f]Total agricultural...

dairy products the discrepancy between the sample and AMS estimates appears to be statistically significant. No reason for this is known. For remaining items where comparable data are available agreement for the two sources is apparent.

ERRORS

Data taken by interview and by sample can usually be rightly suspected of containing error of one sort or another. We are concerned here with the problem of determining the nature and extent of this error.

ERRORS IN DATA TAKEN BY INTERVIEW

By design, data were collected to test the memory of interviewees for error. The livestock section in the questionnaire used on the 1939 survey was constructed in the much used form wherein beginning inventory numbers + numbers raised and bought + change in inventory numbers could be checked on the spot with ending inventory numbers + numbers sold, butchered and died. If discrepancies were detected, adjustments were made in cooperation with the farmer whenever possible. With this kind of statement on the number of the several kinds of livestock on the farm 12 months ago, we had the previous year's statement from the same farmer (on the matched sample) on the numbers he had on hand at that time. Similar data were obtained on feed stocks except that no cross checks were attempted. Farmers were not informed of the test being made on their ability to remember, hence some wondered why we were again asking for information they had previously given us. The results of this test are shown in tables 13 and 14.

No differences have been detectable among type-of-farming areas. Renters show an inclination to be slightly more inaccurate than owners, which might well be due to the added complexities of rental transactions.

TABLE 13.   COMPARISON OF INVENTORIES (AS OF JAN. 1, 1939), REPORTED BY 396 MATCHED FARMERS ON THE TWO DATES, JAN. 1, 1938, AND JAN. 1, 1939.

Item	Remembered as a percent of previous report
1. Number of cattle, all ages............	91
2 Number of swine, all ages............	81
3. Number of chickens, all ages............	92
4. Bushels of corn, unsealed.......	92
5. Bushels of oats............	84

TABLE 14.   PERCENT OF FARMERS BY TENURES WHO HAVE FAILED TO
REMEMBER ACCURATELY THEIR INVENTORIES OF A YEAR
AGO. (FOR ONLY THOSE HAVING REPORTED SOME QUANTITY
AT EITHER TIME.)

	Tenure group			
Item	Owners	Renters	Part-owners	All tenures
	(%)	(%)	(%)	(%)
1. Number of cattle, all ages............	76	79	68	76
2. Number of swine, all ages...........	73	82	58	76
3. Number of chickens, all ages....	76	75	80	76
4. Bushels of corn, unsealed......	84	90	83	87
5. Bushels of oats..............	70	78	84	75

We conclude that the discrepancies shown in table 13
represent what may be termed memory biases on those
items. It is not known how consistent these biases might
be through time or how different they might be if question-
naires were of different design. As evidence on the effect
of questionnaire design the data in table 15 may be con-
sidered.

TABLE 15.   SAMPLE SURVEY ESTIMATES OF SELECTED ECONOMIC ITEMS
AS PERCENTAGES OF THE CORRESPONDING AMS ESTIMATES,
STATE OF IOWA, 1938 AND 1939.

Item	1938[a]	1939[b]
	(%)	(%)
Government payments....	77	80
Receipts from sales of:		
Cattle, calves.........	73	84
Hogs..................	60	84
Sheep, lambs	39	54
Chickens...	..	45
Eggs.....................	60	76
Dairy products.....................	74	85

[a]Based on AMS revised estimates.
[b]Based on AMS preliminary estimates.

It appears that the more complete and detailed ques-
tionnaire of the 1939 survey was getting more accurate
information than its briefer predecessor. In addition to bias
there is a large random component in the errors of memory.

DISCREPANCIES BETWEEN REPORTS TO THE TOWNSHIP ASSESSOR AND THE SAMPLE SURVEY ENUMERATOR

To test for possible discrepancies between the reports
given the two data-collecting agencies, sample survey farms
were identified in the assessor records and the relevant
data compared. This was done for both 1938 and 1939.
Of the 773 sample survey farms of 1938 only 576 could be

TABLE 16. NUMBERS OF SAMPLE SURVEY FARMS WHICH COULD BE COMPLETELY MATCHED, PARTIALLY MATCHED AND NOT MATCHED AT ALL (NOT FOUND) IN THE ASSESSOR RECORDS, 1938, GIVEN BY TENURE GROUP WITH MEAN FARM SIZE.

Class	Owner		Renter		Part-owner		All	
	%	Av. size	%	Av. size	%	Av. size	%	Av. size
Total farms (773) .	36	148	54	191	10	206	100	177
Completely matched (576)........ ...	37	147	56	185	7	188	100	171
Partially matched (121)...... . ..	33	193	46	228	21	240	100	219
Not found (76)	45	112	46	175	9	155	100	145

completely identified (those having approximately the same name and within 10 acres of the same size of farm). The remaining 197 were of two kinds: one, 76 which could not be found listed at all and two, 121 found listed but having sizes differing 10 acres or more from the size reported in the survey. Table 16 (above) summarizes the effect this procedure has had on the representativeness of the data.

We conclude that the group of farms for which reports are available from both sample survey and assessor, are somewhat smaller than the original group. It appears also that there is no significant difference in the proportions among the tenure groups although there is some evidence that part-owners reported quite different farm acres to the two agencies.

However, we believe that this group will be quite useful in an investigation of discrepancies in reports to the two agencies. Table 17 presents a comparison of totals reported by both agencies for a selected list of items. (Page 30.)

We see in table 17 that except for sheep, livestock items are definitely biased. As shown elsewhere (page 11) the sample survey figures agree well with AMS estimates and therefore we conclude that it is the assessor who receives the understatements. Among other items showing a bias is corn yield. We now have some evidence that difference between the sample survey and assessor corn yields (see table 2) are real and not likely the result of sampling variation. We present the following data from table 2:

Year	State census (assessor) (bu./acre)	Sample survey (bu./acre)
1938	46.3	47.7 ± .5
1939	52.2	54.6 ± .4

In both years the sample surveys obtained higher yields. No data are available for determining which is closer to the true yields.

TABLE 17. SUMMARY OF BIAS AND RANDOM ERROR IN THE REPORTS OF FARMERS TO THE SAMPLE SURVEY AND IOWA ASSESSOR. 1938 AND 1939 DATA.

Item	Total reported to assessor as % of sample survey		Bias[a] (departure of assessor from sample survey) in percent		"Random" error (coefficient of variability of the differences[b] in percent of sample survey mean)	
	1938	1939	1938	1939	1938	1939
Corn acres, total	100.4	99 4	.....	—0 6	.....	6
Corn acres, harvested	100 8	98 9	.....	—1 1	.. ..	7
Corn production (bu.)	97.9	97 1	.....	—2.9	.....	13
Corn yield (bu./acre)	98 1	97.8	.....	—2 2	.....	10
Oat acres, grain	100.2	100.8	.....	.....	.....	14
Oat production (bu.)	99.8	98 4	.....	.....	. ...	20
Oat yield (bu./acre)	101 3	97.5	.....	.....	....	
Wheat acres, grain	104 8	93 4	....	.....	.....	24
Wheat production (bu)	97 9	102 1	. ...	.....	.....	42
Wheat yield (bu /acre)	98 0	99 1	.....	.....	... .	
Barley acres	105 0	93 2	... .	... .	.....	26
Barley production (bu)	106 5	89.4	.....	... .	.....	47
Barley yield (bu./acre)	97 8	89 5	.....	.....	....	
Alfalfa acres, hay	98 6	93.3	.....	—6 7	. . ..	35
Pasture acres, all		100 7		.....		25
Horses and mules	96 7	.. [c]	— 3 3	.....	17	...
Cattle	93 9	.. [c]	— 6 1	.....	26	..
Sheep	99 2	.. [c]	.....	.....	88	...
Swine	87.4	.. [c]	—12 6	.....	27	...
Cows milked during year	91 1	.. [c]	— 8 9	.....	21	...
Sows and gilts bred	97.9	.. [c]	— 2.1	.....	37	...

[a]Differences have been designated a "bias" only when they show statistical significance. Blank spaces indicate that no bias has been detected.
[b]Residual variation after farm differences and bias has been removed. For those reporting "some" to either assessor or sample survey—that is, those reporting "none" to both assessor and survey were excluded in the analysis of random errors.
[c]This information was not obtained by the assessor in 1939.

The random errors as measured by the coefficients of variability of the differences are indications of the extent of errors in data taken by interview. These are the results of misunderstandings, vagueness, indifference, deliberate misstatement and to a small extent, errors of memory (the enumerators appeared at different times—sometimes as much as 2 months apart). Except for the last reason both enumerator and enumeratee may be at fault. It may be noted that acres in corn is quite reliably stated (judging from the relatively low random error). Acreage control programs have probably helped to acquaint many farmers with their exact acreage in corn.

BIAS WHICH MAY RESULT FROM SAMPLING PROCEDURE

Enumerators were instructed to visit those farms, the farmsteads of which were situated on the selected quarter-section grids. If information could not be obtained from any of these designated farms, they were instructed to visit the nearest farm as a substitute. Since this was a relaxation of strict sampling procedure, made necessary because we were dealing with people, we were interested in getting some idea of whether or not this failure to get the original selected farms would result in a biased sample. Consequently enumerators were requested to record the tenure and size of those farms which we:e not enumerated, together with the reason. Both in 1938 and 1939 it was necessary to substitute 29 percent of the farms first visited. The number of farms visited but not enumerated, and reasons therefor, are listed in table 18.

TABLE 18. NUMBER OF FARMS FOR WHICH SUBSTITUTIONS WERE MADE LISTED BY REASON GIVEN BY ENUMERATOR. 1939 SURVEY.

Reason	Number of farms	Number in group
I—Operator living on farm		
A—Operator at home		
1—Uncooperative..		55
a. Landlord would object	2	
b. Dislike for AAA	2	
c. Dislike government interference........................	20	
d. Afraid information goes to packers	4	
e. Assessor advised against giving information..............	1	
f. Resented being singled out for sampling.................	1	
g. Gave unreasonable data...............................	3	
h. Other, or not given..............................	22	
2—Cooperative, apparently, but....		44
a. Busy...	29	
b. Sickness.............................	8	
c. Too difficult to reach...	5	
d. Drunk...............	2	
B—Operator not at home............................		76
a. At a sale, in town......	21	
b. Visiting....................	7	
c. Vacationing..	1	
d. No reason given.....	47	
II—Operator not living on farm...........		6
A—Absentee operator......................	3	
B—Nobody on farm at present...........	3	
III—No reason given.................	15	15
Total....	196	

In table 19 are summarized the data from the enumerators' reports on the tenure and size of the non-enumerated farms together with the enumerated farms of 1938 and 1939.

TABLE 19. NUMBER, PERCENT AND SIZE OF FARM BY TENURE GROUP FOR THE NON-ENUMERATED FARMS OF 1939 AND THE ENUMERATED FARMS OF 1938 AND 1939.

Farm group	Owner			Renter			Part-owner			All tenure		
	No.	%	Av. size	No.	%	Av. size	No.	%	Av. size	No.	%	Av. size
Non-enumerated, 1939	67	43	163	80	51	166	9	6	210	156	100	167
Enumerated, 1939.....	292	38	154	398	51	179	88	11	221	778ᵃ	100	175
Enumerated, 1938....	278	36	148	415	54	191	80	10	206	773	100	175

ᵃFour managed farms excluded.

We conclude from the data presented in table 19 that no perceptible bias on either farm size or tenure is evident.

DISCUSSION ON ERRORS IN DATA TAKEN BY INTERVIEW

In general, errors due to inaccuracies in the data appear to be larger than errors due to sampling (where the sample is of the size of the two surveys). Except for the unbiased items, further increase in size will scarcely increase the accuracy of sample information. Certainly a complete census does not provide **accurate** information by the mere fact of complete enumeration.

It has been suggested that improvements in the design of the questionnaire have shown real increases in accuracy. Better education of the enumerators will also help. But there still remains the problem of minimizing errors due to bad memory on the part of the interviewee.

As an experiment, several questionnaires on which beginning inventories from the previous years' record were posted, were tested in the 1939 survey. It seemed the farmers were quite satisfied in having the enumerator remind them of the facts 12 months past. Sales which would have otherwise been overlooked were picked up and any changes in farm population, farm size, feed stocks, etc., were easily detected and checked on the spot. Matching farms without providing the enumerator with all relevant previously obtained information resulted in errors which are quite damaging to matched samples where change is being measured. In our case probably a good part of our "sampling errors" is really variation due to these inaccuracies.

Further lessening of errors of memory can come from shortening the period over which the interviewee is called upon to remember. If data are required over a fiscal year, probably more than two visits will be advisable. Or perhaps some simple account system could be devised by which farm-

ers could be persuaded to record certain transactions without much effort. This could be merely a request that the cooperating farmer keep transaction slips available for the enumerator. Such simple bookkeeping might be offered as a free service for his cooperation. Even with all this, however, recalcitrants will continue to be a problem.

EFFECT OF STRATIFICATION (COMPLETE) ON SAMPLING EFFICIENCY

By stratification is generally meant the division of the population under inquiry into two or more parts known as "strata." For instance the population of Iowa farms is "stratified" if it is regarded as composed of owners, renters, part-owners and managers; or as Allamakee County farms, Adams County farms, etc. If two conditions can be met, stratification can improve efficiency of sampling when an accurate estimate of the overall mean is desired. First, strata must be unlike (owners as a group must be different than renters as a group in the character being measured) and second, the total number of elements in each stratum must be known. If these conditions have been satisfied, either one of two usual sampling procedures can be adopted.

If a population is divided into K strata having

$$N_1 , N_2, \cdots , N_K$$

sampling units and

$$\sigma_1 , \sigma_2, \cdots , \sigma_K$$

standard deviations, the most efficient sample will be composed of

$$n_1 , n_2, \cdots , n_K$$

sampling units from the several strata such that

$$\frac{n_1}{N_1\sigma_1} = \frac{n_2}{N_2\sigma_2} = \cdots = \frac{n_K}{N_K\sigma_K} \tag{20}$$

where $\sigma_1 = \sigma_2 = \ldots \sigma_K$, equation (20) becomes

$$\frac{n_1}{N_1} = \frac{n_2}{N_2} = \cdots = \frac{n_K}{N_K} \tag{21}$$

In the usual case, where the σ's are unknown beforehand, stratified samples are allocated according to condition (21),

which implies that the σ's have been assumed equal. This is the case of our sample surveys.

We are now in a position to speculate on the merits of both the method of the sample surveys (the choice of the county as the stratum and the assumption of equal σ's) and of alternatives which can be proposed.

The relative efficiencies of stratifications can be obtained directly from the variances within the several kinds of strata. Variances within township, counties and type-of-farming areas are most easily obtained by analysis of variance[10]. In table 20 are presented efficiencies which may be expected if the survey samples were stratified by township and type-of-farming area or completely unstratified, compared with stratification by counties.

It can be seen that there is considerable difference in the way individual items behave but that in general the town-

TABLE 20. RELATIVE EFFICIENCIES OF SAMPLES STRATIFIED BY TOWN-SHIPS, TYPE-OF-FARMING AREAS AND DRAWN WITHOUT STRATIFICATION FROM THE STATE COMPARED WITH SAMPLES STRATIFIED BY COUNTIES SUCH AS THE SAMPLE SURVEYS. 1938 AND 1939[a] DATA.

(Figures represent percent efficiencies. Efficiency of county stratified samples taken as 100.)

Item	1938			1939		
	Twps.	Areas	State	Twps.	Areas	State
1. Number of swine	104	100	97	110	84	83
2. Number of horses	105	95	95	183	112	112
3. Number of sheep	54	100	97	97	100	99
4. Number of chickens	103	95	90	90	112	110
5. Number of eggs yesterday	105	95	89	129	89	88
6. Number of cattle	96	97	96	108	99	98
7. Number of cows milked yesterday	78	96	88	74	96	80
8. Number of gallons milked yesterday	80	92	89	88	93	80
9. Receipts from sales of dairy products	78	95	85	. . .	. . .	. .
10. Number of farm acres	101	101	101	73	96	95
11. Number of corn acres	74	92	80	95	92	79
12. Number of oat acres	66	84	75	105	82	71
13. Corn yield	120	83	69	123	73	60
14. Oat yield	104	91	90	157	92	73
15. Commercial feed expenditures, farm	291	98	95	. . .	. . .	. . .
16. Total cash expenditures, operator	163	97	94	94	103	98
17. Total cash receipts, operator	191[b]	106[b]	104[b]	131	106	101
18. Net cash receipts, operator	148[b]	104[b]	103[b]	113	101	101
19. Number of hogs sold	. . .	. . .	. . .	95	85	84
20. Number of cattle sold	. . .	. . .	. .	318	103	103
21. Number of hogs bought	. . .	. . .	. .	810[c]	113	113
22. Number of cattle bought	. .	. . .	. . .	167	98	97
23. Number of cows and heifers milked during year	.	. . .	. .	74	99	79
Average	115	96	91	121[c]	97	91

[a]Computations on unmatched farms only, therefore independent of the 1938 sample.
[b]Cash-grain area not included.
[c]"Number of hogs bought" not included in average.

[10]In our case a correction was theoretically necessary because the survey samples were not random without restriction. See Cochran (6). It was found, however, that in this case the corrections were so small that they could be ignored.

ship is more efficient than the larger stratification units. The type-of-farming area is only slightly less efficient than the county (indicating a relatively high degree of similarity among the counties of which it is composed). With no stratification at all the average loss for the items investigated amounted to 10 percent both years. For corn yield this loss was as high as 31 percent and 40 percent.

We conclude that except for certain individual items, the statistical gain from geographic stratification is not very large for Iowa except when carried to the township. Since there are about 1600 townships in the state, this means that complete township stratification would require samples of at least 1600 sampling units, and therefore would be feasible only for large samples at best. A decision on relative merits of county versus area stratification is not directly available. It appears that the average loss of 3 percent or 4 percent obtained by shifting from the county to the type-of-farming area as the stratum is roughly balanced by savings in cost. The two, therefore, should be approximately equivalent for census-type inquiries. The case for no stratification at all has no appeal mainly because certain items would be estimated with great inefficiency, the savings in cost would not be very much over that where type-of-farming areas are stratified and usually information is desired by type-of-farming areas anyway.

The 1939-survey data was examined to determine the efficiencies available in a stratification based on a farm classification scheme. The classification scheme chosen for this investigation was that proposed by Jebe (10). Jebe's scheme grouped farms into seven classes designed to bring about the greatest possible degree of homogeneity within classes in regard to eight items. A stratification

TABLE 20a. RELATIVE EFFICIENCY OF A FARM CLASSIFICATION BY TYPE-OF-FARMING AREA STATE OF IOWA, 1939

Item	Index, with type-of-farming area total, using the efficiency of the latter at 100%
1. Farm acres	110
2. Corn sales ($)	135
3. Cash operating expenditure $	111
4. Cattle sales ($)	137
5. Swine sales ($)	157
6. Dairy products sales ($)	141
7. Cash receipts ($)	145
8. Net income* ($)	113

*Net cash receipts with a positive...

based on this scheme appears to provide greater sampling efficiency than one based on the usual five type-of-farming areas of Iowa. The relative efficiencies of the two methods of stratification are shown in table 20a. The figures given in this table represent the estimated efficiency of the farm classification as compared with type-of-farming area stratification where the efficiency of the latter is taken as 100. In every case stratification by the classification scheme is more efficient. In practice, however, stratification by some farm classification scheme would require, if estimates for all farms are desired, relatively accurate information on the relative sizes of the classes (strata). For similar reasons the sizes of the type-of-farming areas must be known with reasonable accuracy. In the case of the sample surveys the sizes of the type-of-farm classes were not known. We conclude, therefore, that until additional information is obtained on the relative sizes of farm classes, the type-of-farming area (and other geographic strata) is the recommended basis for stratification.

The possible merits of stratification by tenure group (owner, renter and part-owner) were investigated by means of analysis of variance on a selected group of items. In table 21 are presented item means by tenure, tests of the significance of their differences and the efficiency of a sample

TABLE 21.   ITEM SAMPLE MEANS BY TENURE AND RELATIVE EFFICIENCY OF TENURE STRATIFICATION COMPARED WITH NO STRATIFICATION, STATE OF IOWA, 1939.

Item	State mean per farm by tenure, 1939				Relative efficiency
	Owners	Renters	Part-owners	All	
					(%)
1. Number of swine........................	51.2	51 6	62.0	52 6	101.0
2. Number of horses and mules............	3 74	4 12	4 81	4 06	101 4*
3. Number of sheep........................	4.20	5 35	12.2	5 68	100 0
4. Number of chickens.......	164	165.	153.	163.	99 6
5. Number of eggs yesterday...............	25 4	22 9	22.3	23 8	99 6*
6. Number of cattle..............	25 4	22 9	30 1	24 3	101.6
7. Number of cows milked yesterday........	4 62	4.94	6 02	4 95	100.6
8. Number of gallons milked yesterday... ...	9 93	10 57	11 70	10 5	99 7
9. Number of farm acres....................	157	179.	221.	175.	103.0**
10. Number of corn acres................ ...	38 3	51 3	62 4	47 7	105.8**
11. Number of oat acres..........	19 3	28 1	29 1	24 9	102.0*
12. Corn yield per acre......................	57 3	53 4	52 9	54 5	102.1*
13. Oat yield per acre..............	32 0	30 8	30 4	31 0	101.2
14. Net income, operator ($).................	1252	928	1607.	1128.	103.8
15. Number of hogs sold....................	43 5	42 2	47 9	43.4	99.6
16. Number of cattle sold...................	12 5	7.7	15 1	10 4	100.7
17. Number of hogs bought.................	3 9	4.6	3 1	4 2	99.3
18. Number of cattle bought................	8 3	4 8	11 2	6.9	100.3
19. Number of cows milked during year.......	7 0	7 1	7 9	7 1	99.7
Average................					101.1

*Statistically significant at 5 percent level.
**Statistically significant at 1 percent level.

TABLE 22. ITEMS HAVING LARGE DIFFERENCES BETWEEN TENURE GROUPS, 1939 SURVEY DATA.

Item	Mean per operator			
	Owner	Renter	Part-owner	All tenure
Number of persons on farms, 1/1/40, farm	4 024	4 530	5 034	4 405
Number of persons born during 1939, farm	0445	1030	0455	0742
Number of persons died during 1939, farm... ...	0240	0352	0455	0320
Receipts from machine work, 1939, operator...	18 42	43 91	49 23	34 86
Receipts from labor, non-farm, 1939, operator...	40 59	9 44	12 88	21 67
Receipts from labor, farm, 1939, operator	2 40	11 89	1 31	7 11
Receipts from "other income"ᵃ, 1939, operator...	42 74	20 93	28 92	30 08

ᵃIncludes pensions, income from sales work, etc.

stratified by tenure compared with one drawn at random in the state.

We note that for the items shown there are few having very large tenure differences, and any gain in efficiency by tenure stratification is almost negligible.

There are items, however, where tenure differences are large. As an example a few have been selected from survey data and are shown in table 22.

We conclude that except for some special inquiries, stratification by tenure does not promise to be very effective. Furthermore, there still remains the problem of determining the sizes of these tenure groups before tenure stratification can be used.

EFFICIENCY IN THE ALLOCATION OF THE SAMPLING UNITS BETWEEN AND WITHIN COUNTIES: INCOMPLETE STRATIFICATION OR SUBSAMPLING

We wish here to determine the effects on sampling efficiency resulting from different geographical allocations of the quarter-sections selected for the sample. For example, what efficiency would we expect from the same 900 quarter-sections if, instead of having 9 selected from each of 100 counties, 18 were selected from 50 counties (both quarters and counties taken at random). We might also wish to know

TABLE 23. ANALYSIS OF VARIANCE OF NUMBER OF CATTLE PER FARM, STATE OF IOWA, 1938.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	772	382,185	
Type-of-farming area.	4	3,708	927 0
Counties within areas.	96	59,345	618 2
Townships within counties.	421	209,527	497 7
Quarters within townships.	101	52,857	523 3
Farms within quarters	150	56,748	378 3

if sampling efficiency could be improved through the use of various proposed stratification procedures.

To answer these and related questions, we again find it convenient to use analysis of variance procedure. For this, a typical analysis of variance is summarized in table 23.

We note in the table that excepting the township each geographical unit seems to be contributing variation to the population of farms. This being the case quarters and township mean squares for this item can be pooled, giving the following analysis of variance.

Source of variation	Degrees of freedom	Mean square
Total	772	
Area	4	927.0
Counties within areas	96	618.2
Quarters within counties	522	502.6
Farms within quarters	150	378.3

Variance of the sample estimate of mean number of cattle where the sample is taken in the manner of the 1938 survey will be given by mean square of quarters within counties divided by **total number of farms** or

$$\sigma_{\bar{Z}}^2 = \frac{502.6}{773} = .6502$$

The standard error will be $\sqrt{.6502}$ or .81 head.

If number of quarter-sections were doubled within each county, variance of the sample mean, or $\sigma_{\bar{Z}}^2$,would be halved (approximately, since the number of farms so selected would not necessarily be exactly doubled).

Now if the number of quarters within counties (sampled) were doubled but the number of counties sampled halved, then $\sigma_{\bar{Z}}^2$ will be given by the formula[11]

$$\frac{1}{773C}\left[A(C-c) + Bc\right] \tag{22}$$

---

[11]This has been derived from the general formula for incomplete stratification of finite populations:

$$\frac{A}{k}\left(\frac{1}{c}-\frac{1}{C}\right) + \frac{B}{C}\left(\frac{1}{k}-\frac{1}{K}\right) \tag{22.1}$$

where k and K are the number of farms per county in the sample and population, respectively. Since K is large (about 2000 farms) then $\frac{1}{K}$ can be taken as zero, then (22.1) becomes

$$\frac{1}{Cck}\left[A\ (C-c) + Bc\right] \tag{22.2}$$

---

where C = total number of counties in an area (= 20.2)
       c = number of counties in each area selected for sampling (= 10)
       A = mean square between counties within a peso farming area
       B = mean square between quarters within a county

$$\frac{1}{773}\left[618.2(20.2.10.) + .502(6.10)\right]$$
$$= .7257$$

The relative efficiency of this method with respect to the first will be

$$\frac{.6502}{.7259} \times 100 \text{ or } 89 \text{ percent a loss of } 11 \text{ percent}$$

Computations have been carried through in a similar manner for a group of different items, which are summarized in table 24.

We see that for the items investigated the resulting loss in efficiency would have been on the average 10 percent in 1938 and 5 percent in 1939, the greatest loss being 39 percent for oat acreage in 1938. Apparently no loss would have been made in some items such as "total cash receipts" and "net cash income". (Since these efficiencies were based on sample data they are therefore subject to sampling variation. Consequently individual efficiencies are to be taken with caution.)

On the cost side it seems likely that such a sample scheme would reduce costs within county about 11 percent or overall costs at least 5 percent[12]

This being the case it appears that both sampling would provide on the average about the same amount of information for the money spent.

TABLE 24. ESTIMATED RELATIVE EFFICIENCY (COMPARED WITH THE
SAMPLE SURVEYS) BY WHICH SELECTED ITEMS WOULD BE
SAMPLED IF SAMPLING WERE DOUBLED WITHIN COUNTIES
AND THE NUMBER OF COUNTIES HALVED. COUNTIES STRATI-
FIED BY TYPE-OF-FARMING AREA. 1938 AND 1939[a] DATA.

Item	Relative sampling efficiency (1938 and 1939 surveys = 100)	
	1938	1939
	(%)	(%)
1. Number of swine..	99	76
2. Number of horses.........	85	108
3. Number of sheep....	98	100
4. Number of chickens	85	122
5. Number of eggs yesterday..	87	84
6. Number of cattle	89	99
7. Number of cows milked yesterday	88	93
8. Number of gallons milked yesterday.	77	89
9. Receipts from sales of dairy products	87	
10. Number of farm acres	103	94
11. Number of corn acres.....	76	88
12. Number of oat acres......	61	74
13. Corn yield per acre	88	89
14. Oat yield per acre	77	65
15. Commercial feed expenditures, farm	92	
16. Total cash expenditures, operator	91	104
17. Total cash receipts, operator	119[b]	109
18. Net cash income, operator	113[b]	102
19. Number of hogs sold.		76
20 Number of cattle sold .		104
21. Number of hogs bought		123
22. Number of cattle bought	.	97
23. Number of cows and heifers milked during year	..	99
Average	90	95

[a]Computations on unmatched farms only, therefore independent of the 1938 sample.
[b]Cash-grain area not included.

In general, if fairly good estimates are desired on each
of a wide range of items it appears that sampling counties
(that is, taking only a fraction of the counties into the
sample) is not advisable. For income estimates alone it
seems that sampling counties would be quite advisable under
the 1938 and 1939 circumstances.

Another argument for sampling counties is that concen-
trating the areas worked permits greater control over the
field crew. When complicated questionnaires (such as those
designed to obtain income) are used it may be advisable to
have supervisors meet frequently with enumerators during
the survey. Other savings may be made depending, of
course, on circumstances of the survey (whether or not
photographic maps in county AAA offices are consulted).

We conclude that for census-type questionnaires (where
a variety of items are asked for information on each)
sampling counties is not advisable in Iowa. For an income
survey, however, it seems that this procedure is advisable
for years which are not too unlike 1938 and 1939. If there
is uncertainty, the all-county plan is recommended.

It was stated pr...i ..l. that t.. ... .
quarter-sections ...wn from each ... was m..d... ...
tional to the total number of quarter-sect.. ... i. t.. C. ..ty
This was done b..c..use k..owl.dge .f th. va...... ..th.
counties or other strata w..- not a ..ila.le ...w..... ..
have data which will pro.ide estimate. .f t...
within some of t..ese strata ..d th..e...... ... .t..
mine how good .. how bad this ..d oth.. ....

TABLE 25. ESTIMATE.. ....
BASIS) IN EACH TYPE-OI-FARMING ARE.. ....
FOR A SELECTED LIST OF ITEMS, 1938 AND 193.

Type of Farming Ar. .

Item	Year	North..st dairy	Cash grain	W.. te.. livestock	S. .... pasture	.. .. .. livestock
1. Number of swine	1938	984	1,584	1,79.	1 ..	.. ..
	1939	1 926	2,352	2 767	1 98.7	2 23.	2 8.
2. Number of horses and mules	1938	7 98	9 22	9 .8	8	7	.
	1939	5 75	7 73	8 03	6 2.	5 9.	6 .
3. Number of sheep	1938	127	1,698	.73	1. 3	1	.0
	1939	764	20	.18	209	87	2 .8
4. Number of chickens... ..	1938	12,212	12,090	.370	.858	731	600
	1939	15,426	14,467	12 663	10 713	5 .81	043
5 Number of eggs yesterday. ..	1938	665	620	1 028	132	393	763
	1939	1 236	690	710	432	412	721
6 Number of cattle	1938	382	402	514	522	790	523
	1939	312	480	384	306	255	350
7. Number of cows milked . .	1938	20 9	11 8	10	7	13	14
	1939	23 6	23 5	4 9	6 8	13	17
8 Number of gallons milked	1938	137 2	96 8	19 2	2 7	35 7	3. 1
	1939	179 7	93 1	48 5	31 1	77 3	9 7
9 Receipts from dairy products	1938	11 912	70	.30	17	67	9
10 Number of farm acres... .	1938	8,49.	92.	12 13.	13 ..	11 ..	
	1939	5,55.	8 34.	13 .6	14 9 .	. ..	
11. Number of corn acres ..	1938	824	1,068	2 388	1 262	1 20..	.1
	1939	446	993	1 202	915	80.	1 .4
12 Number of oat acres	1938	587	1 008	1 585	151	30.	21
	1939	390	771	39.	332	26.	32
13. Corn yield .	1938	194	155	17 3	172	26	2.
Corn yield	1939	236	171	1 .5	172	22 3	25.
14 Oat yield.	1938	123	132	155	1 5	21 7	14
Oat yield	1939	122	160	239	38	77	15 .
15 Commercial fe.. expenditures.	1938	333	588	144	31	17	35
	1939						
16 Total cash expenditures, op.	1938	81.	583	344	34	4.	3.
	1939	001.	4 535	370.	336	30.	1.
17 Total cash receipts, operator	1938	3 015.		3 779.	2 429.	3,351.	3 231.
	1939	3,453.	730.	7 928.	2 944.	4 779.	4 929.
18 Net cash income operator., . ..	1938	4,148.		7 456.	7 985.	1 585.	1,445.
	1939	443.	925.	7 433.	033.	1,732.	1,239.
19. Number of hogs sold, farm	1938	79.					
	1939	737	311	2 755	315	3 755	3 77.
20. Number of cattle sold, farm	1938	.. .	..				
	1939	3.	337	38	2 3.	. ..	. .
21. Number o 1 .. bought, far.. .	1938	.					
	1939		3.	4 7 7	7	..	
22 Number of catt.. bought, farm	1938						
	1939		3	3			
23. Number of c.. & heifers a il..d during year	1938						
	1939	3	3	3	3	3	3

.. ..
. (000)

pling allocations are or would be. We can now compare the relative efficiencies of stratified samples allocated as

$$\frac{n_1}{N_1} = \frac{n_2}{N_2} = \cdots = \frac{n_K}{N_K} \tag{23}$$

with samples allocated as

$$\frac{n_1}{N_1 \sigma_1} = \frac{n_2}{N_2 \sigma_2} = \cdots = \frac{n_K}{N_K \sigma_K} \tag{24}$$

For convenience and in order to assure fairly good estimates of the σ's a stratification by type-of-farming area will be considered. Again the analyses of variance provide the necessary information. When corrected for county stratification, the mean square for quarter-sections within a type-of-farming area is an estimate of the σ^2 for that stratum. In table 25 (p. 41) are shown the sample estimates of the population variances for each of the five areas and for the state as a whole (unstratified) for a selected list of items.

It can be seen that the areas do not have the same relative positions (with one another) in regard to variance. No area is consistently high or low for all items. There is even a tendency to shift relative positions from one year to another on the same item (see number of cattle). Allowance should be made for sampling variation, since these figures are merely estimates of the true variances. It is interesting to note, however, that for this set of items, the Northeast Dairy and Southern Pasture Areas, occur more frequently with lowest variances whereas Western Livestock and Eastern Livestock are found with highest variances. In general, however, there seems little reason for saying that a certain area is more variable than another without regard for the specific items under consideration.

Let us say, however, that we are interested in one item in particular, then what (if any) gain is to be obtained by different allocation? For example let us select an item that appears to have large differences in variances among the areas such as "net cash income to the operator."

We have the following information of the type-of-farming area populations and of the sample (1939).

Type-of-farming area	Number of rural farms		
	Population[a]	Sample	Estimated n
Northeast dairy	39,574	153	121
Cash grain	38,412	163	183
Western livestock	44,017	162	213
Southern pasture	36,935	141	88
Eastern livestock	41,832	163	179
State	200,770	782	732

[a]Derived from Iowa Farm Census data. See Appendix, 1.

If the 782 rural farms drawn for the sample were so allocated among the five areas that

$$\frac{n_1}{N_1 \sigma_1} = \frac{n_2}{N_2 \sigma_2} = \frac{n_3}{N_3 \sigma_3} = \frac{n_4}{N_4 \sigma_4} = \frac{n_5}{N_5 \sigma_5}$$

then we should use the values of n shown in the above table as "Estimated n."

The best estimate of "net cash income to the operator" (mean per farm for all farms in the state) would be the weighted mean

$$\bar{x}_w = \frac{N_1\bar{x}_1 + N_2\bar{x}_2 + [N_3\bar{x}_3 + N_4\bar{x}_4 + N_5\bar{x}_5}{N_1 + N_2 + N_3 + N_4 + N_5} \qquad (25)$$

where $\bar{x}_1$ is the mean for farms in area 1, etc.

N_1 is the total number of rural farms in area 1, etc., and its variance would be estimated by

$$s^2_{\bar{x}_w} = \frac{\sum_i N_i^2 s_i^2 n_i}{(\sum_i N_i)^2} \qquad (26)$$

$$i = 1, 2, \cdots, K$$

For "net cash income to the operator," $s^2_{\bar{x}_w} = 2{,}079$. This is to be compared with the $s^2_{\bar{x}}$ which would have been obtained if the sample had been drawn at random from each type-of-farming area such that the number of sample farms was proportional to total number of farms in each area, ignoring differences in the σ's. In this case $s^2_{\bar{x}}$ is obtained directly from the analysis of variance as the mean square of quarter-sections within areas for the state divided by 782. It will be found that $s^2_{\bar{x}}$ is about 2,214. The relative efficiency of the two kinds of samplings is

$$\frac{s^2_{\bar{x}}}{s^2_{\bar{x}_w}} = \frac{2214}{2079} \cdot 100 .$$

which indicates that about 6 percent can be gained for this item by considering variances when allocating the sample within the type-of-farming areas. The gain is not large and what is more, it is not a clear gain since estimates of σ's were used. Moreover, by allocating the sample in this manner some damage has been done to the accuracy of es-

timating other items of the survey. For example, corn yield in 1939 would have suffered a loss of 7 percent in sampling efficiency.

From an inspection of the variances of individual items it appears then that no great gains could have been achieved through reallocation of the sample.

THE PROBLEM OF MAXIMIZING AMOUNT OF INFORMATION OBTAINABLE FROM A GIVEN EXPENDITURE BY VARYING SIZE OF THE SAMPLING UNIT AND THE NUMBER TAKEN

Up to now where relative efficiencies of alternative sampling schemes were being compared, we have been usually satisfied with making comparisons on the basis of statistical sampling efficiency alone. We shall attempt here to investigate the more practical and also more difficult problem of deciding which sampling schemes provide the most information for the money available.

For simplicity, the case to be considered here will be samples, of which sampling units are of varying size, taken at random within the State of Iowa.

We have the two factors:

y, the number of sampling units taken
and x, the number of farms per sampling unit

which can be varied independently at will by the sampler. Now both sampling variance and cost are functions of these two factors:

$$\text{Sampling variance,} \quad \sigma_z^2 = f(x,y) \qquad (27)$$

$$\text{Sampling cost,} \quad E = \phi(x,y) \qquad (28)$$

Our objective is to determine what values of x and y will minimize σ_z^2 for a given E. To do this we must first determine, if we can, the explicit forms of $f(x,y)$ and $\phi(x,y)$.

A VARIANCE FUNCTION

If we regard the State of Iowa as composed of Y grids of X farms each, then we can set up an analysis of variance (on a farm basis) as follows:

Source	Degrees of freedom	Mean square	Sum of squares
Total	$XY - 1$	K	$(XY - 1)K$
Grids	$Y - 1$	A	$(XY - 1)K - Y(X - 1)B$
Farms within grids...	$Y(X - 1)$	B	$Y(X - 1)B$

From the table we can write for the grid mean square,

$$A = \frac{(XY - 1)K - Y(X - 1)B}{Y - 1} \qquad (29)$$

Suppose now that a sample of y grids was taken, then the variance of sample mean per farm, $\bar{z}$ is given by

$$\sigma_{\bar{z}}^2 = \frac{A}{Xy} = \frac{(XY - 1)K - Y(X - 1)B}{Xy(Y - 1)} \qquad (30)$$

which becomes when Y is large (that is, when grids are relatively small),

$$\sigma_{\bar{z}}^2 = \frac{K}{y} - \frac{(X - 1)}{Xy} B, \qquad (31)$$

and in the usual case X is not known but must be estimated from the sample, then $\sigma_{\bar{z}}^2$ must be estimated by

$$s_{\bar{z}}^2 = \frac{K}{y} - \frac{(x - 1)}{xy} B \qquad (32)$$

Now as a matter of fact for a given grid size the numbers of farms vary from grid to grid and where the grid becomes relatively small (a section or less) some grids will contain no farms at all. Since the number of degrees of freedom associated with the grid mean square depends on the number of grids having farms, it will be necessary to regard Y and y as the population and sample number of grids having farms, and X and x as the population and sample mean number of farms per grid having farms. (About two-thirds of quarter-sections and about 99 percent of sections have farms.)

An estimate of K can be obtained from a sample; moreover K is independent of x and y and is therefore a constant. B, the variance of farms within grids, may or may not be independent of x, although it is independent of y. What can we say of the relationship of B and x? Our answer is essentially empirical.

Estimates of B's for the quarter-section, township, county and state are available from the analyses of variance (after proper corrections are made). See Cochran (6). If the logarithms of these B's are plotted against the logarithms of the corresponding quarter-section, township, county and state areas, it will be seen that for a good number of items a fairly good linear relationship exists. (See fig. 2.) Smith (23) found that a similar empirical relationship existed between the variances of crop yields and plot areas.

Since it seems to be somewhat more reasonable, mean square distance among points within grids rather than area will be used as a measure of grid size in this empirical function. Hence we can write

$$\log B = \log c_1 + g \log d \qquad (33)$$

or
$$B = c_1 d^g \qquad (34)$$

where: c_1 and g are constants (g is the slope of B on d when graphed on double log paper).

d is the mean square distance among points within the grid.

If a and b are the sides of a rectangle[13], $d = \dfrac{a^2 + b^2}{6}$. When $g = 0$, then $B = c_1 = K$, which would mean that the item concerned is as variable in small groups as in large —that there is no intra-class correlation. If, for conven-

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[13]No reference can be given for this formula in the literature. With the aid of Dr. C. P. Winsor the formula was developed in the following manner:

In the attending diagram the distance between any two points, x_0, y_0 and x_1, y_1 in the rectangle is given by
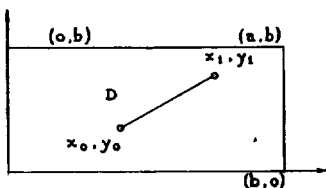
$$D = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}$$

$$D^2 = (x_1 - x_0)^2 + (y_1 - y_0)^2$$

mean D^2 for all points is given by

$$d = \frac{1}{a^2 b^2} \int_0^b \int_0^b \int_0^a \int_0^a (x_1^2 - 2x_1 x_0 + x_0^2 + y_1^2 - 2y_1 y_0 + y_0^2) dx_1 dx_0 dy_1 dy_0$$

solving,

$$d = \frac{a^2 + b^2}{6}$$

In the case of a square, $b = a$, and therefore

$$d = \frac{a^2}{3}$$
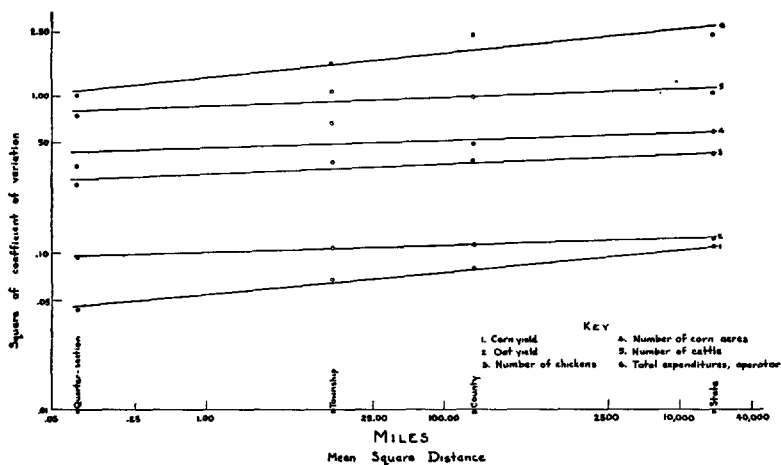
Fig. 2. Regressions of log coefficients of variation squared on log mean square distance for six selected items of the 1938 survey. For convenience of scale, means squares (estimates of variances) of items were divided by the squares of their means thus giving the squares of coefficients of variation $\left(v^2 = \dfrac{s^2}{\bar{z}^2} \right)$

ience, we limit ourselves to the case where grids are square, then (34) can be written in terms of x, thus[14]

$$B = c_2 x^{g/2} \tag{35}$$

---

[14]The intermediate steps are as follows: If a is the side of a square area and k is the number of farms per unit area, then

$$x = ka^2 \qquad \text{and } a^2 = \frac{x}{k}$$

Since for a square,

$$d = \frac{a^2}{3} \qquad \text{and since} \quad a^2 = \frac{x}{k}$$

then

$$d = \frac{x}{3k}$$

Now $B = c_1 d^g$ can be written

$$B = c_1 \left(\frac{x}{3k} \right)^g$$

or $\quad B = c_2 x^g \qquad \left(\text{where } c_2 = \dfrac{c_1}{(3k)^g} \right)$

We can now write (32) in terms of x, y and determinable quantities, where now

$$s_{\bar{z}}^2 = \frac{K}{y} - \frac{(x-1)}{y} c_2 x^{g-1} \qquad (36)$$

This then is our function, $f(x,y)$, the variance function. Let us now look at cost.

A COST FUNCTION FOR SAMPLE SURVEYS

If a route connecting y points located at random in a fixed area is minimized, the total distance, D, of that route is[15]

$$D = d\left(\frac{y-1}{\sqrt{y}}\right) \qquad (37)$$

where d is a constant.

This relationship is based upon the assumption that points are connected by direct routes. In Iowa the road system is a quite regular network of mile square mesh. There are very few diagonal roads, therefore, routes between points resemble those taken on a checkerboard. A test wherein several sets of different members of points were located at random on an Iowa county road map, and the minimum distance of travel from a given point on the border of the county through all the points and to an end point (the county border nearest the last point on route), revealed that

$$D = d\sqrt{y} \qquad (38)$$

works well. Here y is the number of randomized points (border points not included). This is of great aid in setting up a cost function.

To proceed, let:

    x = number of farms in a sampling unit
    q = time (in hours) spent on a farm. (This covers total time elapsing during the farm visit.)
    w = salary and living expenses (in dollars per hour while working)
    t = average distance between farms within the sampling unit (in miles)
    m = cost per mile of travel (in dollars)
    s = average speed of travel (miles per hour)
    y = number of sampling units in the sample

then the costs at and among y sampling units will be:

Cost due to	Costs at y sampling units	Costs among y sampling units
Time: enumerating	yxqw	
traveling	yxtw/s	$\sqrt{ydw/s}$
Transportation:	yxtm	$\sqrt{ydm}$

---

[15]Found stated in Mahalanobis (14).

Total cost[16] E, therefore is the sum of these costs or

$$E = yxtm + \sqrt{ydm} + yxqw + yxtw/s + \sqrt{ydw/s}$$

$$= xy(tm + qw + tw/s) + d(m + w/s)y^{\frac{1}{2}}$$

putting $(tm + qw + tw/s) = A$

and $d(m + w/s) = B$

then $E = Axy + By^{\frac{1}{2}}$ (39)

In Iowa, t is approximately a constant having the value 1 mile for points randomly selected within the state while d is roughly 232. The remaining variables will depend on the circumstances of the proposed survey.

We now have an expression for $\phi(x,y)$ the cost function.

With $\quad s_{\bar{z}}^2 = \dfrac{K}{y} - \dfrac{(x-1)c_2 x^{g-1}}{y}$

and $\quad E = Axy + By^{\frac{1}{2}}$,

$s_{\bar{z}}^2$ can be minimized[17] for a given E.

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[16]Not to be confused with total cost of survey. Only those costs largely affected by x and y have been considered in this cost function.

[17]The minimum can be obtained by minimizing

$$f(x,y) - \lambda\phi(x,y)$$

which gives two equations, $\dfrac{\partial f}{\partial x}$ and $\dfrac{\partial f}{\partial y}$; and a third, $\phi(x,y) = E$ to determine the three unknowns: x, y and λ. The first two equations are:

$$\frac{\partial f}{\partial x} = \lambda\frac{\partial\phi}{\partial x}$$

$$\frac{\partial f}{\partial y} = \lambda\frac{\partial\phi}{\partial y}$$

which become, when λ is eliminated,

$$\frac{\partial f}{\partial x}\frac{\partial\phi}{\partial y} - \frac{\partial f}{\partial y}\frac{\partial\phi}{\partial x} = 0$$

and when substitutions are made we obtain

$$A\left(K - c_2 x^g + c_2 x^{g-1}\right) + \left(Ax + \frac{By^{\frac{1}{2}}}{2}\right)\left[-c_2 g x^{g-1} + c_2(g-1)x^{g-2}\right] = 0$$

which reduces to

$$y = \frac{B^2}{4A^2 x^2}\left\{\frac{g(x-1)+1}{\frac{Kx^{1-g}}{c_2} - x(g+1)+g}\right\}^2$$

This equation together with

$$E = Axy + By^{\frac{1}{2}}$$

provides two equations to determine x and y for the minimum. It can be seen that the complete solution becomes rather difficult.

Since an algebraic solution of these equations is rather difficult we shall have to adopt a rougher but more convenient procedure of determining the best allocation of expenditure by trial and error.

For investigation we selected seven sampling units, the individual farm and the following six grids: quarter-section, half-section, full section, 2 adjacent sections, 4-section block and the 36-section block (survey township). Assuming (in the cost equation) an s of 30 miles per hour, w to be a dollar per hour and q and m given specified values, total number of sampling units which can be covered for a given expenditure have been computed[18]. They appear in table 26.

TABLE 26. NUMBERS OF SAMPLING UNITS WHICH CAN BE COVERED, GIVEN SEVERAL COST SITUATIONS, TWO EXPENDITURE LEVELS, AND SEVEN DIFFERENT SAMPLING UNITS[a]. UNSTRATIFIED SAMPLE IN THE STATE OF IOWA.

Sampling unit	Number of farms per sampling unit[b]	Mileage at 2¢ / mile			Mileage at 5¢ / mile		
		Length of farm visit			Length of farm visit		
		15 min.	60 min.	120 min.	15 min.	60 min.	120 min.
A. Total expenditure of $1000							
Individual farm	1.000	1644	650	371	1088	517	315
Quarter-section	0.914	1745	699	401	1140	551	339
Half-section	1.828	1073	392	218	764	336	192
Section	3.656	624	213	116	475	186	105
Two-sections	7.312	347	113	60	278	102	56
Four-sections	14.624	187	59	31	156	54	29
Thirty-six sections	131.616	21	7	4	17	6	3
B. Total expenditure of $2000							
Individual farm	1.000	4012	1452	803	2886	1223	712
Quarter-section	0.914	4293	1569	871	3057	1314	769
Half-section	1.828	2494	852	462	1900	744	421
Section	3.656	1388	451	241	1112	407	225
Two-sections	7.312	749	235	124	623	217	118
Four-sections	14.624	396	121	63	338	113	61
Thirty-six sections	131.616	44	14	7	38	13	7

[a]Computed from the formula: $y = \left(\dfrac{-B \pm \sqrt{B^2 + 4ACx}}{2Ax} \right)^2$

[b]Computed from the sample survey data.

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[18]In addition it was assumed that costs per farm became constant for sampling units exceeding in size the 4-section block. This decision was made because it was felt that where the enumerator must travel to a town for overnight lodging it was no less costly for him to locate himself at a new sampling unit than return to that being worked the previous day. It can be seen that this holds only roughly but it is believed to be a good approximation for the purposes at hand.

In table 27 are shown computed numbers of farms which can be visited for a given expenditure and the corresponding average cost per farm.

TABLE 27. ESTIMATED NUMBER OF FARMS WHICH CAN BE ENUMERATED AND AVERAGE COST PER FARM, GIVEN SEVERAL COST SITUATIONS, TWO EXPENDITURE LEVELS AND SEVEN DIFFERENT SAMPLING UNITS.

Expend-iture and Samp-ling unit	Mileage at 2¢ / mile						Mileage at 5¢ / mile					
	Length of farm visit						Length of farm visit					
	15 min.		60 min.		120 min.		15 min.		60 min.		120 min.	
	No. of farms	Cost per farm	No. of farms	Cost per farm	No. of farms	Cost per farm	No. of farms	Cost per farm	No. of farms	Cost per farm	No. of farms	Cost per farm
A. Total expenditure of $1000												
I.F.	1644	$0.61	650	$1.54	371	$2.70	1088	$0.92	517	$1.93	315	$3.17
S₄	1595	0.63	639	1.56	366	2.73	1042	0.96	504	1.99	309	3.24
S₂	1962	0.51	717	1.39	398	2.51	1397	0.72	614	1.63	352	2.84
S	2280	0.44	778	1.29	422	2.37	1737	0 58	680	1.47	385	2.60
2-S	2538	0.39	825	1.21	440	2.27	2034	0.49	744	1.34	411	2.43
4-S	2739	0.37	860	1.16	453	2.21	2277	0.44	791	1.26	430	2.33
36-S	2739	0.37	860	1.16	453	2.21	2277	0.44	791	1.26	430	2.33
B. Total expenditure of $2000												
I. F.	4012	0.50	1452	1.38	803	2.49	2886	0.69	1223	1.64	712	2 81
S₄	3923	0.51	1434	1.39	796	2.51	2794	0.72	1201	1.67	703	2.84
S₂	4559	0.44	1557	1.28	845	2.37	3473	0.58	1360	1.47	770	2.60
S	5076	0.42	1650	1.21	881	2.27	3955	0.49	1447	1.34	799	2 44
2-S	5479	0.37	1720	1.16	907	2.21	4553	0.44	1585	1.26	859	2.33
4-S	5784	0.35	1771	1.13	926	2.16	4936	0.41	1657	1.21	888	2.25
36-S	5784	0.35	1771	1.13	926	2.16	4936	0.41	1657	1.21	888	2.25

B-values were computed for a set of items including both 1938 and 1939 data, where $B = c_1 d^g$. Then with equation (32)

$$s_{\bar{z}}^2 = \frac{K}{y} - \frac{(x-1)}{xy} B$$

modified to give relative sampling error in percent of the means, we have,

$$v_{\bar{z}} = \frac{100}{\bar{z}} \sqrt{\frac{K}{y} - \frac{(x-1)}{xy} B} \qquad (40)$$

as a formula by which the relative sampling errors of the various sampling units and cost conditions can be computed. A set of these computations appears in table 28.1. In appendix A other sets will be found.

TABLE 28.1. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case I: Expenditure of $1000, 15-minute questionnaire and 2¢ per mile.)

Items	\	\	\	Sampling unit	\	\	\
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine	2.67	2.82	2.74	2.90	3.36	4.11	9.99
2. Number horses	1.83	1.93	1.87	1.98	2.27	2.80	6.87
3. Number sheep	9.61	9.76	8 80	8.16	7.74	7.44	7.44
4. Number chickens	1.61	1.70	1.66	1.78	2.07	2.57	6.34
5. Number eggs yesterday	3.17	3.21	2.90	2.69	2.55	2.45	2.45
6. Number cattle	2.55	2.67	2.55	2.65	2.98	3.62	8.66
7. Number cows milked	1.98	2.07	2.00	2.09	2.37	2.88	6.79
8. Number gallons milked	2.34	2.45	2.32	2.39	2.64	3.15	7.17
9. Dairy product receipts	2.99	3.11	2.93	2.97	3.24	3.79	8 55
10. Number farm acres	1.54	1.63	1.57	1.64	1.87	2.28	5.58
11. Number corn acres	1.95	2.06	1.98	2.08	2.37	2.87	6.88
12. Number oat acres	2.36	2.59	2.66	3.05	3.78	4.91	12.76
13. Corn yield	.82	.90	.94	1.09	1.36	1.78	4.73
14. Oat yield	.84	.88	.84	.86	.96	1.15	2.71
15. Comm. feed expenditures	6.23	7.06	7.60	9.14	11.78	15.71	43.07
16. Total expenditures, op.	3.96	4.36	4.51	5.21	6.48	8.46	22.36
17. Total receipts, op.	3.16	3.49	3.64	4.23	5.29	6.93	18.39
18. Net cash income, op.	3.54	3.82	3.84	4.26	5.13	6.57	16.82
1939							
1. Number swine	2.16	2.33	2.33	2.58	3.09	3.92	10.01
2. Number horses	1 59	1.62	1.46	1.35	1.28	1.24	1.24
3. Number sheep	6.51	6.82	6.53	6.79	7.64	9.17	21.65
4. Number chickens	1.68	1.75	1.66	1.70	1.86	2.21	4.82
5. Number eggs yesterday	2.73	2.88	2.78	2.93	3.35	4.10	9.98
6. Number cattle	1.98	2.01	1.81	1.68	1.59	1.53	1.53
7. Number cows milked	2.05	2.12	1.98	1.98	2.11	2.40	5.09
8. Number gallons milked	2.30	2.41	2.31	2.40	2.70	3.29	7.71
9. Dairy product receipts	....	....	....	....	....	....	....
10. Number farm acres	1.57	1.59	1.44	1.33	1.26	1.22	1.22
11. Number corn acres	1.66	1.78	1.72	1.72	1.92	2.30	5.25
12. Number oat acres	2.10	2.35	2.49	2.83	3.61	4.77	13.74
13. Corn yield	.57	.61	.60	.65	.77	.96	2.41
14. Oat yield	1.33	1.42	1.40	1.52	1.82	2.29	6 07
15. Comm. feed expenditures	....	....	....	....	....	....	....
16. Total expenditures, op.	2.47	2.60	2.50	2.61	2.96	3.61	8 63
17. Total receipts, op.	2.45	2.68	2.78	3 25	4 05	5.30	14 01
18. Net cash income, op.	6 57	7.18	7.32	8.30	10.19	13.17	34.24
19. Net income, op.	....	....	....	....	....	....	....
20. Number hogs sold	2.55	2.58	2.33	2.16	2.05	1.97	1.97
21. Number cattle sold	5.71	6.44	6.87	8.21	10.50	13.94	38.00
22. Number hogs bought	10.05	11.49	12.48	15.22	19.82	26.59	73.92
23. Number cattle bought	8.90	9.95	10.50	12.40	15.72	20.81	56.42

In table 29 the effect of cost factors on overall sampling efficiency of the six-grid sampling units is clearly shown. Low mileage costs, long questionnaires and large total expenditure require smaller grids; and conversely, high mileage costs, short questionnaires and small total expenditure require larger grids.

For a sample survey on the expenditure level of the 1938

TABLE 29. SUMMARY OF SAMPLING UNIT EFFICIENCIES. NUMBER OF ITEMS MOST EFFICIENTLY ESTIMATED BY THE SIX-GRID SAMPLING UNITS, 1938 AND 1939.

Expenditure, mileage rate and questionnaire length			Sampling unit					
			S₄	S₂	S	2-S	4-S	36-S
Expenditure of $1000								
I	2¢ / 15 min.	1938...........	6	10	....	....	1	1
		1939..........	6½	8½	1	....	2	2
II	2¢ / 60 min.	1938...........	13	3	....	....	1	1
		1939..........	14	2	....	....	2	2
III	2¢ / 120 min.	1938...........	16	....	....	....	1	1
		1939..........	16	....	....	....	2	2
IV	5¢ / 15 min.	1938...........	1	12½	2½	....	1	1
		1939..........	4	9	3	....	2	2
V	5¢ / 60 min.	1938...........	6	10	....	....	1	1
		1939..........	7½	8½	....	....	2	2
VI	5¢ / 120 min.	1938...........	11½	4½	....	....	1	1
		1939..........	12	4	....	....	2	2
Expenditure of $2000								
VII	2¢ / 15 min.	1938...........	7	9	....	....	1	1
		1939..........	8	8	....	....	2	2
VIII	2¢ / 60 min.	1938...........	16	....	....	....	1	1
		1939..........	15	1	....	....	2	2
IX	2¢ / 120 min.	1938...........	16	....	....	....	1	1
		1939..........	16	....	....	....	2	2
X	5¢ / 15 min.	1938...........	5	11	....	....	1	1
		1939..........	6	8	2	....	2	2
XI	5¢ / 60 min.	1938...........	12½	3½	....	....	1	1
		1939..........	12	4	....	....	2	2
XII	5¢ / 120 min.	1938...........	12½	3½	....	....	1	1
		1939..........	14	2	....	....	2	2

and 1939 Iowa surveys (Case V: $1000, 5c per mile and 60 minute questionnaire) it looks as if both the quarter- and half-section grid would have about the same efficiency. For certain administrative reasons (not-at-home farms could be revisited more cheaply and conveniently, an accurate determination of the number of farms on the chosen areas can be made more conveniently in the county AAA offices, etc.), the half-section may be recommended over the quarter-section as a sampling unit for this kind of survey. If, however, a much larger sample is taken (greater expenditure) then the quarter-section becomes the better choice. (Compare cases V and XI, table 29.)

It must be remembered that these observations on the efficiencies of sampling units apply only to the case where item means **per farm** are being estimated. Efficiencies may be quite different in the case where item means are being estimated on a **per grid** basis.

EFFICIENCY OF INCOMPLETE MATCHING

By design the 1939 sample was half independent of and half matched with the 1938 sample. The problem with which we are here concerned is the estimation of the efficiency with which this incompletely matched sample estimates item means in 1939 as compared with one which is wholly independent.

Let the value of an item (per grid) in 1939 be related to its value in 1938 such that we can express the relationships as

$$y = a + bx \qquad (41)$$

where y and x are values of the item for the same grid in 1939 and 1938, respectively, b the coefficient of regression of y on x and a is a constant.

For the population we can write

$$\bar{Y} = A + B\bar{X} \qquad (42)$$

where $\bar{Y}$ and $\bar{X}$ are the true means per grid in 1939 and 1938 respectively and A and B are the population parameters. After the samples are drawn, we would like to know the best possible estimates of $\bar{Y}$ and $\bar{X}$. Using sample data alone the best estimate of $\bar{X}$ is merely the 1938 sample sum of the item divided by the 900 grids of which it was composed. Let this be $\bar{x}$ and let the 1938 mean of the 450 matched grids be $\bar{x}_m$. Furthermore let $\bar{y}_m$ be the mean of the 450 matched grids in 1939, $\bar{y}_u$ the mean of the 450 unmatched grids in 1930 and $\bar{y}$ the overall mean of all 900 grids of 1939. Ordinarily $\bar{y}$ would be used as the estimate of $\bar{Y}$. But as an alternative, $\bar{y}_m$ could be adjusted if $\bar{x}_m \neq \bar{x}$ such that the adjusted $\bar{y}_m$,

$$\bar{y}_m' = \bar{y}_m + b\ (\bar{x} - \bar{x}_m) \qquad (43)$$

Now the variance of $\bar{y}_m'$, $\sigma^2_{\bar{y}_m}'$ is given by [19]

$$\sigma^2_{\bar{y}_m}' = \frac{\sigma^2(1-\rho^2)}{n} \left[1 + \left(\frac{N-n}{N}\right) \frac{1}{(n-3)} \right] + \frac{\sigma^2 \rho^2}{N} \qquad (44)$$

---

[19]Developed by W. G. Cochran. It is assumed that N is a small portion of the population.

where $N =$ number in the 1938 sample
            $n =$ number out of N which were matched in 1939
            $\sigma^2 =$ true sampling variance of the item in 1939
            $\rho =$ true correlation coefficient of the population

The variance of $\sigma^2_{\bar{y}_m}$ is $\dfrac{\sigma^2_{y}}{n}$. It can be seen that $\sigma^2_{\bar{y}_m}{}'$ is less than $\sigma^2_{\bar{y}_m}$ if there is any substantial correlation. Let us assume for the moment we have these correlations and therefore adopt $\bar{y}'_m$ as the best estimate of $\bar{Y}$ from the matched portion of the sample.

We have now two estimates of $\bar{Y}$, $\bar{y}_u$ and $\bar{y}'_m$, which are independent of each other, representing the two portions of the sample and differing in variances. Combining the two for the best overall estimate of $\bar{Y}$ we obtain the weighted estimate (weighted inversely as the variances),

$$\bar{y}_w = \frac{\bar{y}'_m \, \sigma^2_{\bar{y}_u} + \bar{y}_u \, \sigma^2_{\bar{y}_m}{}'}{\sigma^2_{\bar{y}_u} + \sigma^2_{\bar{y}_m}{}'} \qquad (45)$$

having the variance,

$$\sigma^2_{\bar{y}_w} = \frac{\sigma^2_{\bar{y}_u} \, \sigma^2_{\bar{y}_m}{}'}{\sigma^2_{\bar{y}_u} + \sigma^2_{\bar{y}_m}{}'} \qquad (46)$$

The variance of the unweighted mean $\bar{y}$ in our sample is

$$\frac{\sigma^2_{y}}{2n} \text{ or } \frac{\sigma^2_{y}}{900}$$

We compare the variance of the two estimates $\bar{y}$ and $\bar{y}_w$ to determine relative efficiencies of the incompletely matched sample as compared with an unmatched sample. This relative efficiency is given by the ratio

$$\text{Relative efficiency} = \frac{\sigma^2_{\bar{y}}}{\sigma^2_{\bar{y}_w}} \times 100$$

which in our case where both n and N are large and where $n = \frac{N}{2}$, reduces to

$$\text{Relative efficiency} = \frac{4 - \rho^2}{2(2 - \rho^2)} \times 100 \qquad (47)$$

TABLE 30. RELATIVE EFFICIENCY OF THE HALF MATCHED HALF UN-
MATCHED 1939 SAMPLE COMPARED WITH THAT OF A COM-
PLETELY UNMATCHED SAMPLE WHEN ITEM MEANS FOR 1939
ARE BEING ESTIMATED.

Item	Relative efficiency
	(%)
1. Acres in farms.....	145
2. Corn acres, harvested....	145
3. Oat acres, grain....	139
4. Barley acres, grain....	131
5. Number of swine....	137
6. Number of horses....	142
7. Number of cattle....	140
8. Number of sheep....	143
9. Number of chickens....	141
10. Receipts from sales of dairy products....	136
11. Gross expenditures, operator....	131
12. Gross receipts, operator....	138
13. Net cash income, operator....	122
14. Number of persons on farms....	143

Estimated relative efficiencies on a group of items have been computed to show how much the incomplete matching as followed in the sample survey has increased efficiency over unmatched samples in estimating year means. These estimates appear in table 30.

It is clear that estimates of the 1939 means were substantially improved by the adoption of the above method of estimation (45). If correlations were perfect ($\pm$ 1) the gain in relative efficiency would be 50 percent.

The question may now be raised, what would have been the best fraction to match, assuming that the first year's sample had already been taken and that for a given expenditure the best possible estimates of 1939 means were desired? The problem here is to determine how a given expenditure should be made between n matched and m unmatched sampling units, assuming the unit cost of obtaining each is the same.

The best allocation of sampling resources between n and m will be obtained if

$$\frac{\partial \sigma^2_{\bar{y}_m}'}{\partial n} = \frac{\partial \sigma^2_{\bar{y}_u}}{\partial m}. \tag{48}$$

Since

$$\frac{\partial \sigma^2_{\bar{y}_m}'}{\partial n} = \frac{-\sigma^2(1-\rho^2)}{n^2} + \frac{Nn(n-3)-\sigma^2(1-\rho^2)-\sigma^2(1-\rho^2)(N-n)(2Nn-3N)}{N^2 n^2 (n-3)^2}$$

and

$$\frac{\partial \sigma^2_{\bar{y}_u}}{m} = \frac{-\sigma^2 y}{m^2}$$

then,

$$\frac{n^2}{m^2}=(1-\rho^2)-\frac{n}{\sigma^2\,N(n-3)}+\frac{(1-\rho^2)+(1-\rho^2)(N-n)(2Nn-3N)}{N^2(n-3)^2}\quad(49)$$

But if N is large, σ^2 fairly large and n >3,

$$\frac{n^2}{m^2}=1-\rho^2$$

and

$$m/n=\sqrt{\frac{1}{1-\rho^2}}\quad(50)$$

When $\rho=0$, $m/n=1$, that is when there is no year to year correlation matched and unmatched sampling units are equal in sampling information—it makes no difference whether matching is done or not. When $\rho=\pm1$, however, $m/n\to\infty$, which would indicate that no matching should be done at all—that only unmatched sampling units should be taken. But (50) is an approximation and appropriate only when N is large and n >3. Actually when $\rho=\pm1$, n must be two in order that the regression can be determined for the adjustment of $\bar{y}_m$. Any further increase in n would yield no more information, hence all further increase in sample size should be with unmatched sampling units.

For illustration, m/n values, that is the optimum allocation ratios of unmatched to matched, have been computed for a set of items shown in table 31.

TABLE 31. ESTIMATED CORRELATION COEFFICIENTS AND OPTIMUM ALLOCATION RATIOS OF UNMATCHED TO MATCHED GRID SAMPLING UNITS FOR A SELECTED SET OF SAMPLE SURVEY ITEMS.

Item	r	$\dfrac{m}{n}=\sqrt{\dfrac{1}{1-r^2}}$
1. Farm acres	.9724	4.29
2. Corn acres	.9709	4.18
3. Oat acres	.9368	2.86
4. Barley acres	.8763	2.08
5. Number of horses	.9539	3.33
6. Number of cattle	.9415	2.97
7. Number of swine	.9229	2.60
8. Number of sheep	.9590	3.53
9. Number of chickens	.9476	3.13
10. Receipts from dairy products	.9185	2.53
11. Total expenditures, farm	.8736	2.05
12. Total receipts, farm	.9269	2.66
13. Net cash income, operator	.7759	1.59
14. Number of persons	.9612	3.62

It can be seen that, for the kind of items investigated, roughly 2 or 3 unmatched sampling units should be taken to every one that is matched. For this particular sampling problem the half-and-half sample is not as efficient as one having a smaller portion matched, regardless of what the correlation coefficient may be.

Let us now consider the problem of determining the allocation of sampling units among the three categories of a sample design involving incomplete matching: (a) N, the sample of the first year (b) n, the matched sample of the subsequent year and (c) m, the unmatched sample of the subsequent year. The problem is to find the relationship which N, n and m must hold with each other such that (a) the variance of the sample means is the same each year and (b) that the total of N, n and m is a minimum for given sampling variances. In other words, what is the best allocation of sampling resources between and within years for this kind of sampling design?

Algebraically we want these three conditions satisfied:

(a) $\sigma_{\bar{y}}^2 = \sigma_{\bar{y}_w}^2$ (assuming σ^2 is the same both years)

(b) $n = m\sqrt{1-\rho^2}$

(c) $N + n + m$ minimized for a given $\sigma_{\bar{y}}^2$ or $\sigma_{\bar{y}_w}^2$.

It is assumed here that the population variance, σ^2, remains the same both years, that N is large, that $n > 3$, and sampling units are obtainable at equal and constant unit costs.

Then (a) can be written

$$\frac{\sigma^2}{N} = \frac{\sigma_{\bar{y}_u}^2 \; \sigma_{\bar{y}_m}^{2\,\prime}}{\sigma_{\bar{y}_u}^2 + \sigma_{\bar{y}'_m}^2} \tag{51}$$

and since approximately (if N is large and n moderately so)

$$\sigma_{\bar{y}'}^2 = \frac{\sigma^2(1-\rho^2)}{n} + \frac{\sigma^2\rho^2}{N}$$

and also $\sigma_{\bar{y}_u}^2 = \frac{\sigma^2}{m}$

then

$$\frac{\sigma^2}{N} = \frac{\dfrac{\sigma^2}{m}\left[\dfrac{\sigma^2(1-\rho^2)}{m} + \dfrac{\sigma^2\rho^2}{N}\right]}{\dfrac{\sigma^2}{m} + \dfrac{\sigma^2(1-\rho^2)}{n} + \dfrac{\sigma^2\rho^2}{N}} \tag{52}$$

which when $m\sqrt{1-\rho^2}$ is substituted for n finally reduces to

$$\frac{m}{N}=\frac{-(1-\rho^2+\sqrt{1-\rho^2})+\sqrt{(1-\rho^2+\sqrt{1-\rho^2})^2+4\rho^2\sqrt{1-\rho^2}}}{2\rho^2} \quad (53)$$

For several values of ρ and for $N = 1000$, computed optimum values of m and n appear in the following table.

	$\rho = 0$	$\rho = \pm.5$	$\rho = \pm.9$	$\rho = \pm.98$	$\rho = \pm 1.0$
N	1000	1000	1000	1000	1000
m	500	498	443	349	0
n	500	431	193	70	2
Total	2000	1929	1636	1419	1002

Where $\rho = 0$, m and n need not be 500 each—it is necessary only that $m + n = 1000$. Apparently we can conclude that if item year-to-year correlations are rather high (and known beforehand) considerable gain can be obtained by incomplete matching in the manner just considered. By referring to the estimated ρ's given in table 31, it can be seen that since year-to-year correlations vary quite a lot among items incomplete matching would vary in efficiency according to the item. Farm and corn acres would have worked well whereas "Operator's net cash income" would have done only moderately so (about 10 percent fewer sampling units being required.)

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APPENDIX A

ESTIMATES OF SAMPLING ERRORS FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND COST SITUATIONS

For the two expenditure levels, $1000 and $2000; the two mileage rates, 2 cents and 5 cents per mile; and the three questionnaire lengths—15-minute, 60-minute and 120 minute—relative sampling errors have been computed for each

TABLE 28.2. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case II: Expenditure of $1000, 60-minute questionnaire and 2¢ per mile.)

Items	I. F.	S₄	S₂	S	2-S	4-S	36-S
				Sampling unit			
1938							
1. Number swine............	4.24	4.45	4.53	4.96	5.89	7.34	17.82
2. Number horses...........	2.91	3.05	3.09	3.39	3.98	4.99	12.26
3. Number sheep............	15.28	15.41	14.55	13.97	13.57	13.29	13.29
4. Number chickens.........	2.55	2.69	2.75	3.05	3.64	4.58	11.32
5. Number eggs yesterday....	5.03	5.08	4.79	4.60	4.47	4.38	4.38
6. Number cattle............	4.05	4.21	4.21	4.54	5.22	6.46	15.45
7. Number cows milked......	3.14	3.28	3.31	3.58	4.16	5.13	12.12
8. Number gallons milked....	3.73	3.86	3.84	4.09	4.64	5.62	12.80
9. Dairy product receipts.....	4.75	4.90	4.84	5.08	5.68	6.77	15.26
10. Number farm acres.......	2.45	2.57	2.59	2.81	3.29	4.07	9.96
11. Number corn acres........	3.11	3.25	3.27	3.56	4.16	5.13	12.28
12. Number oat acres.........	3.76	4.10	4.41	5.23	6.63	8.77	22.78
13. Corn yield...............	1.30	1.43	1.55	1.86	2.38	3.17	8.44
14. Oat yield...............	1.34	1.39	1.39	1.48	1.69	2.05	4.84
15. Comm. feed expenditures..	9.90	11.15	12.56	15.64	20.67	28.04	76.88
16. Total expenditures, op.....	6.29	6.89	7.46	8.92	11.37	15.10	39.92
17. Total receipts, op........	5.01	5.52	6.02	7.23	9.28	12.37	32.84
18. Net cash income, op.......	5.63	6.04	6.35	7.29	9.00	11.73	30.02
1939							
1. Number swine............	3.44	3.68	3.85	4.41	5.42	7.00	17.87
2. Number horses...........	2.54	2.56	2.41	2.32	2.25	2.20	2.20
3. Number sheep............	10.36	10.77	10.80	11.62	13.40	16.36	38.66
4. Number chickens.........	2.68	2.77	2.75	2.90	3.27	3.94	8.60
5. Number eggs yesterday....	4.34	4.55	4.60	5.01	5.87	7.31	17.82
6. Number cattle............	3.14	3.17	2.99	2.87	2.79	2.73	2.73
7. Number cows milked......	3.27	3.35	3.28	3.38	3.70	4.29	9.08
8. Number gallons milked....	3.65	3.80	3.82	4.11	4.74	5.87	13.76
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	2.50	2.52	2.38	2.28	2.22	2.17	2.17
11. Number corn acres........	2.64	2.81	2.84	2.94	3.37	4.10	9.37
12. Number oat acres.........	3.34	3.72	4.11	4.84	6.33	8.52	24.53
13. Corn yield...............	.91	.96	1.00	1.12	1.35	1.71	4.30
14. Oat yield...............	2.12	2.24	2.31	2.61	3.18	4.09	10.83
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	3.93	4.11	4.14	4.47	5.18	6.45	15.40
17. Total receipts, op........	3.89	4.24	4.60	5.56	7.11	9.46	25.01
18. Net cash income, op.......	10.46	11.34	12.10	14.21	17.88	23.51	61.12
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	4.05	4.08	3.86	3.70	3.59	3.52	3.52
21. Number cattle sold........	9.08	10.17	11.36	14.05	18.43	24.88	67.83
22. Number hogs bought......	15.98	18.15	20.64	26.04	34.77	47.45	131.97
23. Number cattle bought.....	14.15	15.72	17.37	21.23	27.58	37.14	100.71

of seven different sampling units, the individual farm, quarter-section, half-section, section, two-section, four-section and township grid. It has been assumed further that measurement is on a **per farm** basis (as contrasted with a **per grid** basis for example), and that sampling units are drawn at random from the state of Iowa. Computations

TABLE 28.3. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case III: Expenditure of $1000, 120-minute questionnaire and 2¢ per mile.)

Items	Sampling unit						
	I. F.	S_4	S_2	S	2-S	4-S	36-S
1938							
1. Number swine............	5.62	5 88	6.07	6.74	8.06	10.11	24 56
2. Number horses............	3.85	4.02	4.15	4 60	5.45	6.87	16.89
3. Number sheep............	20 23	20.36	19.53	18.96	18.57	18 30	18 30
4. Number chickens.........	3.38	3.55	3.69	4.14	4.98	6 31	15 60
5. Number eggs yesterday....	6.66	6.71	6.43	6 25	6.12	6 03	6 03
6. Number cattle............	5.36	5.56	5.65	6.16	7.15	8.90	21.29
7. Number cows milked......	4 16	4.33	4.44	4.85	5.69	7.07	16.70
8. Number gallons milked....	4.94	5.10	5.16	5 54	6.35	7.74	17.64
9. Dairy product receipts.....	6 29	6.48	6.50	6.90	7.78	9 32	21.03
10. Number farm acres.......	3 25	3.39	3.47	3.82	4.50	5 61	13.72
11. Number corn acres........	4.12	4.29	4.39	4.83	5.70	7.06	16 92
12. Number oat acres.........	4.98	5 41	5.92	7.10	9.07	12.08	31 38
13. Corn yield...............	1 72	1.88	2.08	2.53	3.26	4.36	11 63
14. Oat yield................	1.78	1.84	1.86	2.00	2.32	2.82	6 67
15. Comm. feed expenditures..	13.11	14.73	16.86	21.23	28.29	38.62	105.93
16. Total expenditures, op.....	8.33	9.10	10.01	12.12	15.56	20.79	55.00
17. Total receipts, op........	6 63	7.29	8.08	9.82	12.70	17.04	45 24
18. Net cash income, op.. . . .	7.45	7.98	8 52	9 89	12.33	16.16	41 36
1939							
1. Number swine............	4.55	4 86	5.16	5.98	7 42	9.64	24.62
2. Number horses............	3.36	3.38	3.24	3.14	3.08	3 04	3 04
3. Number sheep............	13.71	14.22	14 50	15.78	18.34	22 54	53.26
4. Number chickens.........	3.54	3.66	3 68	3 94	4.48	5 43	11 85
5. Number eggs yesterday....	5.75	6 01	6 17	6 80	8 04	10.07	24 55
6. Number cattle............	4.16	4.19	4.02	3 90	3 82	3.76	3 76
7. Number cows milked......	4.32	4.43	4.41	4 59	5.07	5 91	12 51
8. Number gallons milked....	4.83	5.02	5 12	5 57	6 50	8 09	18.96
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	3.31	3.33	3.19	3.10	3 04	2.99	2.99
11. Number corn acres........	3.49	3.71	3.81	3.99	4.62	5.65	12 91
12. Number oat acres.........	4.42	4.91	5.52	6 57	8.66	11.73	33 80
13. Corn yield...............	1.20	1.27	1.34	1.51	1.84	2.35	5.93
14. Oat yield................	2.80	2.96	3.10	3.54	4.36	5.64	14.92
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	5.20	5.43	5.56	6.07	7.10	8 88	21.22
17. Total receipts, op........	5.15	5.60	6.17	7 54	9 73	13.02	34.46
18. Net cash income, op.......	13.84	14.97	16 24	19.29	24 48	32 38	84.21
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	5.36	5.39	5.17	5 02	4.92	4.85	4 85
21. Number cattle sold........	12 02	13.43	15.25	19.07	25 22	34.26	93.45
22. Number hogs bought......	21.15	23.97	27.70	35.35	47.59	65.35	181.82
23. Number cattle bought.....	18 74	20.75	23.30	28.81	37.75	51.15	138.76

have carried out on both 1938 and 1939 sample survey data on a selected group of items.

The tables should be useful in gaining an idea of the sampling errors to be expected on different items and also in seeing the relative merits of different sampling schemes under varying conditions of cost.

TABLE 28.4. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case IV: Expenditure of $1000, 15-minute questionnaire and 5¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine............	3.28	3.49	3.24	3.32	3.75	4.51	10.95
2. Number horses..........	2.25	2.39	2.21	2 27	2 54	3.07	7.53
3. Number sheep............	11.81	12.07	10.42	9.35	8.64	8.17	8.17
4. Number chickens........	1.97	2.10	1.97	2.04	2 32	2.82	6.96
5. Number eggs yesterday....	3.89	3.98	3.43	3.08	2.85	2.69	2.69
6. Number cattle............	3 13	3.30	3.02	3.04	3.32	3.97	9.49
7. Number cows milked......	2.43	2.57	2.37	2.39	2.65	3.16	7.44
8. Number gallons milked....	2.88	3.02	2.75	2.74	2.96	3.45	7.87
9. Dairy product receipts.....	3.67	3.84	3.47	3.40	3 62	4.16	9.38
10. Number farm acres.......	1.90	2.01	1.85	1.88	2.09	2.50	6.12
11. Number corn acres........	2.40	2.54	2.34	2.38	2.65	3.15	7.54
12. Number oat acres.........	2.91	3.21	3.16	3.50	4.22	5.39	13.99
13. Corn yield...............	1.00	1.12	1.11	1.25	1.52	1.95	5 18
14. Oat yield.................	1.04	1.09	.99	.99	1.08	1.26	2.98
15. Comm. feed expenditures..	7.66	8.73	9.00	10.47	13.16	17.23	47.24
16. Total expenditures, op.....	4.86	5.40	5.34	5.97	7 24	9.28	24.53
17. Total receipts, op........	3.87	4.32	4.31	4.84	5.91	7.60	20.17
18. Net cash income, op.......	4.35	4.73	4.55	4.88	5.74	7 21	18 44
1939							
1. Number swine............	2.66	2.88	2.76	2.95	3.45	4.30	10.98
2. Number horses...........	1.96	2.00	1.73	1.55	1.43	1.36	1.36
3. Number sheep............	8.01	8.43	7.74	7.78	8.53	10.06	23.75
4. Number chickens.........	2.07	2.17	1.97	1.94	2.08	2.42	5.28
5. Number eggs yesterday....	3.36	3.56	3.29	3.35	3.74	4.49	10.94
6. Number cattle............	2.43	2.48	2.14	1.92	1.78	1.68	1.68
7. Number cows milked......	2.52	2.63	2.35	2.26	2.36	2.64	5.58
8. Number gallons milked....	2.82	2.98	2.74	2.75	3.02	3.61	8.45
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	19.31	19.73	17.04	15.28	14.12	13.35	13.35
11. Number corn acres........	2.04	2.20	2.03	1.97	2.15	2.52	5.76
12. Number oat acres.........	2.58	2.91	2.94	3.24	4.03	5.24	15.07
13. Corn yield...............	.70	.75	.71	.75	.86	1.05	2.64
14. Oat yield.................	1.64	1.76	1.66	1.75	2.03	2.51	6.65
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	3.04	3.22	2.97	2.99	3.30	3 96	9.46
17. Total receipts, op........	3.01	3.32	3.29	3.72	4.53	5.81	15 36
18. Net cash income, op......	8.08	8.88	8.67	9.51	11.39	14.45	37.55
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	3.13	3.20	2.76	2.48	2.29	2.16	2.16
21. Number cattle sold........	7.02	7 96	8.14	9.40	11.74	15.29	41.67
22. Number hogs bought......	12.35	14.21	14.79	17.43	22.14	29.16	81.08
23. Number cattle bought.....	10.94	12.31	12.44	14.21	17.56	22.82	61.87

TABLE 28.5. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case V: Expenditure of $1000, 60-minute questionnaire and 5¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine............	4.76	5.01	4.89	5.31	6.20	7.65	18.58
2. Number horses..........	3.26	3.43	3 34	3.62	4.19	5.20	12.78
3. Number sheep...........	17.14	17.36	15.72	14.94	14.29	13 85	13.85
4. Number chickens........	2.86	3.03	2.97	3.26	3.83	4.78	11.80
5. Number eggs yesterday....	5.64	5.72	5.18	4.92	4.71	4.56	4.56
6. Number cattle...........	4.54	4.74	4.55	4.85	5.50	6.74	16.11
7. Number cows milked......	3.52	3.69	3.58	3.82	4.38	5.35	12.63
8. Number gallons milked....	4.18	4.35	4.15	4 37	4.89	5.86	13.34
9. Dairy product receipts.....	5.33	5.52	5.23	5.44	5 98	7.06	5 91
10. Number farm acres.......	2 75	2.89	2.80	3.01	3 46	4.24	10 38
11. Number corn acres........	3 48	3.66	3.54	3.81	4 39	5.35	12.80
12. Number oat acres.........	4.22	4.61	4.76	5 59	6 98	9.14	23 74
13. Corn yield..............	1.46	1.61	1.68	1.99	2.51	3.30	8.80
14. Oat yield....	1.50	1.57	1.50	1.58	1.78	2.14	5.05
15. Comm. feed expenditures..	11.10	12.56	13.57	16.73	21.76	29.23	80.14
16. Total expenditures, op.....	7.05	7.76	8.06	9 55	11.97	15.74	41.61
17. Total receipts, op.........	5.62	6.22	6 50	7.74	9.78	12.90	34.23
18. Net cash income, op.......	6.31	6.80	6.86	7.79	9.48	12.23	31.29
1939							
1. Number swine............	3.85	4.14	4.16	4.72	5 71	7.30	18.63
2. Number horses..........	2.84	2.88	2 61	2.48	2.37	2.30	2.30
3. Number sheep...........	11.61	12.13	11.67	12.43	14.11	17.06	40.29
4. Number chickens	3.00	3.12	2.97	3.11	3.44	4.11	8.96
5. Number eggs yesterday....	4.87	5.12	4.97	5.36	6.18	7.62	18.57
6. Number cattle............	—	—	—	—	—	—	—
7. Number cows milked......	3.66	3.78	3.55	3.62	3.90	4.47	9.47
8. Number gallons milked....	4.09	4.28	4.12	4.39	5.00	6.12	14.34
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	2.80	2.84	2.57	2.44	2.34	2.26	2.26
11. Number corn acres........	2.95	3.17	3.07	3.14	3.55	4.28	9.77
12. Number oat acres.........	3.75	4.19	4.44	5.18	6.66	8.88	25.57
13. Corn yield..............	1.02	1.08	1 08	1.19	1.42	1.78	4.49
14. Oat yield...............	2.37	2.52	2.50	2.79	3.35	4.27	11.29
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	4.41	4.63	4.48	4.78	5.46	6.72	16.06
17. Total receipts, op.........	4.36	4.77	4.97	5.94	7.48	9.86	26.07
18. Net cash income, op.......	11.72	12.77	13.08	15.20	18.83	24.51	63.71
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	4.54	4.60	4.17	3.96	3.79	3.67	3.67
21. Number cattle sold........	10.18	11.45	12.28	15.03	19.41	25.94	70.70
22. Number hogs bought......	17.92	20.44	22.30	27.86	36.62	49.47	137.56
23. Number cattle bought.....	15.87	17.70	18.76	22.71	29.05	38.72	104.98

TABLE 28.6. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case VI: Expenditure of $1000, 120-minute questionnaire and 5¢ per mile.)

Items	I. F.	S₄	S₂	S	2-S	4-S	36-S
				1938			
1. Number swine..	6 09	6.40	6 46	7.06	8.34	10.38	25 16
2. Number horses.	4.17	4.38	4 41	4.82	5.64	7 06	17.32
3. Number sheep...	21.95	22.15	20 78	19.86	19 22	18.79	18.79
4. Number chickens	3.66	3.86	3.93	4.33	5 16	6 48	16.00
5. Number eggs yesterday.. .	7.23	7.30	6.85	6.54	6.33	6 19	6 19
6. Number cattle	5.82	6 06	6.02	6.45	7.40	9.14	21.84
7. Number cows milked......	4.51	4.71	4.73	5.08	5.89	7.26	17.12
8. Number gallons milked....	5.35	5.55	5.49	5.81	6.57	7.94	18.09
9. Dairy product receipts.....	6.82	7 05	6.91	7.23	8 05	9.57	21.57
10. Number farm acres	3 52	3.69	3.70	4.00	4.66	5.78	14.08
11. Number corn acres........	4.46	4 67	4.67	5.06	5.90	7.25	17 35
12. Number oat acres........	5.40	5.89	6.30	7.43	9.39	12.40	32 19
13. Corn yield...............	1 86	2 05	2 22	2.65	3.37	4.48	11 93
14. Oat yield................	1.93	2 00	1.98	2.10	2.40	2 90	6.84
15. Comm. feed expenditures..	14.22	16.03	17 94	22.23	29 28	39 65	108.65
16. Total expenditures, op.....	9 03	9.91	10.66	12.69	16.10	21.35	17 84
17. Total receipts, op...... ...	7.19	7.93	8.60	10.28	13.15	17.50	46.40
18. Net cash income, op.......	8.08	8.68	9 06	10.36	12.76	16.59	42.42
				1939			
1. Number swine...........	4.94	5.29	5 50	6.27	7.68	9.90	25 25
2. Number horses	3.64	3.67	3.45	3.29	3.19	3 12	3 12
3. Number sheep..........	14.87	15.48	15.43	16.53	18 98	23.14	54 62
4. Number chickens.........	3 84	3.98	3.92	4.13	4 63	5 58	12.15
5. Number eggs yesterday....	6.24	6.54	6.57	7.12	8 32	10 34	25.18
6. Number cattle...........	4.51	4.55	4 27	4 08	3.95	3.86	3 86
7. Number cows milked......	4.69	4.82	4.69	4 81	5 25	6 06	12 84
8. Number gallons milked....	5.24	5 47	5 45	5.84	6 72	8 31	19 44
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres......	3.59	3.62	3.40	3 25	3.14	3.07	3.07
11. Number corn acres........	3.78	4.0⅃	4 05	4 18	4.78	5 81	13.25
12. Number oat acres........	4.80	5 34	5 87	6 88	8 96	12 05	34.66
13. Corn yield.......	1.31	1.38	1 42	1 58	1 91	2.42	6 08
14. Oat yield...	3.04	3.22	3.30	3 71	4.51	5.79	15.3℃
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	5.64	5.91	5.92	6 36	7.34	9 12	21 77
17. Total receipts, op.........	5.59	6.09	6 57	7 90	10 07	13 37	35 34
18. Net cash income, op.......	15.01	16.29	17.29	20 21	25 33	33.25	86 37
19. Net income, op.	—	—	—	—	—	—	—
20. Number hogs sold.........	5 81	5.87	5.51	5 26	5.09	4.98	4.98
21. Number cattle sold.......	13 04	14 61	16 23	19.97	26.11	35 19	95 85
22. Number hogs bought......	22.94	26 09	29 48	37 02	49 25	67 10	186.49
23. Number cattle bought.....	20.32	22.59	24.80	30.18	39 07	52 52	142.32

TABLE 28.7. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case VII: Expenditure of $2000, 15-minute questionnaire and 2¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
			1938				
1. Number swine............	1.71	1.80	1.79	1.94	2.50	2.83	6.87
2. Number horses...........	1.17	1.23	1.22	1.33	1.52	1 92	4.73
3. Number sheep............	6.15	6.22	5.77	5.47	5.26	5.12	5.12
4. Number chickens.........	1.03	1.08	1.09	1.19	1.41	1.77	4.37
5. Number eggs yesterday....	2.03	2.05	1.90	1.80	1.73	1.69	1.69
6. Number cattle............	1.63	1.70	1.67	1.78	2.03	2.49	5.96
7. Number cows milked......	1.26	1.32	1.31	1.40	1.61	1.98	4.67
8. Number gallons milked....	1.50	1.56	1.52	1.60	1.80	2.17	4.94
9. Dairy product receipts.....	1.91	1.98	1.92	1.99	2.20	2.61	5.88
10. Number farm acres.......	.99	1.04	1.03	1.10	1.27	1.57	3.84
11. Number corn acres........	1.25	1.31	1.30	1.39	1.62	1.98	4.73
12. Number oat acres.........	1.51	1.65	1.75	2.05	2.57	3.38	8.78
13. Corn yield................	.52	.58	.62	.73	.92	1.22	3.25
14. Oat yield.................	.54	.56	.55	.58	.66	.79	1.87
15. Comm. feed expenditures..	3.99	4.50	4.98	6.12	8.02	10.81	29.64
16. Total expenditures, op.....	2.53	2.78	2.96	3.50	4.41	5.82	15.40
17. Total receipts, op.........	2.02	2.23	2.39	2.84	3.61	4.78	12.69
18. Net cash income, op.......	2.27	2.44	2.52	2.86	3.50	4.53	11.59
			1939				
1. Number swine............	1.38	1.48	1.53	1.73	2.10	2.70	6 89
2. Number horses...........	1.02	1.03	.96	.91	.87	.85	.85
3. Number sheep............	4.17	4.35	4.28	4.55	5.20	6.31	14 90
4. Number chickens.........	1.08	1.12	1.09	1.14	1.27	1.52	·3.32
5. Number eggs yesterday....	1 75	1.84	1.82	1.96	2.28	2.82	6 87
6. Number cattle............	1.27	1.28	1.19	1 12	1.08	1.05	1.05
7. Number cows milked......	1.32	1.35	1.30	1 32	1.44	1 65	3.50
8. Number gallons milked....	1.47	1.54	1.51	1 61	1.84	2.26	5 30
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	1.01	1.02	.94	.89	.86	.84	.84
11. Number corn acres........	1.06	1.14	1.13	1.15	1.31	1.58	3.61
12. Number oat acres.........	1.35	1.50	1.63	1.89	2.45	3.28	9 46
13. Corn yield................	.37	.39	.40	.44	.52	.66	1 66
14. Oat yield.................	.85	.90	.92	1.02	1.24	1.58	4 17
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	1.58	1.66	1.64	1.75	2.01	2.49	5.94
17. Total receipts, op.........	1.57	1.71	1.82	2.18	2.76	3.65	9.64
18. Net cash income, op.......	4.21	5.01	4.80	5.56	6.94	9.07	23.56
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold........	1 63	1.65	1.53	1.45	1.39	1.36	1.36
21. Number cattle sold	3 66	4.10	4.51	5.50	7.15	9.59	26.15
22. Number hogs bought......	6.43	7.33	8.19	10.20	13.49	18.30	50.87
23. Number cattle bought. ...	5.70	6.34	6.89	8.31	10.70	14.32	38.82

TABLE 28.8.   RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case VIII: Expenditure of $2000, 60-minute questionnaire and 2¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine...	2.84	2 97	3 07	3.41	4 08	5.12	12.41
2. Number horses....	1.94	2.03	2.09	2.33	2.76	3.48	8.54
3. Number sheep.......	10.23	10.29	9.87	9.59	9.40	9.26	9.26
4. Number chickens....	1.71	1.79	1.87	2.09	2.52	3.19	7.89
5. Number eggs yesterday....	3.37	3.39	3.25	3.16	3.09	3.05	3.05
6. Number cattle.....	2.71	2.81	2 86	3.11	3.62	4 50	10 76
7. Number cows milked......	2.10	2.19	2.25	2.46	2.88	3 58	8.44
8. Number gallons milked....	2.49	2.58	2.61	2.80	3.21	3 91	8.92
9. Dairy product receipts.....	3.18	3.27	3.28	3.49	3.93	4.72	10.63
10. Number farm acres.......	1.64	1.71	1.76	1.93	2.26	2 84	6.94
11. Number corn acres..	2.08	2.17	2.22	2 44	2.88	3.57	8.55
12. Number oat acres.........	2.52	2.74	2.99	3.59	4.59	6.11	15.86
13. Corn yield.......	.87	.95	1.05	1.28	1 65	2 21	5.88
14. Oat yield.	.90	.93	.94	1.01	1.17	1.43	3.37
15. Comm. feed expenditures..	6.62	7.45	8 53	10 74	14.31	19 54	53.55
16. Total expenditures, op. .	4 21	4.60	5.06	6 13	7.88	10 53	27.83
17. Total receipts, op.........	3.36	3.69	4.09	4 98	6 44	8.64	22.92
18. Net cash income, op......	3.77	4.03	4.31	5 01	6.24	8 18	20 93
1939							
1. Number swine...........	2.30	2.46	2.61	3.03	3 75	4.88	12.45
2. Number horses...........	1.70	1 71	1.64	1.59	1 56	1.54	1.54
3 Number sheep....	6.93	7.19	7.33	7.98	9 28	11.40	26.92
4 Number chickens.........	1 79	1.85	1.86	1 99	2.26	2.75	5.99
5. Number eggs yesterday....	2 91	3.04	3.12	3 44	4.07	5.09	12 41
6. Number cattle......	2 10	2.12	2.03	1 97	1 93	1.90	1 90
7. Number cows milked. . . .	2 19	2.24	2.23	2 32	2.56	2.99	6 33
8. Number gallons milked....	2 44	2.54	2 59	2 82	3.29	4 09	9 58
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres........	1 67	1 68	1.61	1 57	1.54	1.51	1 51
11. Number corn acres..	1.76	1 88	1 93	2.02	2.34	2.86	6 53
12. Number oat acres.........	2 24	2 48	2 79	3.32	4 38	5.94	17 08
13. Corn yield	.61	64	.68	.77	.93	1.19	3 00
14. Oat yield	1 42	1.50	1.57	1.79	2.21	2.85	7 54
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	2.63	2.74	2.81	3.07	3.59	4 49	10.73
17. Total receipts, op.	2 60	2.83	3.12	3 82	4.92	6.59	17 42
18. Net cash income, op..	6 99	7.57	8.21	9 76	12 38	16.38	42 57
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	2.71	2 73	2.62	2 54	2.49	2.45	2 45
21. Number cattle sold........	6 08	6.79	7 71	9.65	12.76	17.34	47 24
22. Number hogs bought......	10 69	12.12	14 01	17 88	24.08	33.06	91.92
23. Number cattle bought. ..	9 47	10 49	11 78	14 58	19 10	25 88	70 45

TABLE 28.9. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case IX: Expenditure of $2000, 120-minute questionnaire and 2¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine............	3.82	3.99	4.17	4.66	5.62	7.08	17.18
2. Number horses...........	2.61	2.73	2.85	3.18	3.80	4 81	11.82
3. Number sheep............	13.75	13.81	13.41	13.13	12 94	12 81	12 81
4. Number chickens.........	2.30	2.41	2.53	2.86	3.47	4.42	10.91
5. Number eggs yesterday....	4.53	4.55	4.42	4.32	4.26	4.22	4.22
6. Number cattle............	3.64	3.77	3.88	4 26	4.98	6 23	14.89
7. Number cows milked......	2.83	2.94	3.05	3.36	3.96	4 95	11 68
8. Number gallons milked....	3.35	3.46	3.54	3.84	4 42	5 41	12 34
9. Dairy product receipts.....	4 27	4.39	4.46	4.78	5.42	6.52	14.71
10. Number farm acres.......	2 21	2.30	2.39	2 64	3 13	3 92	9.60
11. Number corn acres.......	2.80	2.91	3 02	3.34	3 97	4.94	11 84
12. Number oat acres...... ..	3.38	3.67	4 06	4 91	6 32	8.45	21.95
13. Corn yield	1.17	1.28	1 43	1.75	2 27	3 05	8.13
14. Oat yield................	1 21	1 25	1.28	1 39	1 61	1.98	4.67
15. Comm. feed expenditures..	8 91	9.99	11 58	14 70	19.71	27.02	74 10
16. Total expenditures, op....	5 66	6.17	6.87	8.39	10 85	14 56	38.50
17. Total receipts, op..	4 52	4 95	5.55	6 81	8 87	11 95	31.72
18. Net cash income, op.	5 07	5 41	5.85	6 86	8 60	11.32	28 96
1939							
1. Number swine............	3.09	3 30	3 55	4 14	5 17	6.75	17.22
2. Number horses...........	2.28	2.29	2 22	2 18	2.14	2.12	2.12
3. Number sheep............	9.34	9 65	9.95	10 93	12 78	15.77	37 26
4. Number chickens..... ...	2 41	2.48	2 53	2 73	3 12	3 80	8.29
5. Number eggs yesterday ...	3.91	4.07	4.24	4 71	5 60	7.04	17.17
6. Number cattle...... ...	2.83	2.84	2.76	2 70	2 66	2.63	2 63
7. Number cows milked......	2 94	3 00	3.02	3 18	3 53	4.13	8 75
8. Number gallons milked....	3.28	3 41	3 52	3 86	4 53	5 66	13.26
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres	2.25	2.26	2 19	2.15	2.11	2.09	2.09
11. Number corn acres..... ..	2.37	2 52	2 62	2.76	3.22	3.96	9 04
12. Number oat acres.........	3.01	3 33	3.79	4.55	6.04	8.21	23 64
13. Corn yield	.82	86	.92	1.05	1.28	1.65	4.15
14. Oat yield	1 90	2.01	2.13	2 45	3 04	3.94	10.44
15. Comm. feed expenditures	—	—	—	—	—	—	—
16. Total expenditures, op....	3.54	3.68	3.82	4.20	4 94	6.22	14.85
17. Total receipts, op...	3 50	3 80	4.24	5.22	6 78	9.11	24 10
18. Net cash income, op... .	9.41	10 15	11 15	13 36	17 05	22 66	58.90
19. Net income, op.	—	—	—	—	—	—	—
20. Number hogs sold........	3 64	3.66	3 55	3 48	3 43	3 39	3 39
21. Number cattle sold.	8.17	9 11	10 47	13 20	17 58	23 98	65 37
22. Number hogs bought . . .	14 37	16 26	19 02	24 48	33 16	45 73	127 19
23. Number cattle bought. ...	12 73	14.08	16 00	19 95	26 31	35 80	97.06

TABLE 28.10. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case X: Expenditure of $2000, 15-minute questionnaire and 5¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S

	I. F.	S4	S2	S	2-S	4-S	36-S
1938							
1. Number swine...........	2 01	2.13	2.06	2.17	2.51	3.06	7.44
2. Number horses...	1 38	1.46	1.40	1.48	1 69	2.08	5 12
3. Number sheep....	7.25	7.37	6 61	6.20	5 77	5.55	5 55
4. Number chickens	1 21	1 29	1 25	1.33	1 55	1.91	4 72
5. Number eggs yesterday....	2 39	2.43	2 18	2.04	1.90	1 83	1.83
6. Number cattle...........	1.92	2.01	1 91	1.98	2.22	2 70	6 45
7. Number cows milked. ...	1.49	1 57	1 50	1.56	1.77	2.14	5.06
8. Number gallons milked ...	1.77	1 85	1 75	1.79	1.97	2.34	5.34
9. Dairy product receipts....	2 26	2 35	2 20	2 22	2.42	2.82	6.37
10. Number farm acres	1.16	1.23	1 18	1.23	1.40	1 70	4.16
11. Number corn acres..	1.48	1.55	1 49	1.56	1.77	2 14	5.12
12. Number oat acres.......	1.78	1.96	2 00	2 29	2.82	3 66	9 50
13. Corn yield....	62	.68	70	81	1.01	1.32	3 52
14. Oat yield....	.64	.66	63	65	.72	.86	2.02
15. Comm. feed expenditures .	4 70	5.33	5.71	6 84	8.80	11.70	32.08
16. Total expenditures, op. ...	2 99	3.30	3 39	3 32	4.84	6.30	16.66
17. Total receipts, op.. ...	2 38	2.64	2 74	3 16	3.95	5.16	13 70
18. Net cash income, op. .	2.67	2.89	2 88	3 19	3 83	4 90	12 53
1939							
1. Number swine...........	1.63	1.76	1.75	1.93	2 31	2.92	7.46
2. Number horses.	1.20	1.22	1 10	1.03	96	92	.92
3. Number sheep...	4.92	5.15	4.91	5 08	5 70	6 83	16.13
4. Number chickens...	1 27	1 33	1 25	1 27	1 39	1 65	3 59
5. Number eggs yesterday.	2.06	2.18	2 09	2.19	2.50	3.05	7 43
6. Number cattle..... ...	1 49	1.52	1 36	1 27	1.19	1.14	1.14
7. Number cows milked	1.55	1 60	1 49	1 48	1 58	1 79	3.79
8. Number gallons milked ...	1 73	1 82	1 74	1 80	2.02	2 45	5.74
9. Dairy product receipts. ...	—	—	—	—	—	—	—
10. Number farm acres.	1.19	1.20	1.08	1.01	94	91	.91
11. Number corn acres... .	1.25	1.34	1.29	1.28	1.44	1 71	3 91
12. Number oat acres... ..	1 59	1 78	1 87	2.12	2 69	3.56	10.24
13. Corn yield....... ...	.43	.46	45	.49	57	.71	1.80
14. Oat yield...	1 00	1.07	1 05	1 14	1 36	1.71	4 52
15. Comm. feed expenditures .	—	—	—	—	—	—	—
16. Total expenditures, op. ...	1.87	1.97	1 88	1 96	2 21	2 69	6 43
17. Total receipts, op..... ...	1.85	2.03	2 09	2 43	3 02	3.95	10.44
18. Net cash income, op.	4.96	5.42	5.50	6 22	7.61	9 81	25 50
19. Net income, op..... ..	—	—	—	—	—	—	—
20. Number hogs sold	1.92	1.95	1.75	1.64	1.53	1.47	1.47
21. Number cattle sold...... .	4 31	4.86	5.16	6 15	7 84	10 38	28.30
22. Number hogs bought. .	7 58	8 68	9.38	11 39	14 80	19 80	55 07
23. Number cattle bought	6 72	7 52	7 89	9 29	11 74	15 50	42 03

TABLE 28.11. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case XI: Expenditure of $2000, 60-minute questionnaire and 5¢ per mile.)

Items	Sampling unit						
	I. F.	S₄	S₂	S	2-S	4-S	36-S
1938							
1. Number swine............	3.09	3.25	3.29	3.59	4.25	5.29	12.84
2. Number horses...........	2.12	2.22	2.24	2.45	2.87	3.59	8.83
3. Number sheep............	11.14	11.25	10.56	10.24	9.79	9.57	9.57
4. Number chickens.........	1.86	1.96	2.00	2.20	2.62	3.30	8.15
5. Number eggs yesterday....	3.67	3.70	3.48	3.37	3.22	3.15	3.15
6. Number cattle...........	2.95	3 07	3.06	3.28	3.77	4.65	11.13
7. Number cows milked......	2.29	2 39	2.40	2.59	3.00	3.70	8.73
8. Number gallons milked....	2.72	2.82	2.79	2.95	3.35	4.05	9.22
9. Dairy product receipts....	3.46	3.58	3.51	3.68	4.10	4.88	10.99
10. Number farm acres.......	1.79	1.87	1 88	2.04	2.37	2.93	4.42
11. Number corn acres........	2.27	2.37	2.38	2.57	3.00	3.69	8.84
12. Number oat acres.........	2.74	2.99	3.20	3.78	4.78	6.32	16.40
13. Corn yield..............	.95	1.04	1.13	1.35	1.72	2.28	6.08
14. Oat yield...............	.98	1 01	1.01	1.07	1.22	1.48	3.49
15. Comm. feed expenditures..	7.22	8.14	9.12	11.31	14.91	20.20	55.37
16. Total expenditures, op.....	4.59	5 03	5.42	6.46	8.20	10.88	28.75
17. Total receipts, op........	3.65	4 03	4.37	5.23	6.70	8.91	23.65
18. Net cash income, op......	4.10	4.41	4.61	5.27	6.50	8.45	21.62
1939							
1. Number swine............	2.51	2.68	2.79	3.19	3.91	5.04	12.87
2. Number horses.......: ..	1.85	1.86	1.75	1.70	1.62	1.59	1.59
3. Number sheep............	7.55	7.86	7.84	8.41	9.67	11.79	27.84
4. Number chickens........	1.95	2.02	1 99	2.10	2.36	2.84	6.19
5. Number eggs yesterday....	3.17	3.32	3.34	3.62	4.24	5.27	12.83
6. Number cattle........ ...	2.29	2.31	2.17	2.11	2.01	1.97	1.97
7. Number cows milked... ..	2.38	2.45	2.38	2.45	2.67	3.09	6.54
8. Number gallons milked....	2.66	2.78	2.77	2.97	3.42	4.23	9.91
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres..	1.82	1.84	1.73	1.67	1.60	1.56	1.56
11. Number corn acres........	1.92	2.05	2.06	2.12	2.43	2.96	6.75
12. Number oat acres.........	2.44	2.71	2 98	3.50	4.56	6.14	17.67
13. Corn yield..............	.66	.70	.72	81	.97	1.23	3.10
14. Oat yield...............	1.54	1 64	1.68	1.89	2 30	2.95	.78
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.. ..	2.87	3.00	3.01	3.24	3.74	4.65	11.09
17. Total receipts, op....	2.84	3.09	3.34	4.02	5.13	6.81	18.01
18. Net cash income, op.......	7.62	8.27	8 79	10 28	12.90	16.94	44 02
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	2.95	2.98	2.80	2.71	2.59	2.54	2.54
21. Number cattle sold........	6.62	7.42	8.25	10.16	13.29	17.92	48.85
22. Number hogs bought. . .	11.65	13.24	14.99	18.84	25.08	34.18	95.04
23. Number cattle bought.....	10.32	11.47	12.61	15.35	19.90	26.76	72.53

TABLE 28.12. RELATIVE STANDARD ERRORS (PERCENT OF ITEM MEANS PER FARM) ESTIMATED FOR SAMPLES OF DIFFERENT SAMPLING UNITS AND TAKEN AT RANDOM WITHIN THE STATE, 1938 AND 1939.

(Case XII: Expenditure of $2000, 120-minute questionnaire and 5¢ per mile.)

Items	Sampling unit						
	I. F.	S_4	S_2	S	2-S	4-S	36-S
1938							
1. Number swine............	4.05	4.25	4.32	4.83	5.77	7.23	17.54
2. Number horses...........	2.78	2.90	2.95	3.30	3.90	4.91	12.07
3. Number sheep............	14.60	14.70	14.05	13.79	13.29	13.08	13.08
4. Number chickens........	2.44	2.56	2.62	2.97	3.56	4.51	11.15
5. Number eggs yesterday....	4.81	4.84	4.63	4.54	4.38	4.31	4.31
6. Number cattle............	3.87	4.02	4.02	4.42	5.12	6.36	15.21
7. Number cows milked......	3.00	3.13	3.16	3.48	4.07	5.05	11.93
8. Number gallons milked....	3.56	3.68	3.67	3.98	4.55	5.59	12.60
9. Dairy product receipts.....	4.54	4.68	4.62	4.95	5.57	6.66	15.02
10. Number farm acres.......	2.34	2.45	2.47	2.74	3.22	4.01	9.80
11. Number corn acres........	2.97	3.10	3.12	3.46	4.08	5.05	12.09
12. Number oat acres.........	3.59	3.91	4.20	5.09	6.49	8.63	22.42
13. Corn yield...............	1.24	1.36	1.48	1.81	2.33	3.12	8.31
14. Oat yield................	1.28	1.33	1.32	1.44	1.66	2.02	4.77
15. Comm. feed expenditures..	9.46	10.64	11.98	15.22	20.25	27.60	75.68
16. Total expenditures, op.....	6.01	6.57	7.12	8.69	11.14	14.86	39.30
17. Total receipts, op.........	4.79	5.26	5.74	6.81	8.70	12.56	34.52
18. Net cash income, op.......	5.38	5.76	6.05	7.09	8.82	11.55	29.55
1939							
1. Number swine............	3.28	3.51	3.67	4.29	5.31	6.89	17.60
2. Number horses...........	2.42	2.44	2.33	2.29	2.20	2.17	2.17
3. Number sheep............	9.89	10.27	10.30	11.32	13.13	16.10	38.05
4. Number chickens..........	2.56	2.64	2.62	2.83	3.20	3.88	8.47
5. Number eggs yesterday....	4.15	4.34	4.39	4.88	5.75	7.19	17.54
6. Number cattle............	3.00	3.02	2.89	2.83	2.73	2.69	2.69
7. Number cows milked......	3.12	3.20	3.13	3.29	3.63	4.22	8.94
8. Number gallons milked....	3.49	3.63	3.64	4.00	4.65	5.78	13.54
9. Dairy product receipts.....	—	—	—	—	—	—	—
10. Number farm acres.......	2.39	2.40	2.30	2.25	2.17	2.14	2.14
11. Number corn acres........	2.52	2.68	2.71	2.86	3.30	4.04	9.23
12. Number oat acres.........	3.19	3.55	3.92	4.71	6.20	8.38	24.14
13. Corn yield...............	.87	.92	.95	1.09	1.32	1.68	4.24
14. Oat yield................	2.02	2.14	2.21	2.54	3.12	4.03	10.66
15. Comm. feed expenditures..	—	—	—	—	—	—	—
16. Total expenditures, op.....	3.76	3.92	3.95	4.35	5.08	6.35	15.16
17. Total receipts, op.........	3.72	4.04	4.39	5.41	6.96	9.31	24.62
18. Net cash income, op.......	9.99	10.81	11.55	13.83	17.52	23.14	60.16
19. Net income, op...........	—	—	—	—	—	—	—
20. Number hogs sold.........	3.87	3.89	3.72	3.65	3.52	3.46	3.46
21. Number cattle sold........	8.68	9.70	10.84	13.68	18.05	24.49	66.76
22. Number hogs bought......	15.26	17.31	19.69	25.35	34.06	46.70	129.90
23. Number cattle bought.....	13.52	14.99	16.57	20.66	27.02	36.55	99.13

APPENDIX B

THE QUESTIONNAIRES

Since the primary aim of the two Iowa sample surveys was to provide data and experience in sampling problems, the questionnaires therefore were by necessity limited to a more or less collection of a variety of items. Emphasis was placed on getting at *income* information, however, although in regard to the 1938 questionnaire no attempt was made to get complete income information. The 1938 questionnaire required on the average 32 minutes for enumeration, the 1939 questionnaire required 50 minutes. The printed questionnaire constitutes only a skeleton of the real content of the questionnaires. It was believed that the details could be better handled as special instructions to enumerations. It was found, however, that wherever it is convenient questions should be self-explanatory on the printed questionnaire. This and other field and office experience suggests that the questionnaires used on the Iowa sample surveys could be very much improved. The questionnaires are presented here not as models, therefore, but merely as part of the descriptive material.

(Short) 12/12/38

No. of Farm_____   Date_____
Time: Beg. _____ End_____   Enumerator_____

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
and
Iowa Agricultural Experiment Station

SCHEDULE FOR ANNUAL SURVEY OF FARM RETURNS AND RELATED DATA

Inventory items, December 31, 1938—Production, Income, Expense, Calendar year, 1938.

I. Farm and Operator

1. a. Location of farmstead: State_____County_____
   b. Twp._____ Section_____ Range _____ Twp._____
   c. Miles and direction from town _____
   d. Type of road at farmstead _____
2. a. Operator _____
   b. P. O. _____State_____

II. Tenure, 1938

	Acres	Rent Paid
3. a. Total acres operated: _____ (Acres)		
b. Owned by operator	_____	
c. Cash	_____	$_____ (Per A.) (Total)
d. Crop share	_____	
e. Operated under livestock share lease	_____	
f. Managed	_____	
		Amt. Received
g. Rented out:		
(1) Cash	_____	$_____ (Per A.) (Total)
(2) Crops (crop share).......	_____	_____
	_____	_____
	(Kind of crop)	(Bu. T. $)

III. Crop Acreage and Production, Sales and Purchases, 1938

Crops	Harvested Acres	Harvested Quantity	Lld's share	Amt. on hand Dec. 31, 1938 Sealed	Unsealed	Operator's Sales[a] Amt.	Pr.	V.	Purchases Amt.	Pr.	V.
4. Total corn.................. _____											
Acres											
a. Husked...... _____		_____	_____		_____	_____	_____	_____	_____	_____	_____
b. Silage....... _____		_____	_____		_____	_____	_____	_____	_____	_____	_____
c. Fodder..... _____		_____	_____		_____	_____	_____	_____	_____	_____	_____
d. Hogged..... _____		_____	_____		_____	_____	_____	_____	_____	_____	_____
5. Oats, grain..................	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
6. Wheat, grain.................	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
7. Barley, grain................	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
8. Soy beans, grain.............	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
9. Alfalfa, hay.................	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
10. Other cash crops.............	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____		_____	_____	_____	_____	_____	_____	_____

11. a. Quantity of 1937 corn crop sealed under 1937 AAA program...........................Bu._____

   b. Quantity redeemed ....Bu._____

   c. Price .... $_____

   d. Quantity resealed ....Bu._____

   e. Price .... $_____

[a]Sales in 1938 from 1937 and 1938 crops.

IV. Livestock Numbers, Sales, and Purchases, 1938
(Include *both* operator's and landlord's livestock)

Class	Number on hand Dec. 31, 1938	Lld's share	TOTAL SALES[a]				TOTAL PURCHASES[a]			
			No.	Wt.	Pr.	V.	No.	Wt.	Pr.	V.
12. Horses, all ages..	____	____	__	__	__	__	__	__	__	__
13. Mules, all ages ..	____	____	__	__	__	__	__	__	__	__
14. Cattle, all ages, All kinds........	____	____	__	__	__	__	__	__	__	__
15. Swine, total, All ages.........	____	____	__	__	__	__	__	__	__	__
16. Sows and gilts bred or to be bred for spring farrow.	____	____	__	__	__	__	__	__	__	__
17. Sows and gilts farrowed since June 1, 1938....	____	____	__	__	__	__	__	__	__	__
18. Other hogs......	____	____	__	__	__	__	__	__	__	__
19. Sheep, all.......	____	____	__	__	__	__	__	__	__	__
20. Turkeys, all.....	____	____	__	__	__	__	__	__	__	__
21. Chickens, all....	____	____	__	__	__	__	__	__	__	__

22. (a) Hens and pullets of laying age yesterday... _____

    (b) Yesterday's eggs .... _____

23. Receipts from egg sales, 1938 .... $_____

24. Cows and heifers milked
    (a) during all or any part of 1938.......... _____

    (b) yesterday .... _____

    (c) milk produced yesterday .... _____
                                                        Gals.   Lbs.

[a]Sales and purchases for this farm by both operator and landlord.

25. Receipts from dairy products sold, 1938 .... $_____
26. Wool: yield_____lbs. Receipts (Evaluate if unsold)$_____

V. Miscellaneous Income

27. Payments, AAA program, and soil   Operator $_____
    improvement practices ....
                        Landlord $_____

	Days	Rate	Receipts

28. Work off farm with or without
machinery .... ____ ____ $_____
either on other farms or in industry ____ ____ $_____
                                  ____ ____ $_____

29. Other income (pensions, interest, etc.)............ $_____

VI. Farm Expenses in 1938

	Operator	Landlord

30. Feed purchases—(concentrates) .... $_____ $_____
31. Fertilizer purchases, 1938 ....$_____ $_____
32. Seed purchased, 1938 ....$_____ $_____

Days Rate

33. Cash paid for labor hired for ____ ____ $_____ $_____
farm work on this farm. 1938 ____ ____ $_____ $_____
                        ____ ____ $_____ $_____

34. Custom work (labor hired
with machinery) .... ____ ____ _____ _____
                     ____ ____ _____ _____
                     ____ ____ _____ _____

35. Amount of 1938 taxes:
       (a) on real estate ....$_____ $_____
       (b) on personal porperty...... $_____ $_____
36. (a) Number of autos (Make_____)..... _____
    (b) Miles driven, 1938 .... _____
    (c) Number of trucks (Tons_____)..... _____
    (d) Miles driven, 1938 .... _____
37. (a) Number of tractors:_____Size and ages: _____
                                      _____
                                      _____

    (b) No. of tractor days (10 hr. equivalent day). _____

VII. Farm Credit, 1938

38. Amount of credit now outstanding:
    (a) Secured by real estate........................ $_____
    (b) Other: 1 yr. or over.......................... _____
       Less than 1 yr............................ _____

VIII. Movement of Farm Population

                                      Number

39. (a) Persons living on this farm now (Jan. 1, 1938).. _____
    (b) Persons living on this farm on Jan. 1, 1938...... _____
    (c) Persons moving to this farm from towns and
       cities during 1938 .... _____
    (d) Persons moving from this farm to towns and
       cities during 1938 .... _____

IX. Standard of Living

40. _____

	Year purchased or installed	Cost of 1938 purchases
(a) Electric lights............	_____	$_____
(b) Radio in house..........	_____	_____
(c) Running water in house...	_____	_____

Record No._____   Date_____
(Enumerator omit)

Enumerator_____

Matched farm: Yes____No____   Substitute: Yes_____ No_____
Request report: Yes____No____

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
and
Iowa Agricultural Experiment Station

SCHEDULE FOR ANNUAL SURVEY OF FARM RETURNS AND RELATED DATA
For the year beginning January 1, 1939

Operator: Name _____
Post Office Address_____State_____County_____
Landlords: Name   Occupation   Address
  1. _____ _____ _____
  2. _____ _____ _____
Acres_____ Sec._____ Twp._____ Rge._____
Acres_____ Sec._____ Twp._____ Rge._____

TOTAL ACRES OPERATED ....   _____

Operated acres owned ...._____
Operated acres rented ...._____
  Operated acres rented livestock share_____
  Operated acres rented crop share ..._____
  Operated acres rented cash ...._____
    Total amount of cash rent,
      paid or payable.......$_____

LAND RENTED OUT (OWNED OR RENTED LAND
  SUBRENTED) ACRES _____

Acres cash rented_____ Rental per acre $_____
Acres rented crop share_____ Total amount received $_____
Section_____ Twp. _____ Rge._____
  Estimated taxes on land rented out $_____

USE OF LAND, CROP PRODUCTION, LANDLORD'S SHARE, OPERATOR'S PURCHASE, SALES, AND INVENTORIES, 1939

Crops	Harvested			Total Lld's share crop & cash	On hand 1/1/39	Operator's transactions						On hand 1/1/40
	Acres	Unit	Amount			Purchases[1]			Sales[2]			
						Amount	Price	Value	Amount	Price	Value	
TOTAL CORN:												
a. Husked for grain............		bu.										
b. Silage.....................		tons										
c. Fodder....................		tons										
d. Hogged...................		bu.										
SORGHUMS, all...............												
GRAINS:												
a. Wheat, all.................		bu.										
b. Oats......................		bu.										
c. Barley....................		bu.										
d. Rye......................		bu.										
e. Soybeans.................		bu.										
f. _____												
HAYS:												
a. Alfalfa...................		tons										
b. Soybean..................		tons										
c. Clover and timothy.........												
d. Other legumes.............												
e. Grain....................												
f. _____												
SEEDS:												
a. _____												
b. _____												
c. _____												
OTHER CROPS:												
a. _____												
b. _____												
Rotation pasture.............												
TOTAL ACRES CULTIVATED..												
Permanent past. till..												
Permannet past. not till.												
Woods not pastured...........												
Idle and fallow...............												
Farmstead and roads..........												
TOTAL ACRES												

[1]Include crops redeemed.   [2]Include crops sealed.

Amount of 1939 corn crop sealed, bu._____ Wheat, bu._____

Corn sealed prior to 1939 and turned over to government in 1939, bu._____

Amount of sealed crops redeemed in 1939: corn, bu._____ wheat, bu._____

How many bushels of 1939 crop do you expect to seal: Corn, bu._____

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NUMBER OF LIVESTOCK ON THIS FARM, RAISED, PURCHASED, SOLD, DIED, AND USED IN HOME OF OPERATOR AND LANDLORD

	Raised to weaning age	Number on hand 1/1/39	No.	Purchased Av. weight	Price	Value	No.	Sold Av. weight	Price	Value	No. home used	No. died	Number on hand 1/1/40
Horses, all ages......................	(——)			XXX				XXX			XX		
Mules, all ages......................	(——)			XXX				XXX			XX		
Dairy cows and heifers, 2 yrs. and over.....	XXX												
Beef cows and heifers, 2 yrs. and over.....	XXX												
Calves under 1 year.................	(——)												
Steers, bulls, heifers, 1 to 2 yrs............	XXX												
TOTAL CATTLE................	(——)			XXX	XXX			XXX	XXX				
Sows and gilts bred or to be bred..........	XXX										XX		
Fall pigs (born since June 1)...............	(——)												
Spring pigs (born before June 1)...........	(——)												
Stags and boars.........................	XXX										XX		
TOTAL HOGS.................	(——)			XXX	XXX			XXX	XXX				
Sheep 1 year and over...................	XXX												
Sheep under 1 year.....................	(——)												
TOTAL SHEEP................	(——)			XXX	XXX			XXX	XXX				
Turkeys..............................				XXX									
Chickens..............................	XXX			XXX									

Landlord's share of livestock purchased and sold, percent, _____ or, dollars_____. In what items did landlord share (list)_____

Hens and pullets of laying age yesterday: No._____. Yesterday's eggs: No._____.

Number of cows and heifers milked during all or any of 1939_____ Yesterday_____.

Quantity of milk produced yesterday, gallons_____.

Number of cattle grain fattened and sold, winter 1938-39_____ summer 1939_____ winter 1939-40_____.

Number of sheep grain fattened and sold, winter 1938-39_____ summer 1939_____ winter 1939-40_____.

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LIVESTOCK PRODUCTS SOLD (LANDLORD'S AND OPERATOR'S)
Jan. 1, 1939, to Jan. 1, 1940

Item	Unit	Amount	Price	Value
Whole milk	Lb.			
Butterfat	Lb.			
Butter	Lb.			
Eggs	Doz.			
Poultry	Lb.			
Meat products	Lb.			
Wool	Lb.			
Other				

Which of the above items did landlord receive a share for rent_____
Percent received_____

PRODUCTS FROM THIS FARM USED IN HOUSEHOLD

	Operator	Landlord
Milk, average qts. per day.........	No._____	No._____
Cream, average pints per week....	No._____	No._____
Butter, average lbs. per week.......	No._____	No._____
Eggs, average doz. per week.......	No._____	No._____

OPERATOR'S INCOME FROM OTHER SOURCES,
JAN. 1, 1939, TO JAN. 1, 1940

Farm work off farm with team $_____ tractor $_____
  truck $_____ combine $_____ corn picker $_____
Farm work off farm, hand labor, days_____rate_____receipts_____
Farm work off farm, hand labor, days_____rate_____receipts_____
Non-farm work off farm   days_____rate_____receipts_____
Payments 1939 AAA and SC practices, operator $_____
  landlord $_____
Other income (exclude income from land rented out) $_____
Months of operator's labor on this farm, mo. _____
Months of family labor on this farm, mo. _____
Corn resealed, bushels _____ $_____

FARM EXPENSES, JAN. 1, 1939, TO JAN. 1, 1940

(Enter the full amounts of expenses incurred by operator and landlord in connection
with the operation of this farm even though they were not paid in full during the
year. Do not include payments of expenses incurred in the previous years.)

Items of expense	Kind	Quantity	Unit	Rate	Amount	
					Operator	Landlord
					$	$
Labor hired, except	With board					
contract labor for	With board					
construction of farm	With't. bd.					
improvements and	With't. bd.					
making repairs	Piece work					
FEEDS: 1. tankage						
2. minerals 3. oilmeal						
4. millfeeds						
5. laying mash						
6. pastures, etc.						
1. Fertilizer						
2. Lime						
SEEDS: 1. hybrid						
2. ord. corn 3. wheat						
4. oats 5. alf. 6. red clo.						
7. sw. clo. 8. tim.						
9. grass 10. plants						
SUPPLIES: 1. twine						
2. sacks 3. spray mat.						
4. boxes 5. crates						
6. bail wire 7. misc.						
MACHINE HIRE: 1. thresh						
2. combine 3. silo fill						
4. corn pick 5. grinding						
6. baling 7. spraying						
8. tractor and mach. work						
MISCELLANEOUS:						
1. vet. 2. med. 3. breeding						
fees 4. Bureau dues						
5. storage 6. electricity						
7. phone 8. insurance, etc.						
NEW EQUIPMENT PUR- CHASES[a]:						
1. tools 2. autos						
3. truck 4. tractor						
5. plows 6. disc						
7. cultivators, etc.						
Repairs, machinery, except auto, truck and tractor						
Repairs, building and improvements including contract labor						
Cost of new buildings and improvements constructed during 1939						

[a]Net after allowing for trade-ins.

DATA ON TRACTOR*

Row-Crop type: No_____plow size_____rubber_____steel_____
           No_____plow size_____rubber_____steel_____
Standard type; No.____plow size____No.____plow size____No.____plow size____
Use of tractors on this operating unit:
    1. Spring work, plowing days_____2. Seedbed preparation, days____
    3. Corn plowing, days_____4. Harvesting, haying, etc., days_____
    5. Fall drawbar work, days_____ 6. Belt work, hours_____
    *If tractor is in partnership give share owned by this operator,
share_____
Autos: No._____Est. total miles driven during 1939, miles_____
Trucks: No._____Est. total miles driven during 1939, miles_____
Estimated present value of:
    Land $_____ Buildings and improvements $_____
    Machinery and equipment (exclude livestock) $_____

TAXES: Amount of taxes levied in 1939 on operating unit

	Operator	Landlord
1. Total real estate	_____	_____
2. Total personal	_____	_____
3. Real estate exemptions or rebates	_____	_____
4. Net amount	_____	_____

MOVEMENT OF FARM POPULATION

                          Number

Dwellings on this farm now occupied.................... _____
Persons living on this farm, includes labor and all
    (a) now (Jan. 1, 1940).......................... _____
    (b) last year (Jan. 1, 1939)....................... _____
To persons living on this farm during 1939
    (a) babies born .... _____
    (b) deaths .... _____
Persons moved to this farm during 1939*
    (a) from city or village......................... _____
    (b) from other farms .... _____
    (c) from unknown .... _____
Persons moved off this farm during 1939*
    (a) to city or village........................... _____
    (b) to other farms .... _____
    (c) to unknown .... _____
    *A person moving to this farm and remaining one month or more.

STANDARD OF LIVING

Radio in house: Yes_____ No_____ Number_____
Running water in house: Yes_____ No_____
Electricity in home: Yes_____ No_____
    Farm system_____ High-line_____
Members of operator's household attending college during the past
    school year_____
Estimated cash cost for the year to operator for school to these
    members $_____

AMOUNT AND SOURCE OF OPERATOR'S CREDIT
Borrowed prior to 1939

Source	Amount owed 1/1/39	Still owed 1/1/40	Security	Int. rate	Original		Purpose
					Amount	Date	
Local bank...............							
Prod. Credit Ass'n........							
Farm Security Admin......							
Merchant................							
Federal Land Bank.......							
Land Bank Commissioner..							
Insurance company.......							
Landlord................							
Other..................							

Borrowed during 1939

Source	Borrowed	Interest rate	Out-standing 1/1/40	Security	Purpose
Local bank...............					
Prod. Credit Ass'n........					
Farm Security Admin.....					
Merchant................					
Federal Land Bank........					
Land Bank Commissioner..					
Insurance company........					
Landlord.................					
Other....................					

APPENDIX C

COMPARISON OF THE 1939 SAMPLE SURVEY WITH THE 1940 FEDERAL CENSUS, IOWA STATE FARM CENSUS (ASSESSOR) AND THE AGRICULTURAL MARKETING SERVICE

Usable records were obtained from 773 farms in 1938 and 782 farms in 1939. The representativeness of these two sets of data can be tested by comparison with those from other sources, the more important of which are: Iowa State Farm Census (Assessor), Agricultural Marketing Service (AMS) and the Federal Census of 1940. Because of variations in the definitions of a farm and for other reasons it seemed most convenient to convert the raw sample survey data into estimates of totals for the state. Table C-1 presents the data of comparable (and near-comparable) items obtained by these and other sources, together with those of the sample surveys. Both the preliminary and revised (not necessarily the final) estimates of the AMS are given in order that an idea of the amount and trend of revision taking place in those estimates may be seen.

Following is a discussion of the comparisons of table C-1 and an evaluation of the relative accuracies of the several estimates.

ITEM 1. NUMBER OF FARMS, LAND IN FARMS AND AVERAGE SIZE OF FARM

The low sample survey figure on number of farms is due partly to the exclusion of farms situated in the incorporated areas of the state (there were about 9,000 in 1938) and partly to a possible difference in definitions (where complicated farm account information is collected by questionnaire we found cases which the assessor and census probably listed as separate farms but which for our purposes were more convenient to handle if put together as single operating units. (See p. 18.) Consequently the sample survey has a larger average size of farm. The 34,080,000 acres of land in farms given as the sample-survey estimate is not independent of the assessor figure. (See p. 99.) An independent estimate (based on sample data alone) would be somewhat less than this due to an enumeration bias. (See p. 17.)

ITEMS 2-14. CROP ACREAGES, PRODUCTIONS AND YIELDS

Since the total amount of farm land varies among the census, assessor and sample survey (because of possible incompleteness on the part of the census, exclusion of incorporated areas on the part of the sample survey) it is advisable to bear this in mind when comparing the crop acreage estimates of the sample survey against the enumerations of the census and assessor. The census, accounting for fewer farm acres, should as a consequence fall short of the assessor in crop acreages. This is true except for corn cut for silage, sorghums, soybeans for grain, alfalfa for hay and clover for seed. In these cases the discrepancies may be explained by differences in definitions. The census, for instances, in its corn cut for silage includes sweet corn which is excluded by the assessor. The discrepancy in sorghum acreage is not readily seen. Both the census and assessor purport to get sor-

TABLE C-1. ESTIMATES[a] OF SPECIFIED ITEMS BY THE SAMPLE SURVEY, FEDERAL CENSUS, IOWA STATE FARM CENSUS (ASSESSOR) AND AGRICULTURAL MARKETING SERVICE.

Item	Sample survey (1939)	Federal census (1940)	State census (Assessor)	Agricultural Marketing Service		
				Preliminary	Revised	Final[b]
1 Farms....................................(number)	195,000[c]	213,318[c]	210,343[c]	——	——	
(acres)	34,080,000	34,148,673	34,545,051	——	——	
(acres/farm)	175.0	160.1	164.2			
(% owners)	37.3	41.3				
(% renters)	50 9	47 6				
(% part-owners)	11 3	10 5				
(% managers)	0.5	0.6				
2 Corn...............................(acres)	9,272,000	9,330,820	9,373,262	9,688,000	9,506,000	9,400,000
a)Harvested for grain... . ...(acres)	8,832,000	8,899,701	8,942,852	9,261,000	9,069,000	8,960,000
(bushels)	481,354,000	469,786,611	467,055,383	481,572,000	471,588,000	470,400,000
(bu/acre)	54.5	52.8	52.2	52.0	52 0	52 5
b) Cut for silage .... (acres)	170,000	188,591	179,489	194,000	180,000	189,000
(tons)	1,915,000	1,876,309	1,953,154	2,400,000	1,962,000	1,962,000
(tons/acre)	11 3	9.9	10.9	10 5	10.9	10.4
c) Hogged, grazed or cut for fodder. .. ..(acres)	270,000	242,528	250,921	233,000	257,000	251,000
3 Sorghums, all......................................(acres)	47,000[d]	80,092	65,598	108,000	108,000	84,000
4 Wheat harvested for grain, all......................(acres)	426,000	367,830	389,187	390,000	392,000	393,000
(bushels)	6,432,000	6,567,597	6,726,050	6,490,000	6,902,000	6,766,000
(bu/acre)	15.1	17.9	17.3	16.6	17.6	17.2
5 Oats harvested for grain, all ....(acres)	4,838,000	4,934,719	4,973,012	5,076,000	5,016,000	5,076,000
(bushels)	149,954,000	155,348,088	154,159,234	154,818,000	155,496,000	159,894,000
(bu/acre)	31.0	31 5	31.0	30.5	31.θ	31 5
6 Barley harvested for grain, all......................(acres)	587,000	525,755	544,087	563,000	577,000	550,000
(bushels)	13,540,000	12,449,209	12,533,032	13,794,000	13,279,000	12,925,000
(bu/acre)	23.1	23.7	23.0	24.5	23.0	23.5

[a]Sample survey estimates are based on expansion method 2 (p. 16). In the section on incomplete matching it was concluded that a more accurate method is available for the 1939 survey. However, for the present purposes the simpler method 2 was regarded as adequate.
[b]Crop Reporting Board historic revisions for period 1935-1939.
[c]Number as of Jan. 1, 1940, for the sample survey; April 1, 1940, for the census and approximately April 1, 1940, for the assessor. Slight change if any from Jan. 1, 1940, to April 1, 1940.
[d]Based on information from 43 farms.

TABLE C-1. ESTIMATES OF SPECIFIED ITEMS (Continued)

7 Rye harvested for grain, all (acres)	65,000*	62,862	67,813	72,000	69,000	68,000
(bushels)	753,000*	943,125	956,485	1,044,000	1,000,000	1,020,000
(bu/acre)	11.5*	15.0	14.1	14.5	14.5	15.4
8 Soybeans harvested for grain, all (acres)	572,000	549,726	539,365	487,000	564,000	550,000
(bushels)	11,738,000	11,359,475	11,095,972	10,227,000	11,562,000	11,385,000
(bu/acre)	20.5	18.2	20.6	21.0	20.5	20.7
9 Alfalfa cut for hay (acres)	845,000	790,568	788,830	879,000	856,000	791,000
(tons)	1,636,000	1,617,589	1,656,543 f	1,846,000	1,798,000	1,622,000
(tons/acre)	1.94	2.05	h	2 10	2.10	2.05
10 Soybeans cut for hay (acres)	694,000	657,083 g	694,152	626,000	725,000	694,000
(tons)	1,430,000	1,140,414 g	1,041,228 f	939,000	1,088,000	1,179,800
(tons/acre)	2.06	1.74	h	1.50	1 50	1.70
11 Clover and timothy hay (acres)	1,629,000	1,536,938	1,613,570	1,571,000	1,620,000	1,584,000
(tons)	2,079,000	1,682,390	1,694,248 f	1,650,000	1,701,000	1,742,000
(tons/acre)	1.28	1.09	h	1.05	1 05	1.10
12 Alfalfa harvested for seed (acres)	6,000 i	19,552	———	23,000	23,000	20,000
(bushels)	34,000 i	18,471	———	25,000	25,000	19,000
(bu/acre)	5.52 i	0.94	———	1 1	1.1	0.95
13 Clover harvested for seed[k] (acres)	292,000 j	305,890	248,989	281,000	315,000	313,000
(bushels)	558,000 j	350,909	288,998	345,100	371,100	360,000
(bu/acre)	1.91 j	1.15	1 16	1.23	1.18	
14 Cropland harvested (acres)	20,658,000	20,076,641	20,132,514	———	———	
15 Horses, all ages, 1/1/40 (hd.)	743,000	728,213 l	———	752,000	752,000	
16 Mules, all ages, 1/1/40 (hd.)	46,000	45,680 l	———	54,000	52,000	

*Based on information from 28 farms.
fHay yields are estimates based on reports from AMS crop correspondents.
gCensus figure for "annual legumes saved for hay, excluding sweet clover and lespedeza." Soybeans, however, is the most important crop in this classification.
hHay yields obtained from AMS crop respondents.
iBased on information from 6 farms.
jBased on information from 78 farms.
kRed, alsike and sweet.
lOf those on the farm now and over 8 months old, April 1, 1940.

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TABLE C-1. ESTIMATES OF SPECIFIED ITEMS (Continued)

Item	Sample survey (1939)	Federal census (1940)	State census (Assessor)	Agricultural Marketing Service		
				Preliminary	Revised	Final
17 Cattle and calves, 1/1/40...........................(hd.)	4,721,000	4,213,010 [1]	——	4,688,000	4,688,000	
18 Total dairy and beef cows 2 years and over, 1/1/40.......(hd.)	1,992,000	1,940,347 [1]	——	1,903,000	1,903,000	
a) Dairy cows and heifers 2 years and over, 1/1/40[m]......(hd.)	1,265,000	1,430,279 [1]	1,320,753 [n]	1,487,000	1,487,000	
b) Beef cows and heifers 2 years and over, 1/1/40........(hd.)	727,000	510,068 [1]	——	416,000	416,000	
19 Cows and heifers milked during all or part of 1939........(hd.)	1,419,800	1,292,606	——	1,386,000	1,393,000	
20 Hogs and pigs, all ages, 1/1/40.........................(hd.)	10,240,000	4,902,446 [o]	——	9,651,000	10,714,000	
21 Sheep and lambs, all ages, 1/1/40 ....(hd.)	1,105,000	1,203,408 [p]	——	1,844,000	1,789,000	
22 Chickens, all ages, 1/1/40.............................(hd.)	31,736,000	26,558,884 [o]	27,846,039 [n]	30,930,000	30,930,000	
23 Turkeys, all ages, 1/1/40..............................(hd.)	100,000 [q]	126,539 [o]	——	380,000	380,000	
24 Horse colts born......................................(hd.)	52,000 [r]	——	45,799 [t]	47,000 [s]	47,000 [s]	
25 Mule colts born.......................................(hd.)	3,000 [r]	——	2,917 [t]	3,000 [s]	3,000 [s]	
26 Lambs born...(hd.)	656,000 [r]	——	750,702 [t]	1,041,000	1,041,000	
27 All pigs born...(hd.)	13,053,000 [r]	——	12,556,260 [t]	14,358,000	15,472,000	
a) Spring pigs...(hd.)	9,703,000 [r]	——	9,595,341 [tu]	10,648,000	11,326,000	
b) Fall pigs...(hd.)	3,350,000 [r]	——	2,960,919 [tv]	3,710,000	4,146,000	
28 Calves born..(hd.)	1,559,000 [r]	——	1,429,146	1,644,000	1,644,000	

[m]The question as put by census enumerators was "cows and heifers that were 2 years old and over Jan. 1, 1940, and are kept mainly for milk production;" as put by AMS questionnaire "cows and heifers, 2 years and older, kept for milk." Assessor's is similar to AMS' question.

[n]Average date of enumeration (and of inventory) about 2/15/40.

[o]Over 4 months old on 4/1/40.

[p]Over 6 months old on 4/1/40.

[q]Only 28 farms in sample survey had turkeys.

[r]Number born and raised to weaning age.

[s]Less than 1 year old at end of year.

[t]Does not include those that died between the time of birth and time of enumeration (average date about 2/15/40).

[u]Covers period 12/1/38 to 6/1/39.

[v]Covers period 6/1/39 to 12/1/39.

TABLE C-1. ESTIMATES OF SPECIFIED ITEMS (Continued)

#	Item					
29	Whole milk sold, 1939 ....(gal.)	48,972,000	68,610,375	———	———	103,000,000wx
30	Butterfat sold, 1939 ....(lb.)	169,632,000	150,647,347	———	———	173,780,000w
31	Butter sold, 1939 ....(lb.)	2,938,000y	724,618	———	———	800,000w
32	Receipts from dairy products sold, 1939.. ....($)	50,784,000z	50,591,432	———	60,789,000a′	60,789,000a′
33	Wool shorn, 1939 ....(lb.)	6,036,000	7,927,248	———	9,875,000	———
34	Number of cattle and calves butchered, 1939 ....(hd.)	32,000b′	66,502	———	45,000	45,000
35	Number of hogs and pigs butchered, 1939 ....(hd.)	229,000b′	478,017	———	560,000	560,000
36	Number of sheep and lambs butchered, 1939 ....(hd.)	2,000b′	3,586	———	11,000	11,000
37	Total number of cattle and calves bought, 1939 ....(hd.)	1,412,000	1,639,477	———	———	———
	a) Number of cattle bought, 1939......................(hd.)	985,000	1,270,794	———	———	———
	b) Number of calves bought, 1939......................(hd.)	427,000	368,683	———	———	———
38	Number of hogs and pigs bought, 1939 ....(hd.)	776,000	1,084,027	———	———	———
39	Number of sheep and lambs bought, 1939 ....(hd.)	390,000	825,067	———	———	———
40	Total number of cattle and calves sold, 1939 ....(hd.)	2,196,000	2,282,958	———	———	2,167,208
	a) Number of cattle sold, 1939........................(hd.)	1,395,000	1,803,796	———	———	1,909,943
	b) Number of calves sold, 1939........................(hd.)	801,000	479,162	———	———	257,265
41	Number of hogs and pigs sold, 1939. ....(hd.)	9,474,000	9,334,232	———	———	10,652,540
42	Number of sheep and lambs sold, 1939 ....(hd.)	886,000	1,129,209	———	———	1,555,823

wFrom Livestock, Dairy and Poultry Statistics of Iowa, 1941.
xIncludes 691 million pounds sold wholesale and 152 million
  pounds sold retail.
yBased on only 19 farm reporting items.
zIncludes:

	(thousands)
Whole milk ....$ 9,215	
Butterfat 40,797	
Butter 772	
$50,784	

a′Does not include receipts from direct inter-farm sales.
b′Number butchered and home-used. Census figures include
  those butchered and sold off-farm.

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TABLE C-1. ESTIMATES OF SPECIFIED ITEMS (Continued)

Item	Sample survey (1939)	Federal census (1940)	State census (Assessor)	Agricultural marketing service		
				Preliminary	Revised	Final
43 Receipts from livestock sold, 1939 c'....................($)	272,281,000 d'	258,585,490	———	330,447,000 a' e'	———	
44 Number of chickens sold (alive or dressed), 1939 f'........(hd.)	18,274,000 g'	18,851,478	———	———	32,382,000 a'	
45 Receipts from poultry, eggs, etc., sold, 1939................($)	34,911,000 h' i'	33,822,870	———	41,354,000 a'	41,399,000 a'	
46 Receipts from wool, mohair, meat, hides, bees, honey, fur animals, pelts, etc., sold, 1939....................................($)	1,656,000 j'	2,709,676	———	———	———	
47 Value of crops (excluding fruits and vegetables) sold or to be sold..($)	79,194,000 k'	161,001,006 k'	———	128,472,000 k'	———	
48 Value of food and fuel used by farm families, 1939 ....($)	29,268,000 l'	49,405,199	———	28,365,000 l'	———	
49 Total value of land, buildings and improvements ....($)	3,249,000,000	2,690,744,215	———	3,018,000,000	———	
a) Value of land..($)	2,376,235,000	1,895,842,351	———	———	———	
b) Value of improvements and buildings....................($)	872,500,000	794,901,864	———	———	———	

c'Exclude receipts from sales of poultry, bees and fur-bearing
   animals (captive), horses and mules.

d'Includes:

	(thousands)
Cattle $127,729	
Swine 138,768	
Sheep 5,784	
Total $272,281	

e'Includes sales of livestock products, that is, lard, beef, veal,
   mutton, etc., of the three species: swine, cattle, sheep.

f'Does not include baby chicks.

g'Includes 17,860,000 sold alive, 414,000 sold dressed (1,656,000 lb.)

h'Includes:

	(thousands)
Chickens ....$ 7,662	
Turkeys 9,231	
Eggs 17,720	
Poultry (dressed) 298	
	$34,911

Hence does not include baby chicks (included by Federal Census).

i'Does not include receipts from sales of baby chicks.

j'Includes:

	(thousands)
Wool $1,407	
Meat products 48	
Pelts, etc. 201	
	$1,656

Hence does not include receipts from bees and honey.

k'Includes an evaluation of landlord's share. Sample survey
   figure does not include value of sealed crops. Census
   for field crops, only.

l'For livestock and livestock products only.

  Sample survey breakdown:

Livestock ....$ 5,228,000	
Livestock products 24,040,000	
	$29,268,000

Livestock products include milk, cream, butter and eggs.

TABLE C-1. ESTIMATES OF SPECIFIED ITEMS (Continued)

50	Value of machinery and equipment.........................($)	231,600,000ᵐ′	242,047,158	——	——
51	Total real estate and personal property taxes (owners and p-owners)...($)	15,497,000	15,921,256	——	——
	a) Real estate taxes (owners and p-owners)................($)	——	14,455,376	——	——
	b) Personal property taxes (owners and p-owners)..........($)	——	1,465,880	——	——
52	Total expenditures for hired labor, 1939....................($)	24,845,000	29,500,447	——	——
53	Total feed expenditure, 1939.............................($)	46,199,000ⁿ′	48,942,232	——	——
54	Expenditures for machinery and equipment boughtᵒ′........($)	38,376,000ᵖ′	45,103,124	——	——
55	Total expenditures for buildings and improvements�q′........($)	33,527,000	24,114,867	——	——
	a) Expenditures on building and improvement repairs.......($)	13,140,000	——	——	——
	b) Expenditures for new building and improvements........($)	20,387,000	——	——	——
56	Total expenditures for commercial fertilizer and lime........($)	1,008,000	1,211,579	——	——
	a) Expenditures for commercial fertilizer..................($)	——	351,022	——	——
	b) Expenditure for lime.................................($)	——	860,557	——	——
57	Number of automobiles................................(no.)	198,600	236,601	——	——
58	Number of trucks.....................................(no.)	25,000	26,352	18,840	——
59	Number of tractors....................................(no.)	134,900	128,516	117,833	——
60	Percent of farms having electricity.......................(%)	39.4	40.7	——	——
	a) Percent high-line of those having electricity . ...(%)	77.6	84.5	——	——

ᵐ′Excludes livestock. The census does not specify livestock but does specify that trucks, trailers and motor cars are included. Sample survey probably does not include these latter items.
ⁿ′Includes $19,173,000 commercial feed and $27,026,000 farm grown feed including redeemed crops.
ᵒ′Includes motor cars.
ᵖ′Net after allowance for trade-in.
q′For both repairs and new construction.

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ghum for all purposes except that hogged down or pastured off. Likewise both the census and assessor purport to get total soybean acreage harvested for grain (beans), total alfalfa cut for hay and total red, alsike and sweet clover acreage for seed. This suggests that failure of farmers to remember accurately, and possibly enumerator differences, may have been responsible for discrepancies.

In all cases the sample survey acreage and yield estimates appear to agree reasonably well with the assessor or census figures after allowance has been made for incorporated areas and variation attributable to sampling. In the following items it appears that sample survey estimates was more accurate (as compared with the assessor) than the preliminary AMS estimate: Total corn acres, corn silage acres, sorghum acres, soybean hay acres, clover and timothy hay acres, oat yield, barley yield and soybeans for grain yield. The significance of this is not clear, however, since all of these could have occurred as a chance result of sampling fluctuation in the source of data of either or both agencies. In the case of total corn acres, however, chances are quite small (something like 1 in 20 times) that a figure as large as AMS preliminary figure of 9,688,000 could have come off in the 1939 sample survey. The yield of corn obtained by the sample survey is definitely higher than either the assessor or census (54.5 as compared to 52.2 and 52.8, respectively). There is a definite bias in the reported corn yields as reported to the three agencies. (For the complete enumerations of the census and assessor, the difference between 52.8 and 52.2 is real and not attributable to any fluctuation of sampling.) There appears to be no data available for determining which of the three figures is nearest to the true corn yield.

ITEMS 15-23. INVENTORY NUMBERS OF LIVESTOCK AND POULTRY

Since the census which was taken 3 months after the beginning of 1940, attempted to obtain the numbers of livestock of different ages (from 3 to 6 months and over as of Jan. 1, 1940, varying by species), a direct comparison between the several estimates is not possible. We can, however, form some opinions on the relative merits of the estimates. The numbers of horses and mules should not differ greatly from Jan. 1 to April 1. The census figures for these items, therefore, should be quite near the expected. If this is so, it appears the sample survey is reasonably accurate and possibly better than the estimates of the AMS.

On total cattle, inventories are expected to decrease from Jan. 1 to April and therefore the census figures should be low. The sample survey figure agrees well with that of the AMS.

Cows and heifers both dairy and beef taken together appear to agree exceedingly well among all agencies, federal census, sample survey and AMS. There are, however, real differences among the agencies when they are classified by beef or dairy types, the sample survey having unreasonably more cows classified as beef rather than as dairy. This may be explained possibly by differences in the way the question was asked. The sample survey asked for "dairy" cows whereas the census, AMS and assessor asked for cows "kept for milk" (see footnote m). Evidently farmers regard the latter as a more inclusive classification. Possibly they regard the word "dairy" as pertaining more to breed and the phrase "kept for milk" as pertaining to use of cows. The assessor figure for number of dairy cows appears to be definitely low.

Cows and heifers milked during all or part of 1939 appear to be within a reasonable sampling error of the corrected AMS estimate. The census appears to be definitely low.

Census figures are of little use in the remaining livestock inventory comparisons because of large shifts from Jan. 1 to April 1. Total swine of the sample survey appears to agree within sampling error with either of the AMS estimates but closer to the revised figure. For sheep the sample survey appears to be definitely too low as compared with the AMS although the AMS felt obliged to lower their preliminary estimate somewhat. When compared with the census, the sample survey figure is in agreement but the meaning is not clear. The census figure represents all sheep and lambs 6 months or older on farms April 1, 1940. Without further inquiry it is not clear what a census figure for Jan. 1, 1940, would be. We therefore conclude that a real difference appears between the sample survey and AMS figures and that the census is of no direct aid in interpreting the difference. For chickens the sample survey and AMS again appear to agree. The turkey figure of the sample survey, since it comes from only 28 farms reporting turkeys, is of little use in making estimates for the state.

ITEMS 24-28. NUMBERS OF LIVESTOCK BORN

This item is not comparable among the several agencies; therefore, an accurate evaluation of this item is not possible (see table footnotes 5, 10, 12, 8). The relative level of the sample survey does appear to be quite satisfactory.

ITEMS 29-47. AMOUNTS SOLD AND RECEIPTS FROM SALES OF FARM PRODUCTS

Whole milk sold. The particularly low estimate of the sample survey may in part at least be due to the sample survey's exclusion of incorporated areas. Whole milk sales are more prevalent in these areas. It seems reasonable to believe that this and sampling error (which must be quite large in view of the inadequacy of occurrence and variability of the item) could account for the differences between the federal census and sample survey figures. Both appear to have a large bias of underestimate when compared with the AMS figure.

Butterfat sold. The sample survey figure agrees with sampling error (estimated as slightly larger than the 4 percent of dairy products receipts, say 5 percent) of the AMS figure but is quite definitely larger than the federal census figure. It seems reasonable to conclude that the census has a downward bias of about 11 percent.

Butter sold. The sample survey figure for this item of infrequent occurrence (only about 2.5 percent of Iowa farms) and high sampling error is probably erratic due to sampling. There is no conclusive evidence of bias.

Receipts from dairy products sold. Although the census and sample survey figures agree remarkably well this doesn't appear to be very meaningful. If the sample survey figure is corrected for the deficiency in receipts from whole milk (which is about one-half of what the AMS puts it), a correction amounting to about $9,500,000 (see footnote z), we obtain corrected sample survey figure of $60,284,000 which agrees satisfactorily with the $60,789,000 of the AMS. A similar correction

would not aid the census as much because of the large deficiency in butterfat sold (about 70 percent of dairy receipts).

Wool shorn. The sample survey is low on all sheep items although apparently within reasonable limits of sampling error. According to the AMS figure both the census and sample survey are low. But the accuracy of the AMS figure is uncertain.

Livestock butchered. Difference in definition make evaluations difficult. The census and AMS figures refer to animals slaughtered on the farm for either home use or for sale. The sample survey figures refer only to those animals slaughtered on the farm for home use. The census and AMS discrepancies appear surprisingly large.

Numbers of livestock bought and sold. The most interesting feature of these comparisons is the apparent differences in the definition of "calves." In the sample survey a calf was defined as an animal one year or less in age. As the question appears on the census questionnaire no age limit for a "calf" was made. The sample survey obtained a greater proportion of calves to cattle than the census both in numbers bought and numbers sold. We conclude that the average farmer's concept of a calf is an animal somewhat less than 1 year old.

In numbers of livestock sold the agreement between the census and sample survey is reasonably close (if cattle and calves are taken together). In number of livestock bought, the sample survey figures are low. The reason for this is not clear, but it may be connected with the way in which the questions are asked. In the census the questions were direct and independent of other livestock questions. In the sample survey the questions were part of a table in which incoming and outgoing numbers of animals were required to balance with inventory changes. Apparently the direct census type of question received larger answers. This seems to agree also with the general observation that the direct census type of question on expenditures in general receives larger answers than the more detailed piece-meal question of the sample survey.

As compared with the AMS, the numbers of livestock sold of the census and sample survey are low. The significance of this discrepancy is made worse if we remember that the AMS figures do not include direct inter-farm sales. As shown elsewhere (p. 27) farmers have understated their beginning inventories of livestock from 9 to 19 percent an error which has been termed "memory bias." Because of the balancing features of the sample survey livestock questions, this beginning inventory has probably affected related livestock questions —in this case, sales. This shortage of beginning inventory numbers probably has brought about a similar shortage in sales. If we adjust livestock sales in accordance to this assumption and compare them with the unadjusted and AMS figures, we obtain the following:

Species	Sample survey		AMS	AMS as percent of sample survey
	Unadjusted	Adjusted		
Cattle and calves.............	2,196,000	2,560,000	2,167,208	85
Swine........................	9,474,000	10,744,000	10,652,540	99
Sheep and lambs..............	886,000	1,002,000	1,555,823	155
Chickens....................	18,274,000	20,467,000	32,382,000	158

We see that for cattle and swine the adjusted sample survey figures are substantially above those of the AMS. No information is readily

available on the extent of inter-farm sales and therefore it is not easy to evaluate the accuracy of these figures. However, there is evidence* that inter-farm sales as a percentage of all sales is somewhat greater than 8 percent for cattle and calves, 3 percent for swine and 10 percent for sheep and lambs. On this assumption we see that cattle, calves, and swine are in reasonable agreement but sheep and lambs and chickens are far short for the sample survey. Chicken items were not required to check out on the sample survey questionnaire hence the heavy bias on sales may be due to outright understatement of the answers. In the case of sheep, however, it appears that the low sample survey figure is attributable to sampling error. For cattle and swine the correction for memory bias appears to give satisfactory results.

Receipts from livestock and crop sales. The sample survey figure for livestock receipts appears to be enough greater than the census to conclude that the difference is real and probably due to the difference in the way the questions were asked. The census question was a straight "omnibus" type of question whereas the sample survey's was a detailed "piecemeal" type. Both the sample survey and census are far under the AMS. Use of the correction mentioned above (p. 92) would boost the sample survey figure to $312,837,000 or 95 percent of the AMS.

On receipts from poultry, eggs, etc., the census and sample survey agree within sampling error but both are seriously below the AMS (the sample survey 84 percent of AMS).

On receipts from wool, mohair, meat, hides, bees, honey, pelts, etc., the low figure of the sample survey can be partly explained as a result of the omission of bees and honey.

On value of crops sold and value of home used products, an evaluation of the several figures is complicated by non-comparability.

ITEMS 49-50. VALUE OF LAND, BUILDINGS, EQUIPMENT, ETC.

The sample survey is definitely higher than the census on both value of land and value of buildings and equipment but for the two items taken together agrees satisfactorily with the AMS. Apparently farmers tend to give more conservative estimates of these items to the census enumerators than to those of the sample survey. The difference on value of machinery and equipment is to a large extent due to the fact that motor cars and trucks were not included in the sample survey figure.

ITEMS 51-56. FARM EXPENDITURES

In general (except for expenditures for buildings and improvements) the sample survey figures are lower than the census. This may be due to the differences in the way the questions were asked. The census questions were generally the omnibus type whereas the sample survey's were quite detailed.

ITEMS 57-60. MISCELLANEOUS ITEMS

After allowance has been made for the automobile and trucks of farms in the incorporated areas it can be said that the sample survey and census agree reasonably well. The sample survey appears to be somewhat large on tractors, suggesting that the difference between the census and sample survey may be real.

Since one would expect the farms in the incorporated areas to more likely have electricity than those farther from town and furthermore

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*S. H. Thompson, based on a farm survey made during the summer of 1941 on the sales of livestock for the calendar year, 1940.

since one would also expect that these farms would more likely have high-line service, we conclude that the sample survey figures on these items agree reasonably well with the census.

CONCLUSIONS

One of the most important conclusions to be drawn from these comparisons is that none of the agencies can be said to provide absolutely accurate information. Even the complete (or nearly so) enumerations of the state assessor and federal census do not agree on supposedly identical items. The sample survey has agreed quite well with the other agencies in great number of items. Some of the large discrepancies have been explained as due to possible biases chargeable to questionnaire differences or even to more subtle reasons (case in point: the difference in value of land buildings—the census gets lower values than the sample survey and AMS). In general, it seems that the omnibus type of question (used largely by the census) tends to bring larger answers on expenditures and smaller answers on receipts than the detailed type (used largely by the sample survey). In many cases it appears that the sample survey was more accurate than the AMS, especially with those items appearing on a great number of farms. Furthermore it seems reasonable to believe that in some items the sample survey was more accurate than the census. Below is a list of those items for which the sample survey estimates were more accurate than the preliminary AMS or federal census.

TABLE C-2. EVALUATION OF ACCURACY OF ITEMS GIVEN BY AMS, FEDERAL CENSUS AND SAMPLE SURVEY.

| Accuracy of the sample survey better than | | Accuracy of the sample survey very poor |
Preliminary AMS estimate	Federal census of 1940	
2. Total corn acres 2a. Corn acres harvested for grain 3. Sorghum acres, all 5. Oat yield 6. Barley yield 7. Rye acres for grain 8. Soybean acres for grain Soybean yield 9. Alfalfa acres cut for hay 10. Soybean acres cut for hay 11. Clover and timothy acres cut for hay 12. Number of horses 13. Number of mules	30. Pounds butterfat sold 32. Receipts from dairy products sold 43. Receipts from livestock sold 45. Receipts from poultry, eggs, etc., sold 49a. Value of land 49b. Value of buildings and improvements	4. Wheat yield 11. Clover and timothy hay yield 12. Alfalfa acres harvested for seed Yield of alfalfa harvested for seed 13. Yield of clover harvested for seed 21 Number of sheep and lambs 23. Number of turkeys 26. Number of lambs born 29. Gallons of milk sold 31. Pounds of farm butter sold 33. Pounds of wool shorn

In general the sample survey has proved to be satisfactorily representative. With the exception of a few items of usual minor importance, errors attributable to sampling have been reasonably small. The greatest errors occurred in those items depending on the memory of the enumeratee and are therefore attributable to weaknesses in interview technique. These errors also occurred in the census—in some cases being more serious there than in the sample survey. The more serious errors in the census appeared to be in receipt items, a result attributable to its use of the omnibus type of questions.

APPENDIX D

QUARTER-SECTION GRID COUNT

A count of quarter-section grids was necessary to provide the weights for geographic stratification (see p. 42) and for expanding sample data into estimates of population totals (see expansion method I, p. 16). To make the count it was found advisable to distinguish three classes of grids: 1, incorporated (cities and towns), 2, unincorporated non-agricultural (such as lakes, rivers, public parks, etc.) and 3, unincorporated agricultural. The Iowa sample survey of 1938 and 1939 dealt with the third class only. Since there are some agricultural operations in the incorporated areas, it is obvious that part of the agricultural population was purposely ignored. The importance of this ignored portion is small in the light of the sampling errors met in the present study.

TABLE D-1. NUMBER OF QUARTER-SECTION GRIDS BY TYPE-OF-FARMING AREA, STATE OF IOWA.

Type-of-farming area	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
Northeast dairy	41868	342	800	43010
Cash grain	44398	119	1147	45664
Western livestock	50785	180	889	51854
Southern pasture..	39622	113	505	40240
Eastern livestock	42503	97	812	43412
State total	219176	851	4153	224180

TABLE D-2. NUMBER OF QUARTER-SECTION GRIDS BY COUNTY, NORTH-EAST DAIRY AREA.

County	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
1. Allamakee..........	2605	60	15	2680
2. Blackhawk...........	2216	0	88	2304
3. Bremer.......	1689	0	39	1728
4. Buchanan........ ...	2266	0	38	2304
5. Butler..........	2262	0	42	2304
6. Cerro Gordo.....	2184	32	88	2304
7. Chickasaw...	1987	0	29	2016
8. Clayton.......... ..	2984	143	49	3176
9. Delaware......	2248	10	46	2304
10. Dubuque............	2374	12	26	2412
11. Fayette..............	2828	0	52	2880
12. Floyd..............	1978	0	38	2016
13. Howard..............	1891	0	29	1920
14. Jackson.............	2312	72	48	2432
15. Jones................	2283	2	19	2304
16. Mitchell.............	1894	0	26	1920
17. Winnebago....	1587	6	39	1632
18. Winneshiek..	2692	0	50	2742
19. Worth...............	1588	5	39	1632
Total............... .	41868	342	800	43010

TABLE D-3. NUMBER OF QUARTER-SECTION GRIDS, BY COUNTY, CASH GRAIN AREA.

	County	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
1.	Boone...............	2255	8	41	2304
2.	Calhoun..............	2219	5	80	2304
3.	Clay.................	2266	12	26	2304
4.	Dallas...............	2266	0	38	2304
5.	Dickinson............	1603	9	20	1632
6.	Emmet...............	1576	24	32	1632
7.	Franklin.............	2221	3	80	2304
8.	Greene..............	2240	0	64	2304
9.	Hamilton............	2254	0	50	2304
10.	Hancock.............	2263	11	30	2304
11.	Hardin..............	2237	3	64	2304
12.	Humboldt............	1692	0	36	1728
13.	Kossuth.............	3903	1	32	3936
14.	Osceola.............	1564	4	16	1584
15.	Palo Alto...........	2251	20	33	2304
16.	Pocahontas..........	2280	0	24	2304
17.	Polk................	2051	8	261	2320
18.	Story...............	2228	0	76	2304
19.	Webster.............	2788	4	88	2880
20.	Wright..............	2241	7	56	2304
	Total...............	44398	119	1147	45664

TABLE D-4. NUMBER OF QUARTER-SECTION GRIDS BY COUNTY, WESTERN LIVESTOCK AREA.

	County	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
1.	Audubon.............	1733	0	13	1746
2.	Buena Vista..........	2263	17	24	2304
3.	Cass................	2261	1	42	2304
4.	Cherokee............	2277	1	26	2304
5.	Carroll.............	2266	0	38	2304
6.	Crawford............	2843	0	37	2880
7.	Fremont.............	2016	25	23	2064
8.	Harrison............	2775	20	33	2828
9.	Ida.................	1710	0	18	1728
10.	Lyon................	2378	12	50	2440
11.	Mills...............	1712	11	17	1740
12.	Monona.............	2533	38	37	2608
13.	Montgomery..........	1687	0	41	1728
14.	O'Brien.............	2271	0	33	2304
15.	Page................	2095	0	41	2136
16.	Plymouth............	3406	11	27	3444
17.	Pottawattamie........	3791	0	85	3876
18.	Sac.................	2254	5	45	2304
19.	Shelby..............	2307	0	21	2328
20.	Sioux...............	2930	31	47	3008
21.	Woodbury...........	3277	8	191	3476
	Total...............	50785	180	889	51854

TABLE D-5. NUMBER OF QUARTER-SECTION GRIDS BY COUNTY, SOUTH-
ERN PASTURE AREA.

County	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
1. Adair..................	2285	0	19	2304
2. Adams.................	1720	0	8	1728
3. Appanoose.............	2009	0	51	2060
4. Clarke.................	1717	0	11	1728
5. Davis.................	1976	8	8	1992
6. Decatur...............	2104	0	24	2128
7. Guthrie...............	2376	4	20	2400
8. Jefferson.............	1705	0	23	1728
9. Lee...................	1981	69	42	2092
10. Lucas.................	1703	2	23	1728
11. Madison..............	2278	2	24	2304
12. Marion...............	2276	0	28	2304
13. Monroe...............	1710	0	18	1728
14. Ringgold.............	2095	0	29	2124
15. Taylor...............	2108	2	22	2132
16. Union................	1696	2	30	1728
17. Van Buren...........	1877	16	27	1920
18. Wapello..............	1685	0	43	1728
19. Warren...............	2249	8	31	2288
20. Wayne...............	2072	0	24	2096
Total................	39622	113	505	40240

TABLE D-6. NUMBER OF QUARTER-SECTION GRIDS BY COUNTY, EASTERN
LIVESTOCK AREA.

County	Unincorporated agricultural	Unincorporated non-agricultural	Incorporated	Total
1. Benton...............	2840	0	40	2880
2. Cedar................	2288	0	16	2304
3. Clinton..............	2711	16	61	2788
4. Des Moines..........	1577	5	58	1640
5. Grundy..............	1992	0	24	2016
6. Henry................	1702	0	26	1728
7. Iowa.................	2288	3	13	2304
8. Jasper...............	2850	0	30	2880
9. Johnson.............	2438	0	30	2468
10. Keokuk..............	2257	0	47	2304
11. Linn.................	2775	2	103	2880
12. Louisa...............	1594	32	26	1652
13. Mahaska.............	2262	0	42	2304
14. Marshall.............	2258	0	46	2304
15. Muscatine...........	1673	28	39	1740
16. Poweshiek...........	2269	0	35	2304
17. Scott................	1652	11	97	1760
18. Tama................	2828	0	52	2880
19. Washington..........	2249	0	27	2276
Total................	42503	97	812	43412

APPENDIX E.

STATISTICS OF AGRICULTURE IN THE INCORPORATED AREAS OF IOWA

Mr. Norman V. Strand, with WPA assistance, has compiled agricultural data of the Iowa State Farm Census (Assessor) for 1938 into summaries for both the incorporated and unincorporated (or "rural") areas separately. These data appear in the following tables.

TABLE E-1. NUMBER OF FARMS, ACREAGES IN FARMS AND CROPS IN THE INCORPORATED AND UNINCORPORATED AREAS OF THE STATE OF IOWA, 1938

	Rural + Inc'd.	Inc'd.	Rural	Average per farm		
				All	Inc'd.	Rural
Number of farms..	209,709	8,939	200,770			
1. Number of farm acres............................	34,402,853	325,906	34,076,947	164.05	36.46	169.73
2. Number of corn, all acres.......................	10,270,089	98,174	10,171,915	48.97	10.98	50 66
3. Number of oats, grain acres.....................	5,923,305	44,136	5,879,169	28.25	4.94	29.28
4. Number of winter wheat, grain..................	553,909	4,142	549,767	2.64	.46	2.74
5. Number of spring wheat, grain..................	26,965	95	26,870	.13	.01	.13
6. Number of barley grain..........................	422,104	2,663	419,441	2.01	.30	2.09
7. Number of flax for seed acres...................	11,420	181	11,239	.05	.02	.06
8. Number of rye acres.............................	118,457	752	117,705	.56	.08	.59
9. Number of soybean, grain.......................	305,943	2,839	303,104	1.46	.32	1.51
10. Number of timothy seed.........................	205,195	713	204,482	.98	.08	1.02
11. Number of red and alsike clover seed...........	94,373	384	93,989	.45	.04	.47
12. Number of sweet clover, seed...................	394,829	80	394,749	1.88	.01	1.97
13. Number of alfalfa hay*..........................	813,853	11,153	802,700	3.88	1.25	4.00
14. Number of all tame hay.........................	2,941,917	29,075	2,912,842	14.03	3.25	14.51
15. Number of wild hay.............................	151,658	1,188	150,470	.72	.13	.75
16. Number of pasture, all..........................	10,263,553	102,327	10,161,226	48.94	11.45	50.61
17. Number of all other crop acres.................	200,678	8,098	192,580	.96	.91	.96
18. Number of buildings, feed lots, hwgs...........	1,722,177	21,508	1,700,669	8.21	2.41	8.47
19. Number of wood lots for timber only	202,834	3,020	199,814	.97	.34	1.00
20. Number of waste land...........................	430,816	3,605	427,211	2.05	.40	2.13
21. Number of idle crop land........	600,524	3,475	597,049	2.86	.39	2.97
22. Number of pop corn.............................	20,226	118	20,108	.10	.01	.10

*Included in 14.

TABLE E-2. NUMBER OF FARMS, FARM ACRES AND AVERAGES BY TYPE-OF-FARMING AREAS FOR RURAL AND INCORPORATED AREAS, 1938.

Type of farming area	Total no. farms	No. inc'd. farms	No. rural farms	Total no. acres	No. inc'd. acres	No. rural acres	Av. all farms	Av. inc'd. farm size	Av. rural farm size
Northeast dairy....................	41,092	1,518	39,574	6,563,270	72,112	6,491,158	159.72	47.50	164.03
Cash grain..	40,312	1,900	38,412	6,988,744	98,615	6,890,129	173.37	51.90	179.37
Western livestock........................... ..	45,667	1,650	44,017	8,009,303	58,598	7,950,705	175.38	35.51	180.63
Southern pasture...........................	38,619	1,684	36,935	6,177,334	39,132	6,138,202	159.96	23.24	166.19
Eastern livestock...........................	44,019	2,187	41,832	6,664,202	57,449	6,606,753	151.39	26.27	157.94
State average................................	209,709	8,939	200,770	34,402,853	325,906	34,076,947	164.05	36.46	169.73

TABLE E-3. NUMBER OF FARMS, FARM ACRES AND AVERAGES FOR RURAL AND INCORPORATED AREAS, 1938.

Area—Northeast Dairy.

County	Total no. farms	No. inc'd. farms	No. rural farms	Total no. acres	No. inc'd. acres	No. rural acres	Av. all farms	Av. inc'd. farm size	Av. rural farm size
Allamakee	2,205	43	2,162	395,677	758	394,919	179	18	183
Black Hawk	2,403	151	2,252	339,863	3,645	336,218	141	24	149
Bremer	2,062	100	1,962	269,993	3,654	266,339	131	36	136
Buchanan	2,266	51	2,215	352,821	1,686	351,135	156	33	159
Butler	2,252	94	2,158	357,427	5,103	352,324	159	54	163
Cerro Gordo	1,193	59	1,854	346,235	6,669	339,566	181	113	183
Chickasaw	1,990	77	1,193	306,608	3,221	303,387	154	42	159
Clayton	2,935	112	2,823	471,760	6,159	465,601	161	55	165
Delaware	2,206	73	2,133	352,554	2,819	349,735	160	39	164
Dubuque	2,350	107	2,243	368,029	5,903	362,126	157	55	161
Fayette	3,058	137	2,921	444,897	4,756	440,141	145	35	151
Floyd	1,800	47	1,753	308,867	3,790	305,077	172	81	174
Howard	1,685	61	1,624	294,450	2,775	291,675	175	45	180
Jackson	2,204	50	2,154	390,786	4,106	386,680	177	82	180
Jones	2,164	37	2,127	351,373	1,094	350,279	162	30	165
Mitchell	1,672	63	1,609	284,536	1,534	283,002	170	24	176
Winnebago	1,653	112	1,541	251,876	3,668	248,208	152	33	161
Winneshiek	2,785	68	2,717	427,413	5,305	422,108	153	78	155
Worth	1,489	76	1,413	248,105	5,467	242,638	167	72	172
Total av	41,902	1,518	39,574	6,563,270	72,112	6,491,158	159.72	47.50	164.03

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