Production and Income Variability Of Alternative Farm Enterprises In Northwest Oklahoma

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Bulletin B-563

August, 1960

and

U.S.D.A.

CONTENTS

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Oklahoma State University, Stillwater
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United States Department of Agriculture

Preface

This publication is the first of a series reporting results of research related to management strategies in high-risk farming and ranching areas in Oklahoma. It presents estimates of production, price, and income variability of major crop and livestock enterprises in northwest Oklahoma. Later publications will evaluate normal income expectations of alternative farming and ranching systems, the expected income variability arising from alternative farming and ranching systems, and consequences of alternative managerial strategies designed to maximize business survival and capital accumulation in high-risk farming areas.

It is hoped that results of this research will be useful to individual farmers and ranchers in planning and organizing their operations, and to credit agencies and other private and governmental institutions serving farmers and ranchers in the area. This research also will provide a basis for evaluating alternative public policies that might be designed to (1) serve the need of farmers and ranchers in high-risk areas, and (2) achieve an economically efficient use of the agricultural resources of the Great Plains.

The work reported here is a portion of a research project being conducted jointly by several state agricultural experiment stations in the Great Plains states, in cooperation with the U. S. Department of Agriculture. This project, designated GP-2, is titled: "Organizing and operating dry-land farms in the Great Plains to meet variable climatic and changing economic conditions."

The authors are appreciative of the assistance and cooperation of the members of the technical committee of GP-2. They also are indebted to the following persons for valuable contributions to the conduct of the research and the preparation of this report:

L. F. Miller, Head, Department of Agricultural Economics, Oklahoma State University; E. Lee Langsford, Farm Economics Research Division, Agricultural Research Service, U. S. Department of Agriculture; E. H. McIlvain, Superintendent, U. S. Southern Great Plains Field Station, Woodward, Oklahoma; and D. D. Pittman, Agricultural Statistician in Charge, Oklahoma Crop and Livestock Reporting Service.

TABLES

TABLES (Continued)

Appendix Tables

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The Problem

Farm and ranch production and incomes are highly variable in the Great Plains. A major share of the income variability is generated by highly variable yields and rates of production arising from extreme seasonal and annual fluctuations in quantity and distribution of rainfall. The income problem is further aggravated by rather severe fluctuations in prices farmers and ranchers receive for farm products and pay for production goods and services.

Farmers in the Great Plains face complex and important managerial problems which are unique to high-risk farming and ranching areas. It is difficult to derive meaningful long-term management plans for farms and ranches and to develop suitable strategies of financial management, in the face of highly variable incomes. The problem is often aggravated by the clustering or bunching of favorable and unfavorable years. A series of years of low net incomes, in the face of high fixed costs, sharply reduces the business survival probabilities of farms and ranches. Thus there is need for developing management strategies by which farmers and ranchers may more nearly achieve their economic and social goals. In addition, society is interested in the use of Great Plains resources.

The Study Area

The estimates presented relate specifically to Ellis, Harper, and Woodward counties in Oklahoma. However, the inferences apply to a much wider area (Figure 1).

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Figure 1—General Area of Northwestern Oklahoma and Similar Farming and Ranching Areas of Kansas and Texas to Which Study is Applicable.

The land area in Ellis, Harper, and Woodward counties totals 2.2 million acres. According to the 1955 Census of Agriculture, almost 97 percent of this land area is in farms and ranches, and nearly 65 percent of the area in farms and ranches is in native and/or reseeded grasses.

In 1954, about 524,000 acres of cropland were harvested in the three counties. Almost two-thirds of this was wheat, and approximately 4 percent was grain sorghum. In the same year, there were about 151,000 cattle and calves in the three counties, or approximately one head for each 10 acres of pasture-land. Less than 10 percent of the cattle and calves were classified as milk cows. Numbers of other livestock were small. Thus the small grains and sorghums are the major crops in the area, and various systems of beef production are the major livestock enterprises.

Research Methods

In order to evaluate management strategies and study resource efficiency in the Great Plains, a knowledge of future patterns of production and income variation is needed. Obviously, such information is not available. However, it may perhaps be assumed that the patterns of weather and other variables affecting production and incomes in the area tend to be repetitive in nature. If this is true, historical data may provide an adequate basis for predicting patterns for the future and therefore for evaluating alternative strategies.

To measure precisely the degree and nature of production and income variability associated with individual crop and livestock enterprises on individual farms and ranches, data on crop yields and livestock production for individual farms over a period of years are needed. Unfortunately, these data are not readily available. Thus for purposes of this analysis, it was necessary to estimate these parameters from data derived from other sources.

Available crop yield data for northwest Oklahoma over a period of years are basically of two types: (1) county average yield estimates compiled by the U.S.D.A.'s Crop and Livestock Reporting Service; and (2) data from experiments at the U. S. Southern Great Plains Field Station at Woodward, Oklahoma. Both sources of data were examined. In addition, estimates of average wheat yields on randomly selected farms were obtained from farmers in the area.

Higher average yields would be expected under experimental conditions than would be found on farms, but the yearly variability of yields per acre from experimental plots should approximate the variability expected on individual farms. Therefore estimates of crop yields used in this report were obtained by deflating experimental plot yields to the level of farm yields.

Livestock production data were obtained from experiments conducted at the Southern Plains Experimental Range near Fort Supply, Oklahoma. Data pertaining to a year-long stocker-feeder cattle grazing system with yearling steers are available for 1942-57. Similar data relating to a cow-calf system of production are available for 1952-57.

The practices followed under experimental conditions are closely related to typical rancher practices in northwest Oklahoma. Therefore, these data should afford reasonable estimates of production variability characteristic of these two livestock enterprises.

The production variability estimates for both crop and livestock enterprises are based largely on the 16-year period 1942-57, because livestock data were available only for this time. The cow-calf production data, which were available only for 1952-57, were extended by ascertaining the relationship between production from steers and cow herds and by regression technique predicting cow-calf production rates from known steer production for the earlier years.

Yearly prices of wheat and grain sorghum used in the analysis are seasonal averages, as estimated by the Agricultural Marketing Service

of the U. S. Department of Agriculture. These average prices may slightly understate the variability of prices actually received by individual farmers, as farmers usually market both wheat and grain sorghum in one or two lots rather than continuously throughout the season. The seasonal average price, however, provides a better estimate of the level of prices because it represents the average over the marketing season rather than the price of any specific month.

Typical current production practices, as revealed by a survey of farmers in the area, were used as a basis for computing production costs and estimating returns from the various crop and livestock enterprises. Examples of computations for wheat, grain sorghum, and livestock enterprises are given in the appendix, tables I to IV.

Three sets of prices were applied to the products sold and items used in production to compute gross income and returns to selected factors: (1) yearly prices received by farmers, (2) historical prices deflated to a 1935-39 basis; and (3) constant prices.

Variability Estimates

Production Variability

For purposes of these analyses, yields of wheat and grain sorghum are measured in bushels per planted acre. During the period 1942-57, wheat yields ranged from a low of 6.9 bushels per acre in 1953 to a high of 21.6 bushels in 1952 (Table 1). The mean was 12.5 bushels with a standard deviation of 4.1 and a coefficient of variation 33.1[1] During the same years, yields of grain sorghum per acre ranged from a low point of 2.1 in 1946 to a high of 23.1 in 1951, with a mean of 10.9, a standard deviation of 5.6, and a coefficient of variation of 51.6. These statistics indicate that, during the 16-year period, wheat yields were higher than those of grain sorghum and showed a smaller relative degree of variation. Agricultural statistics for the area reflect farmer preferences for wheat. In the years before production controls, a very large percentage of all cropland was planted to wheat.

Beef production is expressed in pounds of beef produced per acre of rangeland. Beef production per acre under a buy-sell steer system ranged from a low point of 23.4 pounds per acre in 1957 to a high of 56.9 pounds in 1953. The mean production per acre under this system

[1] A statistic was required to permit a comparison of two distributions with different means. The coefficient of variation was adopted as a means of measuring the relative degree of variability of crop yield and livestock production data. This term expresses the standard deviation of the annual series as a percentage of the mean and allows a comparison of the different series.

Table 1.—Production Per Acre, Selected Farm Enterprises, 1942-57

Year	Per Acre Planted[1]		Per Acre of Native Range[2]	
	Wheat	Grain Sorghum	Buy-Sell Steer	Cow-Calf
	Bushels	Bushels	Pounds	Pounds
1942	11.0	13.6	32.6	24.2
1943	12.4	7.5	32.2	23.2
1944	19.3	8.1	48.7	24.9
1945	14.5	10.8	43.9	24.4
1946	14.3	2.1	47.8	24 8
1947	10.1	9.3	34.4	23.4
1948	9.7	7.2	27.4	22.6
1949	13.8	3.6	35.8	23.5
1950	12.6	18.1	46.9	24.7
1951	13.3	23.1	45.3	24.5
1952	21.6	8.2	41.7	24.2
1953	6.9	18.1	56.9	25.9
1954	9.5	8.4	41.7	23.4
1955	7.0	8.4	30.2	23 9
1956	7.4	16.1	37.5	23.9
1957	16.8	12.5	23.4	21.7
Mean	12.5	10.9	39.1	23.9
Standard Deviation	4.1	5.6	9.0	1.0
Coefficient of Variation	33.1	51.6	22.9	4.2

[1] Wheat and grain sorghum yields are based on experiments at the U. S. Southern Great Plains Field Station, Woodward, Okla., adjusted to farmer expectations from yields reported by farmers interviewed in Ellis, Harper, and Woodward Counties.

[2] Livestock production estimates obtained from unpublished data at the U. S. Southern Great Plains Field Station, Agricultural Research Service, United States Department of Agriculture, Woodward, Okla. Since experimental data was available for the cow-calf enterprise for only 5 years, production from cows for the earlier years estimated from known steer-beef production from a similar range. Regression equation used for extending cow-calf production is: $Y=b_0+b_1x$. The fitted equation follows: $\hat{Y} = 19.74844 + .00106\ X_1$ ($\pm .00095$); $r^2 = .80$. The various cow-calf production rates were then predicted using the steer data from the Woodward experiments.

was 39.1 pounds, with a standard deviation of 9.0 pounds, and a coefficient of variation of 22.9. Beef produced per acre with a cow-calf system ranged from a low of 21.7 in 1957 to a high of 25.9 in 1953. The cow-calf system in this comparison includes beef production from both calves and cull cows sold and assumes that enough heifers are retained to allow an annual replacement of 15 percent of the cow herd. The average estimated beef production per acre during the 16 years with the cow-calf program was 23.9 pounds, with a very small standard deviation of 1.0 and a coefficient of variation of 4.2.

Based on the data, grain sorghum exhibits the greatest relative degree of variation in physical production, while beef production using the cow-calf program exhibits the smallest.

Beef production per acre from the steer enterprise exhibits a greater relative degree of variability primarily because rates of steer stocking varied between years in accordance with expected forage supplies during the coming year. Forage expectations were formulated on the basis of estimated forage available when the cattle were purchased during the fall of the year. On the other hand, the stocking rate for the cow-calf program was maintained at essentially the same rate throughout the experimental period.

In measuring the beef production from the cow-calf herd, no account was taken of the variation in average weight of the cow herd. That is, beef production from the cow herd consists of the weight of calves and cull cows actually sold. These data seem to suggest that the brood cow absorbs much of the variability in forage supplies, while the weight of the animals sold changes very little. This tends to reduce the degree of production variability.

Price Variability

The average seasonal price received by Oklahoma farmers for wheat during the period 1942-57 averaged $1.86 per bushel (Table 2). The range of prices during the period was from a low of $1.11 in 1942 to a high of $2.20 in 1951. The standard deviation of wheat prices was $0.34 per bushel and the coefficient of variation 18.3. Prices received for grain sorghum averaged $1.20 per bushel with a range from $0.87 to $1.92 per bushel. The standard deviation of sorghum prices during the period was $0.27 per bushel, giving a coefficient of variation of 22.5.

October sale prices of yearling steers during the 16-year period averaged $18.02 per hundredweight, with a range from $10.67 to $31.96. The standard deviation was $6.09 and the coefficient of variation 33.8. The pattern and magnitude of variation for October sale prices of calves is similar to that for yearling steers.

These data suggest a considerably greater degree of variability in cattle prices than in prices of wheat or grain sorghum. The fact that the degree of price variability has been less for wheat than for grain sorghum may be attributed largely to price-support programs for wheat.

The data in Table 2 may overestimate the degree of price variability because there has been an upward trend in all prices during the period analyzed. Therefore, in Table 3 the prices for the four commodities

Table 2.–Estimated Prices Received for Farm Products, 1942-57[1]

Year	Price per Bushel		Price per Cwt.		
	Wheat	Grain Sorghum	Yearling Steers	Calves	Cull Beef Cows
	Dollars	Dollars	Dollars	Dollars	Dollars
1942	1.11	0.87	11.50	11.22	7.91
1943	1.38	1.23	10.67	10.68	9.56
1944	1.39	.93	10.76	11.40	9.17
1945	1.45	1.20	12.17	12.01	10.57
1946	1.80	1.35	15.24	15.38	12.32
1947	2.17	1.92	18.64	18.55	14.69
1948	1.98	1.20	21.98	22.17	17.48
1949	1.87	1.10	19.88	20.06	14.53
1950	2.02	1.05	28.51	26.06	19.99
1951	2.20	1.29	31.96	30.05	23.24
1952	2.12	1.60	21.94	19.78	14.11
1953	2.13	1.23	14.16	13.46	9.80
1954	2.18	1.23	17.61	15.76	9.81
1955	2.05	.92	16.98	15.67	10.20
1956	2.00	1.22	16.03	13.52	9.61
1957	1.93	.92	20.33	19.91	13.77
Mean	1.86	1.20	18.02	17.23	12.92
Standard Deviation	.34	.27	6.09	5.58	4.31
Coefficient of Variation	18.3	22.5	33.8	32.4	33.4

[1] Prices of wheat and grain sorghum are seasonal average prices received by farmers in Oklahoma as reported by Agricultural Marketing Service, United States Department of Agriculture, Oklahoma City, Okla. Cattle prices reflect October prices for yearling steers, cull-beef cows, and calves on the Oklahoma City terminal market, with minor adjustments for location and quality of cattle in northwest Oklahoma.

analyzed have been deflated by the U. S. Bureau of Labor Statistics index of wholesale prices of all commodities. In effect, adjustment transforms the prices to 1935-39 dollars by removing variations in the price level. The adjusted averages, standard deviations, and coefficients of variation of prices are given in Table 3. This adjustment tends to reduce the means as well as the standard deviations and coefficients of variation in the various price series.

Variability of Gross Returns

Analysis of variations in estimated gross income per acre for the different enterprises include the variability owing to both physical production and prices. Two separate gross income estimates are presented for the cow-calf enterprise: (1) ignoring changes in the inventory value of the brood herd; and (2) including these changes. Thus, in (1) the gross income represents sales from calves and cull brood cows, while

Table 3.—Deflated Prices Received for Farm Products, 1942-57[1]
(1935-39=100)

Year	Price per Bushel		Price per Cwt.		
	Wheat	Grain Sorghum	Yearling Steers	Calves	Cull Beef Cows
	Dollars	Dollars	Dollars	Dollars	Dollars
1942	0.91	0.71	9.38	9.15	6.45
1943	1.08	.96	8.34	8.34	7.47
1944	1.08	.72	8.33	8.83	7.10
1945	1.10	.91	9.26	9.14	8.04
1946	1.20	.99	10.14	10.23	8.20
1947	1.18	1.04	10.12	10.08	7.98
1948	.99	.60	11.02	11.12	8.77
1949	.99	.58	10.49	10.59	7.67
1950	1.03	.53	14.48	13.24	10.15
1951	1.00	.59	14.57	13.70	10.60
1952	.99	.75	10.29	9.28	6.62
1953	1.01	.58	6.73	6.40	4.66
1954	1.03	.58	8.36	7.48	4.66
1955	.97	.44	8.03	7.41	4.82
1956	.92	.56	7.34	6.19	4.40
1957	.86	.41	9.05	8.86	6.13
Mean	1.02	.68	9.75	9.38	7.11
Standard Deviation	.09	.19	2.21	2.12	1.89
Coefficient of Variation	8.8	27.9	22.6	22.6	26.6

[1] The index of all wholesale commodities prepared by the Bureau of Labor Statistics, U. S. Department of Commerce, Washington, D. C., was used to deflate the price series presented in Table 2. The index, as reported in selected issues of the *Federal Reserve Bulletin*, Board of Governors, Federal Reserve System, Washington, D. C. was converted from a 1947-49 to a 1935-39 base period.

in (2) gross income is defined to be sales plus or minus inventory value changes.

The estimated gross income per acre of wheat ranged from a low point of $12.20 in 1942 to a high of $45.71 in 1952 (Table 4). The average gross income for wheat was $22.97, with a standard deviation of $8.44 and a coefficient of variation of 36.8. The coefficients of variation were 54.7 for grain sorghum and 62.6 for steers. The coefficient of variation in gross income from the cow herd is 36.1 if inventory values are ignored, and 62.8 if inventory values are considered.

Based on these data, variations in gross income for grain sorghum are substantially greater than for wheat. Also, the average gross income from wheat was much higher than that from grain sorghum. Assuming constant cow herd values, the coefficient of variation from the cow-calf system is 36.1 compared with 62.6 for the steer enterprise.

Thus, if inventory changes are ignored, the average gross income expectation from the cow-calf herd is approximately a third less than from the steer enterprise, but the stability of income is much greater (less variable from year to year).

When inventory changes are considered, the relative income variability from a cow-calf system is essentially the same as that from a steer system. If year-to-year inventory values of the cow herd are considered important, gross incomes from a cow-calf system are no less variable than those from a steer system. Because of particular equity and credit situations, year-to-year comparisons of gross incomes including inventory-value changes from a cow-calf system may be more desirable than comparisons ignoring inventory changes (Appendix Table V). Also, estimates including inventory changes are more comparable to the steer system in which yearling steers are sold and replaced with weanling steer calves each year.

Table 4.—Estimated Gross Income Per Acre, Selected Farm Enterprises, 1942-57[1]

(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf	
				Constant cow-herd Values	Variable cow-herd Values
1942	12.20	11.79	3.80	2.65	3.57
1943	17.13	9.18	2.72	2.63	2.49
1944	26.81	7.50	5.06	3.04	3.56
1945	21.08	12.90	5.56	3.20	3.65
1946	25.79	2.82	8.11	4.12	5.21
1947	21.85	17.78	6.97	4.52	7.51
1948	19.25	8.59	6.78	4 97	4.41
1949	25.86	3.94	5.07	4.93	3.88
1950	25.51	19.05	15.54	6 86	10.77
1951	29.35	29.75	14.58	7.93	8.40
1952	45.71	13.18	.31	5.12	—.39
1953	14.65	22.23	2.83	3.51	1.37
1954	20.73	10.28	8.53	3.25	2.89
1955	14.39	7.69	4.59	3.54	3.69
1956	14.76	19.67	4.75	2.81	2.90
1957	32.44	11.54	6.65	3.78	5.42
Mean	22.97	12.99	6.37	4.18	4.33
Standard Deviation	8.44	7.11	3.99	1.51	2.72
Coefficient of Variation	36.8	54.7	62.6	36.1	62.8

[1] Yield and production rates times prices. Gross income from steers equals sales value less purchased costs divided by acres per head. Gross income from cow-calf equal calf beef times price plus cull cow beef times price divided by acres per cow unit. In last column, cow-calf returns are further adjusted by change in value of cow herd from Jan. 1 - Dec. 31 which actually indicate equity changes and not income (See Appendix Table V.).

Table 5 gives estimated gross incomes based on deflated prices (1935-39=100). Again, when this adjustment is made, the cow-calf system, ignoring inventory changes, has the lowest relative degree of variability but the consideration of inventory value changes results in the highest relative degree of variability. Wheat shows a lower relative degree of variability than grain sorghum. Steers exhibit the second greatest relative degree of variation as measured by the coefficient of variation.

Table 6 gives estimates of gross incomes, assuming constant prices for the different products. Using these estimates, the cow-calf system shows the lowest relative degree of variability, followed by steers, wheat and grain sorghum. These results are to be expected since, with prices held constant, the estimates reflect physical production variability.

Resource Returns

Estimated returns above cash costs for the period 1942-57 are returns

Table 5.—Estimated Gross Income Per Acre, Selected Farm Enterprises, Deflated Prices (1935-39=100), 1942-57[1]
(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf	
				Constant cow-herd Values	Variable cow-herd Values
1942	10.00	9.62	3.10	2.16	2.91
1943	13.40	7.16	2.12	2.05	1.95
1944	20.83	5.80	3.92	2.35	2.76
1945	15.99	9.78	4.23	2.44	2.78
1946	17.20	2.07	5.40	2.75	3.47
1947	11.88	9.63	3.79	2.46	4.08
1948	9.62	4.30	3.40	2.49	2.21
1949	13.68	2.08	2.68	2.60	2.05
1950	13.01	9.61	7.89	3.48	5.47
1951	13.34	13.61	6.65	3.62	3.82
1952	21.34	6.18	.15	2.40	—.18
1953	6.95	10.48	1.35	1.67	.65
1954	9.80	4.85	4.05	1.54	1.37
1955	6.81	3.68	2.17	1.67	1.75
1956	6.79	9.03	2.18	1.29	1.33
1957	14.46	5.14	2.96	1.68	2.41
Mean	12.82	7.06	3.50	2.29	2.43
Standard Deviation	4.51	3.32	1.94	.65	1.38
Coefficient of Variation	35.2	47.0	55.4	28.4	56.8

[1] Yields and rates of production multiplied by deflated prices.

Table 6.—Estimated Gross Income Per Acre, Selected Farm Enterprises, Assuming Constant Prices and 1942-57 Yields and Production Rates[1]
(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf
1942	17.58	16.26	5.46	5.25
1943	19.86	8.95	5.38	5.24
1944	30.86	9.67	8.52	5.77
1945	23.26	12.90	7.53	5.65
1946	22.93	2.51	8.42	5.79
1947	16.11	11.11	5.89	5.31
1948	15.55	8.59	4.71	4.92
1949	22.13	4.30	6.01	5.42
1950	20.21	21.77	8.11	5.74
1951	21.34	27.67	7.67	5.74
1952	34.50	9.89	5.43	5.72
1953	11.01	21.68	9.81	5.73
1954	15.22	10.03	6.71	4.67
1955	11.23	10.03	5.10	5.07
1956	11.81	19.34	6.26	4.60
1957	26.90	15.05	4.70	4.22
Mean	20.03	13.11	6.61	5.30
Standard Deviation	6.78	6.76	1.55	.49
Coefficient of Variation	33.9	51.6	23.4	9.24

[1] Yields and rates of production multiplied by assumed constant prices. Assumed prices as follows: Wheat, $1.60 per bu.; grain sorghum, $1.20 per bu.; calves, $22.50 per cwt.; cull-beef cows, $14.51 per cwt.; and yearling steers, $22.25 per cwt.

to land, labor, capital, and management, rather than net returns above all costs (Table 7). Examples of computing these estimates are illustrated in Appendix Tables I-IV.

Estimated returns per acre of wheat averaged $19.02 during 1942-57, with a low of $9.77 in 1942 and a high of $40.72 in 1952. The standard deviation about the mean for the period is $8.16, with a coefficient of variation of 42.9. Grain sorghum exhibits a greater relative variation of 68.2. In each of the years 1942 through 1957, returns to the various factors for both wheat and grain sorghum were positive. Returns are affected by a combination of the level and variability of production, prices, and cash production costs. Therefore, the greater variability of returns compared with the variability of production, prices, and gross income is in accord with logical expectations. Also, returns are important to individual farmers and ranchers because they furnish income available for paying excluded costs, such as taxes, interest on borrowed capital, building and machinery depreciation, and for meeting family living expenses.

Table 7.—Estimated Returns Per Acre Above Specified Cash Costs, Selected Farm Enterprises, 1942-57[1]
(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf	
				Cons'ant cow-herd Values	Variable cow-herd Values
1942	9.77	9.92	3.14	2.09	3.01
1943	14.39	7.11	1.91	1.94	1.80
1944	23.68	5.32	4.10	2.24	2.75
1945	17.88	10.68	4.19	2.07	2.53
1946	22.41	.41	6.74	2.99	4.07
1947	17.74	14.96	5.61	3.40	6.38
1948	14.57	5.44	5.52	3.92	3.37
1948	21.50	.93	3.41	3.54	2.50
1950	21.50	15.95	13.94	5.51	9.43
1951	24.90	26.31	12.70	6.35	6.82
1952	40.72	9.73	—1.30	3.75	—1.76
1953	10.03	19.04	.55	1.69	— .44
1954	16.10	7.10	6.74	1.90	1.54
1955	10.55	4.55	3.07	2.05	2.20
1956	10.43	16.53	3.19	1.75	1.84
1957	28.10	8.29	5.64	2.84	4.49
Mean	19.02	10.14	4.95	3.00	3.16
Standard Deviation	8.16	6.91	3.91	1.37	2.72
Coefficient of Variation	42.9	68.2	79.1	45.7	86.1

[1] Gross income (Table 4) less specified cash costs. See Appendix Tables I to IV for items included and method of computation.

Gross income exceeded cash costs for steers for each year except 1952. The average return to the steer enterprise was $4.95 per acre of native range, with a standard deviation of $3.91 and a coefficient of variation of 79.1. Ignoring inventory-value changes, gross receipts exceeded cash expenses for the cow-calf system in each of the 16 years.

Average return per acre of rangeland, $3.00, was lower for the cow-calf system than for steers, with a standard deviation of $1.37 and a coefficient of variation of 45.7. When cow-herd inventory changes were considered, gross receipts failed to equal cash costs, as defined, during two years of the period. The average return per acre of rangeland from the cow-calf system, considering inventory changes, is $3.16, with a standard deviation of $2.72 and a coefficient of variation of 86.1. The difficulty of calculating returns to the cow-calf enterprise when inventory changes are considered is biased by the fact that no marketing costs are charged. In the buy-sell steer enterprise, all purchase costs are included in the value of the purchased weanling calf and marketing costs are subtracted when the yearling steer is sold.

These data suggest that, if inventory changes are considered, returns from the cow-calf enterprise show the greatest relative degree of variation, followed by the steer enterprise, grain sorghum, the cow-calf herd ignoring inventory values, and wheat.

Estimates of the returns above specified costs from the various enterprises using deflated prices indicate a pattern of variability similar to those with historical prices (Table 8). However, when deflated prices are used, returns to the cow-calf system, ignoring inventory changes, exhibit a lower relative degree of variability than do returns to wheat.

Most of the variability of returns based on constant prices is due to production variability, and the pattern of variation for the several enterprises is similar (Table 9). Again, grain sorghum exhibits the greatest relative degree of variability followed by wheat, steers, and the cow-calf herd.

In summary, historical returns during 1942-57 were least variable

Table 8.—Estimated Returns Per Acre Above Specified Cash Costs, Selected Farm Enterprises, Deflated Prices, (1935-39=100), 1942-57[1]
(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf	
				Constant cow-herd Values	Variable cow-herd Values
1942	7.28	7.67	2.57	1.70	2.46
1943	10.95	5.21	1.49	1.52	1.41
1944	18.19	3.85	3.18	1.74	2.13
1945	13.33	7.83	3.19	1.58	1.93
1946	14.53	.12	4.48	1.99	2.71
1947	9.08	7.68	3.05	1.85	3.47
1948	6.89	2.35	2.77	1.97	1.69
1949	11.14	.13	1.80	1.87	1.32
1950	10.68	7.66	7.08	2.80	4.79
1951	10.94	11.66	5.79	2.90	3.11
1952	18.77	4.23	— .61	1.76	— .83
1953	4.44	8.53	.26	.80	— .21
1954	7.27	2.90	3.20	.90	.73
1955	4.76	1.73	1.45	.97	1.04
1956	4.41	7.08	1.46	.80	.84
1957	12.17	3.19	2.51	1.26	2.00
Mean	10.30	5.11	2.73	1.65	1.79
Standard Deviation	4.45	3.32	1.92	.62	1.39
Coefficient of Variation	43.2	64.9	70.2	37.9	77.5

[1] Gross Income (table 5) less specified cash costs.

Table 9.—Estimated Returns Per Acre Above Specified Cash Costs, Selected Farm Enterprises, Assumed Constant Prices and 1942-57 Yields and Production Rates[1]

(Dollars)

Year	Wheat	Grain Sorghum	Steer	Cow-Calf
1942	13.37	13.01	4.35	4.28
1943	15.70	5.70	4.08	4.14
1944	26.67	6.42	7.23	4.56
1945	19.04	9.65	6.11	4.36
1946	18.74	.74	6.85	4.38
1947	11.87	7.86	4.60	4.15
1948	11.40	5.34	3.76	4.05
1949	17.97	1.05	4.58	4.14
1950	16.38	18.52	6.65	4.41
1951	17.46	24.42	6.20	4.39
1952	30.29	6.64	4.06	4.42
1953	6.89	18.43	8.19	4.27
1954	11.09	6.78	4.91	3.24
1955	7.94	6.78	3.79	3.69
1956	7.87	16.09	4.80	3.51
1957	22.98	11.80	3.77	3.29
Mean	15.98	9.86	5.25	4.08
Standard Deviation	6.70	6.76	1.42	.42
Coefficient of Variation	41.9	68.6	26.96	10.23

[1] Gross Income (Table 6) less specified cash costs.

for wheat and most variable for the steer enterprise. The use of a deflated series of prices or a constant price affected the variability of net returns from wheat and grain sorghums very little. In contrast, the use of constant prices significantly reduced the variability of net returns from the livestock enterprises. Therefore, most of the variability in returns during the 1942-57 period was due to variable yields in the case of wheat and grain sorghums but to variable prices in the case of the steer and cow-calf enterprises.

Summary of Variability Estimates

A summary of the estimated coefficients of variation for the specified enterprises indicates that grain sorghum is more variable than wheat in production, price, gross income, and returns (Table 10). The cow-calf system, ignoring inventory changes, is the more stable of the two livestock enterprises. However, when inventory changes are included, the cow-calf enterprise is more variable.

Considering all the enterprises, grain sorghum is relatively the most

Table 10.—Summary of Estimated Coefficients of Production and Income Variation Per Acre, Selected Farm Enterprises, Alternative Price Assumptions, 1942-57
(Coefficient of Variation)

Item	Wheat	Grain Sorghum	Steers	Cow-Calf	
				Constant cow-herd values	Variable cow-herd values
Production per acre	33.1	51.6	22.9	4.2	4.2
Prices received	18.3	22.5	33.8	32.4	32.4
Prices received (deflated)	8.8	27.9	22.6	22.6	22.6
Gross income	36.8	54.7	62.6	36.1	62.8
Gross income (deflated)	35.2	47.0	55.4	28.4	56.8
Gross income (constant prices)	33.9	51.6	23.4	9.24	9.24
Returns	42.9	68.2	79.1	45.7	86.1
Returns (deflated)	43.2	64.9	70.2	37.9	77.5
Returns (constant prices)	41.9	68.6	27.0	10.2	10.2

variable in production, price, gross income, and returns under constant prices. Livestock prices are relatively more variable than crop prices. The cow-calf enterprise, including inventory values, shows the greatest relative degree of variation in gross income and returns using actual and deflated prices.

Bunchiness or Runs of Years

From the standpoint of planning strategies designed to maximize or improve business survival probabilities, the pattern, or sequence, of favorable and unfavorable years may be at least as critical as the degree of variation over years.

Farm operators might view income variability as unimportant if favorable and unfavorable years always occurred in runs of one, such as a favorable year followed by an unfavorable year, and so forth. Similarly, bunching of good and bad years would be of little consequence if the income variance over years were negligible. Thus, it would seem that both a measure of variation over years and a measure of the tendency for good and bad years to bunch are necessary for an adequate evaluation of different income streams.

Observers of Great Plains agriculture have suggested that good and bad years come in bunches, and many references have been made to dry and wet cycles. Clearly, if such cycles do occur, feed and financial reserves are necessary for financial survival in Great Plains agriculture. The hypothesis that weather in the Plains occurs in bunches, or runs of greater than one year, has been subjected to the following tests: (1) A tabulation of the number of runs of specified duration of extreme years; (2) examination of 4-year moving averages, and (3) a nonparametric statistical test. Each test was applied to data relating to annual rainfall at Woodward and to production per acre for wheat, grain sorghum, steer, and cow-calf enterprises.

In making tests for bunchiness, data for different years were used. This was done to obtain as long a period as possible for each series. For rainfall, 73-year data were used compared with 16 years for the beef-cattle enterprise, 36 for wheat, and 44 for grain sorghum.

Runs of Specified Duration

A tabulation of the maximum number of consecutive years of values falling within 85-115 percent of the average, above this range, and below it, indicate that yields of grain sorghum were both below for one 7-year period and above for another 7-year period. The maximum number of consecutive years within the range was 2 (Table 11). At the other extreme, all of the cow-calf observations fall within the 85-115 percent range.

Obviously the selection of the 85-115 percentage range is arbitrary.

Table 11.—Longest Time Period When Crop Yields, Livestock Production and Rainfall were Within Specified Ranges, Selected Data[1]
(Number of Years)

Years of Data And Enterprise	Less than 85 percent of average	Between 85 and 115 percent of average	Greater than 115 percent of average
1914 to 1957 (44) Grain Sorghum	7	2	7
1922 to 1957 (36) Wheat	4	3	2
1942 to 1957 (16) Steer	2	1	2
1942 to 1957 (16) Cow-calf	0	16	0
1885 to 1957 (73) Rainfall, Woodward, Okla.	3	5	2

[1] Yields and rates of livestock production from unpublished experimental data, U. S. Southern Great Plains Field Station, Woodward, Okla.

However, these data suggest that yields of grain sorghum tend to come in runs below and above average. Wheat yields, beef production from the steer enterprise, and rainfall exhibit lesser tendencies to bunch. Cow-calf production exhibits a maximum tendency to bunch at an average value which would be expected from the low coefficient of variation for the cow-calf data.

Four-Year Moving Totals

A historical summary of 4-year production totals for selected crop and livestock enterprises in northwest Oklahoma, and for rainfall at Woodward, Okla., emphasizes the stability of production from the cow-calf beef enterprise (Table 12). The 4-year production from the cow-calf system did not fall below 80 percent of normal during the 16 years for which data were available. Wheat fell far below 80 percent of average in five of 36-years. Three of these years were at the close of the drought of the 1930's and two at the close of the long drought of the 1950's.

Four-year moving total yields of milo were less stable than wheat or the beef enterprises. Cumulative yields were less than 80 percent of the 44-year average during 11 years, or 25 percent of the time. In the 73 years in which rainfall records are available, the 4-year moving total

Table 12.—Summary of 4-Year Moving Totals and Related Statistics, Yields and Rates of Production, Selected Enterprises

Enterprise	Unit	Period	Four-Year Moving Total Production	80 Percent of Four-Year Moving Total Production	Years in Which Previous 4-Year Production was Less than 80 Percent Of Average 4-Year Production	
					No. of Years	Specific Years
Wheat	Bushel per acre	(1922-57) 36 years	51.0	40.8	5	1935, 1936, 1937 1956, and 1957
Grain Sorghum	do.	(1914-57) 44 years	56.2	45.0	11	1919, 1936, 1937, 1943, 1945, 1946, 1947 1948, 1949, 1950, and 1955
Steer	Pound per acre[1]	(1942-57) 16 years	156.6	125.3	0	
Cow-calf	do.	(1942-57) 16 years	95.6	76.5	0	
Rainfall, Woodward, Okla.	Inch	(1885-1957) 73 years	91.3	73.0	7	1889, 1893, 1894 1936, 1954, 1955 and 1956

[1] Per acre of native rangeland.

annual rainfall was less than 80 percent of the long-time average in only 7 years. Three of these years occurred consecutively at the close of the drought in the 1950's.

Nonparametric Statistical Test

Most tests for cyclical fluctuation or runs of years are based on an assumption of a normal distribution or are parametric in nature. A non-parametric test developed by Wallis and Moore[2] is more general in the sense that it is valid for any distribution. The Wallis and Moore test is essentially a test for randomness of a series. Like other nonparametric tests, it is relatively inefficient but the computations are simple.

Expected frequencies for runs of various durations are compared with observed frequencies by a test criterion designated χ_p^2. The test statistic is distributed approximately as $6/7\chi^2$ for 2 degrees of freedom for value of $\chi_p^2 < 6.3$, and as χ^2 for 2.5 degrees of freedom for χ_p^2 values ≥ 6.3.

In their original paper, Wallis and Moore define phases or runs in terms of relative minimum and maximum values. For purposes of this analysis, runs are defined in terms of the mean values of the various series. The mechanics of performing the test are given in Appendix B page 38.

The χ_p^2 values in each instance are of sufficient magnitude that the hypothesis of a random series can be rejected at the one percent probability level (Table 13). In all instances, runs of four or more years made the greatest contribution to the χ_p^2 test statistic. The χ_p^2 value is greatest for grain sorghum and smallest for the cow-calf enterprise.

Summary

Each of the three tests for bunchiness suggests the presence of cycles or bunches in each of the series of data tested. The tendency of the cow-calf data to bunch near the mean with a low coefficient of variation emphasizes the relative stability of cow-calf production. The relatively high coefficients of variation for the other series, however, along with bunching tendencies, emphasizes the importance of reserves and long-term planning in the Great Plains.

Obviously, farmers and ranchers are more interested in bunching of incomes than in production or rainfall. Analysis suggests that incomes tend to bunch to an even greater degree than yields or rates of production.

[2] W. Allen Wallis and Geoffrey H. Moore, *A Significance Test for Time Series*, Technical Paper 1, National Bureau for Economic Research, New York (1941).

Table 13.—Bunchiness Coefficients and Coefficients of Variation of Production, by Enterprises, Specified Periods, 1885-1957.

Enterprise	Period	Total χ^2_p	χ^2_p Contributed by 1-Year Runs	χ^2_p Contributed by 2-Year Runs	χ^2_p Contributed by 3-Year Runs	χ^2_p Contributed by Runs 4-Years or More	Coefficient of Variation
Wheat	1922-57 (36 yrs.)	27.0	4.4	0.1	0.1	22.4	38
Grain Sorghum	1914-57 (44 yrs.)	55,009.6	5.9	1.5	.5	55,001.6	57
Steer	1942-57 (16 yrs.)	64.0	3.6	2.2	10.1	48.1	23
Cow-Calf	1942-57 (16 yrs.)	11.6	1.1	.6	3.5	6.4	4
Rainfall Woodward, Okla.	1885-1957 (73 yrs.)	67.8	.1	1.7	.7	63.4	27

Correlations

Per acre yields of wheat apparently are not related to grain sorghum yields nor to livestock production from native range (Table 14). This is evidenced by the fact that none of the coefficients differ statistically from zero at the 5-percent level. There was no substantial correlation between yields of wheat, the major user of cropland, and grain sorghum; nor was there correlation between yields of wheat and per acre production of beef from native range. This implies that, given a favorable year for wheat, the probabilities are equal for a good, bad, or indifferent year for grain sorghum, steer and cow-calf production. Weather influences production during a different growing season for wheat than for the other enterprises.

Historical prices of the various commodities are positively correlated to a relatively high degree (appendix table VI). However, the correlation between prices of wheat and grain sorghum does not differ statistically from zero at the 5-percent level. The prices of wheat and beef cattle are correlated at a degree significantly different from zero at the 1-percent level. On the other hand, the deflated prices of wheat differ statistically from zero for grain sorghums only.

The relationship of historical prices between wheat and beef cattle may be explained by the same general effect of the overall price level on the individual prices. Past experience indicates that beef prices are significantly related to the overall price level, and support prices for wheat in 1942-57 have been related to the overall price level through the parity concept. On the other hand, price supports were effective for grain sorghum in fewer years during the period than for wheat; and grain sorghum prices were supported at a lower percentage of parity.

Table 14.—Coefficients of Correlation and Variation of Yields Per Acre and Livestock Production Rates, Selected Farm Enterprises, 1942-57[1]

Item	Wheat	Grain Sorghum	Steer	Cow-Calf
Wheat	1.00	— 0.24	0.09	—0.05
Milo		1.00	.28	.36
Steers			1.00	.94
Cow-calf				1.00
Coefficient of Variation	33.1	51.6	22.9	4.2

[1] Detailed comparisons of correlation coefficients for production, prices, gross incomes, and returns above cash costs are included in appendix table VI.

The use of the index of wholesale commodity prices (1935-39=100) to deflate historical prices resulted in a significant correlation between wheat and grain-sorghum prices but there were insignificant correlations between wheat prices and prices received for beef cattle. With the effect of the overall price trend removed, the level of wheat and grain-sorghum prices has no significant relationship to the level of beef-cattle prices.

For reasons similar to those explained for prices, the computed correlation coefficients indicate that gross returns and returns above cash costs per acre of wheat are somewhat correlated with the returns per acre of native range from the cow-calf[3] enterprise (Tables 15 and 16). That is, the coefficient differs statistically from zero at the 5-percent level. No statistically significant correlations were observed between returns from wheat and grain sorghum or the buy-sell steer enterprise.

Gross and net returns per acre of grain sorghum are not significantly correlated with returns per acre of native range from the livestock enterprises. As might be expected, production, prices, and returns for the steer and cow-calf enterprises are very closely related. (Appendix Table VI).

Another investigator has reported that the justification given for diversification in the Great Plains has been that diversification will reduce variability of returns.[4] If the desire for income stability is great, farm operators may wish to combine enterprises that would reduce the variability of annual incomes even at the cost of some reduction in average income over a period of time. The resulting variance of in-

Table 15.—Coefficients of Correlation of Gross Income with Historical Prices, Selected Farm Enterprises, 1942-57.

Item	Wheat	Milo	Steer	Cow-Calf	
				constant cow-herd values	variable cow-herd values
Wheat	1.0	---	0.08	0.49	0.01
Milo	---	1.0	0.40	0.48	.34
Steer	---	---	1.0	.72	0.90
Cow-Calf: Constant cow-herd values	---	---	---	1.0	.64
Variable cow-herd values	---	---	---	---	1.0
Coefficient of Variation	36.8	54.7	62.6	36.1	62.8

[3] Assuming constant cow herd values.
[4] Emery N. Castle, *Adopting Western Kansas Farms to Uncertain Prices and Yields*, Kan. Agr. Expt. Sta Tech Bul. 75. (Feb 1954)

Table 16.—Coefficients of Correlation of Returns Above Specified Cash Costs, With Historical Prices, Selected Farm Enterprises, 1942-57

Item	Wheat	Milo	Steer	Cow-Calf	
				constant cow-herd values	variable cow-herd values
Wheat	1.0	—0.05	0.06	0.49	0.01
Milo	---	1.0	.36	.30	.29
Steer	---	---	1.0	.72	.90
Cow-Calf					
Constant cow-herd values	---	---	---	1.0	.66
Variable cow-herd values	---	---	---	---	1.0
Coefficient of Variation	42.9	68.2	79.1	45.7	86.1

come from a combination of more than one enterprise is dependent upon the variance of the individual enterprises to be considered and the degree of association or correlation of the returns of these enterprises. If farm resources, measured in terms of land or capital investment, were divided equally among two or more enterprises, total variance would be reduced provided the variances of the individual enterprises were approximately equal and there was less than perfect correlation between the enterprises. No systematic evaluation of income effects of combination of enterprises has been considered in the analysis presented in this publication. Farm and ranch organizations for both optimum and less variable income opportunities will be considered in the next stage of the overall study. These organizations will be based on typical farm and ranch resource situations within size groupings. However, present data indicate that adding grain sorghum to a straight wheat-cropping system would reduce the variability of annual returns as well as the overall average returns per acre of cropland.

Summary and Conclusions

Variable production and prices have caused farm and ranch incomes in northwestern Oklahoma to be erratic. The variability of production, price, and income per acre has been determined for the four main enterprises: wheat, grain sorghum, steer, and cow-calf system.

Based on 16 years of yield data 1942-57, grain sorghum had a greater production variability than any of the other three enterprises. Beef

production from a cow herd had the most stable production, showing a coefficient of variation of only 4.2 percent. Wheat production was less variable than grain sorghum, but more variable than either of the beef enterprises. The buy-sell steer enterprise, with a production variability of 22.9 percent, was considerably more variable than production from a beef cow herd.

Probably because of price-support programs, wheat prices were less variable in 1942-57 than were prices of other enterprises. Beef cattle prices, with a coefficient of variation of 33 percent, were less stable than those of wheat (18.3 percent coefficient of variation) and grain sorghum (22.5 percent). A positive correlation existed between historical prices for all combinations of the four enterprises during the 16 years. Price correlations between calves and yearling steers were highly significant. Also, highly significant price correlations were found when wheat was paired with steers and with calves.

Per acre gross and net returns were computed for wheat, grain sorghum, and the two systems of beef production for the years 1942-57. Three price series—actual, deflated, and constant—were combined with production to obtain three sets of gross income. Variable production costs only were subtracted from gross returns; thus, the returns above selected cash costs are returns to land, labor, capital, risk, and management.

Estimated returns above specified cash costs with historical prices and costs indicate that:

(1) Cropland used for wheat production had a much higher return per acre ($19.02) than did grain sorghum ($10.14). Also, the coefficient of variation of per acre returns from wheat was 42.9 percent compared with 68.2 percent for grain sorghum.

(2) Rangeland grazed by steers averaged $4.95 per acre return for the 16 years. A cow-calf enterprise on similar range returned $3.00 per acre above specified cash costs. The coefficient of variation of returns from the steer enterprise was 79.1 percent compared with 45.7 percent for the cow-calf enterprise.

The use of a deflated series of prices or a constant price had little effect on the variability of net returns from wheat and grain sorghums. In contrast, the use of constant prices significantly reduced the variability of net returns from the livestock enterprises. Therefore, most of the variability in returns during the 1942-57 period was due to variable

yields in the case of wheat and grain sorghums but to variable prices in the case of the steer and cow-calf enterprises.

Each of the three tests for bunchiness (runs of specified duration, 4-year moving averages, and nonparametric statistical test) suggest the presence of cycles or bunches in each of the series of data tested. The tendency of the cow-calf data to bunch near the mean with a very low coefficient of variation emphasizes the relative stability of cow-calf production. On the other hand, the relatively high coefficients of variation for the other series, along with bunching tendencies, emphasizes the importance of reserves and long-term planning in the Great Plains.

Obviously, farmers and ranchers are more interested in the bunching of incomes than in production or rainfall. Analysis suggests that incomes tend to bunch to an even greater degree than yields or rates of production.

A negative correlation was found between returns per acre from wheat and from steer production. Only a slight positive correlation existed between returns from wheat and grain sorghum or the cow-calf enterprise.

The small amount of correlation between wheat returns and the returns from each of the other chief farm enterprises may imply a stabilizing effect when enterprises are combined. No systematic evaluation of income effects of combination of enterprises has been considered in this analysis. Farm and ranch organizations for both optimum and less variable income opportunities will be considered in the next stage of the overall study. These organizations will be based on typical farm and ranch resource situations within size groupings. However, present data indicate that adding grain sorghum to a straight wheat-cropping system would reduce the variability of annual returns as well as the overall average returns per acre of cropland.

If conditions in the future are similar to those in the past, wheat is likely to continue as the major cash crop in northwestern Oklahoma. Cropland not well suited to wheat production will continue to produce feed supplementary to native range in beef cattle production.

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APPENDIX A

TABLES

Appendix Table I.—Wheat: Estimated Returns Per Acre Above Specified Cash Costs, 1957

Item	Unit	Quantity	Price per Unit	Value
			Dollars	
Production	bushel	16.8	1.93	32.42
Inputs:				
Preharvest:				
Seed	Pound	.75	2.80[1]	2.10
Variable machine costs	Acre	1		.232
Variable tractor costs	Dollar	1		1.13
Harvest[2]				
Variable combine and truck costs	Dollar	1		.676
Variable tractor costs	Dollar	1		.206
Total variable cost[3]				4.34
Returns above specified cash costs				28.08

[1] The price of seed wheat was assumed to be 140 percent of the previous year's market price per bushel.

[2] Harvested costs calculated on basis of the percentage of planted acreage harvested for grain.

[3] Estimated 1957 costs based on reported costs of farmers in Ellis, Harper, and Woodward counties, Okla. Costs for earlier years adjusted by the index of prices paid by United States farmers for production items *Agricultural Prices*, p. 52 Supp. Oct. 1, 1957, U. S. Agricultural Marketing Service. For example, machine and power costs for 1942 estimated 57.3 percent of the level of 1957 costs.

Appendix Table II.—Grain Sorghum: Estimated Returns per Acre Above Specified Cash Costs, 1957

Item	Unit	Quantity	Price per Unit	Value
			Dollars	
Production	Bushel	12.54	0.92	11.54
Inputs:				
Preharvest:				
Seed	Pound	8	.06	.480
Variable machine costs	Acre	1	---	.234
Variable tractor costs	Dollar	1	---	1.092
Harvest:				
Variable combine and truck costs	Dollar	1	---	1.106
Variable tractor costs	Dollar	1	---	.336
Total variable cost[1]	----	----	---	3.25
Returns above specified cash costs	----	----	---	8.29

[1] Estimated 1957 costs. For earlier years adjusted in the same manner as described for wheat, Appendix Table I.

Appendix Table III.—Steer Enterprise: Estimated Returns Per Acre of Range Above Cash Costs, 1957

Item	Quantity	Price	Amount
	Cwt.	Dollars	
Per steer:			
Sold	8.18	20.33	166.36
Purchased	4.64	15.37	71.32
Gross income			95.04
Cash expenses[1]			
Drugs			.50
Salt			.20
Cottonseed cake			8.19
Taxes on steer			.80
Horse and pickup cash costs			1.64
Repairs on fences, etc.			2.68
Interest on direct cash costs			.34
Total			14.35
Returns above specified cash costs			80.69
Per acre: (14.3 acres per head)			
Gross income			6.65
Returns above specified cash costs			5.64

[1] Estimated 1957 costs for earlier years were adjusted in line with cost changes of items purchased for the U. S. Southern Plains Experimental Range.

Appendix Table IV.—Cow-Calf Enterprise: Estimated Returns Per Acre of Range Above Specified Cash Costs, 1957

Item	Quantity	Price	Amount
	Cwt.	Dollars	
Per cow:			
Calf sales	4.28	19.91	85.21
Cull cow sales	1.14	13.77	15.70
Gross income			100.91
Cash expenses[1]			
Drugs			.74
Salt			.29
Cottonseed cake			11.72
Taxes on cow			1.35
Horse and pickup cash costs			2.91
Bull cash costs per cow			2.30
Repairs on fences, etc.			5.01
Interest on direct cash costs			.58
Total			24.90
Returns above specified cash costs			76.01
Per acre: (26.7 acres per head)			
Gross income			3.78
Returns above specified cash costs			2.85

[1] Estimated 1957 costs for earlier years were adjusted in line with cost changes of items purchased for the U. S. Southern Plains Experimental Range.

Appendix Table V.—Beef Cow Values, 1941-57

Year	End of Year		Change in Cow Value During Year
	Index[1]	Cow Value	
		Dollars	Dollars
1941	8.78	84	
1942	10.86	104	+20
1943	10.52	101	− 3
1944	11.47	110	+ 9
1945	12.34	118	+ 8
1946	14.20	136	+18
1947	20.76	199	+63
1948	18.94	182	−17
1949	16.85	162	−20
1950	23.99	230	+68
1951	24.76	238	+ 8
1952	15.66	150	−88
1953	12.23	117	−33
1954	11.55	111	− 6
1955	11.88	114	+ 3
1956	12.07	116	+ 2
1957	16.67	160	+44

[1] This index was based on the price of top grade slaughter cows (good-1941-50, commercial—1951-58) at Oklahoma City for January following the close of the grazing year. Ratio of per head cow values to this index is 9.6:1 based on the relationship existing Jan. 1, 1958, between commercial cows at Oklahoma City and range beef cows in the Woodward area.

Appendix Table VI.—Correlation Coefficients ("r") of Price and Production Per Acre, Gross Income, and Net Income, Selected Farm Enterprises, 1942-57

Item	Wheat with —				Grain Sorghum with —			Steer with —		Cow-Calf[1] with—
	Grain Sorghum	Steer	Cow-Calf[1]	Cow-Calf[2]	Steer	Cow-Calf[1]	Cow-Calf[2]	Cow-Calf[1]	Cow-Calf[2]	Cow-Calf[2]
Production	—.241	.090	—.053	—.053	.280	.363	.363	.939**	.939**	1.000**
Prices, historical	.460	.676**	.631**	.631**	.182	.180	.180	.987**	.987**	1.000**
Prices, deflated	.813**	.096	.190	.190	—.042	.062	.062	.971**	.971**	1.000**
Gross Income, historical	.004	.076	.494*	.014	.402	.475	.336	.715**	.900**	.644**
Gross Income, deflated	—.178	.014	.435	.095	.260	.262	.274	.718**	.890**	.691**
Gross Income, constant prices	—.240	.002	.320	.320	.311	.052	.052	.655**	.655**	1.000**
Net Income, historical	—.051	.064	.489*	.006	.355	.296	.293	.716**	.899**	.659**
Net Income, deflated	—.183	.104	.432	.081	.247	.251	.266	.718**	.893**	.704**
Net Income, constant prices	—.233	.028	.389	.389	.528*	.307	.307	.516*	.516*	1.000**

[1] Assumes no inventory change in cow-herd values between years.
[2] Cow-herd values varied from year to year.
*Statistically different from zero at the 5-percent level.
**Statistically different from zero at the 1-percent level.

APPENDIX B

Examples of the Computation of the Wallis-Moore Test for Cyclical Fluctuations[1]

In a random series of N observations, the expected number of runs of length L is given by:

$$(1.1) \qquad \frac{2(L^2 + 3L + 1)\quad (N - L - 2)}{(L + 3)!}$$

Thus, the expected number of runs of 1 is:

$$(1.2) \qquad U_1 = \frac{5(N - 3)}{12}$$

The number of runs of 2 is:

$$1.3) \qquad U_2 = \frac{11(N - 4)}{60}$$

etc.

We now compare the expected frequencies with observed frequencies by the test criterion χ_p^2. Let u_i be the observed number of runs of length i. Then

$$(2.1) \qquad \chi_p^2 = \frac{(u_1 - U_1)^2}{U_1} + \frac{(u_2 - U_2)^2}{U_2} + \cdots + \frac{(u_n - U_n)^2}{U_n}$$

From the wheat-yield data, the observed frequencies are as follows:

$u_1 = 6$
$u_2 = 5$
$u_3 = 2$
$u_4 = 2$
$u_5 = 1$

Therefore

$$(2.2) \quad \chi_p^2 = \frac{(6 - 13.75)^2}{13.75} + \frac{(5 - 5.87)^2}{5.87} + \frac{(2 - 1.64)^2}{1.64} + \frac{(2 - .35)^2}{.35} + \frac{(1 - .06)^2}{.06}$$

$$(2.3) \quad \chi_p^2 = 27.02$$

[1] Wallis and Moore, op. cit., p. 23.