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Comparison of Pasture and Grain Farming on Claypan Soil

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FOREWORD

Missouri farming, though highly diversified, is dominated by the production of livestock. Of the 230,000 Missouri farms, 88 percent are keeping and selling some form of livestock or livestock products. Results of this study, therefore, add to our accumulation of knowledge about a leading Missouri industry.

This bulletin is an attempt to go beyond the simple reporting of yields obtained from pasture, grain, and hay. It covers two periods at different levels of fertilizer treatment. An effort has been made to evaluate the costs of production and returns for commodities produced at two price levels. Although the costs and returns of the farming enterprise are constantly changing, the range of prices in this study provides a useful basis for evaluation.

The study was conducted in East Central Missouri on Mexico silt loam, a soil with a heavy plastic clay subsoil. Similar studies will be needed to determine the extent to which the data are applicable to other soils and locations of the state.

In the present study, the pastures were grazed in a manner designed to obtain maximum utilization of herbage without overgrazing. There were times when daily gains were relatively small. In practice, the beef man might remove cattle that are being fattened on pasture at such times and utilize the area with cows or other cattle to which sustained gain is not so important. Moreover, the various pastures would be fitted together in a grazing schedule to provide as near year-around grazing as possible. Much of the grain and hay produced in the grain systems also would be marketed through livestock under farm conditions. These are all problems of management and are not included in this study. The placing of a dollar value on the production costs and the commodities produced in each of the several systems, however, suggests points of attack for increasing operating efficiency and gives further justification to Missouri's Program of Land Improvement envisioned in Experiment Station Circular 303.

J. H. Longwell
Director

This bulletin is a report on Department of Field Crops project number 47 entitled, "Pasture Improvement."

Comparison of Pasture and Grain Farming on Claypan Soil*

D. M. Whitt**

The value of grasses and legumes in conserving soil and water while they occupy the land is generally understood and appreciated. Their use as soil conditioning crops to reduce erosion from corn, soybeans, and small grain crops has recently been measured and reported by Smith and Whitt (18). Powerful means though they are for erosion control and tilth maintenance, the full extent of their usefulness is determined partly by their capacity to compete with cash crops for available crop land (8).

The climatic hazards existing on the claypan soils of Northeast Missouri encouraged the start of investigations on pasture farming in 1940, with major emphasis on production and utilization of forage crops. These studies have continued with the objectives of measuring the soil and water losses and production from several pasture areas. The purpose of this investigation was to evaluate the production and economic return from pasture systems and to compare their returns with returns from cash grain farming systems.

EXPERIMENTAL METHODS

Experimental Areas

Soils. The experimental plots were located on the Midwest Claypan Soil Conservation Experiment Farm near McCredie, Callaway County, Mo. Soils on this station are representative of approximately ten million acres of midwestern claypan soils, half of which are in Missouri. They tend to be excessively wet in the spring and droughty in the summer. Large acreages of corn, soybeans, and small grain have been planted on them without regard to land slope. This intensive cropping on soils of moderate to low fertility, with little attention to conservation measures and fertilizer practices, has had serious erosional effects.

Soil on the experimental plots is classified as Mexico silt loam. It has a dark gray silty surface with an underlying light brownish-gray subsurface (16). A dense and slowly permeable subsoil begins at a depth of about 15

*The basic data used in this study were collected in a project operated jointly by the Missouri Agricultural Experiment Station and the United States Department of Agriculture, Soil Conservation Service. The work was transferred from the Soil Conservation Service to the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration in November, 1952.

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inches. This soil is similar to Putnam. At one time it was called the sloping phase of Putnam, but the subsurface is light brownish-gray instead of gray and is more friable than the soil presently mapped as Putnam silt loam.

Plot Layout. Pasture plots designated as Series I were two acres in size. In two of the plots, 7 and 8, water loss measurements were made from the entire two-acre pasture with type H rate measuring flumes. Soil loss from these areas was not determined.

Soil and water loss measurements were made on five of the pastures (plots 1 to 5) from small triplicate plots located within the two-acre pasture area. These small plots were the same size as those on cash grain system plots that were used for comparative purposes. The latter plots, designated as Series II, were 90 feet long and 10.5 feet wide and were surrounded by steel dividers. Borders 3.5 feet on each side of the plot were farmed the same as the plot itself. Farming operations were up and down the slope. All of the plots were on a 3 percent slope. Runoff and soil loss measuring equipment consisted of a sediment tank, a 9-slot divisor unit, and a second tank. Measurements of soil and water losses were made in a manner described previously (17).

Soil Treatments. The early period of study, 1940-1946, was conducted with light applications of fertilizer, while the later period, 1947-1951, was conducted on a much higher plane of fertilizer treatments. These two levels of fertilizer usage reflect the recommendations being made to Missouri farmers at the beginning of the two periods (3, 4, 7, 9, 10, 11, 12, 13). The grass and legume pastures were established with 200 pounds per acre of 0-20-10 fertilizer, and five years later began receiving the same amount and kind in alternate years. An unplowed Kentucky bluegrass pasture was fertilized with 400 pounds of 0-20-10 at the beginning of study and three years later treated with 200 pounds per acre of 0-20-10 fertilizer. Small grain-lespedeza plots received 100 pounds per acre of 0-20-10 each year when the small grain was seeded. This same treatment was made on small grain in the barley-soybean rotation. In the cash grain systems used for comparison, only the small grain received fertilizer. Here the application was 200 pounds per acre of 0-20-10 at the time of small grain seeding. Some check areas were managed without soil amendments. Lime was applied to all plots receiving fertilizer. Table 1 lists the cropping systems and soil treatments for this early period of study.

Soil treatments applied in the later period were made according to soil tests. As indicated in Table 2, the level of treatments made in this period far surpassed that of the earlier years. Lime, phosphate, and potash were brought up to sufficiency levels on areas receiving treatments, and the use of nitrogen fertilizer was begun on certain areas.

These applications of calcium, phosphorus, and potassium corrected the differences in levels of these nutrients which were created in the early years of study. For example, plot 2, which had oats removed for hay and Korean lespedeza grazed, required 108 pounds of potassium to bring the

TABLE 1--CROPPING SYSTEM AND SOIL TREATMENT ON PASTURES AND CASH GRAIN ROTATIONS IN THE SEVEN-YEAR PERIOD, 1940-1946*

Plot	Cropping System	Soil Treatment Amount Per Acre
Series I	Pastures	
1	Timothy and lespedeza	Lime: 3 tons 1938, 2 tons 1946; 200 lbs. 0-20-10 in 1938, 1943 and 1945
2	Oats (hay) and lespedeza	Lime: 3 tons 1938, 2 tons 1946; 100 lbs. 0-20-10 each year with small grain seeding.
3	Wheat & lespedeza	
4	Barley and soybeans (hay)	
5	Timothy-sweet clover and lespedeza	Lime: 3 tons 1938, 2 tons 1946; 200 lbs. 0-20-10 in 1938, 1943 and 1945.
7	Bluegrass - renovated	Lime: 3 tons 1942; 400 lbs. 0-20-10 in 1942; 200 lbs. 0-20-10 in 1945.
8	Bluegrass - check	None
Series II	Grain Rotations	
1, 3, 5	Oats (hay) and lespedeza	Lime: 3 tons 1938, 2 tons 1946; 100 lbs. 0-20-10 each year with small grain seeding.
2, 4, 6	Wheat and lespedeza	
9, 14, 19, 24	Corn-corn-oats-wheat (sweet clover)	Lime: 3 tons 1939; 200 lbs. 0-20-10 with oat seeding, 200 lbs. 0-20-10 with wheat seeding; sweet clover under before first corn; stalks of first corn remain as residue.
29,33, 37	Corn-wheat-meadow**	Lime: 3 tons 1939; 200 lbs. 0-20-10 with wheat seeding.
25, 26	Corn-oats	None. Corn stalks remain as residue.

*All crops in Series I grazed except as noted; all crops in Series II for grain and hay except as noted.

**Meadow consisted of mixture: timothy, red top, red clover, alsike clover, and Korean lespedeza.

potash level up to that on adjacent plot 3, which had wheat and Korean lespedeza used only for grazing. The removal of potash in oat hay accounted for this large difference in potash level. Plot 4, in barley for pasture and soybeans for hay, also showed a low level of potassium at the end of the first seven years of study, as a result of potash removal in soybean hay.

Production Measurements

Production on the pasture areas was determined by grazing with one and two-year-old cattle. All of these animals were produced on the experimental farm by the breeding herd of Hereford grade cows and registered bull. The number of cattle grazing each pasture was adjusted as necessary to assure maximum utilization of herbage without overgrazing. Because of excessive moisture in some spring months and deficient moisture at other times, it was not possible to pasture the same number of cattle for the same periods of time in successive years. Hence, the average production data

TABLE 2--CROPPING SYSTEM AND SOIL TREATMENT ON PASTURES AND CASH GRAIN ROTATIONS IN THE FIVE-YEAR PERIOD, 1947-1951

Plot	Cropping System	Soil Treatment Amount Per Acre
Series I	Pastures	
3	Wheat and Korean lespedeza	1947-48: 100 lbs. 10-20-20 on wheat. 1949 and later: Basic: 2 tons lime and 466 lbs. rock phosphate. Maintenance: 200 lbs. 0-20-20 and 60 lbs. 33-0-0 on wheat.
5	Kentucky bluegrass and Korean lespedeza	1947: 200 lbs. 10-20-20. 1949 and later: Basic: 830 lbs. 0-20-10 in 1949. Maintenance: 200 lbs. 0-20-20 in 1951.
6	Bromegrass (Sweet clover seeded 1947-1949)	1947: 200 lbs. 10-20-20. 1949 and later: Basic: 2 tons lime and 760 lbs. 0-20-10 in 1949. Maintenance: 200 lbs. 0-20-20 in 1951, 100 lbs. 33-0-0 fall and spring beginning fall 1950.
7	Kentucky bluegrass (Sweet clover seeded in 1947)	1947: 200 lbs. 10-20-20. 1948 and later: Basic: 2 tons lime and 800 lbs. 0-20-10 in 1949. Maintenance: 200 lbs. 0-20-20 in 1951, 100 lbs. 33-0-0 fall and spring beginning fall 1948.
8	Kentucky bluegrass	None
4	Rye and Soybeans (grain)	Established 1948 (Previously limed) Basic: 450 lbs. rock phosphate, 200 lbs. 0-0-50 in 1948. Maintenance: 150 lbs. 10-20-20 with rye, 150 lbs. 0-20-20 with soybeans in 1949 and 1950.
1	Alta fescue (Ladino clover seeded spring 1951)	Established spring 1949 Basic: 2 tons lime, 2000 lbs. rock phosphate, 315 lbs. 0-0-50, 325 lbs. 8-8-8 starter. Maintenance: 200 lbs. 0-20-20 in 1951.
9	Bromegrass and Ladino clover	Established spring 1949 Basic: Surface 10 inches: 6 tons lime 2000 lbs. rock phosphate, 357 lbs. 0-0-50, 115 lbs. 0-20-20 starter. Subsoil (10-15 inch horizon) 3 tons lime. Maintenance: 200 lbs. 0-20-20 every other year.
Series II	Grain Rotations	
7, 12, 17,22	Corn (rye*) - Soybeans - Wheat - Meadow *plowed under before beans.	1947-48: 2 tons lime, 250 lbs. 10-20-20 on corn, 225 lbs. 10-20-20 on beans, 200 lbs. 10-20-20 on wheat, 150 lbs. 10-20-20 on rye.

TABLE 2--(CONTINUED)

Plot	Cropping System	Soil Treatment Amount Per Acre
		1949 and later: Basic treatment 1000 lbs. rock phosphate, 100 lbs. 0-0-50. Corn: 311 lbs. 33-0-0 plowed under, 300 lbs. 3-12-12 starter. Beans: 200 lbs. 0-20-20 starter. Wheat (1949): 200 lbs. 10-20-20, 50 lbs. 33-0-0. Wheat (1950-51): 200 lbs. 0-20-20, 75 lbs. 33-0-0. Rye (1950-51): 150 lbs. 0-20-20, 100 lbs. 33-0-0.
29, 33, 37	Corn - Wheat - Meadow	1947-48: 2 tons lime 400 lbs. 10-20-20 on corn, 200 lbs. 10-20-20 on wheat. 1949 and later: Basic: 1000 lbs. rock phosphate, 100 lbs. 0-0-50. Corn: 300 lbs. 33-0-0 plowed under, 300 lbs. 3-12-12 starter. Wheat (1949): 200 lbs. 10-20-20, 50 lbs. 33-0-0. Wheat (1950): 200 lbs. 0-20-20, 150 lbs. 33-0-0. Wheat (1951): 200 lbs. 0-20-20, 200 lbs. 33-0-0.
11, 16, 21	Soybeans - Small Grain - Meadow	1947-48: 2 tons lime, 400 lbs. 10-20-20 on beans, 200 lbs. 10-20-20 on barley (1947) and rye (1948). 1949 and later: Basic treatment 1000 lbs. rock phosphate, 100 lbs. 0-0-50. Beans: 200 lbs. 0-20-20 starter. Rye (1949): 200 lbs. 10-20-20, 50 lbs. 33-0-0. Rye (1950) and Wheat (1951): 200 lbs. 0-20-20, 75 lbs. 33-0-0.
5, 6	Corn - Oats (sweet clover*) *plowed under before corn	1947-48: 2 tons lime, 200 lbs. 10-20-20 on corn, 200 lbs. 10-20-20 on oats. 1949 and later: Basic: 1000 lbs. rock phosphate, 100 lbs. 0-0-50. Corn: 200 lbs. 33-0-0 plowed under, 300 lbs. 3-12-12 starter. Oats (1949): 200 lbs. 10-20-20 Oats (1950): 200 lbs. 0-20-20, 150 lbs. 33-0-0. Oats (1951): 200 lbs. 0-20-20, 200 lbs. 33-0-0.
25, 26	Corn - Oats	None

showed a gradual increase up to a maximum, followed by a gradual decrease to zero as grazing ceased. Grain and hay yields were determined by adjusting the harvested weights to a uniform moisture basis and then converting to yield per acre.

Economic Evaluation

Complete records of farming operations and amounts of seed and fertilizer used were maintained for all areas. The number of days cattle were on the various pasture plots was recorded and complete records of production were obtained. With this information, it was possible to compute the costs and returns from the various pasture and cropping systems under measurement.

Widely differing price levels existed during the two periods of investigation. Prices and costs were markedly lower in the period 1940-1946, when light soil treatments were applied, than they were in the period 1947-1951, when much larger amounts of fertilizers were used. Application of price levels of both periods to the data collected in each of the periods seemed desirable. Accordingly, the average prices of supplies and services bought and of products produced were determined for the two periods 1940-1946 and 1947-1951. This latter period includes the post-war base period, 1947-1949, recommended by the Division of Statistical Standards for all revised federal index numbers (15).

The studies of Frame (6), in which he determined the time required for various farming operations, were used as a basis for converting the plot data to a field basis. Appropriate time values were multiplied by the number of operations on the experimental plots. Machinery costs on an hourly basis were secured for the early period from published data (1) and for the later period from C. L. Day, assistant professor of agricultural engineeing, Univesity of Missouri. Fuel consumption rates were supplied by M. M. Jones, Chairman, Department of Agricultural Engineering, University of Missouri. Farm labor wages for Central Missouri were secured from A. C. Brittain, Agricultural Statistician in charge, Bureau of Agriculture Economics, U. S. Department of Agriculture, Columbia, Mo. The cost per acre for each farming operation was computed for each price period from these data.

Lime was charged off over an eight-year period at the price paid for lime, delivered and spread on the experimental farm. Fertilizer for the early period was charged at the price listed by the Office of Price Administration on August 13, 1946. Price lists of the Missouri Farmers Association, records of the Agricultural Statistician, BAE, USDA, Columbia, Mo., and prices paid by the experimental farm were used in determining the average prices paid by farmers in the period 1947-1951. Basic treatments of fertilizer applied in the later period were amortized over a ten-year period. These included all applications listed as basic treatments for pasture and grain systems in Table 2.

Seed costs were charged at the average price paid by Missouri farmers. These prices came chiefly from the Bureau of Agricultural Economics monthly bulletin, "Agricultural Prices." Local market prices and estimates based on prices of other seeds were used when data were unobtainable from this source.

Labor required in caring for the cattle was charged on the basis of the man labor distribution published (1), for the actual time cattle were on the pasture, and the labor wage mentioned previously. An interest charge was made against each pasture for the actual time cattle were on the pasture. Interest was computed at 5 percent per annum for the period 1940-1946 and 5.5 percent per annum for the period 1947-1951. These were the average rates charged by Production Credit Associations, including the service charges. The original cost of 500 to 700-pound steers on the Kansas City market was taken from "Livestock, Meats, and Wool Market Statistics and Related Data," Bureau of Agricultural Economics, U. S. Department of Agriculture.

EXPERIMENTAL RESULTS

Light Soil Treatment Period

Soil and Water Losses. Soil and water loss data for this period are summarized in Table 3 and tabulated by years in Appendix Tables 14 to 30. The two timothy pastures, one with sweet clover and Korean lespedeza and the other with Korean lespedeza only, averaged less than one-half ton of soil loss per acre per year. Much of this loss came in the early years before good establishment. The plot with sweet clover gave somewhat better runoff control than the plot without this legume. It retained an average of two inches more water annually. This reduction in runoff indicates the bene-

TABLE 3--AVERAGE ANNUAL RUNOFF AND SOIL LOSS FROM PASTURES AND CASH GRAIN SYSTEMS 1940-1946 WITH AVERAGE ANNUAL PRECIPITATION OF 40.34 INCHES

Plot	Cropping	Runoff (Inches)	Soil Loss (Tons)
Series I	Pastures		
1	Timothy and lespedeza	9.50	0.40
2	Oats (hay) and lespedeza	10.53	2.59
3	Wheat and lespedeza	10.33	2.01
4	Barley and soybeans (hay)	8.70	3.93
5	Timothy, sweet clover and lespedeza	7.41	.30
7	Bluegrass - renovated	11.90*	* *
8	Bluegrass - check	12.34*	* *
Series II	Grain Rotations		
1, 3, 5	Oats (hay) and lespedeza	9.19	1.78
2, 4, 6	Wheat and lespedeza	9.19	1.31
9, 14, 19, 24	Corn - corn - oats - wheat (sweet clover)	9.71#	4.91
29, 33, 37	Corn - wheat - meadow	9.00@	1.64@
25, 26	Corn - oats	12.34#	7.50#

*Estimated for 1940-44, measurements begun in 1945. Not comparable with other runoff data because measurements are from full length of slope and subsurface flow is included.

**Not measured.

\# Estimated for 1940, measurements begun in 1941.

@ Estimated for 1940-42, measurements begun in 1943.

ficial effects of sweet clover on soil of low permeability. The high rate of root decay after the plant dies leaves an open column through the surface soil and into the upper layer of the clay subsoil. This, together with beneficial additions made by sweet clover to the organic fraction of the soil, resulted in increased rainfall absorption by all plots which included this legume.

Management of the two small grain-Korean lespedeza pastures called for harvesting oats hay and grazing the lespedeza on one while grazing both wheat and lespedeza on the other. Runoff was essentially the same from the two plots, but soil loss from oats exceeded that from wheat by approximately one-half ton per acre annually. This difference was due largely to lower soil moisture in the fall (which permitted more rainfall retention and the preparation of a better seedbed for wheat) and to the lack of intense rains in the fall. Such rains were common in the spring at oat seeding time.

Erosion losses under small grain-Korean lespedeza harvested for grain and hay, were measured in another study at the farm. Results are included in Table 3 for comparison (18). Soil loss was approximately one-third less where grain and hay were harvested than where crops were removed by grazing. This was attributed to the better cover resulting from small grain left to mature, to the lack of soil compaction and pulverization by trampling of animals and, to a lesser extent, to the larger amount of undecayed crop residue remaining on the plots harvested for grain and hay.

Barley and soybeans, where the barley was grazed and the beans were harvested for hay, gave the most erosive pasture system under study in the early period. The average annual soil loss was almost four tons per acre. This combination of soybeans and barley had two significant soil loss periods. The most serious of these was in the spring when barley was being grazed at its maximum and during seeding and early development of the beans. The other was in the fall when barley was being seeded and was establishing a soil cover.

Soil losses were not determined for the two Kentucky bluegrass pastures. Measurements on other grass pastures at this station and elsewhere (17) show that soil losses from such areas are negligible if there are no active gullies. Rate and amount of runoff from the entire two-acre plots were determined by use of rate-measuring flumes. Two years' data are available. There was no difference in runoff from the check and renovated bluegrass pastures in 1945, but in 1946 the renovated area had 8 percent less runoff than the check area. A study by seasons showed practically no difference in total runoff until new growth started in the spring. From May 10 to the end of the year, the renovated pasture had 10 percent less water loss than the check area.

Soil losses from two of the grain systems exceeded those from the most erosive pasture system, barley and soybeans. The intensive rotation of corn-oats, without soil treatment, permitted the largest soil loss. This was a common rotation in the early history of this section. Such intensive cropping on a soil of moderate to low fertility with little attention to conservation measures had serious erosional effects. The four-year rotation, corn-corn-oats-wheat with sweet clover under, lost an average of almost five tons per acre annually, and while this is markedly less than the loss from corn oats, it is still too great for sustained agriculture on this soil. A corn-wheat-meadow rotation had a comparatively low soil loss. Erosion was reduced in this rotation through the use of grass and legume meadow. Losses were negligible while the meadow occupied the land, and erosion was drastically reduced from corn as a result of the conditioning effects on soil of plowing under the meadow.

The soil losses reported above were measured from plots 90 feet long on a 3 percent slope farmed up and down hill. An estimate of erosion under these various systems, on typical field areas, is possible by using degree and length of slope and practice effectiveness data developed at the farm (19). For example, the average length of a 3 percent slope at the experimental farm is 470 feet. Soil losses for the systems would be 46 percent greater than those listed in Table 3 for a field with the same characteristics but farmed on the contour. Terraces would be necessary on such fields with many of the cropping systems to keep the soil loss to the suggested allowable maximum of 2.5 tons per acre annually (20).

Comparison by Production. Average annual production data for the period 1940-1946 are presented in Table 4. The variety of commodities harvested makes direct comparisons between some of the cropping systems difficult. One method of reducing all products to a common denominator is to convert them to corn equivalent. Values given in another publication on a net energy basis were used for this purpose (1). It was assumed that cattle of the age and quality pastured would require 16 bushels of corn equivalent per 100 pounds of gain. Production on this basis ranged from 18 to 42 bushels of corn equivalent per acre on the pastures and from 19 to 33 bushels on the grain system plots.

Wheat-Korean lespedeza, both grazed, was the highest producing pasture 3 years out of 7, and produced the highest average annual beef cattle gain, 261 pounds per acre. Usually one-half of the gain was made on wheat and one-half on lespedeza, but drought during June and July in 1944 reduced the gain made on lespedeza to only 71 pounds per acre.

Consistently high steer gains, which average 241 pounds per acre annually and which fell below 200 pounds only once in seven years, were obtained on timothy, sweet clover, and Korean lespedeza pasture. This plot was started with the idea of maintaining first and second-year sweet clover in a pasture simultaneously. In general, a good stand of first-year sweet clover was secured from seeding. This growth added to the production during the year, but not enough plants lived over the winter and into the second year to furnish pasture and produce a natural seeding. These results corroborated those of Brown and Helm at the Lathrop, Mo., field (2). At Lathrop, a grazing schedule which made full use of the grass and associated second-

TABLE 4--AVERAGE ANNUAL PRODUCTION PER ACRE FROM PASTURES AND CASH GRAIN SYSTEMS 1940-1946

Plot	Cropping System	Production Per Acre: Crop	Yield *	Corn Equivalent	Animal Unit Days	Beef Gain Per Animal Unit Day
Series I	Pastures			Bushels		
1	Timothy and Korean lespedeza	Beef	228	36.5	123	1.85
2	Oats (hay) and Korean lespedeza	Beef	117	18.7	82	1.43
		Hay	1.09	17.1		
		Total		35.8		
3	Wheat and Korean lespedeza	Beef(Wheat)	130	20.8	51	2.55
		Beef(Lesp.)	131	21.0	80	1.64
		Total	261	41.8	131	1.99
4	Barley and Soybeans (hay)	Beef	105	16.8	48	2.19
		Hay	1.29	22.4		
		Total		39.2		
5	Timothy, sweet clover, Korean lespedeza	Beef	241	38.6	136	1.77
7	Kentucky bluegrass and sweet clover**	Beef	165	26.4	120	1.38
8	Kentucky bluegrass - check**	Beef	115	18.4	93	1.24
	No soil treatment.					
Series II	Grain Rotations					
1, 3, 5	Oats (hay) and Korean lespedeza	Oat hay	1.12	17.5		
		Lesp. hay	.66	12.8		
		Total		30.3		
2, 4, 6	Wheat and Korean lespedeza	Wheat	16.5	19.0		
		Lesp. hay	.71	13.8		
		Total		32.8		
9, 14, 19,24	Corn - Corn - Oats - Wheat (sweet clover)	Corn	34.7	34.7		
		Corn	30.3	30.3		
		Oats	32.7	15.4		
		Wheat	16.7	19.2		
		Average		24.9		
29, 33, 37	Corn - Wheat - Meadow	Corn	32.6	32.6		
		Wheat	15.0	17.3		
		Hay***	1.26	21.8		
		Average		23.9		
25, 26	Corn - Oats No soil treatment	Corn	28.4	28.4		
		Oats	21.9	10.3		
		Average		19.4		

*Yield of grain in bushels, hay in tons, and beef in pounds.
**Average for 4-year period 1943-46.
***Predominantly red clover and timothy.

year sweet clover weakened or destroyed first-year sweet clover.

The same mixture without the sweet clover produced almost as much gain at a much lower annual cost. Korean lespedeza was easy to maintain with timothy and made substantial contributions to the yield every year, particularly in July and August.

Two of the systems under measurement, oats with Korean lespedeza and barley with soybeans, had one of the crops removed for hay. On a corn equivalent basis they produced 36 and 39 bushels, respectively.

It should be pointed out that none of these systems would be in competition with one another on a farm. They should be used in suitable combination to secure the maximum profitable production on the farm throughout the year. Flexibility is a necessary requirement in a livestock enterprise, not only because of changing market conditions, but because of weather hazards. Many of these systems provide considerable latitude in management, which is already well appreciated by Missouri farmers.

Lime and a light application of phosphate and potash fertilizer raised production on a native pasture from 115 to 165 pounds of beef per acre annually. Kentucky bluegrass was the predominant grass on these two plots. Sweet clover was seeded in the treated plot every spring during this period in an effort to secure and maintain first and second-year sweet clover. Fair stands were obtained generally, but practically none carried over into the second year.

Corn yields in the grain systems averaged from 28 bushels, where no soil treatments were used, to 35 bushels, where sweet clover was turned under before corn and the small grain in the rotation received 200 pounds of 0-20-10 fertilizer. Wheat yield was 15 to 17 bushels with fertilizer. Oats produced 22 bushels without treatment and 33 bushels with 200 pounds of 0-20-10 fertilizer.

Economic Evaluation. Yields from the different pastures and cropping systems are not sufficient basis for comparison since costs of production and value of commodities produced vary between the different systems. Net return in dollars and cents is the most readily understood and, therefore, the best basis for comparison. There are, however, inherent difficulties with this yardstick. Although farm prices tend to move up and down together, the degree of price change of the various commodities with time is not the same (14). Likewise, the costs of production fluctuate and create higher or lower net returns when applied to gross returns, depending upon the purchasing power of the different commodities at the time. A system with the highest net return at one time may not have the highest under a different set of economic conditions.

An effort was made to indicate the effect of changing economic conditions by using two price levels.

The first price level was the average of prices for the period 1940-1946. This was the period when data were collected under light fertilizer treatments. Costs of various items of production, gross return, and net return are tabulated in Table 5.

TABLE 5--AVERAGE ANNUAL COSTS OF PRODUCTION AND RETURNS FROM PASTURES AND CASH GRAIN SYSTEMS WITH LIGHT SOIL TREATMENTS 1940-1946 COMPUTED AT THE AVERAGE PRICE LEVEL OF 1940-1046

		Average Annual Production Costs Per Acre							Returns Per Acre	
Plot	System*	Farming	Lime	Fertilizer	Seed	Cattle Labor	Cattle Interest	Total	Gross	Net**
Series I	Pastures									
1	Timothy & Korean lespedeza	$1.18	$0.92	$1.95	$0.53	$1.80	$1.40	$ 7.78	$26.43	$18.65
2	Oats(hay) & Korean lespedeza	5.82	.92	2.28	1.88	1.12	.88	12.90	27.88	14.98
3	Wheat & Korean lespedeza	3.32	.92	2.28	3.02	1.91	1.49	12.94	30.25	17.31
4	Barley & soybeans(hay)	7.34	.92	2.28	7.62	.74	.57	19.47	32.28	12.81
5	Timothy, sweet clover, Korean lesp.	1.43	.92	1.95	2.71	1.98	1.54	10.53	27.93	17.40
7	Ky. bluegrass & sweet clover	1.06	.92	2.44	3.66	1.73	1.35	11.16	19.12	7.96
8	Kentucky bluegrass - check#	.43	-	-	-	1.34	1.05	2.82	13.33	10.51
Series II	Grain Rotations									
1, 3, 5	Oats(hay) & Korean lespedeza	9.51	.92	2.28	1.86	-	-	14.57	24.90	10.33
2, 4, 6	Wheat & Korean lespedeza	8.00	.92	2.28	2.82	-	-	14.02	31.92	17.90
9,14,19,24	Corn-corn-oats-wheat(sweet cl)@	6.34	.92	2.28	2.36	-	-	11.90	25.00	13.10
29,33,37	Corn-wheat-meadow	5.35	.92	1.52	3.69	-	-	11.48	22.65	11.17
25, 26	Corn - oats#	5.81	-	-	1.14	-	-	6.95	19.42	12.47

*All crops in I are grazed except as noted. All crops in II for grain and hay except as noted.
**Includes return for land and management.
No soil treatment.
@ Sweet clover turned under before first corn crop.

TABLE 6--AVERAGE ANNUAL COSTS OF PRODUCTION AND RETURNS FROM PASTURES AND CASH GRAIN SYSTEMS WITH LIGHT SOIL TREATMENTS 1940-1946 COMPUTED AT THE AVERAGE PRICE LEVEL OF 1947-1951

		Average Annual Production Costs Per Acre							Returns Per Acre	
Plot	System*	Farming	Lime	Fertilizer	Seed	Cattle Labor	Cattle Interest	Total	Gross	Net**
Series I	Pastures									
1	Timothy & Korean lespedeza	$1.53	$0.94	$2.05	$0.85	$3.39	$3.12	$11.88	$59.10	$47.22
2	Oats(hay) & Korean lespedeza	7.62	.94	2.39	2.83	2.12	1.95	17.85	48.22	30.37
3	Wheat & Korean lespedeza	4.18	.94	2.39	4.83	3.59	3.31	19.24	67.65	48.41
4	Barley & soybeans(hay)	9.49	.94	2.39	12.11	1.39	1.28	27.60	51.91	24.31
5	Timothy, sweet clover, Korean lesp.	1.90	.94	2.05	4.51	3.73	3.44	16.57	62.47	45.90
7	Kentucky bluegrass & sweet clover	1.45	.94	2.55	5.43	3.25	3.00	16.62	42.77	26.15
8	Kentucky bluegrass - check#	.54	-	-	-	2.52	2.33	5.39	29.81	24.42
Series II	Grain Rotations									
1, 3, 5	Oats(hay) & Korean lespedeza	12.52	.94	2.39	2.80	-	-	18.65	29.78	11.13
2, 4, 6	Wheat & Korean lespedeza	10.43	.94	2.39	4.62	-	-	18.38	45.44	27.06
9,14,19,24	Corn-corn-oats-wheat(sweet cl)@	7.95	.94	2.39	3.76	-	-	15.04	38.98	23.94
29,33,37	Corn-wheat-meadow	6.88	.94	1.59	6.83	-	-	16.24	33.98	17.74
25, 26	Corn - oats#	7.27	-	-	1.72	-	-	8.99	29.70	20.71

*All crops in I are grazed except as noted. All crops in II for grain and hay except as noted.
**Includes return for land and management.
No soil treatment.
@ Sweet clover turned under before first corn crop.

Costs of production varied widely between systems. Least cost, $2.82 per acre annually, was on native bluegrass pasture. The only charges were for occasional mowing to control weeds and labor and interest charges for the cattle. Largest cost of production was on the one-year system of barley for pasture and soybeans for hay. Farming costs, consisting of two seedbed preparations, harvest of hay, and the purchase of seed for two crops accounted for over 75 percent of the costs on this area. Cost of production on the grain systems varied between a low of $6.95 on corn-oats without treatment to almost $15.00 on one-year rotations of small grain with Korean lespedeza.

Gross returns from pastures ranged from $13.33 per acre annually on unfertilized bluegrass to $32.28 on barley and soybeans. Grain systems had gross returns ranging from a low of $19.42 on corn-oats, unfertilized, to $31.92 on wheat with Korean lespedeza.

Highest net return at this price level, $18.65 per acre, was obtained from timothy-Korean lespedeza. While not the highest in gross return, this system had the lowest cost of production, with the exception of the two unfertilized systems. Next in order of net return were wheat with Korean lespedeza, harvested for grain and hay; timothy with sweet clover and lespedeza, used as pasture; and wheat with lespedeza, both pastured. These three systems produced net returns between $17.00 and $18.00 per acre annually.

Oats for hay with Korean lespedeza grazed produced almost $15.00 net per acre, annually. Barley grazed, followed by soybeans for hay—the system with the highest gross return—had a net return of only $12.81. This combination had the highest cost of production of any system under study. It was also the most erosive pasture. That fact, coupled with the low net return would place it well down the list of rotations for this area.

Grain rotations which included corn made net returns of $11.17 to $13.10. Higher costs of production for the rotation corn-wheat-meadow were sufficient to give this rotation a $1.30- lower net return per acre than corn-oats without treatment. The wide difference in soil loss between these two systems, however, would more than offset this difference in net return.

The two bluegrass pastures that have never been plowed make an interesting contrast. Beef production averaged 50 more pounds per acre on the fertilized plot which had sweet clover seeded in it than on the untreated area. This made almost $6.00 per acre difference in gross return. Costs of production were $11.16 on the renovated plot compared to $2.82 on the untreated pasture. The costs for seeding the renovated plot were essentially wasted, however, since the sweet clover made little contribution to production. It should be added that the fertilized pasture improved with time. Both of these plots were in an area which had been grazed for 40 years or more without soil treatment and at times were severely overgrazed. They were in a low state of growth and production when measurements began. Cattle made a gain of about 100 pounds per acre on each area in 1943. In 1946, beef gain was 310 pounds on the treated plot and 132 pounds on the untreated area.

Rejuvenation of deteriorated pastures on claypan soil with such small amounts of soil treatment, without plowing and reseeding, proved to be a slow process. Two to three years were required for beneficial effects to become evident. Work at the Station in the early 1950's indicated that a more profitable procedure would be to prepare a seedbed with field cultivator and disk, leaving the dead vegetation on the surface as a mulch, and seed an adapted legume.

The second price level applied to the data was the average of prices in the period 1947-1951. This was a markedly different economic period. Prices received by farmers were higher, but the costs of production were likewise higher.

An analysis showed that farm wage rates were up 89 percent in 1947-1951 over the previous period, seed costs were up 70 percent, fertilizer costs were up 12.5 percent, and farm operation costs were 29 percent higher. Interest charges on cattle were 122 percent higher. Interest rate increased only from 5 to 5.5 percent, but the increased value of the cattle more than doubled this charge to the pastures. Prices received for commodities advanced as follows: beef, 124 percent; grain, 52 percent; soybeans, 41 percent; and hay, 23 percent. Economic data for this price level are shown in Table 6.

Computing the costs and returns at this higher price level caused some shift in the rank of income from the various systems. Systems in which beef was the major item naturally made the largest advances. Wheat-Korean lespedeza became the largest producer of net income, yielding $48.41 per acre annually. Barley grazed and soybeans for hay dropped to the lowest net return for pastures, $24.31. At these prices, the production on renovated Kentucky bluegrass was sufficient to pay the costs of treatment and seeding and to give almost $2.00 per acre more net return than untreated Kentucky bluegrass.

Net income from all of the pasture systems was higher than that from any grain system except wheat for grain and Korean lespedeza for hay. All grain systems showed substantially higher net returns at this higher price level than at the 1940-1946 level. But the advances for these commodities were far short of the advance for beef. Consequently their relative increases were smaller.

Without explanation, it would be disturbing to many to hear that corn-oats, without soil treatment, was higher in net return than corn-wheat-meadow, with fertilizer on wheat, even at this higher price level. Remember that average yields over a seven-year period were used in determining the gross returns on all systems. In 1940, corn yields in the two rotations were about equal, but by 1946 the yield in the corn-oats rotation had dropped to slightly more than 70 percent of that in the other system. No nitrogen was included in the fertilizer used on any of the systems. As a result, maximum benefit was not secured from the phosphate and potash treatments. Inclusion of this nutrient undoubtedly would have boosted the gross as well as the net return on all the fertilized grain systems. In time, even without nitrogen, this apparent discrepancy in value of fertilizer would be eliminated where legumes were used, and the value of good soil management would become obvious.

TABLE 7--AVERAGE COST OF PRODUCING A BUSHEL OF CORN EQUIVALENT WITH LIGHT SOIL TREATMENTS, 1940-1946, AT TWO PRICE LEVELS*

Plot	Cropping System	Cost of producing one bushel of corn equivalent 1940-46 Prices	1947-51 Prices
		Dollars	Dollars
Series I	Pastures		
1	Timothy and Korean lespedeza	.213	.325
2	Oats (hay) and Korean lespedeza	.360	.499
3	Wheat and Korean lespedeza	.310	.460
4	Barley and Soybeans (hay)	.497	.704
5	Timothy, sweet clover, Korean lespedeza	.273	.429
7	Kentucky bluegrass and sweet clover	.423	.630
8	Kentucky bluegrass-check	.153	.293
	Average	.318	.477
Series II	Grain Rotations		
1, 3, 5	Oats (hay) and Korean lespedeza	.481	.616
2, 4, 6	Wheat and Korean lespedeza	.427	.560
9, 14 19, 24	Corn-Corn-Oats-Wheat (Sweet clover)	.478	.604
29, 33, 37	Corn-Wheat-Meadow	.480	.679
25, 26	Corn-Oats	.358	.463
	Average	.445	.584

*These data were computed from the data in Tables 4, 5 and 6 of this report.

Another method of analyzing the production and return of the various systems was attempted. The favorable price relationship of beef in the higher price level period, 1947-1951, is illustrated by the beef-corn price ratio. This ratio is defined as the number of bushels of corn that 100 pounds of beef will purchase. Using the price data in this study, the ratio averaged 12.6 in the period 1940-1946, but jumped to an average of 17.4 for the five years, 1947-1951. The obvious effect of such a relationship between grain and beef was to make the pasture systems show up in much better light than the grain systems.

As a means of eliminating this effect, the cost of producing a bushel of corn equivalent was computed. The data are presented in Table 7. At the 1940-1946 price level, the cost of producing a bushel of corn equivalent on the pastures ranged from 15 cents on untreated Kentucky bluegrass to 50 cents on the system utilizing barley for pasture and soybeans for hay, with an average of 32 cents. On grain systems the range was 36 to 48 cents, with three of the rotations having the latter value.

At the 1947-1951 level, the pastures ranged from 29 to 70 cents per bushel of corn equivalent and averaged 48 cents. Grain systems averaged 58 cents, with a range of 46 to 68 cents.

High-level Soil Treatment Period

Soil and Water Losses. Average runoff and soil losses were substantially less in the period 1947-1951 than in the preceding seven years. There were three principal reasons for this difference: (1) Better rainfall distribution with lower intensities at critical periods; (2) crop residues such as corn stalks and soybean and small grain straw were incorporated with the soil instead of being removed; and (3) application of sufficiency levels of mineral nutrients and the use of nitrogen helped create more vigorous plants, which provided better cover and better soil conditioning.

Unfortunately, not all of the systems under measurement earlier were operated in this period. Sufficient data had been collected to evaluate some of the pastures and grain systems from an erosion standpoint, the primary objective, so measurements were terminated. Four of the pasture plots, however, were under measurement both periods. They were the two Kentucky bluegrass pastures, wheat and Korean lespedeza, and Kentucky bluegrass with Korean lespedeza. This latter plot was seeded originally to timothy in 1938. Timothy was gradually replaced by Kentucky bluegrass, and by 1947 little timothy remained. Two of the grain systems were under study during both periods, corn-oats without treatment and corn-wheat-meadow. Runoff and soil loss data for this period are summarized in Table 8 and tabulated by years in Appendix Tables 14 to 25 and 31 to 35.

Highest soil loss occurred from wheat with Korean lespedeza, both grazed, which lost an average of 1.69 tons per acre. Much of this loss was

TABLE 8--AVERAGE ANNUAL RUNOFF AND SOIL LOSS FROM PASTURES AND CASH GRAIN SYSTEMS, 1947-1951 (AVERAGE ANNUAL PRECIPITATION FOR THE PERIOD WAS 36.69 INCHES)

Plot	Cropping	Runoff	Soil Loss
Series I	Pastures	Inches	Tons
3	Wheat and Korean lespedeza	5.50	1.69
5	Kentucky bluegrass and Korean lespedeza	4.67*	.12*
7	Kentucky bluegrass	5.63**	#
8	Kentucky bluegrass - check	7.65**	#
4	Rye and Soybeans (grain)	3.41@	.57@
Series II	Grain Rotations		
7, 12, 17, 22	Corn (rye) - Soybeans - Wheat - Meadow	5.20	1.01
29, 33 37	Corn - Wheat - Meadow	5.02	.84
11, 16, 21	Soybeans - Small grain - Meadow	5.13	.66
5, 6	Corn - Oats (Sweet clover)	4.87	.84
25, 26	Corn - Oats	9.79	.84

*Average of 1947-50, not measured in 1951.

**Measured from full length of slope and not comparable with other runoff measurements.

\# Not measured.

@ Estimated for 1947 and 1951.

the result of one runoff period. Almost 45 percent of the total erosion in five years was caused by a single rain in March, 1949. Wheat had been damaged by heaving in the late winter and had made practically no growth when the rain occurred.

All other systems under measurement lost a ton or less of soil per acre annually. Even the one-year rotation of rye for pasture and soybeans for grain, which required two seedbed preparations each year, had nominal soil loss. This system also had the smallest runoff of any under measurement, attesting to the favorable distribution of rainfall in this period.

The fertilized bluegrass plot retained two inches more water on the average than the adjacent untreated bluegrass pasture. The application of nitrogen on the treated plot started the growth of grass ten days to two weeks earlier and continued the growth later in the fall. This, together with greater growth throughout the year, increased the use of water on the fertilized plot and left the soil more receptive to precipitation.

Comparison by Production. The higher level of soil treatment, supported by more favorable rainfall distribution in the growing season, resulted in substantially higher yields in the period 1947-1951 than in the earlier period of study. Production data for this period are tabulated in Table 9. The most notable yield increase was made by corn where sufficiency levels of phosphate, potash and lime were applied and substantial nitrogen applications were made. Table 2 gives specific soil treatments applied to each cropping system. Corn yields were nearly three times as large as in the former period. Meadow yields were almost doubled. Small grains showed some yield increases but in smaller proportions.

Comparison of beef gains on pastures in operation both periods shows higher production in the later years. Wheat with Korean lespedeza produced almost 100 more pounds per acre. Gains on treated Kentucky bluegrass went from 165 pounds to 262 pounds, but not all of these increases can be attributed to higher application of fertilizer. The untreated bluegrass pasture went from 115 to 173 pounds of beef annually. More favorable weather was partly responsible, therefore, for higher yields in this period. Pastures generally did not show as high percentages of increase in production as did the grain systems.

A new pasture under measurement in this period was bromegrass on plot 6. Sweet clover was seeded in the plot from 1947 through 1949 in an effort to keep first and second-year sweet clover in bromegrass. The results were more promising than the trials with bluegrass but were not entirely successful. Starting in 1950, this area received ammonium nitrate spring and fall. Bromegrass gave a marked response to nitrogen and the stand began thickening. Sweet clover, as the only source of nitrogen, was not sufficient to produce vigorous bromegrass on this poorly drained claypan soil. Average beef production over the 5-year period was 254 pounds, but indicative of the response to nitrogen was the yield of 303 pounds of beef per acre in 1951.

TABLE 9--AVERAGE ANNUAL PRODUCTION PER ACRE FROM PASTURES AND CASH GRAIN SYSTEMS 1947-1951

Plot	Cropping System	Crop	Production: Yield *	Production: Corn Equivalent	Animal Unit Days	Beef Gain Per Animal Unit Day
Series I	Pastures			Bushels		
3	Wheat and Korean lespedeza	Beef(Wheat)	156	25.0	46	3.39
		Beef(Lesp.)	202	32.3	93	2.17
		Total	358	57.3	139	2.58
5	Kentucky bluegrass and Korean lespedeza	Beef	308	49.3	135	2.28
6	Bromegrass	Beef	254	40.6	109	2.33
		Sweet clover seed	5	.1		
		Total		40.7		
7	Kentucky bluegrass	Beef	262	41.9	143	1.83
8	Kentucky bluegrass - check	Beef	173	27.7	87	1.99
4	Rye and soybeans (grain)**	Beef	139	22.2	27	5.15
		Beans	32.5	37.4		
		Total		59.6		
1	Alta fescue***	Beef	321	51.4	149	2.15
9	Bromegrass and Ladino clover***	Beef	350	56.0	203	1.72
9	Bromegrass and Ladino clover#	Beef	493	78.9	259	1.90
Series II	Grain Rotations					
7, 12, 17, 22	Corn(rye) - Soybeans - Wheat - Meadow##	Corn	90.5	90.5		
		Beans	27.0	31.1		
		Wheat	28.8	33.1		
		Hay	2.54	44.0		
		Average		49.7		
29, 33, 37	Corn - Wheat - Meadow	Corn	91.3	91.3		
		Wheat	19.8	22.8		
		Hay	2.31	40.0		
		Average		51.4		
11, 16, 21	Soybeans - Small grain - Meadow	Beans	25.2	29.0		
		Rye@	30.2	27.5		
		Hay	2.09	36.2		
		Average		30.9		
5, 6	Corn - Oats (Sweet clover)	Corn	94.7	94.7		
		Oats	31.8	14.9		
		Average		54.8		
25, 26	Corn - Oats	Corn	20.3	20.3		
		Oats	6.1	2.9		
		Average		11.6		

*Yield of grain in bushels, hay in tons, seed and beef in pounds.
**Average of three years 1948-1950.
***Average of two years 1950-1951.
One year of data - 1951.
Rye winter cover turned under as green manure before soybeans.
@ Yield is rye equivalent, was in barley one year, wheat one year, rye three years.

Measured as corn equivalent, the production on pastures ranged from 28 bushels on unfertilized Kentucky bluegrass to 57 bushels on wheat with Korean lespedeza. These systems were under measurements for the entire 5-year period. Production for a more limited number of years is included in Table 9 for three other pasture systems. These are presented to indicate the high yields possible when all conditions affecting production are at an optimum, or nearly so. It is quite likely that such high production as shown here for rye and soybeans or bromegrass and ladino clover cannot be maintained over an extended period.

The grain systems included for comparison showed corn equivalent yields of 12 to 55 bushels per acre annually. Corn yield averaged above 90 bushels in all rotations that received fertilizer, and 20 bushels in the untreated system. Table 2 shows that high-level nitrogen additions were not made until 1949, though some nitrogen was included in the fertilizer in 1947 and 1948. Corn population was approximately 7,000 stalks per acre in 1947 and from 12,000 to 14,000 in subsequent years. These factors, together with low rainfall in August, resulted in corn yields of 30 to 40 bushels per acre in 1947. Yields in later years ranged from 83 to 119 bushels per acre.

On a corn equivalent basis, the production of pastures compared favorably with that of grain systems under high-level fertility treatments. Unfertilized Kentucky bluegrass produced more than twice the corn equivalent yielded by an unfertilized rotation of corn-oats.

Economic Evaluation. The two price levels used on the low-level soil treatment data were applied to this high-level soil treatment period. Results of applying the first, an average of prices existing in the period 1940-1946, are tabulated in Table 10. Costs of production ranged from $3.02 on unfertilized Kentucky bluegrass to $25.73 on rye for pasture and soybeans for grain. Fertilizer and seed accounted for almost 70 percent of the costs in the latter system. Costs on other pastures ranged from $12.66 to $17.57 per acre annually. Production costs on the grain systems ranged from a low of $7.59 on the untreated corn-oats rotation up to $20.00 to $24.00 on the fertilized rotations.

Highest system in gross return at these prices was rye for pasture and soybeans for grain, returning almost $75.00 annually for the three years it was under study. Lowest gross return on the pastures came from unfertilized Kentucky bluegrass. Grain systems grossed from $35.97 to $52.78 an acre where soil treatments were used, compared with $11.11 on the unfertilized corn-oats rotations.

The relationship between price of commodities and costs of items in their production gave the grain systems higher net return than most pasture systems. The rye and soybeans plot was an exception, but in this case one of the crops, soybeans, was removed and sold as grain. Beef production on bromegrass and ladino clover at the 1951 level over a period of years would exceed that from any of the grain systems, but it is doubtful if production at this level could be sustained.

TABLE 10--AVERAGE ANNUAL COSTS OF PRODUCTION AND RETURNS FROM PASTURES AND CASH GRAIN SYSTEMS WITH HIGH-LEVEL SOIL TREATMENTS 1947-1951 COMPUTED AT THE AVERAGE PRICE LEVEL OF 1940-1946

		Average Annual Production Costs Per Acre							Returns Per Acre	
Plot	System*	Farming	Lime	Fertilizer	Seed	Cattle Labor	Cattle Interest	Total	Gross	Net **
Series I	Pastures									
3	Wheat & Korean lespedeza	$3.10	$0.92	$6.69	$3.39	$1.89	$1.58	$17.57	$41.49	$23.92
5	Ky. bluegrass & Korean lespedeza	1.34	.92	4.82	2.19	1.85	1.54	12.66	35.70	23.04
6	Bromegrass	1.80	.92	6.54	2.29	1.50	1.25	14.30	29.94	15.64
7	Kentucky bluegrass	1.77	.92	9.13	1.79	1.96	1.63	17.20	30.37	13.17
8	Kentucky bluegrass-check#	.80	-	-	-	1.21	1.01	3.02	20.05	17.03
4	Rye & soybeans(grain) (1948-50)	6.32	.92	10.36	7.34	.43	.36	25.73	74.94	49.21
1	Alta fescue (1950-51)	1.47	.92	8.08	1.34	1.96	1.63	15.40	37.20	21.80
9	Bromegrass & Ladino clover (1950-51)	1.87	.92	6.76	.99	2.67	2.22	15.43	40.57	25.14
9	Bromegrass & Ladino clover (1951)	1.87	.92	6.76	.99	3.39	2.82	16.75	57.14	40.39
Series II	Grain Rotations									
7,12,17,22	Corn(rye)##-soybeans-wheat-meadow	7.40	.92	10.10	5.61	-	-	24.03	51.70	27.67
29,33,37	Corn - wheat - meadow	7.16	.92	10.05	4.43	-	-	22.56	47.93	25.37
11,16,21	Soybeans-smallgrain-meadow	6.17	.92	7.64	5.77	-	-	20.50	35.97	15.47
5, 6	Corn - oats(sweet clover)@	6.55	.92	11.59	3.03	-	-	22.09	52.78	30.69
25, 26	Corn - oats#	6.23	-	-	1.36	-	-	7.59	11.11	3.52

*All crops in I are grazed except as noted. All crops in II for grain and hay except as noted.
**Includes return for land and management.
No soil treatment.
##Rye winter cover turned under before soybeans.
@ Sweet clover turned under before first corn crop.

Difference in production on fertilized and unfertilized Kentucky bluegrass did not equal the difference in production costs on the two plots. The unfertilizer plot gave a net return of $17.03 compared with $13.17 on the plot which received a basic treatment of phosphate and potash drilled on the surface and nitrogen added spring and fall, beginning in 1948. It will be recalled that the difference in production between these two plots under light fertilizer additions was also insufficient to pay for additional treatment on the fertilized plot at this price level. Kentucky bluegrass, which gradually replaced timothy on plot 5, showed almost $10.00 per acre more net return than the fertilized bluegrass plot just discussed. These two plots had the same mineral fertilizer treatment but plot 5 had Korean lespedeza and did not receive nitrogen fertilizer. Higher gross return and lower costs of production accounted for this large difference in net income. Fertilized rotations containing corn produced net incomes of $25.37 to $30.69 per acre. Corn-oats with sweet clover turned under as green manure was the highest. Soybeans-small grain-meadow produced $10.00 less net income than corn-wheat-meadow. This was due almost wholly to the fact that gross income from corn was a little over twice as great as it was from soybeans in these two rotations. An average soybean yield of 41.5 bushels per acre would have been necessary for net income to have been the same on these two systems.

The unfertilized rotation of corn-oats made an average net return of $3.52 per acre. When it is remembered that net income, as used in this report must pay for land and management, this is hardly subsistence farming. Yields on these plots steadily declined from the time cropping first began on them in 1940. Average yield in the first seven-year period was 28 bushels of corn and 10 bushels of oats, while average yield in the last five-year period was 20 bushels of corn and 6 bushels of oats. This decrease in yield occurred in spite of more favorable weather. Calculated at the price level of 1940-1946, yield in the earliest period was sufficient to produce a net income of $12.47, whereas yield in the later period showed a net income of only $3.52.

Results of applying the price level of the period of study 1947-1951 to these data, are tabulated in Table 11. Average costs of production were 41 percent greater on the pastures at this price level than at the earlier, 1940-1946, price level, whereas production costs on grain systems were up only 30 percent. The much higher purchasing power of beef during this period, however, gave pastures substantially higher gross and net returns than grain producing areas.

Gross returns from pastures which were operated the full five-year period ranged from a low of $44.84 per acre annually on unfertilized Kentucky bluegrass to a high of $92.79 on wheat and Korean lespedeza. Gross returns from the grain systems were from $50.63 to $82.95 on the fertilized areas and $17.51 on the unfertilized corn-oats rotation.

Net returns were generally higher from pastures than from grain systems at this price level, just the reverse of results using the 1940-1946 price level. Fertilized pastures made net returns of $44.21 to $68.11 per acre an-

TABLE 11--AVERAGE ANNUAL COSTS OF PRODUCTION AND RETURNS FROM PASTURES AND CASH GRAIN SYSTEMS WITH HIGH-LEVEL SOIL TREATMENTS 1947-1951 COMPUTED AT THE AVERAGE PRICE LEVEL OF 1947-1951

		Average Annual Production Costs Per Acre							Returns Per Acre	
Plot	System*	Farming	Lime	Fertilizer	Seed	Cattle Labor	Cattle Interest	Total	Gross	Net**
Series I	Pastures									
3	Wheat & Korean lespedeza	$3.88	$0.94	$7.41	$5.37	$3.57	$3.51	$24.68	$92.79	$68.11
5	Ky. bluegrass & Korean lespedeza	1.79	.94	5.29	3.37	3.48	3.42	18.29	79.83	61.54
6	Bromegrass	2.41	.94	7.34	3.78	2.82	2.78	20.07	66.61	46.54
7	Kentucky bluegrass	2.36	.94	10.39	2.70	3.68	3.63	23.70	67.91	44.21
8	Kentucky bluegrass-check#	1.01	-	-	-	2.27	2.24	5.52	44.84	39.32
4	Rye & soybeans (grain) (1948-50)	7.99	.94	11.74	11.70	.82	.81	34.00	118.91	84.91
1	Alta fescue (1950-51)	1.95	.94	8.81	2.24	3.68	3.63	21.25	83.20	61.95
9	Bromegrass & Ladino clover (1950-51)	2.39	.94	7.27	1.66	5.02	4.95	22.23	90.72	68.49
9	Bromegrass & Ladino clover (1951)	2.39	.94	7.27	1.66	6.39	6.29	24.94	127.79	102.85
Series II	Grain Rotations									
7,12,17,22	Corn(rye)##-soybeans-wheat-meadow	9.46	.94	11.49	9.64	-	-	31.53	77.10	45.57
29,33,37	Corn-wheat-meadow	9.21	.94	11.55	7.91	-	-	29.61	72.80	43.19
11,16,21	Soybeans-small grain-meadow	8.03	.94	8.65	10.09	-	-	27.71	50.63	22.92
5, 6	Corn - oats(sweet clover)@	8.21	.94	13.28	4.75	-	-	27.18	82.95	55.77
25, 26	Corn - oats#	7.77	-	-	2.01	-	-	9.78	17.51	7.73

*All crops in I are grazed except as noted. All crops in II for grain and hay except as noted.
**Includes return for land and management.
No soil treatment.
##Rye winter cover turned under before soybeans.
@ Sweet clover turned under before first corn crop.

TABLE 12--AVERAGE COST OF PRODUCING A BUSHEL OF CORN EQUIVALENT WITH HIGH-LEVEL SOIL TREATMENTS, 1947-1951, AT TWO PRICE LEVELS*

Plot	Cropping System	Cost of producing 1 bushel of corn equivalent 1940-46 Prices	1947-51 Prices
		Dollars	Dollars
Series I	Pastures		
3	Wheat and Korean lespedeza	.307	.431
5	Kentucky bluegrass and Korean lespedeza	.257	.371
6	Bromegrass	.351	.493
7	Kentucky bluegrass	.411	.566
8	Kentucky bluegrass - check	.109	.199
	Average	.287	.412
Series II	Grain Rotations		
7, 12, 17, 22	Corn (rye) - Soybeans - Wheat - Meadow	.484	.634
29, 33, 37	Corn - Wheat - Meadow	.439	.576
11, 16, 21	Soybeans - Small grain - Meadow	.663	.897
5, 6	Corn - Oats (Sweet clover)	.403	.496
25, 26	Corn - Oats	.654	.843
	Average	.529	.689

*These data were computed from data in Tables 9 and 11 of this report.

nually, compared with $22.92 to $55.77 for the fertilized grain plots.

The price of beef was sufficient to make the addition of fertilizers to a native bluegrass pasture profitable. Plot 7, which received sufficiently level mineral treatment and nitrogen, spring and fall after 1948, had a net return almost $5.00 per acre above that of unfertilized plot 8. Kentucky bluegrass, without the nitrogen but with Korean lespedeza, showed a net return of $61.54, compared with $44.21 on bluegrass with nitrogen.

Three other pasture areas, bromegrass with Ladino clover, rye and soybeans, and alta fescue, gave high returns for the short periods they were under measurement. Production on one of these, bromegrass with Ladino clover, was high enough in 1951 to surpass $100.00 net return per acre. As mentioned previously, this average probably cannot be maintained, just as an average corn yield of 100 bushels probably cannot be maintained, but it does indicate the high yield and high net return possible from pastures when rainfall is ample and fertility and price levels are high. It suggests the desirability of making provision for supplemental irrigation for the low rainfall summers like the one in 1953.

The cost of producing a bushel of corn equivalent in the five-year period 1947-1951 with the various systems is indicated in Table 12. Only those pasture systems which were under measurement the full five-year period were included. At the 1940-1946 price level the average cost of producing a bushel of corn equivalent on pastures was 29 cents. This was 3 cents cheaper than when small amounts of fertilizer were applied in the earlier period.

In contrast, the grain systems had an average cost of 53 cents for producing a bushel of corn equivalent with high-level treatments, 7 cents higher than the cost with light soil treatments when both were calculated at the 1940-1946 price level.

The cost of producing a bushel of corn equivalent at prices prevailing in the five-year period 1947-1951 was lower for pastures than for grain systems. Average cost was 41 cents for pasture and 69 cents for grain systems.

From indications of these data the use of high-level soil treatments could be applied to pastures just as economically as to grain systems at even less favorable beef-corn ratios than those existing during the 12-year period of this study.

DISCUSSION

The greatly increased interest in grassland farming in recent years led to a need for evaluating the production and economic returns from various grassland farming systems. Pasture plots which were under measurement at the Midwest Claypan Soil Conservation Experiment Farm near McCredie, Mo., from 1940 through 1951, provided an opportunity for such an evaluation. Data from various grain rotations under comparable conditions of soil, topography, and fertility treatments were available for comparative purposes.

Two widely differing soil treatment levels were used on the experimental areas in this 12-year period. Only small amounts of fertilizer were applied in the first seven years of study, whereas high or sufficiency levels of plant nutrients were used in the last five-year period. These levels of soil treatment corresponded with recommendations being made to farmers of the State at the beginning of these two periods. It was possible in this study, therefore, to evaluate the production and return from pastures under two levels of soil treatment.

Changing economic conditions make it difficult to evaluate the return from any system of farming or any cropping practice within a system. Profitable management techniques under one set of conditions may not be profitable under different circumstances. Since the shift from one type of farming to another cannot be made hurriedly, however, these objections are not acute. Furthermore, the effects of some management practices, such as fertility additions, in improving soil tilth on land in grain crops are accumulative and have their full measure of influence over a period of years. In this study, price levels in effect during two different periods were applied to the data collected under the two levels of soil treatment.

Some factors were omitted in the economic evaluations. In the case of pastures, no charges were made for fences or water supply. No charge was made for erosion control practices on grain or pasture systems, and none was levied against the grain rotations for grain and hay storage. These items vary so much, depending upon the farm to which they are applied, that their evaluation under conditions existing at the experimental farm would serve no useful purpose. Measurements of soil loss indicate that erosion control measures would cost more on the grain systems than on the pastures. On the other hand, water and fences required in the pasture systems are items of cost not represented on the cash grain areas. Net income as reported in this bulletin, therefore, does not include these items nor a charge for land and management. Land was a constant, and no satisfactory way is known of charging for management in the various systems of farming represented in the study .

Weather was not eliminated as a variable in this investigation. Rainfall was much more favorable during the high-level soil treatment period. Comparison of production and net income between pasture and grain systems during this period, therefore, was favorable to the grain systems. Production from pastures is not dependent upon suitable weather throughout the whole of a growing season as is the case with some grain crops. For example, a harvest of corn and, to a lesser extent, soybeans can be reduced or lost altogether by a dry July or August.

Light Soil Treatment Period

1940-1946 Price Level. Small amounts of soil treatment were applied just as economically to pastures as to cash grain systems on claypan soil at the price level of 1940-1946. Under these conditions, four of the seven pastures under study had net returns larger than those from grain systems containing corn. Wheat and Korean lespedeza, harvested for grain and hay, was the most remunerative grain system, with a net return of almost $18.00 per acre. Production by a Kentucky bluegrass pasture, fertilized and seeded to sweet clover, was not increased enough to pay the cost of the treatment at this price level. The seeding of sweet clover in timothy and Korean lespedeza pasture was not profitable, but it did reduce the runoff by almost 2 inches annually.

Land without soil treatment produced $2.00 more per acre annually when farmed in a corn-oats rotation at the 1940-1946 price level than when left in Kentucky bluegrass and pastured. This was at the expense of the soil, however, through heavy erosion and nutrient removal by corn and oats. Production and net return declined steadily on this rotation until net return at the 1940-1946 price level was only $3.52 per acre annually during the last five years of the 12-year period of study. Kentucky bluegrass, during this same five-year period, netted $17.03 per acre annually. This is striking evidence of the effect of erosion and the sale of the capacity to produce through nutrient removal in crops.

1947-1951 Price Level. Small amounts of fertilizer were more profitably applied to pasture than to cash grain systems at prices existing in the five-year period, 1947-1951. Average costs of production of pastures advanced 41 percent in this period over the previous seven-year average, compared with a 30 percent advance for grain systems. The much greater advance in prices received for beef than for grain and hay, however, resulted in substantially larger net returns from pastures.

The seven pastures under measurement exceeded all but one of the grain systems in net return at this price level. Beef production on unfertilized Kentucky bluegrass was sufficient to give a higher net return per acre than any of the rotations containing corn. Wheat for grain and lespedeza for hay, the top grain system in net return, produced a net income of about $27.00 per acre annually, compared with slightly over $48.00 where these same crops were both pastured out. Net return from these two systems was about equal at the lower price level.

Another contrast with the lower price level was the net return on the two Kentucky bluegrass pastures. A difference of 50 pounds in beef production at the 1947-1951 prices was sufficient to pay the costs of fertilizer and seed and give almost $2.00 greater net return per acre than an unfertilized plot.

Land without soil treatment was more profitably left in native bluegrass pasture and grazed, than farmed in a corn-oats rotation at this price level. Net return was almost $4.00 per acre larger from the pasture than from the grain rotation. The plowing of native pastures to produce grain without soil treatment, or with only small amounts of fertilizer, does not seem wise in view of these data.

When small amounts of fertilizer were used under the weather conditions of 1940 through 1946, the cost of producing a bushel of corn equivalent was less with pastures than with grain and hay. This was true whether applying the price level which existed in the early forties, 1940-1946, or late forties and early fifties, 1947-1951.

High-Level Soil Treatment Period

1940-1946 Price Level. Soil treatments applied according to soil tests were slightly more remunerative on grain rotations than on pastures at this price level. Yields of corn advanced from about 30 bushels in the light soil treatment period to about 100 bushels per acre in the high-level-treatment period. Such phenomenal increases were not obtained on pastures until 1951, when bromegrass with Ladino clover produced almost 500 pounds of beef per acre.

Net returns ranged from $13.00 to $24.00 per acre on pastures that were under measurement the full five-year period and from $3.52 to almost $31.00 on the grain rotations. Cash grain systems which included corn, produced from $1.00 to $7.00 larger net returns per acre annually than did the highest producing pasture, wheat and Korean lespedeza.

High-level soil treatments at prices existing in 1940-1946 were not economical on native Kentucky bluegrass pastures. A plot which received adequate lime, phosphate and potash as a basic treatment and nitrogen spring and fall, showed a net return of about $13.00 compared with $17.00 on an adjacent unfertilized plot. Kentucky bluegrass and Korean lespedeza with the same mineral treatment, but without the nitrogen addition, showed a net return of $23.00. Production on bromegrass with sweet clover or with nitrogen was not high enough to make this a more desirable pasture than native bluegrass at this price level.

A one-year rotation of rye for pasture and soybeans for grain produced the highest net return during this period. This system was under measurement three years of the five-year period and showed a net income of almost $50.00 per acre anually.

1947-1951 Price Level. High-level soil treatments applied according to soil tests produced larger net returns on pastures than on cash grain systems at prices existing in the five-year period 1947-1951. The relatively higher purchasing power of beef than of grain during this period made pasture farming a highly profitable venture. Fertilized grain systems showed annual net returns of $23.00 to $56.00 per acre, compared with $44.00 to $68.00 on the pastures. The use of fertilizer, including nitrogen, was profitable on Kentucky bluegrass at this price level. An untreated plot had a net return of $39.00 compared with $44.00 on an adjacent fertilized plot.

Bromegrass with Ladino clover gave a net return of more than $100.00 per acre in 1951 by producing 493 pounds of beef. Production by this pasture was only 207 pounds per acre in 1950 as a result of grazing management. The plot was grazed as a unit in 1950 but was rotation grazed in 1951. It seems definite that rotation grazing is necessary for maximum production from these highly fertilized tall grass and Ladino clover mixtures. Two-year average net return was $68.00.

Alta fescue, which was under measurement the same two years, showed a net return of $62.00. This plot was seeded to birdsfoot trefoil and alta fescue originally but the trefoil was lost by heaving. Ladino clover was seeded on it in 1951 but did not contribute measurably to production that year. Data for these plots with fewer years of data are included for general information only and are not intended to indicate the level of production expected over extended periods.

The cost of producing a bushel of corn equivalent with high-level soil treatments was materially less with pastures than with grain and hay rotations. Moreover, it was less expensive to produce a bushel of corn equivalent on pastures with high-level treatments than with small fertilizer additions. With small additions the cost was 32 cents per bushel, while under high-level treatments the cost was 29 cents per bushel. The fact that a more favorable weather period coincided with the high-level soil treatment years should not be overlooked. With grain and hay systems, on the other hand, the cost of producing a bushel of corn equivalent was 17 to 18 percent higher with high-level treatments than with light fertilizer additions. This means of showing the economics of production, while not indicating the return, is useful in showing the relative position of the various systems when the price of commodities produced is removed as a variable.

The extent to which farmers increase their pasture acreage and enlarge their livestock enterprise of necessity depends on many factors. Among these are the farmer's likes, his aptitude, size of farm, livestock program, equipment, physical improvements, and operating capital. The movement toward a predominantly pasture type of farming on these claypan soils seems justified, however, based on the data presented in this report on production, economic return, and conservation of soil and water.

SUMMARY

1. Runoff, soil loss, and production data are presented for several pasture and cash grain systems under two levels of soil fertility treatments on a midwestern claypan soil.

2. The costs of production, gross, and net income from these systems were determined at two price levels. The lower price level was that of the seven-year period 1940-1946, when the beef-corn price ratio was 12.6. The higher price level was that of the five-year period 1947-1951, when the beef-corn price ratio was 17.4.

3. Small amounts of fertilizer were applied just as economically to pastures as to cash grain systems at the lower price level.

4. High-level soil treatments were more profitable on grain rotations than on pastures at the lower price level. Cash grain systems which included corn produced from $1.00 to $7.00 larger net returns per acre annually than the highest producing pasture under these conditions.

5. Net return from pastures was larger than from grain systems at the higher price base. This was true under both levels of fertility treatment.

6. In general, a bushel of corn equivalent was produced more economically on pastures under both levels of fertility treatment and at both price levels, though there were individual exceptions.

7. It was only at the higher prices that fertilizer additions and sweet clover seeding in native Kentucky bluegrass pastures proved economical.

8. Under high-level soil treatment, Kentucky bluegrass with Korean lespedeza produced higher net return than Kentucky bluegrass with nitrogen fertilizer.

9. Unlimed and unfertilized claypan soil produced larger net returns in unimproved pasture than in a rotation of corn-oats.

10. One pasture, bromegrass and Ladino clover with high-level soil treatment, produced a net income of $102.85 in 1951, when computed at the high price level.

11. The movement toward a predominantly pasture type of farming on these claypan soils seems warranted from the standpoints of production, economic return, and conservation of soil and water.

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APPENDIX

TABLE 13--PRECIPITATION BY MONTHS AND YEARS AT RAINGAUGE NUMBER 4 MIDWEST CLAYPAN SOIL CONSERVATION EXPERIMENT FARM, McCREDIE, MISSOURI 1940-1951*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1940	.94	.66	1.90	2.58	3.06	9.18	1.20	8.12	.35	1.99	1.77	2.60	34.35
1941	2.76	.15	.76	6.69	1.97	4.24	7.22	2.45	6.64	17.74	2.46	1.09	54.17
1942	.46	2.47	1.76	2.62	4.57	10.30	2.11	2.39	4.26	1.95	3.91	4.77	41.57
1943	.64	.80	1.75	2.42	12.05	6.19	3.71	1.16	3.13	3.29	1.12	1.66	37.92
1944	.46	2.46	2.94	6.12	4.54	.46	1.85	6.54	4.19	1.77	1.43	1.07	33.83
1945	.87	1.82	5.66	5.43	5.05	7.53	.74	.87	13.13	.86	.98	.52	43.46
1946	2.20	1.85	2.60	3.01	5.99	1.35	1.80	4.84	1.24	5.88	5.30	1.05	37.11
1947	.83	.14	3.08	6.57	3.11	7.69	2.91	.35	2.75	3.17	1.21	1.70	33.51
1948	1.22	1.34	4.41	.95	3.53	6.86	6.24	4.34	2.00	3.65	3.22	1.22	38.98
1949	5.48	2.40	4.67	1.73	3.46	5.93	3.76	4.83	5.04	4.71	.96	3.04	46.01
1950	2.30	1.60	2.65	3.11	1.98	3.07	2.13	5.20	.55	1.04	1.33	.12	25.08
1951	1.50	4.03	3.75	1.99	2.85	6.52	2.35	4.22	5.65	3.59	1.66	1.75	39.86
Normal	2.12	1.78	2.90	3.84	4.73	4.69	3.59	3.59	4.29	3.12	2.51	2.06	39.22

*Precipitation data in this table apply to all other tables containing runoff and soil loss data.

TABLE 14--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM TIMOTHY AND KOREAN LESPEDEZA SERIES I, PLOT I, 1940-1948

Year	Runoff Amount	Soil Loss Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Pounds	
1940	3.10	0.09	145	119
1941	16.62	.75	233	126
1942	11.62	.14	293	142
1943	9.92	.85	221	100
1944	6.52	.62	241	97
1945	13.69	.37	193	132
1946	5.05	0	267	148
1947	6.84	.31	178	103
1948	6.47	.15	395	109

TABLE 15--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM TIMOTHY, SWEET CLOVER, AND KOREAN LESPEDEZA, SERIES I, PLOT 5 1940-1946

Year	Runoff Amount	Soil Loss Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Pounds	
1940	2.21	0.07	215	148
1941	15.63	1.17	246	143
1942	7.05	.11	235	138
1943	7.22	.35	230	123
1944	3.95	.33	256	103
1945	12.98	.10	193	138
1946	2.82	0	313	161

TABLE 16--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM OATS (HAY) AND KOREAN LESPEDEZA SERIES I, PLOT 2, 1940-1948

Year	Runoff Amount	Soil Loss Per Acre	Oat Hay Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Tons	Pounds	
1940	2.82	.08	1.26	103	104
1941	19.13	5.33	1.43	108	75
1942	10.82	1.33	1.31	121	83
1943	10.42	2.74	1.39	130	78
1944	9.34	3.96	.46	75	64
1945	15.79	4.56	.68	77	69
1946	5.36	.10	1.12	204	100
1947	2.40	.34	1.03	251	103
1948	2.64	.71	1.58	111	62

TABLE 17--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM WHEAT AND KOREAN LESPEDEZA SERIES I, PLOT 3, 1940-1951

Year	Date Wheat Completed	Runoff Amount	Soil Loss Per Acre	WHEAT Beef Production Per Acre	WHEAT Animal Unit Days Per Acre	LESPEDEZA Beef Production Per Acre	LESPEDEZA Animal Unit Days Per Acre
		Inches	Tons	Pounds		Pounds	
1940	May 28	3.62	.11	101	57	167	99
1941	June 7	20.81	4.96	152	51	87	66
1942	June 16	11.40	1.72	127*	62	160	87
1943	May 18	9.48	2.89	83	32	86	78
1944	May 26	7.02	1.41	106	33	71	64
1945	June 8	16.00	2.21	154	66	85	69
1946	May 28	4.01	.75	188	55	258	100
1947	June 2	4.98	1.60	219	54	262	137
1948	June 18	7.70	1.94	195	47	213	76
1949	June 15	9.11	4.44	124	39	205	88
1950	June 20	1.52	.08	122	43	132	62
1951	June 5	4.20	.41	122	46	197	102

*Seeded to oats spring 1942, too wet to seed wheat previous fall.

TABLE 18--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM BARLEY AND SOYBEANS SERIES I, PLOT 4, 1940-1947

Year	Runoff Amount	Soil Loss Per Acre	Soybean Hay Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Tons	Pounds	
1940	1.99	.25	1.10	145	95
1941	17.58	7.78	1.25	123	53
1942	10.00	3.57	1.86	*	9
1943	11.66	6.41	1.09	64	27
1944	4.19	1.45	1.58	190	66
1945	11.97	6.85	1.05	86	37
1946	3.51	1.19	1.12	126	47
1947	2.26	.80	**	88	30

*Barley winterkilled.
**Beans harvested for grain 7.66 bushels per acre.

TABLE 19--RUNOFF AND PRODUCTION BY YEARS FROM KENTUCKY BLUEGRASS WITH SOIL TREATMENT SERIES I PLOT 7, 1943-1951

Year	Runoff Amount	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Pounds	
1943	*	109	77
1944	*	78	114
1945	17.15	163	138
1946	6.63	310	149
1947	7.45	184	160
1948	5.00	364	134
1949	10.31	320	157
1950	2.20	203	120
1951	3.18	238	143

*Not measured.

TABLE 20--RUNOFF AND PRODUCTION BY YEARS FROM KENTUCKY BLUEGRASS WITHOUT SOIL TREATMENT SERIES I PLOT 8, 1943-1951

Year	Runoff Amount	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Pounds	
1943	*	104	77
1944	*	78	79
1945	17.02	146	110
1946	7.18	132	107
1947	6.69	139	82
1948	6.69	255	106
1949	12.21	209	96
1950	3.41	98	67
1951	9.27	163	85

*Not measured.

TABLE 21--RUNOFF AND PRODUCTION BY YEARS FROM BROMEGRASS AND LADINO CLOVER SERIES I PLOT 9, 1949-1951

Year	Runoff Amount	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Pounds	
1949	10.81	110	127
1950	2.59	207	147
1951	2.72	493	259

TABLE 22--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM KENTUCKY BLUEGRASS AND KOREAN LESPEDEZA SERIES I, PLOT 5 1947-1951

Year	Runoff Amount	Soil Loss Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Pounds	
1947	5.23	0.27	307	122
1948	4.17	.10	370	124
1949	8.00	.12	232	189
1950	1.29	0	307	119
1951	*	*	323	120

*Not measured

TABLE 23--PRODUCTION BY YEARS FROM BROMEGRASS SERIES I PLOT 6, 1947-1951*

Year	Beef Production Per Acre	Animal Unit Days Per Acre
	Pounds	
1947	389	135
1948	242	78
1949	170	125**
1950	168	66
1951	303	141

*Sweet clover seeded in area 1946-1949. Nitrogen treatments started fall 1950.
**Insufficient cattle to utilize sweet clover; also produced 27 lb. sweet clover seed per acre.

TABLE 24--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM ALTA FESCUE SERIES I PLOT I, 1949-1951

Year	Runoff Amount	Soil Loss Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Pounds	
1949	9.13	2.94	106	122
1950	2.15	0	307	125
1951	*	*	335	172

*Not measured

TABLE 25--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM RYE AND SOYBEANS (GRAIN) SERIES I, PLOT 4, 1948-1950

Year	Runoff Amount	Soil Loss Per Acre	Bean Yield Per Acre	Beef Production Per Acre	Animal Unit Days Per Acre
	Inches	Tons	Bushels	Pounds	
1948	2.23	.39	37.5	350	58
1949	6.30	1.03	30.3	66	23
1950	.94	.06	29.7	*	0

*Rye seeding delayed fall 1949 and winterkilled.

TABLE 26--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM OATS AND KOREAN LESPEDEZA SERIES II PLOTS 1, 3 AND 5, 1940-1946*

Year	Runoff Amount	Soil Loss Per Acre	YIELD Oat Hay Per Acre	Lespedeza Hay Per Acre
	Inches	Tons	Tons	Tons
1940	2.46	.05	1.53	1.63
1941	16.92	4.19	1.71	.43
1942	10.01	.66	1.23	.93
1943	9.62	2.48	1.06	.76
1944	6.34	2.30	.33	.25
1945	14.20	2.67	1.03	.27
1946	4.77	.14	.98	.34

*Data are the average of three plots.

TABLE 27--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM WHEAT AND KOREAN LESPEDEZA SERIES II PLOTS 2, 4 AND 6, 1940-1946*

Year	Runoff Amount	Soil Loss Per Acre	YIELD Wheat Per Acre	Lespedeza Hay Per Acre
	Inches	Tons	Bushels	Tons
1940	3.20	.07	23.7	1.77
1941	17.79	3.31	16.7	.33
1942	9.84	1.84	42.8**	1.31
1943	10.11	1.28	7.7	.88
1944	6.09	1.50	14.3	.09
1945	13.64	1.04	20.2	.44
1946	3.69	.15	15.5	.14

*Data are the average of three plots.

**Oat yield equivalent to 17.5 bushels of wheat. Wheat seeding prevented by wet fall 1941.

TABLE 28--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - CORN - OATS - WHEAT (SWEET CLOVER) SERIES II PLOTS 9, 14, 19 AND 24, 1940-1946*

	FIRST CORN			SECOND CORN			OATS			WHEAT		
Year	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Bushels
1940	**	**	47.4	**	**	35.6	**	**	27.8	**	**	17.8
1941	17.83	7.88	36.9	23.25	17.44	31.4	17.50	10.46	49.7	18.39	6.77	49.0***
1942	10.49	7.22	59.1	10.41	9.26	57.3	13.67	8.35	33.5	9.56	.69	38.2***
1943	10.03	7.00	42.6	9.68	13.64	36.0	10.67	5.00	46.2	11.23	4.14	8.5
1944	7.35	.24	19.4	5.89	2.38	24.1	7.04	6.00	13.7	6.52	5.18	18.2
1945	11.85	3.74	12.4	14.52	5.41	1.9	12.80	9.26	28.1	10.67	1.58	20.4
1946	2.67	.25	24.9	5.35	.60	26.2	8.75	2.61	30.2	2.79	.10	16.1

*Sweet clover turned under before first corn.
**Not measured, equipment installed fall of 1940.
***Oats, wheat winterkilled winter 1940-41 and wheat seeding prevented fall 1941 by wet weather.

TABLE 29--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - WHEAT - MEADOW SERIES II PLOTS 29, 33 AND 37, 1940-1946*

Year	CORN Runoff Amount	CORN Soil Loss Per Acre	CORN Yield Per Acre	WHEAT Runoff Amount	WHEAT Soil Loss Per Acre	WHEAT Yield Per Acre	MEADOW** Runoff Amount	MEADOW** Soil Loss Per Acre	MEADOW** Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Tons
1940	***	***	36.7	***	***	18.5	***	***	1.98
1941	***	***	43.0	***	***	6.5	***	***	1.48
1942	***	***	48.5	***	***	42.9****	***	***	.98
1943	8.43	1.97	37.0	7.36	1.42	13.8	8.31	.03	1.11
1944	6.75	.33	31.0	5.12	2.47	11.5	7.26	.06	.65
1945	13.88	1.87	8.8	13.34	1.30	22.3	13.39	.28	1.34
1946	6.25	1.21	23.5	3.70	.02	14.6	3.70	.03	1.30

*Soil loss values adjusted to a 3 percent slope, plots were on a 3.5 percent slope.
**Meadow was predominantly red clover and timothy except in 1940 when it was Korean lespedeza.
***Not measured, equipment installed fall of 1942.
****Oats, wheat seeding prevented fall 1941 by wet weather.

TABLE 30--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - OATS, SERIES II, PLOTS 25 AND 26, 1940-1946

Year	CORN Runoff Amount	CORN Soil Loss Per Acre	CORN Yield Per Acre	OATS Runoff Amount	OATS Soil Loss Per Acre	OATS Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels
1940	*	*	45.8	*	*	36.0
1941	20.57	20.77	33.5	23.69	8.15	28.8
1942	12.46	14.52	46.0	15.13	5.98	28.8
1943	12.52	21.39	31.0	11.76	4.72	15.5
1944	6.72	2.80	24.0	11.31	6.35	10.1
1945	17.47	6.72	1.7	17.90	9.34	10.0
1946	6.60	.92	17.1	8.32	1.68	23.8

*Not measured, equipment installed fall of 1940.

TABLE 31--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN (RYE) - SOYBEANS - WHEAT - MEADOW
SERIES II, PLOTS 7, 12, 17 AND 22, 1947-1951*

	CORN			SOYBEANS			WHEAT			MEADOW		
Year	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Tons
1947	4.18	.67	30.3	7.04	2.91	1.5	6.56	3.11	26.3	6.24	.64	1.98
1948	9.52	4.69	103.3	3.81	.99	23.8	2.63	.27	40.5	3.36	.06	2.57
1949	9.67	1.75	97.2	11.00	1.07	36.1	9.81	.59	23.0	7.88	.11	2.22
1950	3.27	0	111.2	1.07	.05	40.3	1.46	.04	20.2	1.56	0	2.79
1951	3.01	2.06	110.7	5.33	.56	33.4	1.85	.40	34.2	**	**	3.14

*Rye winter cover turned under before soybeans. Meadow consisted primarily of red clover and timothy.
**Not measured in 1951.

TABLE 32--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - WHEAT - MEADOW SERIES II PLOTS 29, 33 AND 37, 1947-1951*

Year	CORN Runoff Amount	CORN Soil Loss Per Acre	CORN Yield Per Acre	WHEAT Runoff Amount	WHEAT Soil Loss Per Acre	WHEAT Yield Per Acre	MEADOW** Runoff Amount	MEADOW** Soil Loss Per Acre	MEADOW** Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Tons
1947	5.46	.46	29.9	5.04	1.46	16.7	6.24	.53	1.98
1948	7.61	4.27	118.0	2.39	.17	27.3	3.93	.06	2.46
1949	9.52	.59	83.3	10.08	2.23	15.4	9.22	.25	1.92
1950	2.01	0	119.3	1.53	.07	9.5	2.17	0	2.22
1951	1.98	1.95	105.8	2.70	.32	30.0	***	***	2.96

*Soil loss values adjusted to a 3 percent slope, plots were on a 3.5 percent slope.
**Meadow consisted primarily of red clover and timothy.
***Not measured in 1951.

TABLE 33--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM SOYBEANS - SMALL GRAIN - MEADOW SERIES II PLOTS 11, 16 AND 21, 1947-1951

Year	SOYBEANS Runoff Amount	SOYBEANS Soil Loss Per Acre	SOYBEANS Yield Per Acre	SMALL GRAIN* Runoff Amount	SMALL GRAIN* Soil Loss Per Acre	SMALL GRAIN* Yield Per Acre	MEADOW** Runoff Amount	MEADOW** Soil Loss Per Acre	MEADOW** Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels	Inches	Tons	Tons
1947	5.91	1.86	1.2	3.65	1.21	6.7	6.57	.89	1.55
1948	7.05	3.46	24.4	2.93	.20	46.5	3.34	.08	2.69
1949	6.96	.38	36.4	9.74	.61	35.6	12.07	.17	1.94
1950	2.83	0	30.3	1.48	.05	22.1	3.64	0	2.26
1951	2.30	.45	33.8	1.99	.25	32.6	#	#	1.99

*Small grain was barley in 1947, rye in 1948-1950, and wheat in 1951.
**Meadow consisted primarily of red clover and timothy.
Not measured in 1951.

TABLE 34--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - OATS (SWEET CLOVER) SERIES II PLOTS 5 AND 6, 1947-1951*

Year	CORN Runoff Amount	CORN Soil Loss Per Acre	CORN Yield Per Acre	OATS Runoff Amount	OATS Soil Loss Per Acre	OATS Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels
1947	5.45	2.00	42.0	3.55	.35	23.8
1948	6.02	2.68	111.4	3.10	.34	36.7
1949	8.26	.69	99.7	10.16	.48	20.9
1950	.73	0	117.3	1.01	.01	50.0
1951	3.87	1.71	103.0	6.46	.11	27.4

*Sweet clover turned under before corn.

TABLE 35--RUNOFF, SOIL LOSS AND PRODUCTION BY YEARS FROM CORN - OATS SERIES II, PLOTS 25 AND 26, 1947-1951

	CORN			OATS		
Year	Runoff Amount	Soil Loss Per Acre	Yield Per Acre	Runoff Amount	Soil Loss Per Acre	Yield Per Acre
	Inches	Tons	Bushels	Inches	Tons	Bushels
1947	5.06	1.61	6.8	9.45	3.86	10.4
1948	10.79	6.18	27.9	10.85	2.82	4.3
1949	14.75	1.86	20.8	14.61	1.69	5.0
1950	1.94	.04	28.1	2.94	.06	6.5
1951	13.34	5.23	18.0	14.10	1.62	4.3

TABLE 36--AVERAGE COST OF FARMING OPERATIONS IN THE TWO PERIODS, 1940-1946 AND 1947-1951*

Farming Operation	Average Cost Per Acre 1940-1946	1947-1951
Plowing	$1.54	$1.90
Disking	.52	.62
Harrowing	.24	.29
Planting (corn, beans)	.45	.56
Cultivating (first time)	.76	.92
Cultivating (second time)	.56	.67
Cultivating (third time)	.44	.53
Husking	3.03	3.85
Drilling (grain)	.56	.77
Combining	1.75	2.32
Mowing	.57	.72
Raking	.47	.69
Baling	2.50	3.32
Seeding (hand)	.11	.21
Fertilizing (spreader)	.35	.44
Rotary hoeing	.24	.31
Shredding (stalks)	.54	.70

*These costs include machinery, fuel, lubricants and labor.

TABLE 37--AVERAGE COST OF FERTILIZERS IN THE TWO PERIODS 1940-1946 AND 1947-1951

Kind of Fertilizer	Average Cost Per Ton 1940-1946	1947-1951
3-12-12	$40.85	$45.39
8-8-8	46.10	56.35
10-20-20*	88.25	103.37
33-0-0	62.60	73.77
0-12-12	36.75	39.52
0-20-10	45.55	47.74
0-20-20	55.45	58.36
0-0-50	51.95	56.85
Rock Phosphate**	19.94	22.15
Lime**	2.45	2.50

*This is the equivalent cost for the mixture prepared at the farm.
**Prices include cost of spreading in the field.

TABLE 38--AVERAGE COST OF SEED IN THE TWO PERIODS 1940-1946 AND 1947-1951

Seed	Unit	Average Cost Per Unit 1940-1946	1947-1951
Corn	bushel	$7.53	$9.64
Barley	bushel	1.47	2.45
Oats	bushel	.89	1.49
Rye	bushel	1.64	2.74
Wheat	bushel	1.77	3.04
Soybeans	bushel	2.61	4.06
Alfalfa	100 lb.	32.10	53.50
Alsike clover	100 lb.	30.40	49.50
Ladino clover	100 lb.	133.80	223.00
Lespedeza (Korean)	100 lb.	8.21	8.98
Red clover	100 lb.	28.65	50.60
Sweet clover	100 lb.	13.32	21.92
Alta fescue	100 lb.	31.32	52.20
Bromegrass	100 lb.	18.36	30.60
Orchard grass	100 lb.	16.44	27.40
Red top	100 lb.	13.45	38.20
Timothy	100 lb.	7.65	14.44

TABLE 39--AVERAGE COST OF MISCELLANEOUS OTHER ITEMS OF PRODUCTION IN THE TWO PERIODS 1940-1946 AND 1947-1951

Item	Unit	Average Cost Per Unit 1940-1946	1947-1951
Labor	hour	$0.26	$0.49
Cattle*	100 lbs.	12.55	25.38

*Average weight of cattle per head at purchase time, 1940-1946: 548 pounds, 1947-1951: 585 pounds.

TABLE 40--AVERAGE PRICES RECEIVED BY MISSOURI FARMERS FOR VARIOUS COMMODITIES IN THE TWO PERIODS 1940-1946 and 1947-1951*

Commodity	Unit	Average Price Per Unit 1940-1946	1947-1951
Corn	bushel	$0.92	$1.49
Barley	bushel	.90	1.23
Oats	bushel	.58	.78
Rye	bushel	1.03	1.65
Wheat	bushel	1.27	2.01
Soybeans	bushel	1.81	2.55
Sweet clover seed	bushel	5.51	8.52
Clover-timothy hay	ton	15.00	18.42
Oat hay	ton	13.14	16.41
Soybean hay	ton	15.59	19.14
Lespedeza hay	ton	15.43	17.28
Beef	100 lb.	11.59	25.92

*All prices from Bureau of Agricultural Economics, USDA, except beef. The prices shown for beef are from actual sales of cattle at central markets.