EFFECTS OF WATERSHED TREATMENTS ON FARM PRODUCTION IN THE SABETHA LAKE WATERSHED

by

TERRY PAUL SUTTON

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Approved by:

Wilfred H. Pine
Major Professor

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure Page

CHAPTER I

INTRODUCTION

Background

Public and private feelings about conservation of land and water resources in this country have changed from apathy to active interest and concern during the course of this century. A unit in which a coordinated conservation program is possible is the watershed. A watershed is, basically, a drainage area; an area in which the boundaries may be found readily. A watershed is also an area in which the firms located in its boundaries are interrelated. Events in a watershed affect many people and firms outside its boundaries; this is evidenced by numerous floods and sedimentation of reservoirs and lakes.

Public interest in watershed programs as a means of facilitating conservation of land and water, was first expressed in the Flood Control Act of 1936 in which watershed management was recognized as a principal step toward flood control. Various other acts in later years have been passed concerning watersheds until a number of watershed programs in the United States are underway. This paper deals with the results of one such program in a relatively small watershed in Northeastern Kansas.

This watershed is located near the town of Sabetha, Kansas. The city uses the lake the watershed drains into as a source of municipal water. The watershed program was initiated as a concerted effort to save this lake from sedimentation.

History of the Sabetha Watershed

The town of Sabetha, Kansas, is located in Nemaha County in Northeastern Kansas about seven miles south of the Kansas-Nebraska state line. The town is located in an area that is conducive to agricultural production. The topography is moderately sloping to strongly rolling or hilly; elevations range from 1,089 feet to 1,351 feet above sea level.[1]

The climate of Nemaha County is favorable for production of most of the crops grown in the State of Kansas. The major crops produced in Nemaha County are corn, soybeans, grain sorghums, hay, wheat, oats, and barley (ranked according to total acreages planted in each crop for the year 1959). The county average yields run approximately 115 percent to 120 percent of the state average yields for most crops.[2]

The mean annual temperature in Nemaha County is 53 degrees Fahrenheit, with 114 degrees Fahrenheit and minus 34 degrees Fahrenheit the recorded maximum and minimum. Mean annual precipitation is between 31 and 32 inches, with 44 inches and 23 inches the recorded maximum and minimum. Almost three-quarters of this precipitation falls during the normal growing season of April 25th to October 15th.[3]

The various soils of Nemaha County are the result of the work of nature for thousands of years after the limestone-shale and sandstone-shale hills

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[1] United States Department of Agriculture, Soil Conservation Service, Physical Land Conditions Affecting Use, Conservation, and Management of Land Resources, Nemaha County, (Manhattan, Kansas, October, 1951), p. 1.

[2] Kansas State Board of Agriculture, Kansas Agriculture, 42nd Report to Legislature of State, Kansas State Board of Agriculture (Topeka, Kansas: 1959).

[3] United States Department of Agriculture, Soil Conservation Service, p. 2.

were covered with a variety of materials by glacial activity. After the withdrawal of the glaciers, a thin covering of wind-borne silts (loess) was laid down over the countryside (part of this mantle of silt has been eroded off of the steeper hills). Nemaha County is included in the natural land resource area known as the Kansas-Nebraska Loess Drift Praires.[4]

The biggest single problem facing the agricultural community of Nemaha County is the control of runoff water and the accompanying erosion. The people of Sabetha became acutely aware of this problem in 1951 when a sedimentation study (conducted by the Soil Conservation Service of the United States Department of Agriculture) of the Sabetha Lake Reservoir revealed that the storage capacity had been sharply reduced.

The reservoir, which is five miles west of Sabetha, was built in 1935 as a municipal water supply for Sabetha; water was first pumped for this pumped for this purpose in 1936. Originally, the reservoir had a storage capacity of 1,346 acre-feet; this was reduced to 737 acre-feet in 15 years.[5] This 45 percent reduction in storage capacity was caused mostly by "sheet and rill erosion of the farmland"[6] in the reservoir's watershed. The sedimentation was equivalent to an average annual contribution of nine tons from each acre in the drainage area. This rate was the highest that had been measured for watersheds of comparable size in the Loess-Drift Prairies of Kansas and Nebraska.[7]

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[4] Ibid, p. 1.

[5] Louis M. Glymph, Jr., Advance Report on the Sedimentation Survey of Sabetha City Reservoir, United States Department of Agriculture, Soil Conservation Service (Lincoln, Nebraska: August, 1952), p. 2.

[6] Ibid, p. 7.

[7] Ibid, p. 2.

The sedimentation of the reservoir was the grave concern of two groups in the area. First, the remaining useful life of the reservoir was projected to be about nine years after 1952;[8] a drought after 1961 would place Sabetha in a water shortage crisis. Furthermore, at past rates of storage capacity depletion, the reservoir would be entirely filled in with sediment by 1970.[9]

Secondly, the sedimentation represented a substantial loss in production capabilities[10] together with higher costs of production for those engaged in agriculture in the watershed.

Four alternatives were available to the City of Sabetha to alleviate the approaching disaster; these were:

1. When sediment deposits become too great, dredge the reservoir (this alternative was deemed too costly).

2. Use the reservoir as is until it becomes useless and abandon it along with the accompanying water works and pipeline (this was also a costly alternative).

3. Raise the dam to provide more storage capacity (this was done in 1955, increasing the storage capacity to 1165 acre-feet).

4. Reduce sedimentation by control of runoff water and erosion in the watershed by land treatments designed to do this (this was started in 1952).

The individual farmers in the watershed had a wider range of alternatives--really just varying degrees of one alternative or another. The farmers could have continued farming the land with no more concern for erosion control

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[8] Ibid, p. 9.

[9] Weekly Star Farmer (Kansas City, Missouri) November 19, 1952.

[10] See George H. Walter, Evaluating Measures to Prevent Topsoil Erosion, Agricultural Economics Research, (April, 1950) and J. H. Stallings, Erosion of Topsoil Reduces Productivity, United States Department of Agriculture, Soil Conservation Service, 1950.

than they already had. This could have continued until the intensive level of production being practiced at the time was no longer advisable or profitable. After this intensive level of production became unwise, the average size of the farms could be enlarged until farming was again profitable under a more extensive level. This alternative would entail considerable loss of investment due to abandonment of farmsteads, fences, etc.

The other alternative available to the farmers in the watershed was to initiate erosion control measures in order to hold soil loss at a minimum. Of course, any degree of this erosion control could be applied, depending upon the attitude of the individual farmer.

The City of Sabetha and the farmers in the watershed reacted quickly and almost unanimously to the sedimentation report. In 1950 and 1951, concerned citizens of the city and the farmers met to discuss plans to control the run-off water and erosion in the reservoir's watershed and thereby lengthen the life of the reservoir and the farms involved. The Soil Conservation Service of the United States Department of Agriculture was consulted and plans for grade stabilization structures, waterways, dams, ponds, terraces, and other measures to control erosion were formulated in 1951.[11]

By the last half of 1952, the plan to save the reservoir was well under way--about a third of the erosion control structures had been completed and over ninety percent of the farm owners and operators had agreed to support the plan.[12]

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[11] Weekly Star Farmer, Kansas City, Missouri, June 13, 1951.

[12] Glymph, p. 8.

The Problem

The action of the farmers in the Sabetha Watershed provided a basis for this study. This study is concerned with the question confronting the farmer when he considers initiating erosion control measures on his land: Will land treatments, introduced to gain on-site benefits such as a reduction in soil loss and off-site benefits such as flood and sediment control, increase crop yields substantially? To go a step further, if there is an increase in crop yields, will the benefits exceed the costs associated with the land treatments?

Objectives

The objectives of this study were:

1. To note the significant changes that took place in the Sabetha Watershed over the ten year period studied.

2. To determine how and to what extent specific land treatments affect crop yields and farm income.

3. To ascertain the optimal economic combination of land treatments with respect to farm income.

Hypothesis

The hypothesis tested by this study was: That specific land treatments were economically advisable with respect to farm income for the individual farmer in the Sabetha Watershed.

This hypothesis can be subdivided into two components: (1) Specific land treatments result in a significant increase in crop yields. (2) This increase in crop yields, when put in terms of money, makes the utilization of land treatments profitable for the individual farmer.

The Scope

Because of the relatively small area of the Sabetha Watershed, this study was able to include every farm operation that took place in the watershed during the ten year period studied. However, in some parts of the analysis, much of these data had to be deleted in order to make meaningful comparisons and correct inferences from these comparisons.

General Procedure

A comprehensive set of data was collected from the Sabetha Watershed for the years 1953 to 1962. These data included:

1. Soil classification for each acre of land.
2. Detailed field use information for each acre of land.
3. Detailed land treatment information for each field.
4. If a crop was planted, its type and yield.
5. If a grass was grown, its use, type and yield.
6. Amount and type of fertilizer and lime inputs including manure (which was converted to pounds of nitrogen, pounds of potash, etc.).
7. Crop residue and crop damage.
8. Type and number of livestock on each farm.
9. Type of tenure arrangement on each field.

These data were collected through personal interview and correspondence with the individual farm operators over the ten year period. The information thus gathered was then coded and punched on computer cards for computational ease.

The assumptions used in making inferences from the results of the study were the following:

1. That each farmer strived to gain the maximum net income from his particular operation.

2. That the thirty-nine farmers in the Sabetha Watershed had equal managerial abilities.

3. That each farmer followed techniques approved by the Soil Conservation Service when applying the land treatments he chose for his particular farm.

Data describing the watershed, land uses, and land treatments were summarized and are presented in a subsequent section of this thesis. Statistical analyses were made of crop yields for varying levels of land treatments. The results obtained from these analyses are described later in this thesis also.

Usually one person is in charge of planning, collecting, and analyzing the data in a study of this type. In this particular study however, the data were collected by individuals who left the institution where the research was being done. As a consequence, the objectives of the original workers may have differed somewhat from the objectives of the final worker.

CHAPTER II

REVIEW OF LITERATURE

Interest in research concerning the effectiveness with respect to crop yields of watershed land treatments or erosion control measures was very strong in the late 1940's and early 1950's. As of late, however, the number of articles pertaining to this subject appearing in journals or bulletins has fallen off considerably. For this reason, many of the articles cited here bear dates that are fifteen to twenty years old.

No matter when the research was done, one idea is consistently apparent in almost every article on the relationship between erosion control measures, crop yields and farm income. That is, the results obtained most likely are applicable only to that particular set of circumstances. A locale with different soils, climate, and history will have production capabilities and response to the treatment that are different from the locale where the experiment took place. This should not be interpreted to mean that the direction of influence that erosion control measures have on crop yields will differ between two sites; but only that the magnitude of influence probably will be different.

In addition to agreeing that their results apply only to a particular locale or to a site with similar soils and climate, most researchers find that erosion control measures or "conservation" do influence crop yields favorably and that this influence is enough to result in an increase in net income. In other words, the income increase resulting from increased production because of the erosion control measures exceed the costs of the measures.

Most researchers also find that increases in income as a result of watershed treatments do not occur immediately. Magee, Baird, and Pope[1] working in Texas found that cotton yields did not improve until the third year conservation measures (terraces, contour farming, sodding of permanent waterways, and the correct land use pattern) were in effect. They decided that, "As a rule, conservation measures do not increase farm earnings immediately." This decrease, or at least not an increase, in farm earnings was a result of a reduction in the acreages of cash crops planted without offsetting increases in yields from the cash crops that were planted.

Magee, Baird, and Pope finally concluded that an adjustment period of six years for farms in the Blackland Praires of Eastern Texas is required before the full effect of erosion control measures on farm incomes can be noticed. After this period, earnings should be about 24 percent greater than a similar farm with no erosion control measures. At the end of twelve years, the benefits from conservation should have paid for the cost of installation and maintenance in addition to compensating for the temporary loss of income incurred while the plan was going into effect.

In North Carolina, Coutu, McPherson, and Martin[2] experimented with costs

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[1] A. C. Magee, Ralph W. Baird, J. B. Pope, Conservation Pays in the Blacklands (College Station, Texas: Texas Agricultural Experiment Station, August 1962).

[2] Arthur J. Coutu, W. W. McPherson, and Lee R. Martin, Methods for Economic Evaluation of Soil Conservation Practices (North Carolina: North Carolina Agricultural Experiment Station, January 1959) Technical Bulletin 137.

and projected returns for (1) terracing with contouring and waterways, (2) terracing and meadow outlets without contouring, (3) terracing with contouring and strip cropping. The crops analyzed were cotton and tobacco. By estimating yields needed to make each operation profitable, and using a procedure for compounding costs and revenues to take account of differences in time periods; they found that terracing with meadow outlets and no contour farming would be the most profitable for both crops.

Getting closer to home, there has been much work done in this field of study in the Midwest. In Illinois, Sauer[3] considered yields from fields with contour farming and yields from fields with up and down tillage on the same farms. Taking a seven year average (1939 to 1945), Sauer found that of 124 farms planting corn, the fields with contour farming showed an increase of 6.9 bushels per acre over the non-contoured fields; this amounted to a 12 percent increase in yields. For forty farms planting wheat, a 3.4 bushel per acre or 17 percent advantage was gained by contouring. Sauer also had some interesting figures on the cost of contouring and regular tillage. Taking a four year average (1940 to 1943) of the cost of tillage without contouring ($19.86 per acre; labor and machinery costs lumped together) and comparing that to a four year average of costs associated with contouring ($18.66 per acre); Sauer found that contour farming cost $1.20 per acre less than regular tillage! Even with this, Sauer concluded that an increase in farm earnings could not be expected immediately after the initiation of the erosion control measures.

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[3] E. L. Sauer, "Economics of Soil Conservation", Agricultural Engineering, Vol. 30, No. 5 (May 1949) pp. 226-228.

Sauer, McGurk, and Norton[4] in a 1948 report found that during the period of 1945 to 1947, forty "high conservation" farms had an annual income advantage of $10.63 per acre over forty "low conservation" farms. They concluded that the increased earnings resulting from the conservation measures would cover the cost of installation in 3.3 years.

In a similar report published in 1954, Sauer and Case[5] discovered that high conservation farms in McLean County, Illinois averaged a $4.77 per acre income advantage over low conservation farms.

Also in Illinois, Cohee[6] revealed that contouring brought in $5.00 per acre more than non-contoured fields with no change in rotation; a change to a more intensive rotation did not result in much of an income advantage. Terracing yielded a $4.68 per acre advantage only after a more intensive rotation was introduced.

Allis[7], on small experimental watersheds near Hastings, Nebraska, found that fields that had erosion control measures (terraces, contouring, stubble mulch tillage, improved crop rotation, and grass waterways) implemented on them and planted to corn, yielded over 22 percent better than fields with no treatments. This was during the fourth year that the fields had erosion

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[4] E. L. Sauer, J. L. McGurk, and L. J. Norton, Conservation Pays Off!, Illinois Agricultural Experiment Station Mimeograph (Urbana, Illinois: Illinois Agricultural Experiment Station, July 1948).

[5] E. L. Sauer, and H. C. M. Case, Soil Conservation Pays Off Results of Ten Years of Conservation Farming in Illinois (Urbana, Illinois: Illinois Agricultural Experiment Station, 1954).

[6] Melville H. Cohee, "Economic Evaluation of Soil and Water Management Measures," Agricultural Engineering, Vol. 40 (December 1959) pp. 740-745.

[7] John A. Allis, "Conservation Farming on Experimental Watershed Increases Farm Income," Journal of Soil and Water Conservation, Vol. 6, No. 4 (October 1963).

control measures applied to them. Corn yields on non-treated fields were 26.6 bushels per acre in 1950, while fields that were contoured alone yielded 31.4 bushels an acre. Allis ended his article with the statement, "Crop yields on the small watersheds indicate that the evident reduction in runoff through conservation farming brings considerable gains in crop yields and, consequently, higher income for the farmer."

In Tennessee, Atkins[8] analyzed three levels of conservation and their effects on crop yields and farm income. The three levels of conservation were: (1) Low, which consisted of continuous row cropping with contour tillage and no winter cover crop. This procedure resulted in heavy soil losses. (2) Moderate, with continuous row cropping in parallel strips and no winter cover crops. This procedure was associated with moderate soil losses. (3) High, consisting of continuous row cropping, parallel terracing, and winter cover crops. Soil losses were low. The crops analyzed were cotton, corn, and alfalfa. In the short run Atkins found that net returns of farms with high conservation were below the returns of the farms with low conservation. He also found that the net income of the high conservation farms gain slowly on the net incomes of low conservation farms because of a relatively small difference in crop yields.

A research project[9] similar to the one discussed in this paper was conducted by the Soil Conservation Service on the Honey Creek Watershed in Iowa from 1951 to 1960. The work revealed an increase in crop yields after

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[8] Melville H. Atkins, <u>Economic Appraisal of Conservation Farming in the Grenada-Loring-Memphis Soil Area of West Tennessee</u>, (Nashville, Tennessee: Agricultural Experiment Station of the University of Tennessee, October 1963).

[9] United States Department of Agriculture, Economic Research Service and Soil Conservation Service, <u>Watershed Program Evaluation Honey Creek, Iowa</u>, Economic Research Service Bulletin No. 204 (Washington: United States Department of Agriculture, January 1965).

the conservation plan had been put into effect; but, as stated in the bulletin, "The increased yields of corn during the 1956-60 period, . . . should not be attributed to the effects of the project measures alone. Other variables affect yields, but available data do not permit measurements of their quantitative effects." Total farm incomes in this watershed showed a substantial increase from 1954 to 1960 also. The bulletin, with respect to this increase, states, "Lack of sufficient data in the analytical structure precluded isolation and quantification of the numerous variables which contributed to this increase."

Again in Iowa, Ball, Heady, and Baumann[10] found that even when terraces were constructed in the least costly manner (moldboard plows), net crop incomes dropped. The use of fertilizer with terraces and contouring held crop incomes higher than with terracing and contouring alone. They concluded that the minimum time required for income from a farm practicing soil conservation to exceed the income from a non-conservation farm was four years under the assumption of declining prices. They stated further that the minimum time required for accumulated net farm income under a conservation plan to exceed accumulated net farm income under a non-conservation plan was seven years at 1952 prices.

In a most comprehensive and enlightening publication, Micheel and Nauheim[11] discuss a study on erosion control measures that were put into effect on the Walnut Creek Watershed in Brown County, Kansas. Brown County, Kansas is the county directly east of Nemaha County where the Sabetha

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[10] A. Gordon Ball, Earl O. Heady, and Ross V. Bauman, Economic Evaluation of Use of Soil Conservation and Improvement Practices in Western Iowa, United States Department of Agriculture Tech. Bulletin No. 1162 (Washington: United States Department of Agriculture, June 1957).

[11] Charles C. Micheel and Charles W. Nauheim, Economics of Soil Conservation, Northeastern Kansas (Manhattan, Kansas: Kansas Agricultural Experiment Station, Kansas State University, December 1961).

Watershed is located; consequently, many of the soils in the Walnut Creek Watershed are similar to those found in the Sabetha Watershed.

For analytical purposes, Micheel and Nauheim estimated crop yields for two periods, "present" and "projected." They found that crop yields in this area are not greatly affected by soil losses over a period of five to ten years--the present period; in a longer period of 75 to 80 years, soil losses would affect yields detrimentally. As a result, terraces have little or no effect on yields in the short run. Terraces do help to maintain yields at their current level over the long run. It should be noted here, that Micheel and Nauheim assumed that contour farming was always done on terraced land so that the terraced land they discussed was also contoured. They stated also that terraces may increase yields in the dryer years because of the moisture holding characteristics of terraces. In wetter years, terraces may result in lower yields. The greatest increase in yields came from fields that had fertilizer applied.

With respect to returns, fertilizer was found to be the most profitable on all soils in the study. Terraces and associated practices resulted in lower returns on most of the soils studied. However, terraces held the returns at a relatively constant level without the decrease in returns that usually accompany soil depleting practices.

The final publication to be reviewed here is one written by R. D. McKinney,[12] former leader on the Sabetha Watershed Project. In the report,

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[12] R. D. McKinney, Conservation and Watershed Programs, A Report Prepared for the Department of Agricultural Economics (Manhattan, Kansas: Extension Service, Kansas State College, December 1957).

McKinney used several illustrations taken from the Sabetha Watershed. McKinney found that:

> Terracing generally lowers the yield potential of a soil in the first five years (more or less depending on conditions). The period that yields are lower is short and the spread between no treatment yields and terracing yields widens substantially as the years pass.

McKinney also discovered that fertilizer on Grundy Soil Class II gave a quick yield response which could be maintained over time. However, on Carrington Soil Class III, yields start to decline after a peak is reached with the prolonged application of fertilizer.

McKinney predicted that incomes derived from continuous no treatment fields would decline steadily over time. Terracing and contouring result in an immediate drop in income but the loss in income is gained back; future income from terraced and contoured fields should be higher than income from continuous no treatment fields.

McKinney attributed the initial decline in income from fields terraced and contoured to: (1) Retiring cropland into grassland and waterways; (2) the cost of building the terraces and waterways; (3) the annual maintenance cost of terraces and waterways.

McKinney concludes that, if present income was the only goal that was set by the farm manager, the practice yielding the highest income would be fertilization on both Grundy Soil Class II and Carrington Soil Class III. Since soil losses on Grundy Soil Class II have little effect on yields, the most profitable treatment would be fertilizer only.

McKinney's closing statement is quite interesting and, apropos to this study:

> Often terracing and contouring without fertilizer are expected to increase income immediately. In the majority of cases this will not happen. Reduction, in crop yield losses and soil losses, in the long run, are the major benefits from terracing and contouring.

In an unpublished manuscript, R. D. McKinney[13] presented his findings resulting from trying to fit a Cobb-Douglas type production function to data obtained from the Sabetha Watershed for the year 1952. McKinney used the following variables:

Pasture input (X_1) which was measured in terms of acres.

Cropland (X_2), which was also measured in acres.

Variable machinery costs (X_3), measured in dollars and including fuel, repairs, etc.

Machinery investments (X_4), also measured in dollars.

Fertilizer inputs (X_5), valued in dollars.

Terraces (X_6), measured in dollars and arrived at by multiplying the linear feet of completed terraces by the average cost of 4.5 cents per linear foot.

Terraces plus waterways (X_7), included the cost of construction of the terraces plus an average cost of $75 per acre of waterway completed.

Terraces plus other soil erosion control structures such as waterways, dams, etc. (X_8), which included the costs of the completed structures.

Labor (X_9), which was expressed in months.

The dependent variable was gross farm output (Y) which was the summation of all field outputs for 1952 times the prevailing harvest time prices.

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[13] R. D. McKinney, "Sabetha Watershed" (unpublished report, Kansas State University, 1957) pp. 77-86.

McKinney performed some simple correlations between the dependent variable, gross farm output, and the nine independent variables. The largest correlation coefficient was .900 for cropland. Other significant correlation coefficients were found for pasture input, variable machinery costs, fertilizer inputs, and labor. All other coefficients were insignificant, and therefore of little interest. McKinney concluded from this that, ". . . the contribution of any of the soil conservation practices will be small and probably cannot be regarded as evidence of a real relationship . . . ."

McKinney fitted several Cobb-Douglas type production functions to the data using various combinations of the independent variables. The prediction equations he obtained are reproduced in Table 1.

TABLE 1.--Cobb-Douglas type functions obtained by McKinney for data from the Sabetha Watershed, 1952

Function	Sum of Exponents	R^2
$Y_1 = 17.300\ X_1^{.0762}\ X_2^{.7734}\ X_3^{.1185}\ X_4^{.1083}\ X_5^{.0177}\ X_6^{.0137}$	1.1077	.935
$Y_2 = 12.979\ X_1^{.0778}\ X_2^{.7764}\ X_3^{.1637}\ X_4^{.1085}\ X_5^{.0138}\ X_7^{-.0032}$	1.1299	.933
$Y_3 = 13.680\ X_1^{.0747}\ X_2^{.8012}\ X_3^{.1854}\ X_4^{.0955}\ X_5^{.0091}\ X_8^{-.0255}$	1.1403	.937
$Y_4 = 12.974\ X_1^{.0925}\ X_2^{.8346}\ X_3^{.1572}\ X_4^{.1103}\ X_5^{.0120}\ X_6^{.0120}\ X_9^{-.1658}$	1.0529	.936
$Y_5 = 8.943\ X_1^{.1076}\ X_2^{.8912}\ X_3^{.2438}\ X_4^{.1035}\ X_5^{.0061}\ X_7^{-.0116}\ X_9^{-.3092}$	1.0311	.935
$Y_6 = 8.231\ X_1^{.1113}\ X_2^{.9518}\ X_3^{.2742}\ X_4^{.0939}\ X_5^{.0040}\ X_8^{-.0340}\ X_9^{-.3874}$	1.0058	.942

In Table 1, the exponent value for each X is the b or coefficient of elasticity of that variable. The b_2 (coefficient of elasticity for X_2) is significant in all six equations while none of the other b's is significant. The sum of the exponents is greater than one in every case, indicating possible increasing returns to scale.

McKinney found that the coefficients of multiple correlation or R (terms that reveal how close the equation fits the data) for the six Cobb-Douglas functions were all significant. The R values for the six equations are also given in Table 1.

McKinney decided, that in the Sabetha Watershed for 1952, returns to cropland were increasing; consequently, farm size in terms of cropland should have been increased. The returns to pasture were uncertain; however, the statistical results suggested expansion of pasture land. Furthermore, returns from terraces alone (X_6) were adequate when the cost is considered as an investment requiring only an interest return plus depreciation. Negative returns were found for terraces plus waterways (X_7), and terraces with waterways, dams, etc. (X_8).

Methods of analysis were usually not stated in detail in the reports cited in this review of literature; customarily only a general declaration about where the work was done and the methodology followed by the results was given. Most of the studies, however, were done on actual farm data, while a few (such as Allis' work in Nebraska) were done on experimental plots. It would be safe to say, therefore, that differences in soil type, rainfall, and other factors affecting the productive capability of land were not taken into consideration in any detail. Furthermore, it is possible that the actual farm data used in any given study was taken from superior farm operators and not a random sampling of farm operators.

This review of the literature published on the effectiveness of land treatments with respect to crop yields is by no means exhaustive. Rather, the references cited here are the more prominent and interesting ones available.

CHAPTER III

A DETAILED DESCRIPTION OF THE SABETHA WATERSHED

Soils

The 39 farms in the Sabetha Watershed that were studied totaled 5328 acres--only the farmland in the watershed was considered. Of this total, the most prevalent soil type was found to be Grundy Soil Class III (5Lo B 2 III)[1], which comprised 2013.5 acres or 37.8 percent of the total area. The second most common soil type was Pawnee Soil Class III (5T B 2 III) with 1204.0 acres or 22.6 percent.

Grundy silty clay loam is one of the darkest colored soils found in Kansas. It is a very dark grayish brown, moderately heavy loess soil. Its minimum depth is 60 inches and it is found 300 inches down to bedrock. Its topography is nearly level to undulating with slopes up to seven percent; however, Grundy Soil usually occurs on a four percent grade. The permeability of this soil is slow and the major problems associated with the soil are drainage, acidity, and erosion.[2]

Pawnee silty clay loam is a dark gray soil that has developed on glacial till in northern Kansas. Pawnee Soil is characterized by heavy soil on slopes of two percent to seven percent grade in the Sabetha Watershed.

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[1] For an explanation of soil classification, see Appendix A.

[2] O. W. Bidwell, Major Soils of Kansas, Kansas Agricultural Experiment Station, Circular 336 (Manhattan, Kansas: July 1956).

Pawnee varies in depth from 60 inches to 300 inches with a topography that is undulating to rolling. Problems encountered with this soil are erosion, low permeability, and acidity.[3]

Table 2 gives a complete listing of the thirty different soils found in the Sabetha Watershed.

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[3] Ibid.

TABLE 2.—Soils of the Sabetha Watershed

Soil Symbol	Name	Acres	Percentage of Total
75 A 1 I	Grundy	51.0	1.0
Total in Land Use Capability Class I		51.0	1.0
74 A 1 II	Grundy	49.5	.9
75 A 1 II	Grundy	1.0	---
75F A 1 II	Grundy	9.5	.2
5Lo A 1 II	Grundy	164.5	3.1
5Lo B 1 II	Grundy	132.0	2.5
Total in Land Use Capability Class II		356.5	6.7
5Lo B 2 III	Grundy	2013.5	37.8
5T B 2 III	Pawnee	1204.0	22.6
6Lo B 2 III	Sharpsburg	139.0	2.6
6sh B 2 III	Carrington (like)	131.0	2.5
6T B 2 III	Carrington (like)	405.5	7.6
6T C 2 III	Carrington (like)	2.0	---
75 A 2 III	Grundy	9.5	.2
Total in Land Use Capability Class III		3904.5	73.3
5Lo B 3 IV	Grundy	52.5	1.0
5T B 3 IV	Pawnee	333.0	6.3
6Lo B 2 IV	Carrington (like)	12.5	.2
6sh C 2 IV	Carrington (like)	12.0	.2
6T C 2 IV	Carrington (like)	82.5	1.5
6T B 3 IV	Carrington (like)	88.5	1.7
7sh C 2 IV	Carrington (like)	8.5	.1
7T C 2 IV	Carrington (like)	6.5	.1
Total in Land Use Capability Class IV		596.0	11.1
6sh C 2 VI	None	4.0	---
7ch C 2 VI	None	35.0	.7
7sh C 3 VI	None	9.0	.1
71ch C 2 VI	None	13.5	.3
71L C 2 VI	None	54.0	1.0
71L D 2 VI	None	29.5	.6
83 VI	None	235.0	4.4
Total in Land Use Capability Class VI		380.0	7.1
71L D 3 VII	None	26.0	.5
82 VII	None	14.0	.3

Compared to Nemaha County as a whole, the Sabetha Watershed has approximately the same percentage of land in each Land Use Capability Class. However, Nemaha County has a considerably greater percentage of its land in the best Land Use Capability Class--Class I. Table 3 compares the percentages of Nemaha County and the Sabetha Watershed in each Land Use Capability Class.

TABLE 3.--Percentage of total area in each Land Use Capability Class for Nemaha County and the Sabetha Watershed

Land Use Capability Class	Percentage in Nemaha County	Percentage in the Sabetha Watershed
I	13.8	1.0
II	3.1	6.7
III	60.2	73.3
IV	14.1	11.1
VI & VII	8.1	7.9
Total	100.0	100.0

Farm Tenure

There were thirty-nine farms with land in the Sabetha Watershed during the period 1953 to 1962. The land these farms had in the watershed ranged from thirteen acres to 348.0 acres with the average being 136.6 acres. The percentage of acreage that was owner operated rose from 54.9 percent in 1953 to 75.8 percent in 1962. Figure 1 illustrates the change in the percentage of owner operated land in the Sabetha Watershed.

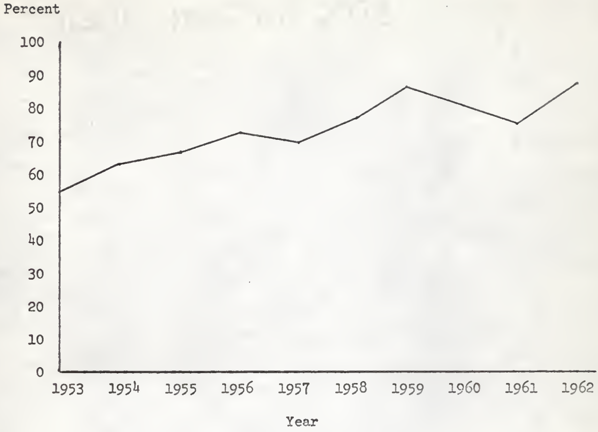

Fig. 1.--Percentage of total farmland owner operated in the Sabetha Watershed, 1953 to 1962.

Land Use

The manner in which the land in the Sabetha Watershed was utilized by the farmers was fairly consistent over the ten-year period studied. Cropland as a percentage of the total area ranged from a high of 63.9 percent in 1959, to a low of 53.9 percent in 1961. Usually cropland accounted for about 58 to 59 percent of the total acreage. Grassland ranked next after cropland in percentage of the total area with an average of about 35 percent. The high in grassland acreage was in 1954 with 37.8 percent of the total area; the low was in 1959 with 31.8 percent. Table 4 gives a complete listing of acreages in each land use for each year.

TABLE 4.--Acres in each land use in the Sabetha Watershed 1953-1962

Year	Cropland	Grassland	Farmstead	Wasteland or Idle	Feed Lot	Soil Bank	School House	Feed Grain Program	Total
1953	3278.5	1918.5	116.0	8.0	4.0	0.0	2.0	0.0	5328.0
1954	3190.0	2008.0	116.0	8.0	4.0	0.0	2.0	0.0	5328.0
1955	3219.0	1981.0	116.0	8.0	4.0	0.0	2.0	0.0	5328.0
1956	3206.0	1988.0	116.0	8.0	8.0	0.0	2.0	0.0	5328.0
1957	3203.5	1825.5	114.0	8.0	8.0	167.0	2.0	0.0	5328.0
1958	3089.5	1873.5	114.0	12.5	8.0	228.5	2.0	0.0	5328.0
1959	3396.5	1701.5	114.0	13.0	8.0	91.0	2.0	0.0	5328.0
1960	3218.0	1792.0	121.5	23.5	8.0	163.5	1.5	0.0	5328.0
1961	2870.0	1872.0	121.5	15.5	8.0	406.5	1.5	33.0	5328.0
1962	2937.0	1773.5	121.5	15.5	8.0	146.5	1.5	34.0	5328.0

Crops

By far the most popular crop in the Sabetha Watershed during the ten-year period studies was corn. The percentage of total cropland planted in corn was 39.2 percent in 1953, and 48.4 percent in 1962--a low figure for land planted in corn was reached in 1958 with only 32.5 percent of the cropland devoted to corn. Wheat and oats were planted on approximately the same number of total acres but oats were slightly more common. Other crops of some importance were milo, alfalfa, and clover. Crops with insignificant acreages were barley, soybeans, and sorghums. Table 5 gives a complete breakdown of the percentage of total cropland for each crop for each year.

TABLE 5.--Percentage of total cropland planted in each crop in the Sabetha Watershed 1953-1962

	Crop							
Year	Corn	Wheat	Oats	Milo	Alfalfa	Clover	Forage	Other
1953	39.2	15.1	17.4	0.0	6.5	11.8	0.0	10.0
1954	45.5	10.7	13.6	1.9	7.4	6.5	0.9	13.5
1955	44.3	8.6	16.8	0.5	10.0	7.2	0.9	11.7
1956	41.8	14.4	16.8	2.9	11.5	6.3	1.2	5.1
1957	39.4	13.7	20.8	8.6	12.9	0.4	2.2	2.0
1958	32.5	14.7	16.8	10.2	11.9	8.5	1.9	3.5
1959	39.4	17.3	15.2	11.0	9.8	3.3	0.6	3.4
1960	43.1	12.8	17.4	7.5	10.2	6.9	1.2	0.9
1961	41.3	14.7	16.2	5.3	9.8	4.7	1.3	6.7
1962	48.4	14.2	9.6	3.2	11.6	6.8	1.0	5.2
Ave.	41.5	13.6	16.1	5.1	10.2	6.3	1.1	6.3

Of the more common soils (132 or more acres) in the Sabetha Watershed, the most popular soil for production of corn was Grundy Soil Class II (5Lo A 1 II). The percentage of total area of this soil planted in corn from 1953 to 1962 was the highest of the major soils. Wheat, although not planted to any great extent on any soil, was planted in the highest percentage on Grundy Soil Class II (5Lo B 1 II). Table 6 shows five-year simple averages of the percentages of the seven major soil types planted in corn and wheat.

TABLE 6.--Five-year simple averages percentages of the major soil types in the Sabetha Watershed planted in corn and wheat

	Corn		Wheat	
Soil Type	1953-1957	1958-1962	1953-1957	1958-1962
5Lo A 1 II	37.7	41.2	9.5	14.3
5Lo B 1 II	28.3	40.2	9.7	16.4
5Lo B 2 III	30.3	30.8	10.1	11.6
5T B 2 III	15.9	17.9	6.3	6.5
5T B 3 IV	12.5	19.0	6.0	8.0
6Lo B 2 III	25.9	28.3	10.4	7.4
6T B 2 III	14.0	16.6	6.9	9.5

Grassland

The amount of land in grass in the Sabetha Watershed during the period 1953 to 1962 was roughly one-third of the total acreage for each year. The ratio of cropland to grassland was usually about three to two. The type of grass grown was relatively stable during the entire period. Waterway grass, however, increased in use over the ten years studied.

The acreage of grass pastured was quite low in 1953 and 1955; probably because of dry weather. After 1955, the number of acres changed little, remaining at about two-thirds of the total grassland acreage each year. Naturally, the number of livestock and animal unit months changed with the pasture acreage.

The most popular grass was Brome, which was used frequently in waterways. During the latter years of the study, however, Brome was utilized quite often as a pasture grass.

Table 7 gives the acres of each type of grass; Table 8, the acres of each use of the grass; Table 9, the acres of each grass; Table 10, the total animal unit months on each grass; Table 11, the total number of each class of livestock; and Table 12, the total acres of grass fertilized, total fertilizer applied, and average fertilizer applied for each year.

TABLE 7.--Acres of each type of grass in the Sabetha Watershed 1953-1962

Year	Type of Grass				Total
	Tame	Native	Temporary	Waterway	
1953	1216.0	482.0	19.0	201.5	1918.5
1954	1262.0	480.5	46.5	219.0	2008.0
1955	1277.5	441.0	39.5	223.0	1981.0
1956	1242.0	391.5	114.0	240.5	1988.0
1957	1135.0	326.5	101.5	262.5	1825.5
1958	1198.0	288.5	139.5	247.5	1873.5
1959	964.5	290.5	158.5	288.0	1701.5
1960	1074.5	283.0	134.5	300.0	1792.0
1961	1189.0	208.5	168.0	306.5	1872.0
1962	1121.5	208.5	152.0	291.5	1773.5

TABLE 8.--Acres of each use of grass in the Sabetha Watershed 1953-1962

	Use of Grass			
Year	Pasture	Hay	Left	Total
1953	331.5	237.5	1349.5	1918.5
1954	1512.0	185.5	310.5	2008.0
1955	409.5	181.0	1390.5	1981.0
1956	1514.0	131.0	343.0	1988.0
1957	1174.0	250.0	401.5	1825.5
1958	1272.0	221.0	380.5	1873.5
1959	1351.0	117.0	233.5	1701.5
1960	1225.0	272.5	293.5	1792.0
1961	1363.5	340.0	169.5	1872.0
1962	1294.5	294.5	184.5	1773.5

TABLE 9.--Total acres of each grass in the Sabetha Watershed 1953-1962

Grass	Year									
	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
Alfalfa	4.5	24.0	23.0	43.5	18.5	41.5	18.5	32.5	31.5	31.5
Brome	378.0	375.0	391.5	380.5	490.0	643.0	722.0	668.5	653.5	607.0
Bluegrass	428.0	388.5	424.5	347.5	268.5	266.5	254.5	279.0	184.5	184.5
Clover	2.0	0.0	0.0	46.0	0.0	23.0	38.0	39.0	134.5	109.5
Sudan & Rye	0.0	13.0	12.0	19.5	72.5	65.0	53.0	16.5	16.5	7.5
Brome & Bluegrass	249.5	256.0	239.0	173.0	269.0	245.5	148.0	178.5	321.0	321.0
Brome, Bluegrass & Lespadesia	237.5	231.0	239.5	317.5	380.0	302.5	166.5	133.0	165.5	61.0
Alfalfa & Brome	20.5	40.5	30.0	14.5	14.5	5.0	17.0	26.0	66.5	131.5
Alfalfa, Clover, Brome & Lespadesia	47.0	50.5	48.5	48.5	33.5	46.5	0.0	0.0	0.0	0.0
Bluegrass, Timothy, Brome & Lespadesia	34.0	43.5	43.5	43.5	34.5	34.5	0.0	1.0	0.0	0.0
Brome & Lespadesia	108.5	118.0	111.5	68.0	6.5	4.5	5.5	23.5	26.5	33.5
Brome, Timothy, & Lespadesia	30.0	7.0	30.0	30.0	41.0	45.0	45.0	14.0	14.0	14.0
Other	379.0	461.0	388.0	456.0	197.0	150.5	223.5	380.5	258.0	272.5

TABLE 10.--Total animal unit months on each grass in the Sabetha Watershed 1953-1962

Grass	Year									
	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
Alfalfa	0.0	30.0	0.0	42.0	0.0	45.9	0.0	0.0	0.0	0.0
Brome	18.3	267.7	250.5	552.9	226.0	841.2	1681.6	1265.6	1440.1	712.5
Bluegrass	334.6	1426.4	178.2	145.1	318.0	427.1	305.6	479.5	288.8	316.7
Clover	0.0	0.0	0.0	75.6	0.0	11.0	138.6	40.0	93.0	68.4
Sudan & Rye	0.0	20.0	30.0	72.3	336.7	342.8	381.8	56.7	81.6	24.0
Brome & Bluegrass	68.1	603.3	90.0	273.3	602.3	274.2	434.0	335.0	835.9	740.0
Brome, Bluegrass, & Lespadesia	181.0	542.6	103.0	319.5	299.6	556.4	345.9	212.0	366.5	114.0
Alfalfa & Brome	0.0	0.0	0.0	0.0	19.5	72.0	156.2	30.3	270.3	210.3
Bluegrass, Timothy, Brome & Lespadesia	0.0	162.7	90.0	165.0	0.0	0.0	0.0	0.0	0.0	0.0
Brome & Lespadesia	50.0	327.7	199.5	51.9	6.4	0.0	0.0	106.4	120.0	38.5
Brome, Timothy & Lespadesia	0.0	27.2	0.0	60.0	100.0	75.0	105.0	30.0	16.2	16.2
Other	279.3	1313.4	93.8	720.5	527.2	286.3	629.3	767.4	721.3	585.9
Total	931.3	4721.0	1035.0	2478.1	2435.7	3031.9	4177.6	3322.9	4233.7	2826.5

TABLE 11.--Total number in each livestock class in the Sabetha Watershed 1953-1962

Year	Livestock Class									
	Cow	Cow & Calf	Steer, Yearling	Heifer, Yearling	Yearling	2-year Old	Calf	Hog	Sheep	Cattle (mixed)
1953	194	10	180	0	25	0	15	200	20	0
1954	1559	100	418	0	556	0	383	1117	51	0
1955	174	26	86	0	60	0	71	280	10	0
1956	679	36	253	40	293	0	275	603	35	0
1957	526	49	42	84	242	0	165	304	20	0
1958	560	150	40	30	584	1	133	555	105	165
1959	978	91	126	30	225	15	181	338	125	363
1960	771	116	118	70	135	0	167	219	224	113
1961	773	178	118	138	153	0	134	324	194	103
1962	615	175	140	108	119	0	101	308	264	111

TABLE 12.--Total[a] and average fertilizer applied, and total acres fertilized for grassland in the Sabetha Watershed 1953-1962

Year	Nitrogen			Phosphorus			Potash		
	Total Acres	Total[b] Fert.	Ave.[c] Fert.	Total Acres	Total Fert.	Ave. Fert.	Total Acres	Total Fert.	Ave. Fert.
1953	286.5	4933.4	17.2	72.0	782.5	10.9	54.0	845.0	15.6
1954	245.0	5719.0	23.3	113.5	1407.5	14.7	95.5	1407.5	14.8
1955	310.5	8515.0	27.4	96.0	822.5	8.6	87.5	949.0	10.8
1956	61.0	2397.0	39.3	18.5	550.0	29.7	6.0	440.0	73.3
1957	128.5	4686.5	36.5	32.0	916.5	28.6	8.5	435.0	51.2
1958	172.0	9361.0	54.4	176.0	7008.5	39.8	53.0	3995.0	75.4
1959	305.0	14363.5	47.1	81.0	2880.5	35.6	51.5	4120.0	80.0
1960	352.5	12103.5	34.3	67.5	1243.5	18.4	0.0	0.0	0.0
1961	333.5	10933.5	32.8	40.0	870.0	21.8	0.0	0.0	0.0
1962	654.0	21366.0	32.7	186.0	7099.5	38.2	3.5	35.0	10.0

[a] Includes manure applied.

[b] Total fertilizer is expressed in pounds.

[c] Average fertilizer is expressed in pounds per acre.

In a comprehensive watershed program such as the Sabetha Watershed program, one would expect a noticeable shift of land in Land Use Capability Classes VI and VII (suitable only for grass or woodland) from cropland to grassland. This was not the case in the Sabetha Watershed; the acreage of cropland in Classes VI and VII, although not large at any time, increased over the ten year period. The reason for this was that the land in this class probably appeared as a fraction of a field of better land. In the Sabetha Watershed the number of acres of Class IV (suitable for limited cultivation with intensive practices) land planted in crops remained relatively stable. (It should be remembered that only 11.1 percent of the total area in the Sabetha Watershed is in Land Use Capability Class IV, while only 7.9 percent of the total area is in Class VI and Class VII together.) Table 13 gives the acreages of Classes IV, VI, and VII in grass and crops for each year.

TABLE 13.--Acres of selected Land Use Capability Classes in cropland and grassland in the Sabetha Watershed 1953-1962

Year	Class IV		Classes VI and VII	
	Crops	Grass	Crops	Grass
1953	253.5	311.0	25.0	387.5
1954	233.0	342.5	21.5	392.0
1955	235.0	340.0	21.5	392.0
1956	235.0	348.5	22.5	390.0
1957	234.0	304.5	58.5	349.5
1958	222.0	295.0	58.5	342.0
1959	288.5	256.0	69.5	336.5
1960	266.0	266.5	48.0	356.0
1961	218.0	272.0	43.0	357.5
1962	248.5	262.0	45.5	375.0

Crop Rotation

Historically, rotation of crops to include legumes in a series of row crop plantings has been considered a method of combatting soil loss inasmuch as the proper rotation kept the fertility of the soil at a high level and in a non-tilled use. A high level of soil fertility enabled a better vegetation cover in the future. In recent years, however, fertilizer has been used successfully to maintain soil fertility. Even though crop rotation is not as important today as it has been in earlier years, it was decided that crop rotation should be investigated in this study in an attempt to discover whether or not crop yields were significantly affected by it.

A thorough analysis of the effects of crop rotation would be very difficult with the data used in this study because of the manner in which the computer cards were originally set up. Any further work along this line would necessitate going back to the original field sheets and punching new data cards set up in a different fashion or doing the computations by hand.

The brief investigation on crop rotation that was done, considered only fields with the same characteristics. These were: The same type of soil--Grundy Soil Class III (5Lo B 2 III)--and corn planted during the last three years of the study (1960 to 1962). Of the approximately 400 to 600 fields in the Sabetha Watershed each year; there were only fifteen fields which met these requirements. Of these fifteen, none was fertilized, seven were terraced and/or contoured in the last three years, four used Dekalb seed corn, four used Pioneer and Dekalb, three used Pioneer alone, and the rest were other hybrids.

The result of this investigation was Table 14, which gives the ten-year rotation of each field with the last three year's corn yields and the three-year corn yield average.

TABLE 14.--Crop rotation and corn yields for selected fields in the Sabetha Watershed 1953-1962

	Crop							Yield of Corn			
Field	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	3-year Average
1	C[a]	C	C	C	C	C	C	27	27	30	28.0
2	O,Cl[b]	Cl	O,Cl	O,Cl	O	Cl	Gr	30	30	30	30.0
3	Al	Al	Al	Al	Al	Al	Al	40	40	45	41.7
4	Cl	C	C	C	C	C	O	40	55	60	51.7
5	Al	Al	C	C	O,C	Al,M	C	40	55	65	53.3
6	C	Cl	Cl	C	C	O	W	60	60	40	53.3
7	C,O	C	C	C,O	O,C	C,Gr	C	50	50	80	60.0
8	W	W	C	O	B	C	C	60	60	65	61.7
9	C,W	O	Gr,W	Cl	C	C	C	50	60	80	63.3
10	C,O	C,O	C,O	W,O	W	Cl	O	60	60	70	63.3
11	Gr	Gr	C,Gr	C,Gr	Gr	M,Al	C	65	65	75	68.3
12	C	C	C	C	W	Cl	C	65	70	70	68.3
13	Al	Al	Al	Al	Al	C,Al	C	60	75	75	70.0
14	W	Gr	Gr	Gr	C	C	C	75	80	75	76.7
15	W,C	C,Al	C,O	C,Cl	C	C	C	80	90	100	90.0

[a] C = corn, W = wheat, O = oats, Al = alfalfa, Gr = grass, Cl = clover, and B = barley.

[b] Several crops indicate that the field was divided in that year.

The conclusion reached was that the crop rotation did not affect corn yields significantly in the Sabethà Watershed from 1953 to 1962. (This conclusion is not based upon any statistical analysis, but only upon a casual examination of Table 14.) Table 14 reveals that the field with the lowest three-year simple average of corn yields was the only one found with a continuous corn rotation. However, all but one field (field 13) in the five highest average yielding fields were fields with numerous corn or grain sorghum rotations. The conclusion stated above was based upon this fact.

Crop Residue

Crop residue, what is done first to the field after the crop is harvested, can be considered a factor in the control of runoff water inasmuch as it affects the water asorbing ability of the ground. The effect of crop residue on yields was not analyzed in this particular study for two reasons: (1) Insufficient data to make a worthwhile study; and (2) it was difficult to associate each residue with particular crops for the same reason that it was almost impossible to fully analyze crop rotations with the data available and the way it was set up.

The most common crop residue utilized in the Sabetha Watershed from 1953 to 1962 was the single operation of plowing, which was done on the average to approximately 45 percent of the cropland each year. The second most frequently used crop residue operation was discing which was used on approximately 25 percent of the total cropland acreage each year.

A few double crop residue operations were recorded for the Sabetha

Watershed over the ten-year period, but not to any great extent. The most popular double operation was discing followed by chiseling; however, use of this operation declined considerably over the ten years. Table 15 gives a complete listing of the acreages of each crop residue operation used for each year.

TABLE 15.--Acres of each crop residue operation used in the Sabetha Watershed 1953-1962

	Crop Residue										
	Single Operations								Double Operations		
Year	Plow	Disc	List	Hay	Left	Chisel	Other[a]	Total	Disc-Chisel	Other[b]	Total
1953	1503.5	866.5	27.5	347.5	53.5	183.0	120.5	3102.0	183.0	0.0	183.0
1954	1391.0	880.0	47.5	310.5	5.5	201.0	81.5	2917.0	253.5	15.0	268.5
1955	1199.5	948.5	17.5	472.5	12.5	191.5	66.0	2908.0	286.5	30.0	316.5
1956	1460.5	749.0	0.0	351.0	211.0	294.5	50.0	3116.0	58.5	37.5	96.0
1957	1126.0	836.0	0.0	380.5	79.5	750.5	25.0	3197.5	0.0	9.5	9.5
1958	1490.5	892.5	0.0	335.0	184.5	82.5	66.0	3051.0	27.5	27.0	54.5
1959	2076.5	840.0	0.0	218.0	143.0	0.0	79.0	3356.5	0.0	46.5	46.5
1960	1974.5	829.5	0.0	192.5	100.5	23.0	88.0	2790.5	0.0	6.5	6.5
1961	1834.0	670.5	0.0	204.5	42.0	0.0	38.5	2790.5	14.0	65.0	79.0
1962	1543.0	683.5	0.0	274.0	150.0	28.5	100.0	2779.5	22.0	96.0	118.0

[a] Includes: Carried over, one-way, plowed under, stubble, and seed.

[b] Includes: Plow-disc, plow-left, plow-hay, plow-chisel, hay-carried over, hay-left, and disc-left.

Lime

Lime was not considered in the statistical analysis of this study because of insufficient data; liming was not used extensively in any of the years in the Sabetha Watershed. In 1953, 224.5 acres had a total of 450.5 tons of lime applied to them; this was the most lime applied during the ten-year period. In 1961, only 6.0 acres had a total of 12.0 tons applied to them for the low in yearly application of lime. Table 16 gives the total acres, total lime, and average tons per acre of the lime applied for each year.

TABLE 16.--Total acres limed with total and average amounts of lime applied in the Sabetha Watershed 1953-1962

Year	Acres	Total (tons)	Average (tons per acre)
1953	224.5	450.5	2.0
1954	111.5	294.8	2.6
1955	47.0	87.2	1.8
1956	69.5	136.0	2.0
1957	55.0	154.4	2.8
1958	203.5	588.0	2.9
1959	65.0	204.5	3.2
1960	23.0	77.0	3.3
1961	6.0	12.0	2.0
1962	92.5	308.0	3.3

Terracing, Fertilizing, and Contouring

Probably most people think of soil erosion measures as being terracing and contour farming. With a little more thought, fertilizing may enter the picture. In the Sabetha Watershed Program, the number of acres of land with these treatments progressively increased during the period studied. In 1962, 46.5 percent of the cropland was terraced, 63.3 percent was contoured, and 51.5 percent was fertilized.

"Fully treated land" (land which had the treatments of terracing, contouring and fertilizing applied to it) increased from 4.3 percent of the total cropland in 1953 to 19.2 percent in 1962. Non-treated land decreased from 37.6 percent of the total cropland to 15.3 percent in 1962; this was not a continuous trend however--in 1957, immediately after the dry year of 1956, non-treated land comprised 39.1 percent of the total cropland. Table 17 lists the percentages of the total cropland under various combinations of treatments.

Grassland that was terraced showed a little increase over the years. However, the acres of grassland that were terraced can be expected to vary from year to year because of different areas of grass, permanent and temporary, going into crops and vice versa. Table 18 gives the acreages of grassland terraced for each year.

TABLE 17.--Percentage of total cropland for varying levels of treatment in the Sabetha Watershed 1953-1962

Year	Level of Treatment								Total		
	T-U-C[a]	U-U-C	T-U-U	U-U-U	T-F-C	U-F-C	T-F-U	U-F-U	Terr.	Cont.	Fert.
1953	13.3	19.3	1.8	37.6	4.3	11.0	0.6	12.1	20.0	47.6	28.3
1954	14.3	17.3	2.7	31.8	4.7	14.4	0.8	14.0	22.5	50.7	33.9
1955	16.1	13.9	2.8	28.4	6.6	13.9	1.5	16.8	27.0	50.5	38.8
1956	23.2	17.2	4.6	34.5	3.6	7.9	0.9	8.1	32.8	52.8	20.8
1957	23.2	16.5	2.8	39.1	6.5	5.4	0.5	6.0	33.2	51.8	18.5
1958	24.0	21.2	1.0	36.2	6.4	4.8	0.1	6.4	31.4	55.9	17.7
1959	31.0	18.6	1.5	27.0	8.5	5.4	0.2	7.8	41.2	63.5	21.9
1960	27.6	13.1	2.4	21.2	11.1	11.8	3.0	9.8	44.1	63.7	35.7
1961	24.5	9.8	2.0	20.3	17.6	10.5	2.2	13.1	46.3	62.3	43.4
1962	22.0	9.5	1.3	15.3	19.2	12.3	3.9	16.5	46.5	63.3	51.5

[a] T indicates terracing, F indicates fertilizing, C indicates contouring; U indicates either unterraced, unfertilized, or uncontoured; according to the position of the symbol.

TABLE 18.--Acres of all types of grassland terraced in the Sabetha Watershed 1953-1962

Year	Acres
1953	91.0
1954	95.5
1955	157.5
1956	98.0
1957	94.0
1958	142.5
1959	161.5
1960	265.0
1961	314.5
1962	257.0

Yields

In the introduction to this paper, it was stated that the average yields of crops in Nemaha County were approximately 120 percent of the state average yields. The average yields of the Sabetha Watershed were about the same as those of Nemaha County as a whole for the ten-year period studied. Average corn yeilds from the watershed were higher every year than the average corn yields from Nemaha County. From 1958 on, there was an increasing divergence of the watershed yields and the county yields. Figure 2 illustrates the trends in average yields for corn from the Sabetha Watershed and Nemaha County.

Average wheat yields for the Sabetha Watershed, when compared to Nemaha County yields, were not quite as favorable as corn. Even though the watershed yields were usually higher than the county average yields, there was no obvious trend as there was with corn. Figure 3 presents the Sabetha Watershed average wheat yields compared to those of Nemaha County.

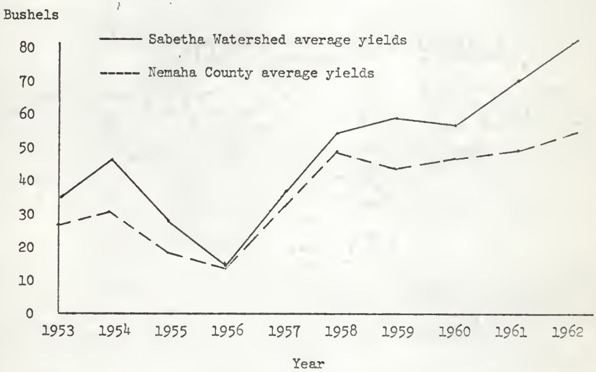

Fig. 2.--Average corn yields of the Sabetha Watershed compared to average corn yields of Nemaha County 1953-1962.

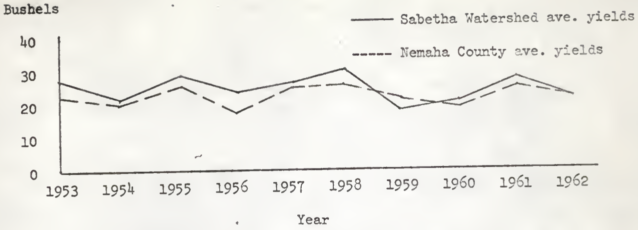

Fig. 3.--Average wheat yields of the Sabetha Watershed compared to average wheat yields of Nemaha County 1953-1962.

Precipitation

Precipitation in Nemaha County during the years studied ranged from dry in 1953 to relatively wet in 1962. The year 1957 saw a sharp increase in rainfall from several dry years. After 1957, precipitation remained at a relatively high level until 1962 with only a minor drop in 1960. The long-run average yearly rainfall for the ten-year period was 33.79 inches.

The reader should note the effect precipitation has on crop yields and the farmer's operations. Corn yields (Figure 2) for the ten-year period fluctuated at the same time and in the same direction as rainfall. Wheat yields (Figure 3) were not affected as much as corn by precipitation changes.

Farmers in the Sabetha Watershed, as would be expected, varied the amount of soil erosion control measures over the years. This is evidenced by Table 17, which shows that the percentage of untreated land rose in 1956 and 1957, when there was little rainfall. The reason for this change was probably a combination of a lack of need for soil erosion control with little precipitation. Figure 4 shows the annual rainfall for 1953 to 1962 as recorded at Centralia in Nemaha County.

Fig. 4.--Precipitation in Nemaha County 1953-1962.[a]

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[a] Precipitation data taken from the yearly issue of Farm Facts, published by the Kansas State Board of Agriculture.

CHAPTER IV

EFFECTS OF TREATMENTS ON YIELDS

Data Considered

To determine the effect specific land treatments had on crop yields in the Sabetha Watershed, it was necessary to place various restrictions on the data used. The first restriction was that the observation (field) be planted in corn or wheat. Corn was chosen because it was the most frequently planted crop in the watershed. Wheat and oats were the second most common crops planted after corn, but wheat was chosen over oats because it is a more important cash crop to the farmer and to the State of Kansas. Other crops were either not grown or not found in significant acreages in the watershed.

The second restriction was soil type. The field had to have 50 percent or more of its acreage in Grundy Soil Class III (5Lo B 2 III) or Pawnee Soil Class III (5T B 2 III). These two soils had the greatest acreage of all soils and were, in fact, the only soils with a sufficient number of observations from which to make meaningful statistical inferences.

Since the two soils were considered separately (to alleviate any difference in crop yields that could be attributed to differences in soil type) and the two crops were considered separately, four categories were formed from which to draw statistical conclusions.

The only land treatments considered were terracing, fertilizing, and contouring. Other treatments, such as crop residue and crop rotation, were not considered either because of insufficient data or the manner in which the data were available.

For the analysis of variance, three classes were formed from the observations: (1) Fields with no treatment; (2) fields with terracing and contouring; (3) fields with contouring alone. Fields with terracing alone were ignored because of an insufficient number of observations. Fields with fertilizer applied to them were not considered in the analysis of variance because fertilizer is more or less a continuous input (varied in quantity) and consequently does not lend itself readily to an analysis of variance.

For the regression analysis, all obervations with the proper crop and soil type were taken into consideration. These included: (1) Fields with no treatment; (2) fields with terracing only; (3) fields with contouring only; (4) fields with fertilizer only; (5) fields with various combinations of terracing, contouring, and fertilizing. Fertilizer is a relatively continuous input and therefore a regression analysis can be applied.

Analysis of Variance--Procedure

The statistical tool, "analysis of variance," was developed by R. A. Fisher and has been used largely in agricultural research.[1] The

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[1] Taro Yamane, Statistics (New York: Harper and Row, Publishers, 1964) p. 622.

analysis of variance is a technique to determine if the general level (average or mean) of two or more sample sets (in the case of the Sabetha Watershed data, non-treated land and land with varying degrees of treatment applied to it) differ substantially or if they are sample sets drawn from the same general population.

The assumptions made when using the analysis of variance are: (1) The observations are normally distributed; and (2) the variances of the sample sets are equal and constant; i.e., the variances are homogeneous.

The null hypothesis to be tested with the analysis of variance is that the means of the sample sets are equal; i.e., H_o: $(\mu_1=\mu_2=\mu_3= \cdots =\mu_n)$. The alternative to this null hypothesis is that some sample means are unequal; i.e., H_a: $(\mu_1\neq\mu_2\neq\mu_3\neq \cdots \neq\mu_n)$.

If the null hypothesis is rejected, one can determine which sample means are unequal by use of several multiple comparison procedures such as Fisher's Least Significant Difference and Duncan's New Multiple Range Test.[2] These tests are commonly known by the initials LSD and NMRT, respectively.

For the analysis of variance test on the data from the Sabetha Watershed, it was initially decided to use a two-way analysis of variance with the ten years and the three levels of treatment. The two-way analysis of variance was chosen because, not only could the effect of treatments be noticed, but also the interaction between treatments and years. However, some difficulty was encountered with the capacity of the 1410 computer then available at the Kansas State University Computer Center when the two-way was

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[2] H. C. Fryer, Experimental Statistics (Boston: Allyn and Bacon, Inc., 1966) pp. 260-262.

being done. To solve by use of the computer, a thirty by thirty matrix had to be inverted. The matrices of the four crop and soil classes were near enough singular (a singular matrix has no inverse) that the 1410 computer was unable to calculate the inverse matrix exact enough so that the results could be accepted. (Kansas State University has since received a 360 Model computer which has the necessary capacity to solve a problem of this type.)

After failure with the two-way analysis of variance, a series of one-way analyses of variance was performed for each year of each crop-soil category.[3] These one-ways were designed to show if there was any difference as a result of the treatment in each year. If there was any definite trend over the years, or any interaction between year and treatment, a comparison of the yearly results would reveal it.

As stated above, an assumption basic to use of the analysis of variance is that of homogeneity of variances. To conclude that this assumption was a reasonable assumption to make for the Sabetha Watershed data, the Hartley maximum-F test[4] was utilized. This test, the simplest and easiest test of this type available, was done on the year to year variances. That is, the test was used to determine if the variances of the three sample sets were the same for the entire ten-year period. The reason a year to year test was used instead of a series of single year tests was that the estimates needed for the year to year tests were readily available on the printouts of the analyses

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[3] The three levels of treatment each year yielded a small enough matrix for the 1410 computer to invert to the correct degree of precision.

[4] Fryer, p. 246.

of variance. Also, it was believed that if the year to year variances were homogeneous, the single year variances would necessarily be homogeneous.

The results of the Hartley maximum-F tests performed on the year to year Sabetha Watershed data were right on the borderline of acceptance or rejection. Since, in this case, a little difference in variances of the sample sets from year to year was to be expected, it was reasonable to make the assumption that variances of the sample sets in each year were homogeneous.

Simple Average Corn and Wheat Yields by Watershed Treatment

An examination of the overall means, or the simple averages, (presented in Tables 19, 20, 21, and 22) of the different levels of treatment for the ten years discloses that there was some (though not statistically significant, as proved by the analyses of variance) advantage gained by utilizing the land treatments in certain years. There is a greater difference in the latter years of the study; indicating that terracing and contouring (as would be expected) are more effective in the wetter years and in the long run. Of the two levels of treatment, the simple averages from contouring alone were greater than the simple averages from terracing plus contouring.

TABLE 19.--Simple averages of corn yields on Grundy Soil Class III (5Lo B 2 III) in the Sabetha Watershed 1953-1962

	Simple Averages (Bushels per Acre)		
Year	Non-treated	Terracing plus Contouring	Contouring Alone
1953	34.7	33.0	37.9
1954	42.2	43.8	45.2
1955	23.0	23.4	26.2
1956	8.5	2.1	2.6
1957	31.6	28.9	36.0
1958	55.2	52.7	45.0
1959	55.0	60.0	53.0
1960	54.3	51.4	52.5
1961	59.3	63.6	67.5
1962	69.2	73.9	74.1

TABLE 20.--Simple averages of corn yields on Pawnee Soil Class III (5T B 2 III) in the Sabetha Watershed 1953-1962

	Simple Averages (Bushels per Acre)		
Year	Non-treated	Terracing plus Contouring	Contouring Alone
1953	30.3	34.0	30.3
1954	34.1	38.8	44.1
1955	26.1	23.4	52.4

TABLE 20.--Continued

Year	Simple Averages (Bushels per Acre)		
	Non-treated	Terracing plus Contouring	Contouring Alone
1956	5.0	5.0	3.3
1957	27.9	35.0	32.5
1958	60.0	48.8	40.6
1959	40.8	55.6	48.6
1960	52.2	56.4	53.4
1961	60.0	60.0	76.7
1962	60.6	60.0	71.7

TABLE 21.--Simple averages of wheat yields on Grundy Soil Class III (5Lo B 2 III) in the Sabetha Watershed 1953-1962

Year	Simple Averages (Bushels per Acre)		
	Non-treated	Terracing plus Contouring	Contouring Alone
1953	30.4	29.9	36.7
1954	24.1	26.0	33.8
1955	38.9	33.0	24.0
1956	26.1	32.1	27.1
1957	36.0	31.9	36.1
1958	38.5	35.6	35.0
1959	15.3	23.1	23.4

TABLE 21.--Continued

Year	Simple Averages (Bushels per Acre)		
	Non-treated	Terracing plus Contouring	Contouring Alone
1960	34.1	20.0	22.0
1961	31.3	29.7	36.7
1962	26.0	24.0	15.0

TABLE 22.--Simple averages of wheat yields on Pawnee Soil Class III (5T B 2 III) in the Sabetha Watershed 1953-1962

Year	Simple Averages (Bushels per Acre)		
	Non-treated	Terracing plus Contouring	Contouring Alone
1953	30.6	27.5	31.3
1954	30.0	20.0	25.0
1955	43.9	10.0	37.0
1956	36.0	23.8	30.0
1957	36.7	29.0	40.0
1958	31.3	40.0	35.0
1959	31.0	24.7	No Observations
1960	32.5	25.0	25.0
1961	10.0	45.0	32.5
1962		Insufficient Data	

Analysis of Variance--Results

The values of the estimates of the statistics derived from the forty analyses of variance performed on the Sabetha Watershed data are shown in Tables 23, 24, 25, and 26. Also in the tables is the region of rejection for each test and the decision about the null hypothesis for each test. The null hypothesis is: H_o: $(\mu_1=\mu_2=\mu_3)$; where μ_1 is the mean of the crop yields from fields with no treatment; μ_2 is the mean of the crop yields from fields with terracing and contouring; and μ_3 is the mean of the crop yields from fields with contouring alone. All F values were tested at the 5 percent level of confidence.

TABLE 23.--Results of analysis of variance of corn yields for three levels of watershed treatment on Grundy Soil Class III (5Lo B 2 III) in the Sabetha Watershed 1953-1962

Year	Source of Variation	d.f.[a]	Mean Squares	F	Region of Rejection	Decision
1953	Between Within	2 135	200.69 145.05	1.383	F>3.06	Accept H_o
1954	Between Within	2 161	142.40 130.24	1.093	F>3.05	Accept H_o
1955	Between Within	2 96	98.07 111.62	0.879	F>3.10	Accept H_o
1956	Between Within	2 86	415.25 191.37	2.169	F>3.13	Accept H_o
1957	Between Within	2 75	249.40 235.69	1.058	F>3.14	Accept H_o
1958	Between Within	2 56	525.48 225.98	2.325	F>3.17	Accept H_o
1959	Between Within	2 66	252.83 206.56	1.224	F>3.15	Accept H_o

TABLE 23.--Continued

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1960	Between	2	49.57	0.152	F>3.15	Accept H_o
	Within	60	325.33			
1961	Between	2	206.45	0.531	F>3.20	Accept H_o
	Within	49	389.14			
1962	Between	2	156.69	0.493	F>3.17	Accept H_o
	Within	54	318.11			

[a] d.f. stands for degrees of freedom.

TABLE 24.--Results of analysis of variance of corn yields for three levels of watershed treatment on Pawnee Soil Class III (5T B 2 III) in the Sabetha Watershed 1953-1962

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1953	Between	2	30.18	0.171	F>3.29	Accept H_o
	Within	37	176.14			
1954	Between	2	690.32	3.902	F>3.15	Reject H_o
	Within	61	176.93			
1955	Between	2	68.42	0.367	F>3.32	Accept H_o
	Within	31	186.19			
1956	Between	2	12.26	0.116	F>3.39	Accept H_o
	Within	25	105.65			
1957	Between	2	48.10	0.562	F>3.74	Accept H_o
	Within	14	85.57			
1958	Between	2	341.18	0.820	F>3.89	Accept H_o
	Within	12	415.91			
1959	Between	2	393.00	1.808	F>3.52	Accept H_o
	Within	19	217.30			

TABLE 24.--Continued

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1960	Between Within	2 21	42.44 215.75	0.197	F>3.47	Accept H_o
1961	Between Within	2 17	583.33 293.14	1.989	F>3.59	Accept H_o
1962	Between Within	2 19	281.88 455.56	0.619	F>3.52	Accept H_o

TABLE 25.--Results of analysis of variance of wheat yields for three levels of watershed treatment on Grundy Soil Class III (5Lo B 2 III) in the Sabetha Watershed 1953-1962

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1953	Between Within	2 46	186.10 40.36	4.611	F>3.21	Reject H_o
1954	Between Within	2 31	263.56 35.69	7.384	F>3.32	Reject H_o
1955	Between Within	2 18	292.87 131.83	2.221	F>3.55	Accept H_o
1956	Between Within	2 40	82.44 130.27	0.633	F>3.23	Accept H_o
1957	Between Within	2 32	53.49 50.62	1.057	F>3.32	Accept H_o
1958	Between Within	2 25	31.99 76.40	0.419	F>3.39	Accept H_o
1959	Between Within	2 32	237.74 137.98	1.723	F>3.32	Accept H_o
1960	Between Within	2 11	299.18 132.62	2.256	F>3.98	Accept H_o

TABLE 25.--Continued

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1961	Between Within	2 22	95.81 60.41	1.586	$F>3.44$	Accept H_o
1962	Between Within	2 13	53.72 58.15	0.924	$F>3.81$	Accept H_o

TABLE 26.--Results of analysis of variance of wheat yields for three levels of watershed treatment on Pawnee Soil Class III (5T B 2 III) in the Sabetha Watershed 1953-1962

Year	Source of Variation	d.f.	Mean Squares	F	Region of Rejection	Decision
1953	Between Within	2 15	11.13 88.95	0.125	$F>3.68$	Accept H_o
1954	Between Within	2 8	50.00 12.50	3.999	$F>4.46$	Accept H_o
1955	Between Within	2 12	537.22 64.07	8.384	$F>3.89$	Reject H_o
1956	Between Within	2 4	70.34 29.69	2.369	$F>6.94$	Accept H_o
1957	Between Within	2 5	73.66 51.73	1.424	$F>5.79$	Accept H_o
1958	Between Within	2 7	51.88 59.82	0.867	$F>4.74$	Accept H_o
1959	Between Within	2 4	552.52 23.17	23.849	$F>6.94$	Reject H_o
1960	Between Within	2 3	37.50 20.83	1.799	$F>9.55$	Accept H_o
1961	Between Within	2 1	318.75 12.50	25.499	$F>199.50$	Accept H_o
1962	Insufficient data--there were no non-treated fields.					

Tables 23, 24, 25, and 26 disclose that, of the forty analyses of variance performed on the Sabetha Watershed data, only five of the F values were large enough to reject the null hypothesis (that the means of the three levels of treatment were equal). Two of these were "outlying" values (Table 26, 1959 and 1961 values) because of an insufficient number of degrees of freedom which indicated a large sampling error.

Naturally, the conclusion drawn from the results of the analyses of variance was that the differences between the means were not significant--that the sample sets all came from the same overall population. In short, the hypothesis tested by this study, that specific land treatments result in significantly increased crop yields, was rejected. Also, interaction between treatment and years was not statistically proven.

Multiple Regression--Procedure

Multiple regression is a statistical technique for estimating the effect several independent variables have upon the dependent variable(s); in other words, the relationship between independent variables and a dependent variable(s). This relationship is estimated by finding the equation of the plane (or hyper-plane) that "fits" the data best by a least-squares method.

The estimating equation obtained would be of the form:

$$Y = a+b_1X_1+b_2X_2+ \ . \ . \ . \ +b_nX_n \ .$$

Where: 1. The dependent variable is denoted by Y.

2. The a is the point where the plane intercepts the Y axis.

3. The b_i, where i=1 to n, is the slope of the plane in the X_i direction (the b_i's are regression coefficients).

4. The X_i's, where i=1 to n, denote independent variables.

To estimate the change in Y with the addition of say, n units of X_1, no other X_i being used; multiply the regression coefficient b_1 by the number of units of X_1 and add the product to a. Any number and combination of independent variables can be "plugged into" the estimating equation.

For the regression analysis of the Sabetha Watershed data, a slightly more complex estimating equation had to be used.

The estimating equation for the Sabetha Watershed data was of the form:

$$Y = a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6 \ .$$

Where: 1. The dependent variable, crop yield, is Y.

2. The a is the Y axis interception point when no treatment is used.

3. The b_1 is the addition to a caused by the use of X_1.

4. The b_2 is the addition to a caused by the use of X_2.

5. The b_i, where i=3 to 6, is the slope of the plane in the X_j direction, where j=3 to 6.

6. The X_1 is a so-called "dummy variable"[1] for terracing plus contouring, which takes the value of one (1) if the observation (field) is terraced <u>and</u> contoured; if the observation is <u>not</u> terraced and contoured, X_1 takes the value of zero (0).

7. Another dummy variable, X_2, takes the value of one (1) when the observation is contoured; and zero (0) when the observation is not contoured alone.

8. A standard variable X_3, is the variable for the amount of nitrogen fertilizer; which can be varied continuously.

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[1] Dummy variables are utilized when the variable is discrete or discontinuous; for instance, a field is either terraced or it is not. For a further discussion of dummy variables, see J. Johnston, <u>Econometric Methods</u> (New York: McGraw-Hill Book Co., Inc., 1963) pp. 221-228.

9. The variable for the amount of phosphorus fertilizer is X_4. (The amount of potash fertilizer was ignored because it was used in insignificant quantities in the watershed.)

10. The variables X_5 and X_6 represent the values of X_3 and X_4 squared respectively.

Multiple Regression--Results

Referring to the following tables with the regression analyses results, the column headed "regression coefficient" lists the respective "b" values. These values express the observed relationship between the variation of the dependent variable (Y) and the variation of the individual independent variable (X_i, where i=1 to 6); with all other independent variables held constant at their mean values.

The column headed "standard error" gives the amount the observations vary from the regression coefficient for each independent variable.

To test whether or not each regression coefficient is significantly different from zero, a t-test was used at the 0.05 percent level of significance. The results of the individual t-tests are presented in the column headed "sample t-value". A significant t-value is indicated by an asterik (*) to the right and above the value.

The value of the constant "a" is given for each regression along with the multiple correlation coefficient (R^2) which indicates the percentage of variation in the dependent variable that was "explained" by the given independent variables. A multiple correlation coefficient close to one indicates a high correlation between the variation of the dependent variable and the variation of the independent variables.

The highest multiple correlation coefficient obtained was 0.8181 for wheat on Pawnee Soil Class III in 1957. As a general rule, however, the multiple correlation coefficients were quite low, indicating that all the factors affecting crop yields were not included in the regression.

The answer obtained for the constant "a" was usually reasonable as was the variance of this constant. However, eight regressions were totally unreasonable as a result of insufficient data (no non-treated observations).

The expected values for the regression coefficients for X_1 and X_2 (that is, b_1 and b_2) were either small positive or negative numbers. Generally, this was the type of answer obtained with a few unrealistic results which could be attributed to sampling errors.

The values expected for the regression coefficient for X_3 and X_4 (the variables for nitrogen and phosphorus fertilizer respectively) were small positive numbers and an accompanying small negative number for the regression coefficients of X_5 and X_6 (the quantities squared for the nitrogen and phosphorus). This would provide a production function for fertilizer of initially increasing yields, then decreasing yields as fertilizer inputs are increased. Of twenty-eight useable regressions for nitrogen, twenty-two (93 percent) were of this form while six had the signs reversed to what was expected. Of twenty-six useable phosphorus regressions, twelve (46 percent) were reasonable and fourteen were unexpected. Scatter diagrams of the data for the regressions with unexpected results revealed that the trend in yields associated with increasing inputs of fertilizer (in the particular situations) was either one with initially decreasing yields then increasing yields, or one with consistently decreasing yields. It should be noted that in each one of these "unexpected" results, the number of total observations was small, with the number of observations for fertilizer being extremely small. Therefore, it is believed that the unreasonable values were the result of insufficient data.

The regression coefficient for terracing plus contouring (b_1) was significantly different from zero in nine out of twenty-seven useable regression analyses, or 33.3 percent of the twenty-seven. Of these nine, five, or 55.5 percent, were significant in the positive direction. There was no apparent trend over the ten-year period studied for the regression coefficients for terracing plus contouring.

For contouring alone, there were eight (or 29.6 percent of the total) regression coefficients (b_2) significantly different from zero, with seven or 87.5 percent of the eight significant in the positive direction. Again, there was no apparent trend in the regression coefficients from 1953 to 1962.

Of the regression coefficients associated with nitrogen fertilizer (b_3), eight were significant with five, or 62.5 percent, significant in the positive direction. There were only six (22.2 percent of the total) regression coefficients for phosphorus fertilizer (b_4) significantly different from zero. Of the six, four, or 66.6 percent, were significant in the positive direction. As with the coefficients for terracing plus contouring and contouring alone, there was no apparent trend in the fertilizer regression coefficients.

The low values obtained for the various multiple regression correlation coefficients (R^2) indicate that all factors affecting crop yields were not included in the regression analyses. The large standard errors evident in almost every regression analysis indicate that there was an insufficient amount of data available and that the observations were highly dispersed.

Insufficient data to make a reasonable regression analysis was the basis of the rejection of thirteen of the forty regressions. Several factors contributed to the insufficiency of data, among these were: (1) The tendency for the farm operators in the Sabetha Watershed to agglomerate several small fields into larger ones toward the end of the study period. (2) Another factor was that as the years passed, the watershed program was progressing and fewer fields were non-treated with the result that the "a" constant in the regression was unreasonable. (3) A final factor was the weather--in the dryer years of the study, fewer fields were planted in crops and fewer fields that were planted were harvested.

The number of observations for each regression analysis is given in Table 27. The number of observations varied greatly with a general decline over the ten years studied. The results of the multiple regression analyses are given in Tables 28, 29, 30, and 31.

TABLE 27.--Number of observations for each regression analysis for the Sabetha Watershed 1953-1962

Year	Corn		Wheat	
	Grundy Soil	Pawnee Soil	Grundy Soil	Pawnee Soil
1953	125	37	61	20
1954	160	49	36	14
1955	67	15	14	13
1956	29	11	35	17
1957	68	15	41	11
1958	56	9	37	13
1959	70	15	32	9
1960	63	18	18	10
1961	52	17	26	9
1962	57	18	21	8

TABLE 28.--Results of multiple regression analysis for corn on Grundy Soil Class III (5Lo B 2 III)

Year	Regression Coefficient	Standard Error	Sample t-value	Variable[a]
1953	0.3518	2.4472	0.1437	1
	4.1423	1.7891	2.3154*	2
	-1.0336	0.7099	-1.4558	3
	0.9235	1.4918	0.6190	4
	0.0202	0.0175	1.1469	5
	-0.0284	0.0729	-0.3891	6
(a=37.0824	R^2=0.1131	d.f.=123)		
1954	1.4712	2.4297	0.6055	1
	4.8428	1.9988	2.4228*	2
	-0.4987	0.1997	-2.4974*	3
	1.2028	0.3596	3.3446*	4
	0.0047	0.0022	2.1134*	5
	-0.0199	0.0088	-2.2806*	6
(a=42.1685	R^2=0.1192	d.f.=158)		
1955	1.6955	2.2699	0.7469	1
	0.4982	1.9883	0.2301	2
	0.5785	0.1874	3.0873*	3
	-1.0204	0.3544	-2.8793*	4
	-0.0063	0.0019	-3.1788*	5
	0.0358	0.0118	3.0326*	6
(a=23.8829	R^2=0.2608	d.f.=65)		

TABLE 28.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1956	Insufficient Data			
1957	7.0998	3.1755	2.2358*	1
	2.9133	3.0011	0.9708	2
	2.8846	1.7373	1.6605	3
	-1.5589	2.9375	-0.5307	4
	-0.0236	0.0241	-0.9766	5
	-0.0082	0.0905	-0.0904	6
(a=32.9002	R^2=0.2027	d.f.=66)		
1958	-2.9786	4.9424	-0.6027	1
	-12.3787	4.9425	-2.5046*	2
	0.1479	68.9941	0.0021	3
	1.6387	137.9775	0.0119	4
	-0.0098	0.3192	-0.0306	5
	-0.0049	1.2775	-0.0039	6
(a=55.1862	R^2=0.1333	d.f.=54)		
1959	3.8533	3.5534	1.0844	1
	-2.8884	4.1432	-0.6971	2
	0.3307	22.9149	0.0144	3
	0.1128	45.8206	0.0025	4
	-0.0056	0.6944	-0.0081	5
	-0.0016	2.7777	-0.0006	6
(a=56.5429	R^2=0.0668	d.f.=68)		

TABLE 28.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1960	-0.6271	4.7956	-0.1308	1
	-4.9804	5.0943	-0.9776	2
	0.4641	0.6003	0.7730	3
	-0.7881	1.5479	-0.5091	4
	-0.0093	0.0138	-0.6731	5
	0.0396	0.0596	0.6654	6
	(a=55.2675 R^2=0.0793	d.f.=61)		
1961	-3.1446	5.2245	-0.6019	1
	-0.8697	7.8539	-0.1107	2
	0.4755	0.2681	1.7739*	3
	0.2020	1.3925	0.1451	4
	-0.0043	0.0033	-1.2879	5
	0.0159	0.0572	0.2785	6
	(a=58.4934 R^2=0.2001	d.f.=50)		
1962	7.4186	4.3853	1.6917*	1
	7.6559	5.1149	1.4968	2
	0.3703	0.1860	1.9909*	3
	2.9683	1.1112	2.6714*	4
	-0.0024	0.0019	-1.2503	5
	-0.0733	0.0355	-2.0653*	6
	(a=58.3248 R^2=0.4349	d.f.=55)		

[a] Variable 1 is terracing plus contouring; 2 is contouring alone; 3 is nitrogen fertilizer; 4 is phosphorous; 5 is the quantity of nitrogen squared; 6 is the quantity of phosphorous squared.

TABLE 29.--Results of multiple regression analysis for corn yields on Pawnee Soil Class III (5T B 2 III)

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1953	-0.7430	7.8926	-0.0941	1
	-1.2007	3.6388	-0.3299	2
	-0.0555	160.3298	-0.0004	3
	-0.0790	320.6716	-0.0003	4
	0.0163	3.5623	0.0046	5
	-0.0107	14.2519	-0.0008	6
	(a=34.3957 R^2=0.0145	d.f.=35)		
1954	2.4097	3.6017	0.6690	1
	9.0434	2.8847	3.1349*	2
	-0.4571	0.2000	-2.2858*	3
	1.8358	0.5884	3.1201*	4
	0.0015	0.0024	0.6222	5
	-0.0272	0.0219	-1.2370	6
	(a=35.1378 R^2=0.4479	d.f.=47)		
1955	9.1920	14.5349	0.6324	1
	13.6198	9.7201	1.4012	2
	0.2635	0.4716	0.5587	3
	-1.2067	1.2989	-0.9290	4
	-0.0026	0.0039	-0.6788	5
	0.0287	0.0479	0.6004	6
	(a=19.7428 R^2=0.5143	d.f.=13)		

TABLE 29.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1956	Insufficient Data			
1957	Insufficient Data			
1958	Insufficient Data			
1959	23.3333	8.7536	2.6656*	1
	23.3333	9.4549	2.4678*	2
	-4.7804	5.6911	-0.8399	3
	6.6745	7.6121	0.8768	4
	-0.0160	15.9206	-0.0010	5
	0.2474	63.6829	0.0039	6
	(a=29.8405 R^2=0.6484	d.f.=13)		
1960	Insufficient Data			
1961	Insufficient Data			
1962	13.5973	7.4411	1.8273*	1
	18.5369	7.6085	2.4363*	2
	0.5362	0.4409	1.2162	3
	0.0000	0.0000	0.0000	4
	-0.0048	0.0078	-0.6225	5
	0.0000	0.0000	0.0000	6
	(a=48.8544 R^2=0.5147	d.f.=16)		

TABLE 30.--Results of multiple regression analysis for wheat yields on Grundy Soil Class III (5Lo B 2 III)

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1953	0.1211	2.2427	0.0540	1
	4.0860	2.0833	1.9613*	2
	0.7775	0.1880	4.1349*	3
	-1.0609	0.2917	-3.6377*	4
	-0.0127	0.0038	-3.3386*	5
	0.0288	0.0113	2.5597*	6
	(a=29.8995 R^2=0.4232	d.f.=59)		
1954	3.6026	3.1453	1.1454	1
	10.5707	3.0653	3.4486*	2
	0.2723	0.8320	0.3272	3
	0.1634	1.6150	0.1012	4
	-0.0022	0.0229	-0.0965	5
	-0.0010	0.0666	-0.0153	6
	(a=21.8257 R^2=0.3758	d.f.=34)		
1955	7.8333	7.7648	1.0088	1
	-3.1667	7.7648	-0.4078	2
	-6.8053	3.5813	-1.9002*	3
	5.0130	2.5939	1.9326*	4
	0.1454	0.0736	1.9749*	5
	-0.0621	0.0386	-1.6091	6
	(a=28.1664 R^2=0.7488	d.f.=12)		

TABLE 30.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1956	10.4164	6.3916	1.6297*	1
	2.2665	3.8280	0.5921	2
	3.9395	3.1058	1.2684	3
	-1.0531	2.3489	-0.4483	4
	-0.0745	0.0634	-1.1755	5
	-0.0293	0.0507	-0.5782	6
	(a=25.2408 R^2=0.3031 d.f.=33)			
1957	-4.9239	2.7569	-1.7861*	1
	0.5148	2.7439	0.1876	2
	0.2353	0.2729	0.8621	3
	-0.0611	0.3749	-0.1630	4
	-0.0048	0.0039	-1.2431	5
	0.0053	0.0096	0.5479	6
	(a=34.2652 R^2=0.2079 d.f.=39)			
1958	-1.4818	3.1158	-0.4756	1
	-1.9337	4.6011	-0.4203	2
	0.4207	0.4437	0.9481	3
	-0.4268	0.4234	-1.0079	4
	-0.0034	0.0099	-0.3433	5
	0.0108	0.0101	1.0693	6
	(a=36.2685 R^2=0.1999 d.f.=35)			

TABLE 30.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1959	9.7536	5.5257	1.7651*	1
	9.0178	6.8610	1.3144	2
	0.2293	1.5767	0.1455	3
	-0.0193	0.8417	-0.0229	4
	-0.0034	0.0425	-0.0811	5
	0.0035	0.0101	0.3461	6
	(a=13.0374 R^2=0.1889	d.f.=30)		
1960	-2.1905	7.2357	-0.3027	1
	-8.7048	5.9883	-1.4536	2
	1.6947	5.8874	0.2879	3
	-1.3931	5.2783	-0.2639	4
	-0.0201	0.0894	-0.2243	5
	0.0229	0.0789	0.2901	6
	(a=29.4435 R^2=0.3335	d.f.=16)		
1961	-3.5297	3.7244	-0.9477	1
	3.3607	4.6675	0.7200	2
	1.4272	1.2607	1.1321	3
	-0.7381	0.7407	-0.9965	4
	-0.0079	0.0314	-0.2539	5
	0.0051	0.0080	0.6419	6
	(a=27.3728 R^2=0.3949	d.f.=24)		

TABLE 30.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1962	-6.8869	3.7512	-1.8359*	1
	-1.7610	4.9078	-0.3588	2
	2.1894	1.2389	1.7673*	3
	-0.9243	0.8024	-1.1519	4
	-0.0397	0.0208	-1.9109*	5
	0.0086	0.0083	1.0403	6
	(a=24.3499	R^2=0.3994	d.f.=19)	

TABLE 31.--Results of multiple regression analysis for wheat on Pawnee Soil Class III (5T B 2 III)

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1953	-4.6465	4.4235	-1.0504	1
	-2.0776	5.2732	-0.3939	2
	0.0254	57.3002	0.0004	3
	1.5492	6.6715	0.2432	4
	0.0027	0.6653	0.0041	5
	-0.0597	0.9433	-0.0633	6
	(a=27.3708	R^2=0.4138	d.f.=18)	

TABLE 31.--Continued

Year	Regression Coefficient	Standard Error	Sample t-value	Variable
1954	-10.6809	5.8247	-1.8337*	1
	-4.7421	5.8409	-0.8119	2
	0.5158	0.5917	0.8718	3
	-0.8269	1.6107	-0.5134	4
	-0.0109	0.0134	-0.8182	5
	0.0476	0.0702	0.6655	6
	(a=27.8383	R^2=0.4171	d.f.=12)	
1955	Insufficient Data			
1956	Insufficient Data			
1957	-11.6651	4.9295	-2.3664*	1
	5.0039	6.6188	0.7560	2
	1.4033	4.7271	0.2969	3
	-1.9242	5.7062	-0.3372	4
	-0.0171	0.0662	-0.2578	5
	0.0509	0.1267	0.4025	6
	(a=34.9965	R^2=0.8181	d.f.=9)	
1958	Insufficient Data			
1959	Insufficient Data			
1960	Insufficient Data			
1961	Insufficient Data			
1962	Insufficient Data			

CHAPTER V

ECONOMIC ANALYSIS

The individual farmer, faced with the decision of initiating land treatments or not, would be more favorable toward the treatments if it could be proven to him that his income from each acre treated would increase. A useful tool available to facilitate making the correct decision is the discounting of future returns and costs.

The discounting method makes use of the well-known fact that human beings tend to discount future revenues--a promise of $150 two years hence may not be as valuable to a person as a sure $100 today. The following formula is used to estimate the present value of future incomes:

$$V = \frac{NR_1}{(1+r)} + \frac{NR_2}{(1+r)^2} + \frac{NR_3}{(1+r)^3} + \cdot \cdot \cdot + \frac{NR_n}{(1+r)^n} ,$$

or

$$V = \sum_{i=1}^{n} \frac{NR_i}{(1+r)^i} .$$

Where: The V is the present value of future net revenues. The NR_i are the net revenues in the i-th time period. The r is the market rate of interest while the i represents the time periods; from 1 to n.

The value of the V represents the amount of money which, if loaned at the current market rate of interest and allowed to accumulate compound interest, would equal the future revenues in thier time periods.

For the Sabetha Watershed data, this method of discounting future net revenues has been used to determine the decision an individual farmer would make if in 1952 he had future knowledge of these data. Since data were available only for a ten year period, that will be the length of the discounting or planning period. The market rate of interest shall, for the sake of simplicity, be 5 percent.

The land treatment of terracing plus contouring has associated with it a large initial construction cost and a relatively low annual maintenance cost. The cost data that were available for the Sabetha Watershed indicated that the average cost of constructing a terrace in 1952 was 4.13 cents per linear foot (this cost has since risen to 6 cents or more per linear foot). Since both soils that were considered had a B slope (5 to 7 percent), each required about 264 feet of terracing per acre.[1] The cost of constructing an acre of terraces on the two soils that were considered was therefore $10.90.

Of the total average cost of construction of terraces in the Sabetha Watershed, the Agricultural Conservation Program (ACP) paid an average of 2.35 cents per linear foot or $6.20 per acre. This resulted in the farmer paying $4.70 per acre for terracing on the two soils considered.

The maintenance costs for terraces were estimated by Micheel and Nauheim[2] as averaging 15 cents per 100 linear feet annually. For 264 feet

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[1] Micheel and Nauheim, p. 30.

[2] Ibid.

of terraces this would amount to 39.6 cents (or 40 cents, to the nearest whole cent) annually.

According to Micheel and Nauheim,[3] cultivating terraced land on the contour results in no additional production cost to the farmer. The only cost to the operator would be a time cost. If the terraces were parallel, this time cost would be nominal. However, if the terraces were non-parallel, this time cost would be more substantial. Since there was no method to estimate this time loss it was ignored in this analysis.

Statistical analysis of the effects of land treatments on crop yields in the Sabetha Watershed from 1953 to 1962 revealed that the treatments had no significant effects on yields. The analyses were restricted by the low number of observations with resulting high standard errors and low multiple correlation coefficients (R^2). Consequently, the regression coefficients that were significant probably cannot be accepted as representative of the actual situation.

Therefore, it is merely for the purpose of illustrating the method that an economic analysis is done. The analysis deals with terracing plus contouring in the wheat and corn classes planted on Grundy Soil. No notice was taken of when a particular field was terraced; therefore, fields that had been terraced for several years were grouped with ones terraced a very short time. It is expected that a field that has been terraced for a long period of time (long enough so that the treatment has "matured") will yield better than a newly terraced one. No attempt was made to group fields terraced in the same year together because the number of observations would

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[3] Ibid.

have declined considerably.

The economic analysis presented there will take the regression coefficient between yield and terracing plus contouring (b_1) as the advantage or disadvantage resulting from the treatment. Regression coefficients that are significantly different from zero at the 10 percent level of confidence for the t-test are included; all other regression coefficients are assumed to be zero. For wheat on Grundy Soil, only four regression coefficients out of ten were significantly different from zero; for corn on Grundy Soil only two of the ten were significant. The value of the advantage or disadvantage resulting from the treatment (in bushels per acre) times the appropriate November market price of the crop yields the revenue gained or lost as a result of the treatment. The market price for each year was obtained from the yearly issues of Farm Facts, published by the Kansas State Board of Agriculture.

The cost of the treatment for each year is then subtracted from the gain or loss in revenue to obtain a net revenue figure. These values are then used in the formula stated above to derive the 1953 value of the future net revenues from terracing plus contouring.

The values needed to compute the discounted value of the future net revenues are listed in Table 32. Using the regression coefficients obtained for each year for terracing plus contouring, a gain in net revenue of $1.16 over the ten-year period is realized for wheat without a government subsidy for part of the cost of installation. With a government subsidy, a gain of $7.06 is realized. Therefore, with or without a subsidy, it is profitable for the individual farmer to terrace and contour his land. This, of course, has been the general feeling about land treatments; however, the values for the advantage or disadvantage of the treatments should not be taken as true for the reasons cited before.

The economic analysis for corn on Grundy Soil disclosed that terracing plus contouring was not profitable without a subsidy (a net revenue loss of \$2.24 was encountered), but was profitable with a subsidy (gain in net revenue of \$3.66).

An economic analysis on fertilizer will not be done as the regression coefficients obtained for fertilizer were associated with high standard errors and cannot be accepted as measuring the true situation.

TABLE 32.--Economic analysis of terracing plus contouring for yields of wheat planted on Grundy soil in the Sabetha Watershed 1953-1962

Year	Regression Coefficient	Price[a]	Revenue	Cost	NR[b] w/o ACP[c]	Discounted NR w/o ACP	NR with ACP	Discounted NR with ACP
1953	0.00	----	0.00	10.90	-10.90	-10.38	- 4.70	- 4.48
1954	0.00	----	0.00	.40	- .40	- .36	- .40	- .36
1955	0.00	----	0.00	.40	- .40	- .35	- .40	- .35
1956	10.42	2.07	21.57	.40	21.17	17.35	21.17	17.35
1957	- 4.92	1.91	- 9.40	.40	- 9.80	- 7.66	- 9.80	- 7.66
1958	0.00	----	0.00	.40	- .40	- .30	- .40	- .30
1959	9.75	1.79	17.45	.40	17.05	12.09	17.05	12.09
1960	0.00	----	0.00	.40	- .40	- .27	- .40	- .27
1961	0.00	----	0.00	.40	- .40	- .26	- .40	- .26
1962	- 6.89	2.00	-13.78	.40	-14.18	- 8.70	-14.18	- 8.70

[a] Price is expressed in dollars per bushel.

[b] NR indicates net revenue.

[c] ACP indicates the government subsidy program payment.

CHAPTER VI

SUMMARY AND CONCLUSION

The primary objective of the Sabetha Watershed study was to ascertain the effects of specific land treatments on crop yields and farm incomes. The secondary objective was to note the significant changes in the watershed over the study period of 1953 to 1962.

An analysis of variance was performed on each class of data (only two soils and two crops had sufficient numbers of observations to make analyses of variance) and each year to determine if sample means of the treated observations (fields) were significantly different from the sample means of the non-treated observations.

A multiple regression analysis was performed in order to support the findings of the analysis of variance, to derive an estimate of the effects of the treatments, and to increase the number of observations by including the fertilized observations. The multiple regression was done on the same classes of data as was the analysis of variance and for each year.

To determine if the treatments were economically justifiable for the individual farm operator, a method of discounting future net returns was proposed.

The statistical analysis revealed that there was no significant effect on yields of the land treatments for the particular time period, soils, and locale of the study. The analysis of variance indicated that terracing plus contouring, and contouring alone did not significantly increase or decrease crop yields. The multiple regression analysis confirmed the results of the analysis of variance and gave somewhat unexpected results for the effects of fertilizer. The multiple regression analysis also indicated that there was a lack of data and revealed that not all the factors affecting crop yields were included in the study.

An economic analysis was performed for terracing plus contouring on fields of Grundy Soil planted in corn and wheat. These two analyses used the proper regression coefficients in Tables 28 and 30 that were significantly different from zero at the 10 percent level of confidence. Because of the low number of observations on which these regression coefficients were based and the low multiple correlation coefficient values, the economic analyses are not conclusive evidence. The economic analyses were performed to illustrate the method. Assuming that the regression coefficients correctly represented the true situation, it was found that terracing plus contouring was profitable for the individual farmer with and without a government subsidy when the field was planted in wheat. Terracing and contouring a corn field on this soil was found to be profitable only with a government subsidy. The results of the economic analyses were based upon only four significant regression coefficients for wheat and two for corn, of the possible ten. Therefore, the results of the economic analyses should not be accepted as conclusive.

Perhaps the most profitable results of this study are the implications it has for future research of this nature. As stated before, it is a generally believed notion that land treatments of the type discussed in this paper are profitable for society and for the individual. However, this study indicates that this might not be true. Examination of the possible causes of this unexpected result will be particularly helpful to those researchers planning work in this field in the future.

Possible causes of the unexpected results are:

(1) For the soils found in this area, soil losses in a short period of time (five to ten years) do not greatly reduce crop yields.[1] Only in the longer run could soil losses reduce crop yields substantially. Therefore, since terracing and contouring normally tend to hold crop yields at a given level, no significant differential in crop yields for the first ten years of a watershed program in this area may be expected between non-treated and treated fields.

(2) The study indicated that the first ten years of a watershed program likely is too brief and too soon to correctly evaluate the relationship between land treatments and crop yields.

(3) This study also indicated that the Sabetha Watershed is too small to yield enough observations to completely evaluate all land treatments for major crops and soils.

(4) Another factor affecting the results of the study was the absence of some data, either from the field sheets and computer cards or from the computer cards alone. Examples are the crop rotation histories of each field (which could be obtained from the field sheets by painstaking work

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[1] See McKinney, "Conservation and Watershed Programs," p. 2; and Micheel and Nauheim, p. 12.

with the results not likely to be worth the cost); the length of time a field had been terraced (available only on the field sheets); some of the information on the field sheets was sketchy; and no data on waterways and grade stabilization structures were available.

The implications for future work that this study has are: (1) Research of this type should be conducted on a large enough watershed to provide each of the major crops, soils, and treatments with adequate numbers of observations to make statistical analyses worthwhile. (2) The study period should be during and after a period of time sufficiently long for the land treatments to have "matured". (3) Accurate and complete data should be gathered for each independent variable that affects the dependent variable.

APPENDIX A

METHOD OF SOIL CLASSIFICATION

The symbols utilized to label and describe different soil types in this paper are the symbols given to each soil and soil characteristic by the Soil Conservation Service of the United States Department of Agriculture. The name given to a soil is usually associated with the locale where the soil is found (for instance, Cherokee soil is found predominently in Cherokee County, Kansas); although this is not a steadfast rule.

In the set of symbols such as 5Lo B 2 III; the 5Lo, or the first set of symbols, denotes the soil type. The symbol Lo represents the parent material, loess. Other symbols such as T (which represents till) denote various other parent materials.

The alphabetical symbol that is immediately after the soil type symbol group (reading left to right), indicates the degree of slope of the particular area being classified. An A slope symbol denotes a mild slope--less than 2, 3, or 5 percent slope, depending upon the kind of soil. The letters continue up to E, which represents the steepest slope--greater than 35 percent.

The Arabic numeral found immediately after the slope symbol, signifies the amount of erosion on the area in question. An erosion symbol of 1 signifies that less than 25 percent of the topsoil has been removed. The increasing numerals denote increasing sheet erosion conditions up to 6, which is the worst condition of sheet erosion. A 7, 8, or 9 indicates worsening degrees of gully erosion.

The last symbol, a Roman numeral, specifies the use capability of the plot being classified. The various use capability symbols and the land they designate follow:[1]

I. Suitable for cultivation without special practices.
II. Suitable for cultivation with simple practices.
III. Suitable for cultivation with intensive practices.
IV. Not suitable for continuous cultivation.
V. Not suitable for cultivation.
VI. Suitable for grazing without special practices.
VII. Suitable for grazing with simple practices.
VIII. Suitable for grazing with intensive practices.
IX. Wasteland.

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[1] Information for this Appendix taken from: E. A. Norton, Soil Conservation Survey Handbook (Washington, United States Department of Agriculture, Publication No. 352, 1939); and, O. W. Bidwell, Major Soils of Kansas, Kansas Agricultural Experiment Station, Circular 336 (Manhattan, Kansas: July 1956.

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EFFECTS OF WATERSHED TREATMENTS ON FARM PRODUCTION IN THE SABETHA LAKE WATERSHED

by

TERRY PAUL SUTTON

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Interest in the conservation of soil and water resources in the United States has increased greatly over the course of this century. Much of this interest has been concentrated on the watershed as a logical unit in which to coordinate a conservation program. This study was concerned with a watershed near Sabetha, Kansas.

The objectives of this study were: (1) To note significant changes in land use, watershed treatments, and crop yields in the Sabetha Lake Watershed from 1953 to 1962. (2) To determine how and to what extent specific land treatments affect crop yields and farm income. (3) To ascertain the optimal economic combination of land treatments with respect to farm income.

The hypothesis tested by this study was: That specific land treatments are economically advisable for the individual farmer in the Sabetha Watershed.

Data concerning land uses, land treatments, farm operations, and crop yields were obtained for all of the land in the watershed and processed by computer. Only two crops (corn and wheat) and two soils had a sufficient number of observations to statistically analyze.

An analysis of variance for each crop-soil class and each year was performed on the observations with no mechanical treatment, those with terracing plus contouring, and those with contouring alone. A multiple regression analysis was performed for each crop-soil class and each year with the dependent variable as crop yield and the independent variables as terracing plus contouring, contouring alone, nitrogen fertilizer, phosphorus fertilizer, and the squared values of nitrogen and phosphorus fertilizers.

The analyses of variance revealed no significant differences between the mean of the treated observations and the mean of the non-treated observations.

The multiple regression analyses results generally supported the results of the analyses of variance; very few of the regression coefficients for terracing plus contouring and contouring alone were significantly different from zero at the 10 percent level of confidence. The regression coefficients obtained for fertilizers were unexpected (with regard to the signs of the coefficients) and probably suffered from an insufficient number of observations. The multiple correlation coefficients associated with each regression indicated that not all the factors affecting crop yields were included in the analyses.

A method of discounting net revenues was presented as a means of determining if a land treatment was profitable for the individual farmer. Given the addition or subtraction to yields of a given land treatment for each year and the cost of the treatment for each year; the present value of future net revenues could be obtained. This process was done for corn and wheat on the most common soil, but the results were not conclusive because of the high standard errors of the regression coefficients and the low number of significant regression coefficients.

Perhaps the most profitable aspect of this study was the implications for future research in this field. These were: (1) Research should be done on a large enough watershed to provide each variable with adequate numbers of observations to make statistical analyses worthwhile. (2) The study period should be during and after a period of time sufficiently long for the land treatments to have "matured". (3) Accurate and complete data should be gathered for each independent variable that affects the dependent variable.

Perhaps these suggestions could be carried out in the following manner: The study area could be a large watershed, a county, or a number of counties. Two or three soils could be chosen as could two or three crops. Data for these classes could be the only data obtained to minimize the cost of the research. The observations in the study area with the proper crop and soil would be included with the further restriction that the treatment had to have been in effect a specified length of time. Also, a sufficient number of non-treated observations would be included.