DECEMBER, 1950 RESEARCH BULLETIN 465

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

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PRODUCTIVITY OF FARM LAND IN MISSOURI

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(Publication authorized October 18, 1950)

COLUMBIA, MISSOURI

FOREWORD

Recognizing the importance of the physical productivity of land in determining not only its value, but more significantly, the limitations which this productivity places on the farm family, the Department of Agricultural Economics of the Missouri Agricultural Experiment Station has been developing methods whereby the total productivity of a farm may be estimated with reasonable dependability. A beginning was reported in Research Bulletin 308 (1939). The next step was to attempt to measure the productive value of pastures. Crop reports so far available do not include pasture yields, but pasture makes up an important part of the total productive power on most Missouri farms. The results of that study were presented in Bulletin 443 (1942).

The report here presented is regarded as a significant addition to these earlier studies representing a refinement and improvement of earlier techniques. Greater accuracy has been achieved, and the results should be more readily applicable to the practical problem of determining how much income a farm family may expect from a particular farm.

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Acknowledgment.—The author wishes to acknowledge his indebtedness to Professor H. J. Meenen, who served as his major advisor and guide throughout this study. Professor Meenen's unfailing patience and enthusiasm were largely responsible for carrying through this analysis to completion. The author also owes much to Professor H. H. Krusekopf of the Department of Soils for technical guidance and encouragement. The land classification which serves as the basis of this study is largely the product of Professor Krusekopf's years of study of the soils of Missouri and their capability. Acknowledgment is also due Dr. Frank Miller for his interest and work of preparing this manuscript for publication.

Productivity of Farm Land in Missouri

BUEL FRANKLIN LANPHER, JR.*

INTRODUCTION

The most fundamental aspect of farm land is its productivity. The volume of grain, hay, fibre, pasture and timber products that can be obtained for conversion into goods and services that satisfy human wants is of concern to people who have no direct connection with agriculture as well as to farmers. Productivity affects the price of land, the use of credit, assessed valuation for tax purposes, the level of income of farmers and their families and the standard of living that can be sustained within the nation.

Various methods of classifying land and of rating soils have been developed. The United States Department of Agriculture has outlined a procedure which is based upon the suitability of land for specific uses. Under this classification the grade in which the land is placed depends upon the intensity of conservation practices needed to prevent serious deterioration of the soil when it is in a specific use such as the production of intertilled crops like corn and cotton, or in close growing crops, oats and wheat, for example, or in sod forming crops like bromegrass and bluegrass and in permanent pasture where the native grasses are dominant.[1]†

The net energy value of the total production of all crops was used by Rawlings and Johnson[2] to determine the gross productivity per acre of farms in certain parts of Missouri and Iowa.

The net income attributable to land has been used by the Farm Credit Administration and other lending agencies as a basis for appraisals for loan purposes. Pine[3] has suggested the use of net income to the land itself as a method of classifying soils on a relative basis. This procedure has been used to determine the value of crop and pasture land in central Kansas.

Soil scientists in the Department of Agriculture have developed a method of rating the productivity of soils for individual crops. The relative standings of the various series and types are based upon the inherent qualities of the soil itself and the yield records as shown by the best estimates available. By this procedure a soil may have a productivity rating

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†See list of References on page 42.

of 85 for corn and alfalfa and only 60 for wheat and oats. The Storie index which is based on soil characteristics that govern its potential use and capacity to yield crops is a similar approach to the problem of determining productivity.[4]

A procedure has been developed for measuring the productive value of pastures on the various soil types in Missouri.[5]

Members of the Montana Agricultural Experiment Station staff worked out a method of valuing land for tax purposes based upon expected wheat yields.[6]

These and other studies not cited here represent important contributions to the development of procedures that can be followed in measuring the productivity of land. Most of the work deals with the theoretical capacity of a soil to yield crops or the value of land for the production of a particular crop. In no case has the total production of all crops and all types of pasture been reduced to a common measure for the purpose of determining the productivity of each class of land in relationship to other classes.

Missouri farm land varies widely in productivity. Marked differences both in the physical yield and in the quality of crops occur inside field boundaries as well as between localities. A measure of these differences will make possible more accurate recommendations to the individual farmer who needs guidance in choosing a farm and setting up his enterprises. It will also aid public officials in assessing taxes and in laying out a desirable pattern of public service facilities that can be supported out of returns from the land.

Soil scientists and men working in related fields have done considerable work in developing criteria that can be used as reliable indicators of differences in productivity. Soil fertility requirements for the various farm crops have been determined. Chemical tests have been developed, laboratories made available and technicians trained to give farmers reliable information about the deficiencies of their soils in plant nutrients. The various soil series, such as the Marshall silt loam, the Grundy silt loam, the Shelby silt loam, the Lindley loam, the Crawford gravelly loam and the Clarksville gravelly loam, have been grouped into land classes according to the yields of crops that can be expected from them and their desirability for agricultural use.* The average production that the farmer can expect from the soils on his farm will give him a basis for judging the results that he can expect to obtain from his work. The procedure outlined here will supplement the other land classification work and will help to bridge the gap between the yields that can be expected where land is used for a particular crop, corn, wheat, or cotton, for example, as compared to the results that can be obtained from usual combinations of crops and pasture in particular sections of the state.

The analysis presented here will deal primarily with the total physical

*Detailed descriptions of the various soils can be found in county soil survey bulletins.

product that a farmer can expect to get from the various classes of land. From the economic point of view the yield of crops is only one factor in profitable land use. The value of the product must be compared with the cost of producing it in order to determine economic usability. This study, however, is limited to the development of procedures that can be followed in finding total productivity. Net returns to the farm operator will vary with the size and types of enterprises that make up his farm business, efficiency in the use of land, capital and labor, weather conditions, type of equipment used, fluctuations in commodity prices, and many other factors. Investigation of the relationships between these factors lies in the field of farm management. It is outside the scope of this study.

The first purpose of the study is to measure the physical productivity of the land in each class area and subarea of the state, where the crops usually grown and the yields customarily obtained under common farming practices are similar. A second purpose is to find out to what extent there is a discernible relationship between the productivity of land in these sections and some of the social and economic factors that affect the welfare of farm people.

Productivity in the various land class areas and subareas is measured by converting the yields of crops and the carrying capacity of pastures to standard units. Only the primary products, such as corn, oats, wheat, hay and the feed value of pastures, are used. No consideration is given to the monetary value that can be added by converting these crops into livestock and livestock products.

The procedure is to convert each crop and each type of pasture into corn and cottonseed meal equivalents[7] on the basis of the energy values outlined in feeding standards and to convert these products into dollar values so items like cotton lint can be added. This separation of feed and forage crops into carbohydrates or energy producing products and proteins seems to be desirable for two reasons.

(1) Plants require more soil nutrients to produce proteins than to produce carbohydrates, and

(2) the monetary value per unit of weight is higher for protein than for the energy producing products such as corn.

Reliable price quotations for corn and cottonseed meal are available over a long period. It is comparatively easy to convert the two commodities into dollar values which can be added to the value of such products as cotton lint to get a gross income figure that is comparable to the productivity of the soils where the crops are grown.

The yields reported by the United States Census and the State-Federal Division of Agricultural Statistics are used in determining gross productivity for each area within the same land class where the land use is similar. The objective is to find the average gross productivity that farmers are obtaining from the land as they are farming it and not the yields that can be expected under the best practices that can be followed. Some of the land areas are subdivided, because the land use and yields in the smaller areas appear to be more accurate than for the larger land class areas. The production of the various crops in these smaller areas is then combined into a single value denoting the average total productivity in the land class, area or subarea. This single value makes comparisons of productivities possible.

The productivity of fifteen land class areas and subareas in the state are presented in the analysis. These figures can be applied to practically all of the land in the state. They provide a basis for calculating the amount of return per acre a farm operator can expect from cultivated land and from all land in farms. These facts give some indication of the size of farm that is needed to obtain a given level of gross income under average price and operating conditions.

Since there are wide differences in gross productivity between land classes, the value of land and buildings, the value of machinery, livestock numbers, farm conveniences and other such data can be expected to vary. Data from the census of agriculture for the years 1940[8] and 1945[9] are used to determine the degree of relationship between several of these factors and gross productivity. The findings show clearly that the capital used on farms and the conveniences that farm people are able to enjoy are closely related to the productivity of the land. Further study is needed to determine the most profitable procedures to use in building up productivity per farm unit. Can net incomes be brought up to desirable levels by expanding the acreage in the operating unit? To what extent can improved farming practices such as crop rotations, water management and the use of fertilizers overcome the handicaps imposed by low soil productivity? These fields of investigation should not be neglected.

DETERMINATION OF GROSS PRODUCTIVITY

Land in Missouri has been divided into seven general classes on the basis of productivity and desirability for agricultural use. The areas that fall in each class are shown in Figure 1.* The cropland is separated into four classes and designated as superior, good, average, and below average. Areas not suitable for cultivation are shown as pasture, pasture-forest, and forest land.

The features that determine productivity and desirability of land for specific uses are topography, character of the soil, and climate. The character of a soil is determined by fertility, texture, consistency, structure of profile, susceptibility to erosion, and depth of surface soil. Topography as a factor in classification requires consideration of steepness of slope, dissection of surface, drainage and erosion. These factors must be considered together in making the classification. The land in a given area may have a very fertile topsoil, but the topography may be steeply rolling. The productivity may be high, but the use limited because of the steep slope and erosion hazard.

*This work has been done by Professor H. H. Krusekopf of the Soils Department, University of Missouri. A large map (unpublished) shows the areas in much more detail than in Figure 1.

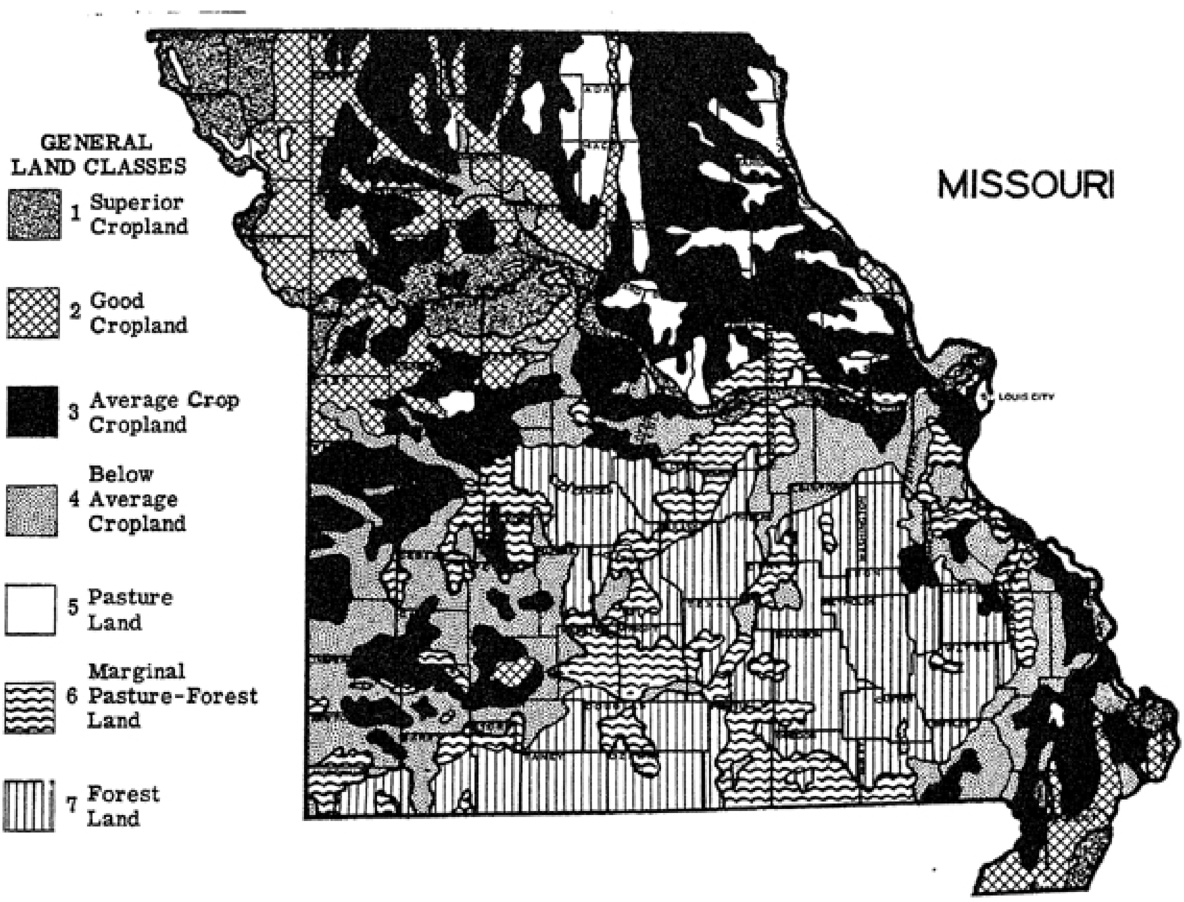

Figure 1.—Location and extent of general land class areas.

The distinguishing characteristics of the land in each of the seven classes are outlined in detail by the classifiers as follows:[10]

Class 1 Land.—"All conditions of soil and topography are highly favorable. The land is permanently first quality and produces dependable yields of crops. The soil does not deteriorate easily; it is adapted to a variety of crops; it has good drainage, safety from erosion and flooding, occurs in large areas, and is easily tilled. All of these factors are at the optimum."

Class 2 Land.—"It is less desirable in one or more respects than class 1, but is very good farm land. It may have a wider range of soil conditions—mainly of texture and structure and for this reason may not have as wide a range of crop adaptation as class 1 land. Rolling areas rarely have slopes of more than 10 per cent. Under good care its permanent productiveness is assured. It should not include more than 10 per cent of non-tillable land."

Class 3 Land.—"Land in this class is rarely above medium in fertility, and requires good management for best results in crop production. It is subject to deterioration under continuous cultivation. The hazard of erosion or incomplete drainage is nearly always present. Crop adaptation is generally limited because of some unfavorable soil feature. Soil improvements such as liming, fertilization, and erosion control are necessary for maximum yields. Rolling areas do not have slopes above 15 per cent. The included non-arable land should not represent more than 20 per cent of the total area."

Class 4 Land.—"This is the lowest class of land suitable for producing cultivated crops. It is land of insurmountable limitations, due either to low fertility or to unfavorable physical properties. Frequent cultivation usually results in rapid deterioration. Fields may be irregular, but slopes are not greater than 20 per cent. The non-arable land included cannot be more than 30 per cent of the total area. Crop yields depend upon tillage practices and weather conditions. Only the exceptional operator gets a fair return. The average farmer makes a subsistence living. Hazards are always present because of some soil condition. Undeveloped areas should be left so."

Class 5 Land.—"This land should be kept in permanent pasture because of one or more of the following conditions: low fertility, steepness of slope, deterioration because of erosion, poor drainage, stone content or rock outcrop, less than 30 per cent of arable land. In general, the fertility of the soil is such that bluegrass will grow."

Class 6 Land.—"Land in this class may have similar physical features—slope, erosion, stone content—as class 5, but the fertility of the soil is lower. Much of the class 6 land is in forest, and its use for pasture or forest depends upon local conditions. The fertility of the soil is so low that bluegrass does not thrive. Most of the acreage in this class is found in the Ozark region."

Class 7 Land.—"All of the land for which tree production is the best use is placed in class 7. It includes steep slopes, gullied areas, and non-arable stony lands, either cleared or forested. The most rugged land in the Ozark region is placed in this class."

One of the principal considerations in placing the soils in the various land classes is capacity to produce the major crop. The yield of corn is used as a guide, except in the southeastern lowlands where cotton is the dominant crop.

In a broad classification of this kind it is impossible to show all of the areas of each land class on a small map. For this reason small areas of other classes of land are included within each major land class. For example, a highly productive area in the northwest corner of the state is designated as class 1 or superior cropland. Included with it are small acreages of less desirable land. A large map would be required to indicate the minor land variations. Similarly small areas of productive land are included in the lower land classes. Because of this mixture of the various classes, the gross productivity values do not represent each class exactly as defined in the description given in the preceding paragraphs. They do show differences in productivity of comparatively broad areas where each of the seven classes of land are dominant.

An effort is made to correct the lack of homogeneity to some extent by sub-dividing each of the cropland classes where there are significant variations in land use and in physical features. A gross productivity figure is calculated for each land class sub-division. By this procedure the gross productivity figures are kept more nearly representative of actual yield conditions than would be the case if a single value were calculated for each land class area as a whole. Ratings are presented for fifteen land classes and sub-divisions. The sub-divisions are identified by the land class number and their geographical location in the state. Thus, sub-division 1NW is a part of land class 1 lying in the northwest corner of the state. The breakdown of general land classes into geographic subdivisions is as follows:

Class 1 into 1NW, 1C, and 1SE;*

Class 2 into 2WC and 2SE;

Class 3 into 3NW, 3NE, 3SW, and 3SE;

Class 4 into 4SW, 4EC, and 4SE;

Classes 5, 6, and 7 are not sub-divided.

Each of these fifteen divisions is called a land class area or subarea in the analysis that follows.

In order to find the productivity, it is necessary to have the average acreages used for each purpose; the yield of crops and the feed units produced on pastures for each land class. The only data that give complete coverage throughout the state are the annual farm census reports published by the Missouri State Department of Agriculture and the federal census of agriculture. These reports contain data on land use and yields of crops by minor political sub-divisions. In order to use this information it is necessary to select reports from sub-divisions which are representative of each land class. Since most counties contain a mixture of land classes, the township data reported in the bi-centennial federal census of agriculture must be used for the basic yields and these figures adjusted to average yields by comparing them with county averages. By using a large map similar to Figure 1, it is possible to find a number of townships where an estimated ninety per cent or more of the land is in the same class. A large number of representative townships can be found in some land classes. In others less than twenty townships can be selected. The data for all of the uniform townships are used in those land class areas and subareas in which less than twenty townships are representative. In the areas, except land class 7, having a large number of nearly uniform townships, twenty are picked at random for use in the analysis. Approximately 170 representative townships can be found in land class 7. A considerable part of the total area is not in farms. For this reason forty townships were used instead of twenty.

The location of the townships from which data are used in subareas 1NW, 1C, and 2WC is shown in Figure 2. No townships on the alluvial soils of the Missouri river valley are included. Much of the bottomland is highly productive in favorable crop years, but the best soils, such as Wabash silt loam, occur in long narrow strips between less productive soils and sometimes are subject to flooding. The crops grown and the yields obtained by

*The letters after each number indicate the general section of the state where the subdivision is located. For example: Subarea 1NW is a section of Class 1 land in the northwestern part of the state.

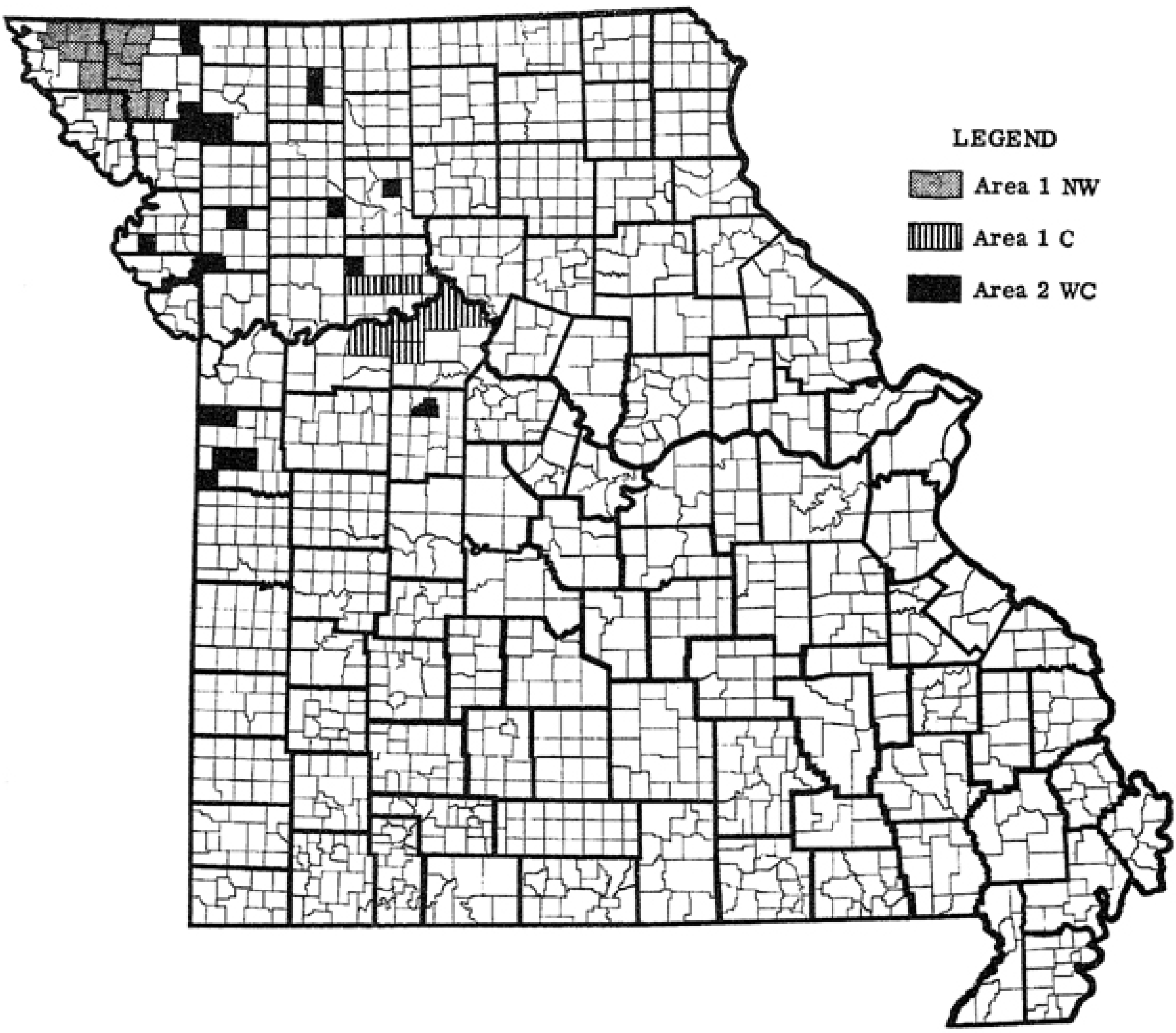

Figure 2.—Sample townships used in determining the productivity of land in subareas 1NW, 1C, and 2WC.

farm operators differ widely from production obtained outside the bottomland. In subareas 1NW and 1C the soils are predominantly of the Marshall Series. Grundy, Summit, and Sharpburg are the dominant soil series in land class 2WC.*

The location of townships from which data were used in determining the physical productivity of the land in subareas 3NW, 3SW, 3NE, 4SW and 4EC is shown in Figure 3. Each subarea contains a number of fairly uniform townships. The topography in 3NW is rolling and the soil has been damaged somewhat by erosion. The land in 3SW and 3NE in general is level to slightly undulating and erosion is less active than in 3NW. Soils of the Shelby series predominate in 3NW. The Oswego and Gerald series occupy most of the 3SW. The Putnam and Edina series are dominant in 3NE. Subarea 4SW is, for the most part, level prairie. Soils of the Cherokee, Baxter, and Bates series are common.* Subarea 4EC has a rolling to-

*Detailed descriptions of the various soils can be found in county soil survey bulletins.

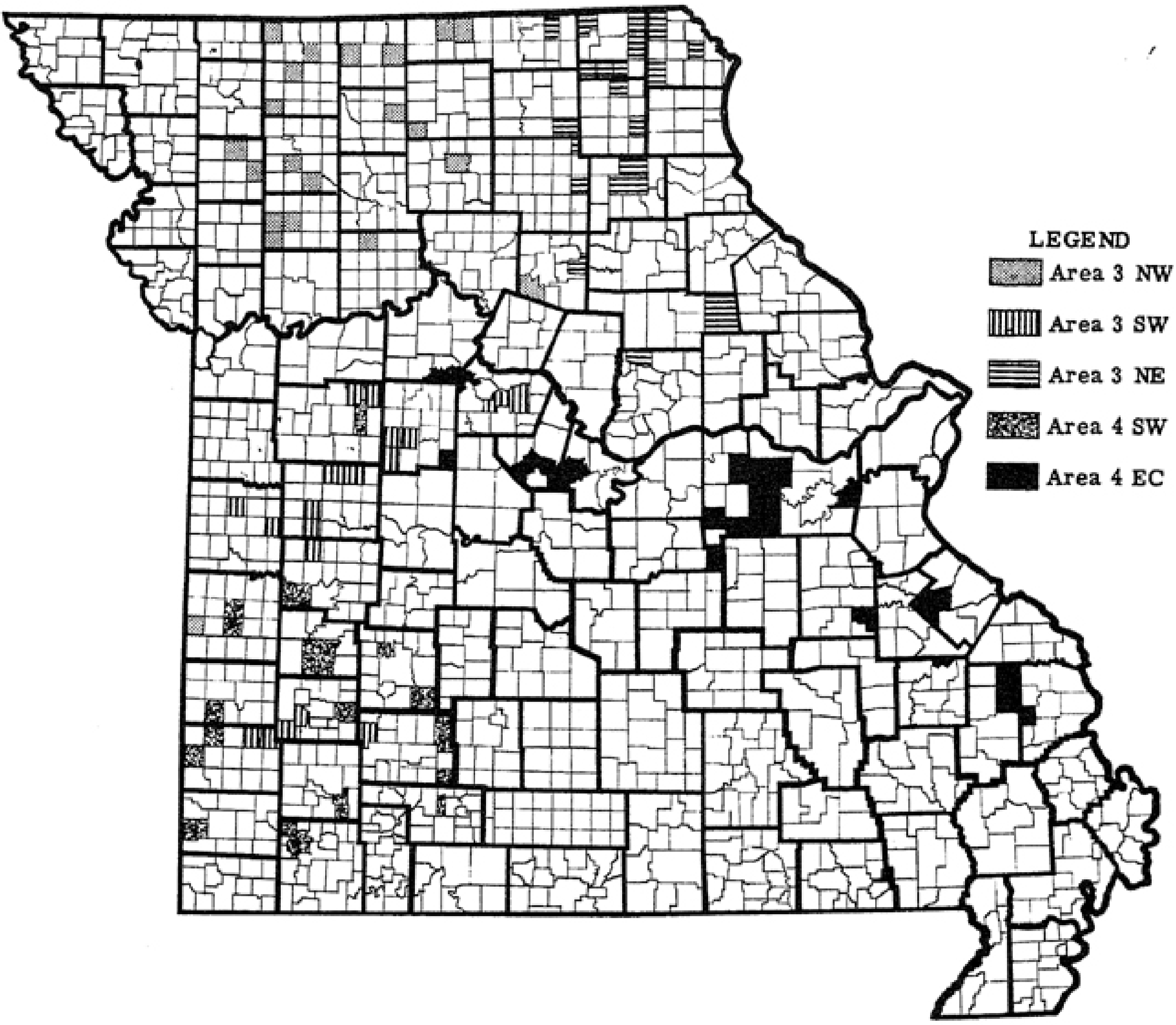

Figure 3.—Sample townships used in determining the productivity of land in subareas 3NW, 3SW, 3NE, 4SW, and 4EC.

pography and was originally timbered. Soils of the Lebanon and Union series are found in this part of the state.

The townships from which data were obtained for use in calculating the gross productivity of land classes 5, 6, and 7 are given in Figure 4. Class 5, which is pasture land, tends to have a steeply rolling topography. Characteristic soils are in the Lindley series, however, other series including Shelby and some of the alluvial soils are found intermingled with Lindley in the Class 5 area. The bottom land soils are productive and frequently are used to grow crops. If these small areas were considered alone, they would stand in a higher land class.

Land class 6 also tends to have a steeply rolling topography. The soils usually are of the Bodine, the better phases of Clarksville and the steeply rolling phases of the Union series. Small areas of better soils are also found in the land class.

Land class 7 is found in rough, broken areas. Clarksville stony loam and rough stony land are characteristic soils. Small acreages of bottom

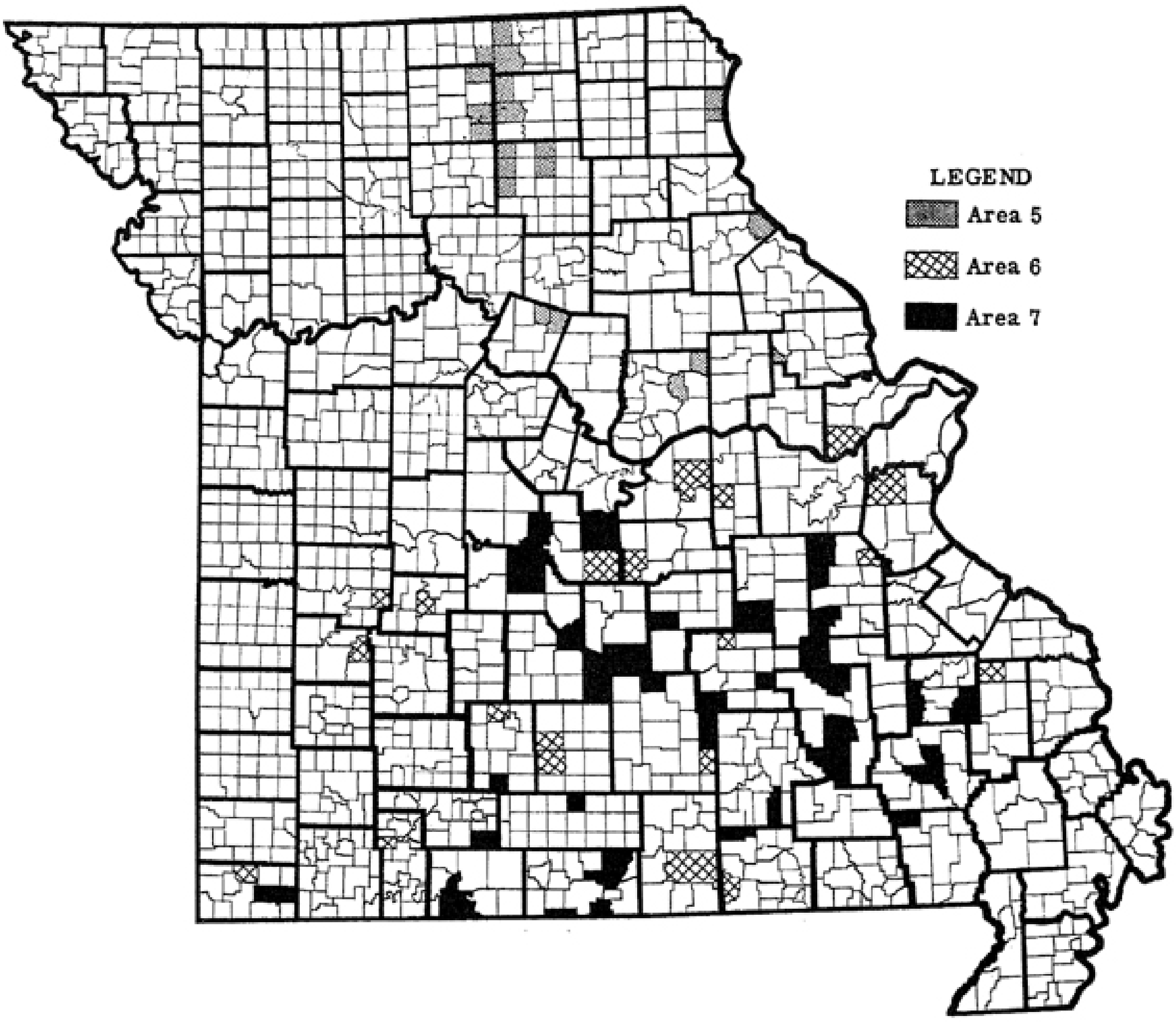

Figure 4.—Sample townships used in determining the productivity of land in classes 5, 6 and 7.

land are found where the soils are much more productive than the predominating upland. These lowlands constitute the major portion of the cultivated acreage and usually are the nucleus of the farms found in this land class.

The location of the townships used in finding the gross productivity of the land in subareas 1SE, 2SE, 3SE, and 4SE is shown in Figure 5. These four subareas are located in the alluvial soils region in the southeast corner of the state. Only five eligible townships could be found in subarea 1SE. Sarpy fine sandy loam is the dominant soil. Subarea 2SE where sharky clay loam predominates has ten eligible townships. Subarea 3SE has eight townships where the land is uniform in grade. Lintonia fine sand and Waverly fine sandy loam are the most common soils. Data from five townships are used in subarea 4SE. Waverly and Calhoun silt loams are the most common soils found in this section.

Acreages of crops, pasture and woodland for the years 1939 and 1944 were taken from the United States Census of Agriculture for the townships

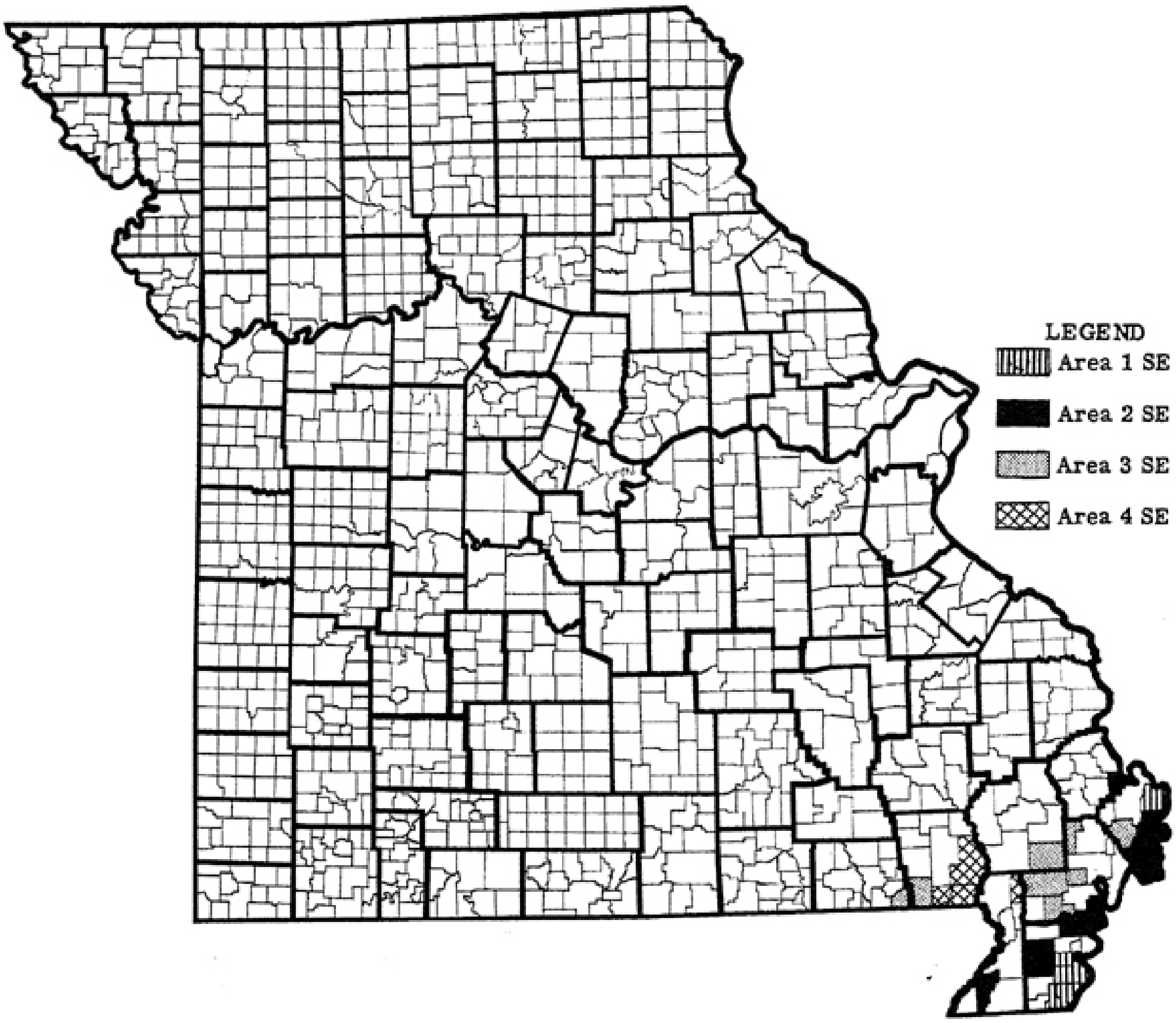

Figure 5.—Sample townships used in determining the productivity of land in subareas 1SE, 2SE, 3SE and 4SE.

shown in Figures 2 to 5. These two years were fairly representative of average cropping practices in the state. During the 1937-1946 ten-year period, there was a tendency to increase the acreage of cash crops, but the change was not great, except for soybeans. The census data were used to find the percentage of land in each class that was in crops and in other uses. The results are shown in Table 1.

The data in Table 1 show that there are wide differences in land use between the various sub-divisions within the same general land class as well as between the various classes. Corn is grown on 33.1 per cent of the land in subarea 1NW. It occupies 25.0 per cent in subarea 1C, and only 18.5 per cent in subarea 1SE. As between classes, corn is grown on 33.1 per cent of the acreage in subarea 1NW, 19.2 per cent in subarea 2WC, 13.3 per cent in subarea 3NW and on 9.0 per cent in subarea 4EC. Wide variations also occur in cotton, wheat, oats, soybeans, and hay crops (Table 1).

Average yields of crops in the various land class areas and subareas are presented in Table 2. The data for each of the uniform townships were first obtained from the census reports and then adjusted to the 1937-1946 ten-year average yield for each crop in the county where the township was located.

Diversity in the land use pattern in the various classes makes it necessary to find a common measure that can be used in combining the crops to determine gross productivity. Two procedures have been used in other

Table 1.--Percentage Distribution of the Average Land Use for Each Land Class.*

Land Class	Corn	Cotton	Wheat	Oats	Barley	Rye	Soybeans
1NW	33.1	----	3.5	5.2	---	0.2	0.6
1C	25.0	----	10.3	7.2	0.4	0.2	0.9
2WC	19.6	----	6.0	8.0	0.2	0.1	1.0
3NW	13.3	----	1.7	6.6	---	---	0.8
3SW	16.9	----	8.7	10.4	1.1	---	1.1
3NE	14.0	----	0.7	5.2	---	0.1	4.6
4SW	9.9	----	7.0	7.1	0.9	0.1	0.7
4EC	9.0	----	5.6	2.5	0.5	---	0.3
5	9.7	----	0.8	2.1	---	---	1.2
6	6.0	----	2.8	1.8	0.3	---	0.2
7	4.7	----	1.0	0.7	0.1	---	---
1SE	18.5	33.7	1.3	.1	.3	---	8.9
2SE	20.2	30.1	1.8	.1	.2	.2	12.0
3SE	21.6	22.6	4.4	.6	.5	.3	9.6
4SE	21.7	10.4	.9	.3	.2	---	4.5

Land Class	Sorghum Forage	Alfalfa Hay	Clover and Timothy Hay	Lespedeza Hay	Misc. Other Hay	Double Crops	Other Crops
1NW	0.3	3.4	3.2	0.5	1.0	8.6	0.7
1C	0.4	1.5	3.5	4.0	0.8	15.7	1.9
2WC	1.2	1.0	3.9	3.5	1.1	13.2	2.1
3NW	0.9	0.6	7.2	3.3	1.4	7.7	0.6
3SW	1.7	0.1	2.4	5.5	1.3	18.1	0.5
3NE	0.8	0.2	7.1	0.7	1.6	5.7	2.4
4SW	1.7	0.2	0.9	5.0	2.1	15.1	5.3
4EC	0.4	0.2	2.7	4.7	1.0	8.6	1.9
5	0.5	0.8	8.0	0.8	1.2	2.9	1.5
6	0.6	0.4	2.0	4.8	1.4	4.9	2.2
7	0.6	0.3	2.1	4.8	1.4	1.9	2.2
1SE	---	12.0	.5	.7	.4	1.8	1.6
2SE	---	2.8	.2	2.8	1.4	2.3	2.8
3SE	---	.9	.4	5.4	1.6	5.8	2.7
4SE	---	.1	.6	3.7	2.3	1.4	4.4

Land Class	Pasture	Woodland Pasture	Woodland	Crop Failure	Cropland Idle	Other Land	Total Percentage**
1NW	34.0	2.3	0.7	1.0	2.9	7.7	108.9
1C	30.4	2.0	1.8	2.0	1.7	8.5	118.2
2WC	37.4	3.2	1.1	1.3	2.0	8.4	114.3
3NW	45.4	8.3	0.8	1.1	1.2	7.4	108.3
3SW	35.1	3.8	1.5	0.7	2.9	8.4	120.2
3NE	41.8	7.7	1.4	0.5	2.6	9.0	106.1
4SW	27.3	13.1	2.4	0.4	2.7	13.3	115.2
4EC	27.6	19.9	10.6	0.4	3.1	9.7	108.7
5	48.3	11.7	2.6	0.3	1.7	8.9	103.0
6	29.0	27.1	9.3	0.4	1.4	10.4	105.0
7	22.1	29.5	20.6	0.1	1.5	8.4	102.0
1SE	6.5	.6	4.2	.8	3.4	6.5	101.8
2SE	6.9	3.5	4.9	1.7	3.1	5.4	102.4
3SE	8.8	7.2	2.6	1.2	2.4	7.3	105.9
4SE	11.0	13.6	16.3	.7	4.1	5.2	101.4

* Calculated from township data for 1939 and 1944, reported in the United States Census of Agriculture and published by the United States Department of Commerce.

** Exceeds one hundred per cent because of double cropping. The percentage of land double cropped is included in the percentage under "double crops," but in some areas a small part of the double cropped land is listed under other land use items.

Table 2.--Average Yields Per Acre in Each Land Class.*

Land Class	Corn (bu.)	Cotton Lint (lbs.)	Cotton-seed† (lbs.)	Wheat (bu.)	Oats (bu.)	Barley (bu.)	Rye (bu.)	Soybeans (bu.)
1NW	41.2	---	---	14.6	27.1	----	16.5	13.7
1C	41.5	---	---	14.2	32.8	20.9	18.5	22.9
2WC	32.9	---	---	14.5	29.2	22.1	18.1	15.4
3NW	31.0	---	---	14.0	26.4	----	----	16.2
3SW	25.2	---	---	12.4	26.5	19.3	----	11.0
3NE	28.6	---	---	13.2	28.9	----	11.8	20.0
4SW	22.8	---	---	12.3	21.8	19.9	22.1	8.0
4EC	28.1	---	---	14.0	21.4	16.0	----	18.5
5	34.6	---	---	15.5	28.1	----	----	21.8
6	30.6	---	---	13.7	21.3	16.1	----	10.6
7	25.7	---	---	10.1	19.2	14.8	----	----
1SE	28.2	482	895	19.2	36.0	24.4	----	30.7
2SE	27.9	470	873	15.2	18.3	18.6	6.0	23.7
3SE	27.9	428	795	14.3	21.6	23.4	8.7	25.2
4SE	26.9	457	849	17.9	25.8	22.1	----	24.6

Land Class	Sorghum Forage (Tons)	Alfalfa Hay (Tons)	Clover & Timothy Hay (Tons)	Lespedeza Hay (Tons)	Misc. Other Hay (Tons)	Pasture‡ (bu. corn equiv.)	Woodland Pasture§ (bu. corn equiv.)
1NW	2.73	2.33	1.19	1.17	1.12	18.1	9.1
1C	4.57	2.93	1.29	1.23	1.45	18.1	9.1
2WC	3.28	2.41	1.10	0.95	1.24	13.4	6.7
3NW	2.43	2.19	0.80	1.09	1.06	11.7	5.9
3SW	2.17	2.71	1.09	1.06	1.05	11.7	5.9
3NE	3.01	2.27	0.88	1.02	1.41	11.7	5.9
4SW	2.80	2.15	1.14	1.11	1.14	10.2	5.1
4EC	1.58	1.88	1.06	1.07	0.86	10.2	5.1
5	3.38	1.99	0.83	0.95	1.08	9.8	4.9
6	1.67	2.68	1.04	1.03	0.89	8.8	4.4
7	1.49	1.87	0.89	0.99	0.91	8.0	4.0
1SE	----	3.75	1.71	1.37	1.71	18.1	9.1
2SE	----	3.31	1.38	1.12	1.14	13.4	6.7
3SE	----	2.92	1.21	1.01	0.98	11.7	5.9
4SE	----	1.64	0.75	0.84	0.80	10.2	5.1

* All yields except for pasture were calculated from actual yield data reported in the United States Census of Agriculture for 1939 and 1944 by townships. The township data is an adjusted ten year average yield (1937-46). The county yields are reported in the Missouri Farm Census which is published annually by the Missouri State Department of Agriculture.

† Cottonseed yields were determined by using the common ratio that the weight of picked cotton will gin out 35 per cent lint and 65 per cent cottonseed.

‡ Pasture yields in each land class taken from average yields obtained on various soil types which corresponded to the soils found in each land class. The average pasture yields for various soil types were reported by Homer J. L'Hote, Measuring the Productive Value of Pastures, Missouri Agricultural Experiment Station Bulletin 443, September 1947, p. 33.

§ Woodland pasture yields were estimated to be 50 per cent of pasture yields. This is based on data reported by Homer J. L'Hote, "A Farm Management Method of Measuring the Productive Value of Pastures in Missouri," (Unpublished Master's Thesis, the University of Missouri, 1940), Table XXXV, p. 82.

studies. The most common has been to find the value of the products of the land at average prices. Another method has been to convert all crops into energy units by reducing them to corn equivalents. A modification of these two procedures is used in this study.

The feed value of crops and pasture is considered to be a more accurate measure of physical productivity than the monetary value arrived at by multiplying average yields by average prices. Average prices of the various products are likely to reflect differences in desirability for specific uses and supply in relation to demand in local communities rather than the energy and protein units that the land produces. Timothy hay contains almost as many energy units per ton as does alfalfa, but alfalfa sells for a higher price because of its protein content. For this reason recognition of the yield in protein as well as in energy units when converted into the monetary value of corn and cottonseed meal equivalents, two products sold at relatively uniform prices wherever livestock are produced, gives a more accurate measure of productivity than the corn equivalent alone. It is necessary to use the monetary value of the total energy equivalent, in terms of corn, and cottonseed meal, in order to secure a common measure of productivity. Conversion into monetary values permits the inclusion of products, such as lint cotton, that have no feed equivalent.

The factors used in converting the yields of crops on the various classes of land to corn and cottonseed meal equivalents are given in Table 3. The procedure followed in each of the land classes is illustrated in Table 4. Analysis of census data showed that 33.12 per cent of the acreage in subarea 1NW was used for corn. The average yield per acre was found to be 41.24 bushels. The total production of corn per 100 acres in this subarea would be 1,365.87 bushels (33.12 acres $\times$ 41.24 bushels per acre = 1,365.87). Corn is low in protein and has no cottonseed meal equivalent, so the production on the proportion of the 100 acres usually planted to corn would be 1,365.87 bushels or 38.2450 tons of corn equivalent.

$$\frac{1{,}365.87 \text{ bushels} \times 56 \text{ pounds}}{2{,}000} = 38.2450 \text{ tons}$$

Data for the representative townships showed that 3.49 per cent of the land in subarea 1NW was in wheat. The average yield was 14.61 bushels per acre (Table 2). Production per 100 acres of subarea 1NW land would be 50.99 bushels or 1.530 tons. Wheat has a corn equivalent of .909, and in addition a cottonseed meal equivalent of .138. The total tons of corn equivalent derived from the wheat usually grown on each 100 acres of subarea 1NW land would be 1.3908 tons (1.530 $\times$ .909 = 1.3908). The cottonseed meal equivalent would be .2111 tons (1.530 $\times$ .138 = .2111).

Table 3.--The Equivalent Corn and Cottonseed Meal Constants of Various Feedstuffs.*

Feedstuff	Constants for Corn	Constants for Cottonseed Meal
Corn (No. 2 Dent)	1.000	0.000
Wheat	0.909	0.138
Oats	0.786	0.109
Barley	0.899	0.083
Rye	0.888	0.114
Soybean Seed	0.248	0.885
Cottonseed	0.836	0.315
Cottonseed Meal (43% protein)	0.000	1.000
Sorghum Fodder	0.416	0.018
Alfalfa Hay	0.299	0.241
Red Clover Hay	0.436	0.111
Clover and Timothy Hay	0.454	0.034
Lespedeza Hay	0.369	0.187
Oat Straw	0.333	0.042
Prairie Hay	0.421	-0.068
Soybean Hay	0.237	0.268
Sudan Grass Hay	0.388	0.044

* Taken from Morrison, F. B., Feeds and Feeding, 20th Edition, Table VIII, p. 1027.

Table 4.--Total Equivalent Tons of Corn and Cottonseed Meal Produced Per Acre in Land Class 1NW.

Land Use Per 100 Acres of Farm Land Land Use	Acres (1)	Average Yield Per Acre (2)	Total Yield Per 100 Acres (3)	Tons of Total Yield (4)
Corn	33.12	41.24 bu.	1365.87	38.245
Wheat	3.49	14.61 bu.	50.99	1.530
Oats	5.15	27.13 bu.	139.72	2.236
Rye	.18	16.50 bu.	2.97	.083
Soybeans	.64	13.65 bu.	8.74	.263
Sorghum Forage	.32	2.729 T.	.873	.873
Alfalfa Hay	3.35	2.233 T.	7.481	7.481
Clover and Timothy Hay	3.21	1.190 T.	3.820	3.820
Lespedeza Hay	.49	1.170 T.	.573	.573
Miscellaneous Other Hay	1.00	1.121 T.	1.121	1.121
Pasture	33.99	18.10 bu. C. E.**	615.22	17.226
Woodland Pasture	2.27	9.05 bu. C. E.	20.54	.575
Other Crops	.71			
Double Crops	8.57			
Woodland	.70			
Crop Failure	1.03			
Cropland Idle	2.93			
Other Land	7.67			
	108.82			

Land Use Per 100 Acres of Land Land Use	Constants For Corn* (5)	Constants For Cotton-seed Meal‡ (6)	Total Tons Corn Equivalent (7)	Total Tons Cottonseed Meal Equivalent (8)
Corn	1.000	.000	38.2450	.0000
Wheat	.909	.138	1.3908	.2111
Oats	.786	.109	1.7575	.2437
Rye	.888	.114	.0737	.0095
Soybeans	.248	.885	.0650	.2319
Sorghum Forage	.416	.018	.3632	.0157
Alfalfa Hay	.299	.241	2.2368	1.8029
Clover and Timothy Hay	.454	.034	1.7343	.1299
Lespedeza Hay	.369	.187	.2114	.1072
Miscellaneous Other Hay	.3630†	.0626†	.4069	.0702
Pasture	1.000	.000	17.2260	.0000
Woodland Pasture	1.000	.000	.5750	.0000
Other Crops	.7501‡	.0339‡	.5325	.0241
Double Crops	.5060‡‡	.0079‡‡	4.3367	.0681
Tons Equivalent per 100 acres Farm Land			69.1548	2.9143
Tons Equivalent per acre Farm Land			.691548	.029143
Tons Equivalent per 55.37 acres Cultivated Land §			51.3438	2.9143
Tons Equivalent per acre Cultivated Land			.927466	.052633

* Taken from Morrison, F. B., Feeds and Feeding, 20th Edition, Table VIII, p. 1027, except for other crops and double crops which are estimated figures in terms of tons equivalent per acre.

** Bushels of corn equivalent.

† The constants for Miscellaneous Other Hay are averages of the constants of five miscellaneous hay crops grown in Missouri.

‡ It was assumed that the productivity of the land used for Other Crops is equal to that used for crops and pasture. Crops for which yields and corn and protein equivalents are reported occupied 84.94 per cent of the land in 1NW. On 18.94 acres of crops and pasture, the equivalent of 63.7106 tons of corn and 2.8221 tons of cottonseed meal were produced. This gives an average of .7501 of a ton of corn and .0339 of a ton cottonseed meal per acre which is shown in columns (5) and (6) respectively.

‡‡ For Double Crops, it was assumed that the production per acre would be equal to that of the average acre used for hay and pasture. Double Crops are usually hay or pasture crops. The calculation of .5060 of a ton of corn and .0079 of a ton of cottonseed meal equivalent per acre shown in columns (5) and (6) respectively for Double Crops was determined in the same manner as the corresponding values for other crops.

§ 55.37 per cent of the land in farms in land class 1NW is cultivated. It is considered that the land use items of pasture, woodland pasture, woodland, and other land occupies land not in cultivation and the remaining land use items are all in cultivation.

This procedure was used in finding the corn and cottonseed meal equivalents of each crop for which specific data were available. The average of these figures was used in determining the corn and cottonseed meal equivalents produced on land listed as in other crops. The average production on hay and pasture land was assigned to the acreage that was double cropped. The value of feed obtained from pasture was converted into corn equivalents by using the average yields on the various soil types found in each land class reported in Missouri Agricultural Experiment Station Bulletin 443.[11] Dollar values of the physical production were obtained by multiplying the tons of corn equivalent by $30.37 and the cottonseed meal equivalent by $47.00. The value of cotton lint at 14.295 cents a pound was added in the subareas where cotton is grown. The prices used are averages for the 1928-1947 twenty-year period. A summary of the results is presented in Table 5.

In subarea 1NW the average acre of land in farms produced the equivalent of .691548 tons of corn and .029143 tons of cottonseed meal. The monetary value at 1928-1947 prices was $22.37. This value is referred to hereafter in the analysis as 22.37 units of productivity. It is not meant to imply that the value of products arrived at by this procedure represents the possible future gross income per acre that will be obtained by farmers who operate land in each class or subclass area. The computed values, however, should be fairly satisfactory measures to use in comparing the productivity of land in the areas and subareas.

The productivity of land in Missouri ranges from 5.78 to 49.60 units per acre. Data in Table 6 show the average and relative values and the number of acres in each productivity class required to equal the units of product normally derived from one acre in subarea 1NW. The most productive land in the state is found in subarea 1SE. In this section only .45 of an acre is required to equal the productivity of one acre in subarea 1NW. In land class 7, where the index of productivity is only 26, using subarea 1NW as a base, 3.87 acres are required. Comparisons between all productivity classes can be made by referring to Table 6.

All of the land in farms was used in making the comparisons presented in Table 6. Similar calculations were made for the cultivated acreage in each land class area and subarea. In compiling the data the acreage in grain and hay crops, other crops, double crops, failure and idle crop land were considered as cultivated land. The results are given in Table 7.

Table 5.--Summary of the Component Parts of Total Production and the Corresponding Units of Productivity Used in Arriving at Productivity Per Acre in Each Land Class.

Land Class	Equivalent tone produced per acre in farms		Average pound of cotton lint produced per acre in farms	Units of productivity determined from each part of total production*			Total units of productivity per acre in farms
	Corn	Cottonseed Meal		Corn	Cottonseed Meal	Cotton Lint	
1NW	.691548	.029143	------	21.00	1.37	-----	22.37
1C	.678886	.043170	------	21.62	2.03	-----	22.65
2WC	.503937	.030232	------	15.30	1.42	-----	16.72
3NW	.392890	.022208	------	11.93	1.04	-----	12.97
3SW	.429049	.032092	------	13.03	1.51	-----	14.54
3NE	.370471	.035179	------	11.51	1.65	-----	13.16
4SW	.330172	.029317	------	10.03	1.38	-----	11.41
4EC	.281031	.020985	------	8.53	.99	-----	9.52
5	.319644	.017638	------	9.68	.83	-----	10.51
6	.233755	.018311	------	7.10	.86	-----	7.96
7	.169231	.013660	------	5.14	.64	-----	5.78
1SE	.500893	.238451	162.16	15.21	11.21	23.18	49.60
2SE	.400152	.155100	141.61	12.15	7.29	20.24	39.68
3SE	.393763	.121422	96.82	11.96	5.71	13.84	31.51
4SE	.312954	.056050	47.70	9.50	2.63	6.82	18.95

* Each equivalent ton of corn, each equivalent ton of cottonseed meal, and each pound of cotton lint produced is equal to 30.37, 47.00, and .14295 units of productivity respectively.

Table 6.--Average and Relative Productivity of All Land in Farms in Each Land Class Area and Sub-Area.

Land Class	Average productivity per acre of land in farms (units)	Relative productivity per acre of land in farms (1NW = 100)	Acreage required to equal the productivity of one acre of 1NW land (acres)
1NW	22.37	100	1.00
1C	22.65	101	.99
2WC	16.72	75	1.34
3NW	12.97	58	1.73
3SW	14.54	65	1.54
3NE	13.16	59	1.70
4SW	11.41	51	1.96
4EC	9.52	43	2.35
5	10.51	47	2.13
6	7.96	36	2.81
7	5.78	26	3.87
1SE	49.60	222	.45
2SE	39.68	177	.56
3SE	31.51	141	.71
4SE	18.95	85	1.18

Table 7.--Average and Relative Productivity of Cultivated Land in Each Land Class Area and Sub-Area.

Land Class	Average productivity per acre of cultivated land (units)	Relative productivity per acre of cultivated land (1NW = 100)	Per cent cultivated land is of all land in farms	Acreage of cultivated land required to equal the productivity of one acre of 1NW land
1NW	30.64	100	55	1.00
1C	31.09	101	57	.99
2WC	24.62	80	50	1.25
3NW	21.12	69	38	1.45
3SW	21.16	69	51	1.45
3NE	20.86	68	40	1.47
4SW	19.31	63	44	1.59
4EC	19.45	63	32	1.58
5	20.97	68	29	1.46
6	19.66	64	24	1.56
7	16.78	55	20	1.83
1SE	58.83	192	82	.52
2SE	48.78	159	79	.63
3SE	40.84	133	74	.75
4SE	32.28	105	54	.95

The variation in productivity per acre of cultivated land is less than for all land in farms. The range is from 58.83 units in subarea 1SE downward to 16.78 units in land class 7. This lesser variation would naturally be expected since only the best land is brought under cultivation in the low producing soil areas.

To some extent low productivity per acre can be offset by varying the size of farms, but the adjustments that have taken place to date have not made the productivities of farms of average size equal in various parts of the state. In subarea 1SE where the average productivity per acre in farms is 49.60 units, operating units averaged only 76.1 acres in 1945. In subarea 1NW where the productivity was 22.37 units per acre, the farms averaged 210.8 acres in size. The 76.1 acre farm on the most productive land had a total productivity of only 3,776 units. The 210.8 acre farm in subarea 1NW had a total productivity of 4,716 units. Ninety-five acres of land in 1SE would be required to equal the productivity of the average 210.8 acre farm in subarea 1NW. In land class 7 where the soil is lowest in productivity 815 acres would be required. In 1945 farms in land class 7 averaged only 169.3 acres (Table 8).

Adjustments in size of operating units are badly needed in the low producing land classes. This fact should be made one of the major considerations in setting up agricultural programs. Permanent stability of social institutions in an area requires the adjustment of man to land so satisfactory levels of income can be obtained without mining the soil. Failure to adjust the size of operating units to the soil's productivity and desirability for agricultural use is one of the principal handicaps to widespread adoption of practical conservation systems on individual farms. Comparisons of average size of farms, relative productivity, and acres required in the various land classes to equal the productivity of the average farm in subarea 1NW are given in Table 8.

The size of farm required in the less productive land classes to make possible a net income or level of living equivalent to that obtainable in the more productive classes is probably larger than the number of acres needed to equate the units of production. In land class 6, 593.2 acres are required to bring total production into line with subarea 1NW. The average operating unit in 1945 was only 152.5 acres. With only 24 per cent of the land in class 6 in cultivation (Table 7), there would be 142.4 acres of cultivated land in the larger unit. The average farm in subarea 1NW contained only 116.7 acres of cultivated land. It is evident, therefore, that more acres of cropland as well as of pasture would be required to turn out the same total volume of product in land class 6 as can be obtained from the average farm in subarea 1NW.

It is doubtful if tillage practices, even for the same crop, are identical in the two areas. Equipment costs likely are lower in the low producing area while labor costs, if standard wages are allowed, are higher. The result is very likely to be higher costs per unit of product in the low producing areas than in the sections where the productivity is high. The net

Table 8.--Productivity of the Average Farm in Each Land Class in 1945 and Acreage Required to Bring the Productivity to the Same Level as the Average Sized Farm in Sub-Area 1NW.

Land Class	Average productivity per acre of land in farms (units)	Average size of farm in 1945 (acres)	Productivity per farm (units)	Relative productivity per farm (1NW = 100)	Cultivated acres in average size farm (acres)	Size of farm required to equal the productivity of average 1NW farm (acres)
1NW	22.37	210.8	4716	100	116.7	210.8
1C	22.65	189.1	4282	91	108.3	208.2
2WC	16.72	179.0	2993	63	89.3	282.0
3NW	12.97	178.5	2316	49	68.0	363.9
3SW	14.54	179.2	2605	55	92.0	324.4
3NE	13.16	199.9	2580	55	80.1	358.3
4SW	11.41	129.6	1478	31	56.8	413.4
4EC	9.52	154.7	1474	31	49.8	495.0
5	10.51	168.2	1767	37	48.1	448.9
6	7.96	152.5	1212	26	37.1	593.2
7	5.78	169.3	979	21	33.1	815.3
1SE	49.60	76.1	3776	80	62.6	95.1
2SE	39.68	76.4	3031	64	60.6	118.8
3SE	31.51	88.0	2773	59	65.2	149.7
4SE	18.95	72.6	1375	29	39.1	248.8

return would, therefore, be low on the relatively unproductive land in comparison to income above costs on the higher yielding soils. Numerous farm management studies have shown that high net returns are associated with high crop yields and high rates of livestock production. It probably would take much more than 593.2 acres to get the same amount of net return from a representative farm in land class 6 as could be obtained from the average 210.8 acre farm in subarea 1NW.

The productivity findings in subarea 3SW were tested statistically for variation. No significant difference was found in the productivity of two groups of representative townships taken at random (Table 9). In the opinion of soil scientists the land in 3SW is more variable in productivity than that of any other class in the state. It was concluded, therefore, that the soils within the various land class areas and subareas were relatively homogeneous in productivity.

As a matter of course, the land in the various counties falls in more than one class. In order to rank the counties according to general soil productivity, a weighted average total productivity of the land in the county was computed. The calculations for Cole County are given in Table 10. The counties were then ranked from highest to lowest according to this total productivity. The results are summarized in Table 11. Pemiscot County with most of its acreage in productivity classes 1SE and 2SE is Number 1 with an average relative productivity of 187.77. Reynolds and Taney Counties are the lowest with a productivity of 25.84.

The relative productivity and the rank of each county is shown on the map in Figure 6. It should be kept in mind that the information presented here represents average situations for entire counties. The data cannot be interpreted to mean that all of the land in a low ranking county is poor and that all land in a county which stands near the top is good.

Table 9.--Differences in Productivity of Individual Townships and of Two Sub-Sample Groups of These Townships in Land Class 3SW.

Name and Location of townships in Sub-Sample One		Average Productivity Per Acre of all land in farms	Name and location of townships in Sub-Sample Two		Average Productivity Per Acre of all land in farms
County	Township	(units)	County	Township	(units)
Bates	Mound	14.44	Bates	Deepwater	15.23
Cooper	Palestine	13.89	Cooper	Clark Fork	16.91
Dade	Grant	16.63	Greene	Boone	15.58
Dade	Lockwood	15.90	Henry	Bear Creek	14.85
Henry	Davis	14.98	Henry	Shawnee	11.64
Jasper	Lincoln	16.49	Henry	Tebo	13.97
Jasper	Sheridan	16.49	Johnson	Grover	15.23
Johnson	Simpson	15.72	Pettis	Green Ridge	14.32
Pettis	Elk Fork	12.88	St. Clair	Monegraw	12.70
Pettis	Prairie	15.18	Vernon	Coal	14.84
	Simple Average	15.26		Simple Average	14.53
	Weighted Average	15.28		Weighted Average	14.55

DM .730

t = - = 1.18* d.f. = 18, P = .2 to .3

DM .617

* With eighteen degrees of freedom a t value of 2.878 is required for a probability of .01.

Table 10.--Determination of Relative Productivity Per Acre in Cole County.

Land Class	Acres of each land class and sub class in Cole County (1)	Relative productivity per acre of all lands in farms (2) (1NW = 100)	Relative productivity times acres in that area (column 1 x column 2)
1NW	------	100.00	------
1C	11,729	101.25	11,876
2WC	------	74.74	------
3NW	------	57.98	------
3SW	55,317	65.00	35,956
3NE	------	58.83	------
4SW	------	51.01	------
4EC	121,524	42.56	51,721
5	10,891	46.98	5,117
6	32,697	35.58	11,634
7	14,242	25.84	3,680
1SE	------	221.73	------
2SE	------	177.38	------
3SE	------	140.86	------
4SE	------	84.71	------
Total	246,400		119,984

Average relative productivity per acre = 48.69
(119,984 ÷ 246,400) 100 = 48.69

Most counties have some superior cropland and some marginal pasture or forest land. A county with a high percentage of superior and good cropland ranks near the top in relative productivity. One with a small acreage of the best grades of cropland and a large acreage of marginal pasture or forest land will stand near the bottom of the list. Highly productive farms can be found in counties that stand near the bottom as well as in those near the top, but the farms will not average as good where a high proportion of the acreage is relatively unproductive as in those counties with a considerable part of their area in superior and good cropland.

RELATIONSHIP BETWEEN GROSS PRODUCTIVITY AND VARIOUS ECONOMIC AND SOCIAL FACTORS

1. **Value of Land and Buildings.**—The price paid for farm land depends primarily upon the quantity and value above production costs of products that can be obtained from it, location, desire to live in a particular community, and other similar amenity values. The value of land and buildings per acre as reported in the United States Census for 1940 and 1945 is given in Table 12 by productivity land classes. The data show that land prices advanced sharply in the 1940-1945 period. The greatest dollar increase occurred in subarea 1SE where the gross productivity is highest. When calculated as a percentage of the 1940 value, the greatest increase (91 per cent) was on average cropland in subarea 3SE. The situation was similar in the other sections of the state outside the cotton producing region. The largest increases occurred in productivity classes 3NW, 3SW, and 3NE—all of them areas containing a high proportion of average cropland. Thus, during the war years, the average cropland sections of the

Table 11.--Ranking of Missouri Counties According to Their Relative Gross Productivity Per Acre of Land.*

County	Rank	Relative Gross Productivity	County	Rank	Relative Gross Productivity
Adair	63	53.83	Linn	37	60.64
Andrew	14	77.87	Livingston	27	64.10
Atchison	7	97.53	McDonald	91	33.51
Audrain	46	58.63	Macon	57	54.57
Barry	81	39.80	Madison	102	30.56
Barton	62	53.67	Maries	93	33.14
Bates	29	62.92	Marion	40	59.94
Benton	89	36.52	Mercer	43	59.29
Bollinger	87	37.83	Miller	99	31.08
Boone	56	55.53	Mississippi	2	170.20
Buchanan	9	86.80	Moniteau	69	51.04
Butler	22	70.30	Monroe	55	56.06
Caldwell	26	65.46	Montgomery	65	52.65
Callaway	64	52.69	Morgan	88	36.60
Camden	107	27.65	New Madrid	3	145.91
Cape Girardeau	53	56.24	Newton	68	51.40
Carroll	11	85.54	Nodaway	12	83.42
Carter	111	26.53	Oregon	97	31.52
Cass	18	72.81	Osage	86	38.07
Cedar	75	47.76	Ozark	112	26.38
Chariton	16	73.41	Pemiscot	1	187.77
Christian	84	38.55	Perry	74	48.26
Clark	41	59.67	Pettis	45	58.86
Clay	21	71.03	Phelps	101	30.80
Clinton	20	72.48	Pike	47	58.43
Cole	73	48.68	Platte	15	75.41
Cooper	39	60.40	Polk	71	50.90
Crawford	104	29.82	Pulaski	109	27.40
Dade	61	53.68	Putnam	58	54.56
Dallas	85	38.42	Ralls	52	56.35
Daviess	32	61.83	Randolph	54	56.19
DeKalb	28	63.30	Ray	17	73.37
Dent	100	30.98	Reynolds	114	25.84
Douglas	106	28.05	Ripley	83	39.12
Dunklin	4	125.63	St. Charles	30	62.49
Franklin	76	45.24	St. Clair	72	49.86
Gasconade	77	43.06	St. Francois	80	40.26
Gentry	23	66.79	St. Louis**	31	61.85
Greene	38	60.43	Ste. Genevieve	79	41.71
Grundy	36	60.75	Saline	10	86.59
Harrison	34	61.16	Schuyler	50	56.94
Henry	35	60.79	Scotland	44	59.03
Hickory	78	42.20	Scott	5	119.25
Holt	8	93.39	Shannon	110	27.05
Howard	33	61.69	Shelby	42	59.34
Howell	94	32.91	Stoddard	6	109.70
Iron	105	28.85	Stone	98	31.36
Jackson	19	72.66	Sullivan	66	52.55
Jasper	60	53.87	Taney	113	25.84
Jefferson	82	39.30	Texas	103	29.85
Johnson	25	66.06	Vernon	51	56.57
Knox	49	57.43	Warren	70	51.03
Laclede	96	31.95	Washington	95	32.38
Lafayette	13	83.11	Wayne	108	27.57
Lawrence	67	52.10	Webster	90	36.05
Lewis	48	57.60	Worth	24	66.50
Lincoln	59	54.27	Wright	92	33.42

* The relative productivity per acre for each county was determined from the relative productivity of each land class as shown in Table 10. The number of acres in each productivity class area and sub-area within the county was multiplied by the corresponding figure in Table 10. The relative productivity per acre of land for each county is the result of the total product of these multiplications divided by total acres in the county.

** This table does not include St. Louis City.

Table 12.--Average Value of Land and Buildings Per Acre in 1940 and 1945 Compared to Productivity of Land in Each Area and Sub-Area.

Land Class	Average value of land and buildings per acre		Increase in value per acre from 1940 to 1945		Relative productivity per acre	Relative value of land and buildings per acre	
	1940	1945	Dollars	Per cent	(1NW = 100)	1940 (1NW = 100)	1945 (1NW = 100)
1SE	$79.86	$123.55	43.69	55	222	132	154
2SE	66.94	99.86	32.92	49	177	111	124
3SE	46.25	88.20	41.95	91	141	77	110
1C	55.57	75.25	19.68	35	101	92	94
1NW	60.43	80.31	19.98	33	100	100	100
4SE	29.56	50.68	21.12	71	85	49	63
2WC	48.25	63.20	12.45	26	75	80	79
3SW	29.19	41.93	12.74	44	65	48	52
3NE	24.10	34.96	10.86	45	59	40	44
3NW	27.00	40.40	13.40	50	58	45	50
5	20.60	38.60	8.00	39	47	34	36
4EC	22.62	29.02	6.40	28	43	37	36
6	19.98	24.00	4.02	20	36	33	30
7	13.38	17.24	3.86	29	26	22	21

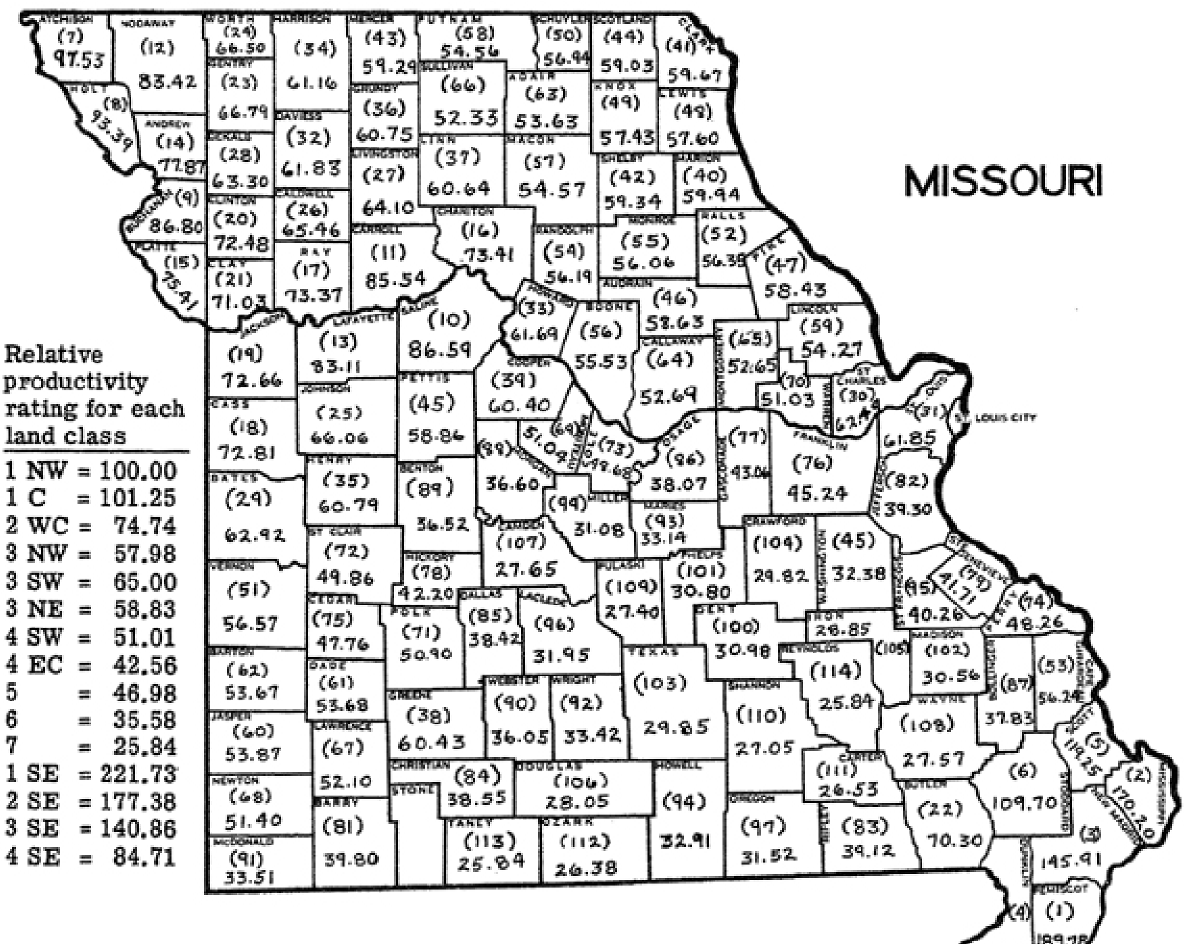

Figure 6.—Ranking of Missouri counties according to their relative productivity per acre of land.

state had the largest percentage increase in value of land and buildings per acre. This situation can magnify the financial difficulties that grow out of the use of credit to buy land. Obviously the increase in value of land of average and below average productivity during the period of inflation was not as fully justified by net earnings as was the increase on the best grades of land. When prices of agricultural commodities decline and farm incomes go down, the surplus of income above operating costs and living expenses of families depending on low producing soils are wiped out. As a consequence loans become delinquent.

It is possible that changing low producing cropland that is farmed intensively to less intensive uses, with simultaneous readjustments in the size of operating units, would make it possible to maintain the surplus of income above operating and family living expenses at a level that would permit farmers to use credit successfully in purchasing land of this quality. Objective inquiry in this field has long been neglected.

The data presented in Table 13 indicate that land values are not uniformly related to productivity per acre throughout the state. Values in southeastern Missouri in 1945 were about $2.62 per unit of productivity. In the grain and meat producing sections the average was about $3.50 per productivity unit. These variations grow out of differences in intensity of land use. High productivity in southeastern Missouri is the result of an intensive type of farming. Cotton and other cash crops occupy most of the tillable acreage. Labor costs are high, particularly for cotton. The result is greater cost per unit of production than in other parts of the state where grain and livestock are the principal enterprises, leaving less net income to be capitalized into land value.

Net rather than gross productivity determines the value of farm land when the influence of location and amenity considerations is eliminated. The use of data from a large area tends to nullify the influence of

Table 13.--Value of Land and Buildings Per Unit of Productivity in Each Land Class.

Land Class	Average productivity per acre of all land in farms (units)	Average value of land and buildings per acre in 1945	Value of land and buildings per unit of productivity
1SE	49.60	$123.55	$2.49
2SE	39.68	99.86	2.52
3SE	31.51	88.20	2.80
1C	22.65	75.25	3.32
1NW	22.37	80.31	3.59
4SE	18.95	50.68	2.67
2WC	16.72	63.20	3.78
3SW	14.54	41.93	2.79
3NE	13.16	34.96	2.66
3NW	12.97	40.40	3.12
4SW	11.41	36.26	3.18
5	10.51	28.60	2.72
4EC	9.52	29.02	3.05
6	7.96	24.00	3.02
7	5.96	17.24	2.98

locational and amenity factors in determining the relationship between productivity and land values. The ideal situation would be to have complete net productivity data. This information is not available. It is necessary, therefore, to divide the various classes into groups in which the costs of capital and labor used in farming operations are similar. An attempt is made to accomplish this purpose by making a separate analysis of the relationship between total productivity and land values in southeastern Missouri and in the remainder of the state.

The relationship between total productivity and value of land for the eleven productivity classes not in the cotton growing section is shown graphically in Figure 7. In the 1940 census reports the value of land and buildings increased $2.77 for each additional unit of productivity ($y = -5.514 + 2.772x$). In 1945 the increase was $3.87 per unit ($y = -7.927 + 3.783x$). The coefficient of correlation was .959 for the 1940 data and .979 for 1945. These values indicate about 92 per cent of covariation in 1940 and 96 per cent in 1945. With nine degrees of freedom an r value of .735 is required to indicate a significant relationship at the one per cent point.

The relationship between value of land and buildings and productivity in southeastern Missouri is shown in Figure 8. In 1940 there was an increase of $1.70 in value for each additional unit of productivity ($y = -3.702 + 1.699x$). The increase was $2.33 per unit in 1945 ($y = -9.369 + 2.325x$). The coefficient was .992 for both 1940 and 1945. An r value of .990 is required for a significant relationship at the one per cent point with two degrees of freedom.

If accurate data for net productivity were available and the influence of location and amenity considerations upon land value could be eliminated, almost perfect correlation could be expected. By dividing the state according to intensity of land use to get comparatively uniform operating costs, the relative total productivity of the various land classes in the two groups was much the same as would have been the relative net productivity had such data been available. Under these conditions total productivity is a very good indicator of comparative values.

The differences in productivity per farm shown in Table 14 indicate a need for material readjustments in operating units in the various productivity classes of land. In subarea 1NW where farms averaged 210.8 acres in size the productivity per farm was 4,716 units. Under similar weather and price conditions only 979 units were produced in area 7. The average investment in land and buildings per farm in subarea 1NW was $16,929 in 1945. The investment per acre was $80.31. It has already been shown that there is a close relationship between the value of land and total productivity in similar type of farming areas. With this fact in mind the question arises as to the extent of adjustment that can be made in the productivity of operating units by keeping the investment in land and buildings somewhere near constant, while the acreage per farm is varied to overcome low income per acre on relatively unproductive land.

The data presented in Table 14 indicate that the investment in land

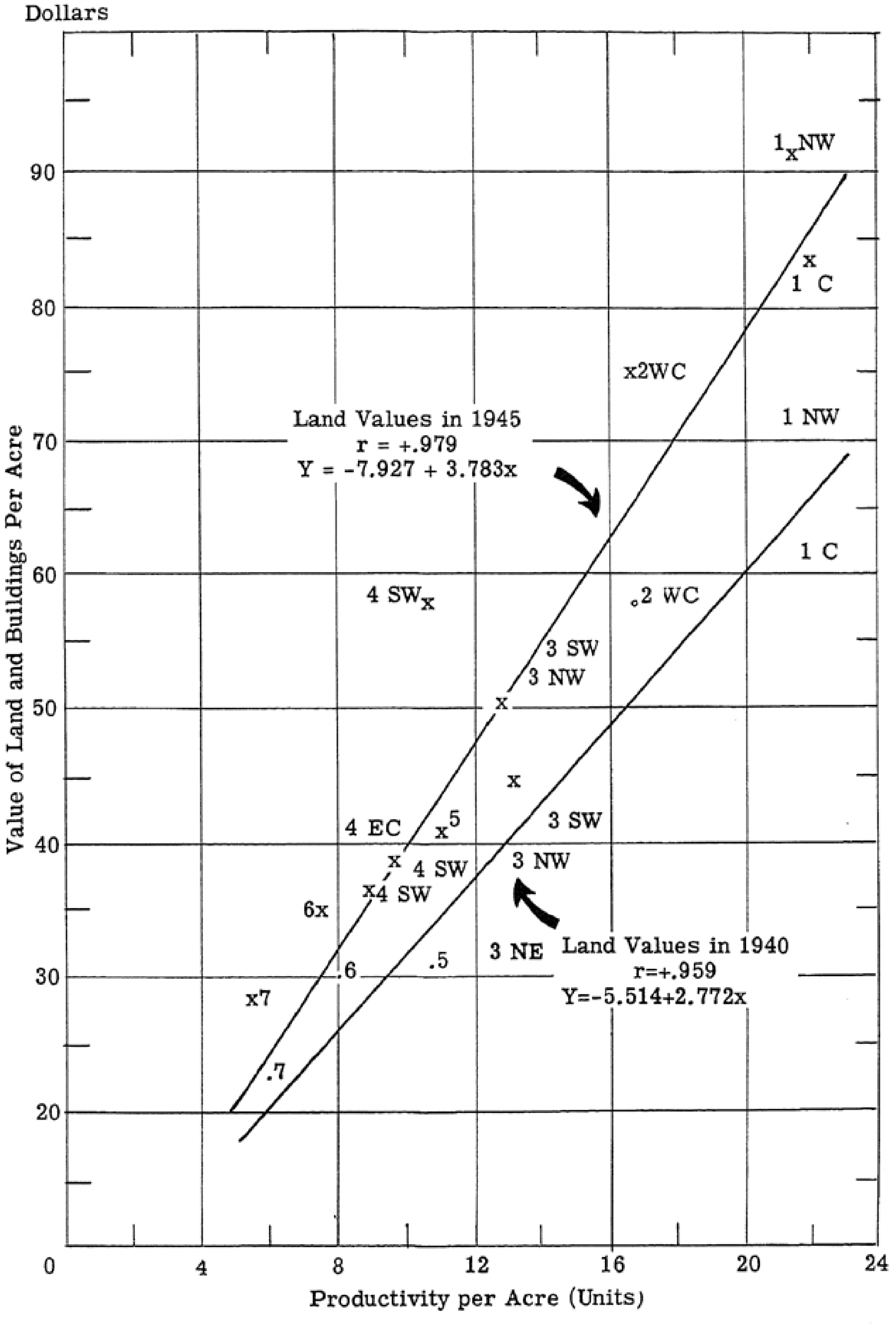

Figure 7.—Relationship of the value of land and buildings per acre to productivity per acre in the land class areas and subareas outside the cotton growing section, 1940 and 1945.

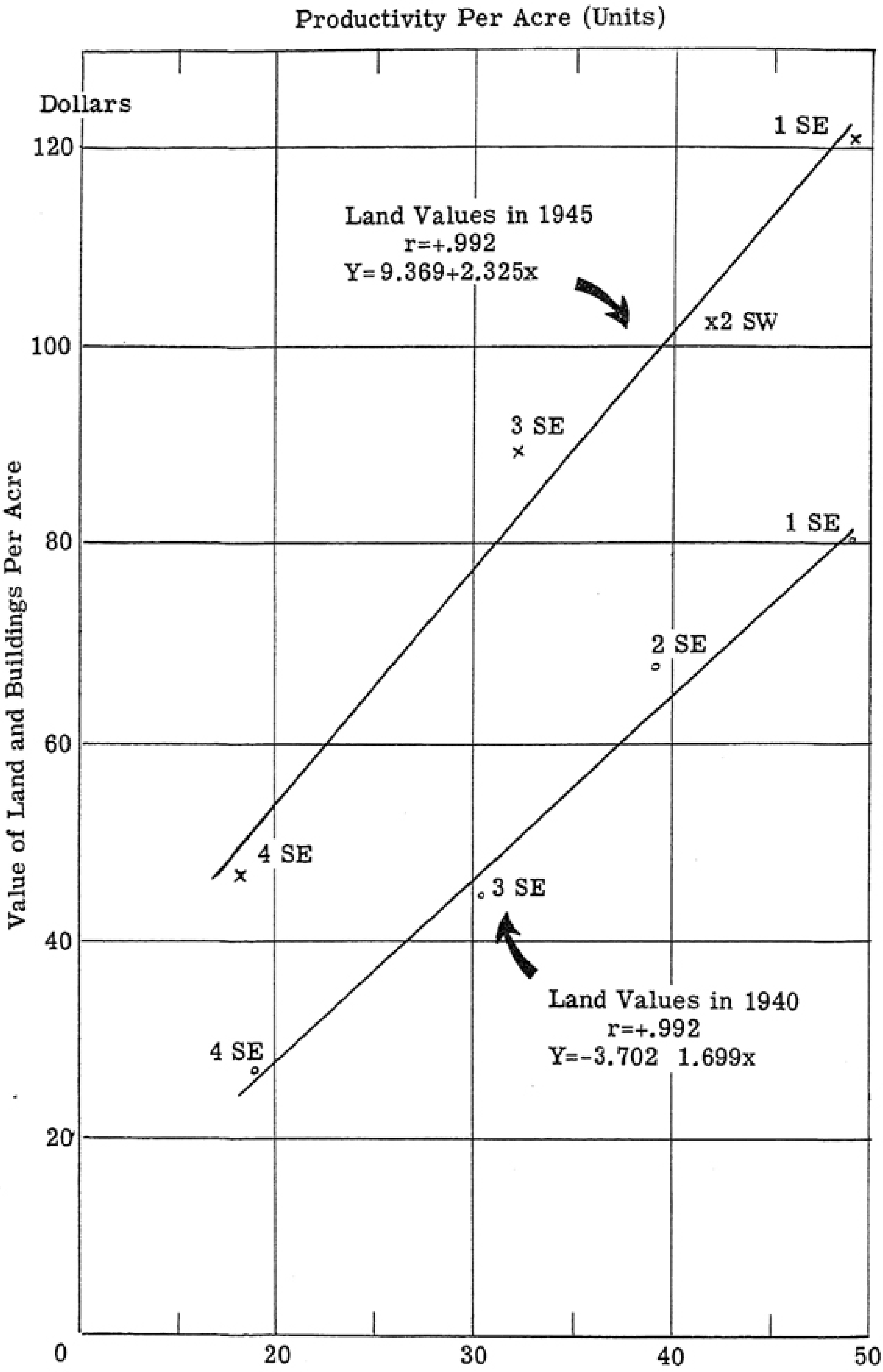

Figure 8.—Relationship of the value of land and buildings per acre to productivity per acre in the subareas of the cotton growing section, 1940 and 1945.

Table 14.--Value of Land and Buildings Per Farm in 1945, Total Productivity Per Farm in Each Land Class and Amount of Investment in Land and Buildings That Would Be Required for a Uniform Level of Total Productivity in the Various Land Classes.

Land Class	Average size of farm 1945	Value of land and buildings 1945		Total productivity per farm (units)	Acreage required to equal the productivity of average farm in sub-area 1NW	Value of the acreage required
		Per acre	Total			
1NW	210.8	$ 80.31	$16,929	4,716	210.8	$16,929
1C	189.1	75.25	14,227	4,282	208.2	15,667
2WC	179.0	63.20	11,311	2,993	282.0	17,822
3NW	178.5	40.40	7,212	2,316	363.9	14,702
3SW	179.2	41.93	7,259	2,605	324.4	13,602
3NW	199.9	34.96	6,989	2,580	358.3	12,526
4SW	129.6	36.26	4,698	1,478	413.4	14,990
4EC	154.7	29.02	4,491	1,474	495.0	14,365
5	168.2	28.60	4,810	1,767	448.9	12,839
6	152.5	24.00	3,658	1,212	593.2	14,237
7	169.3	17.24	2,918	979	815.3	14,056
1SE	76.1	123.55	9,404	3,776	95.1	11,750
2SE	76.4	99.86	7,628	3,031	118.8	11,863
3SE	88.0	88.20	7,761	2,773	149.7	13,204
4SE	72.6	50.68	3,677	1,375	248.8	12,609

and buildings required to provide operating units with a uniform level of productivity in the different land classes has been quite variable. The range outside of the delta cotton area was from a low of $12,526 in subarea 3NE to a high of $17,822 in subarea 2WC. The range in the cotton area was from $11,750 on the most productive soils to $13,204 in subarea 3SE.

The data support the opinion that low producing lands frequently are overvalued, particularly in areas where they are intermingled with more productive soils. Subarea 2WC lies in the same general region as 1C and 1NW, but is much less productive than either of the other classes. The valuation on class 2WC land was $63.20 per acre in 1945. It was $80.31 in class 1NW and $75.25 in class 1C. However, the lower price of the 2WC land did not reflect its lesser productivity adequately. As a result, an acreage large enough to equal the productivity of an average farm on productivity class 1C land would have been valued $2,155 higher than the equal land resource on the more productive soil.

A similar situation prevailed in the delta cotton and corn area where productivity class 3SE land is intermingled with classes 1SE and 2SE. The acreage required to return 4,716 productivity units in 1SE was valued at $11,750 in 1945. A farm of equal productivity on class 3SE land was valued at $13,204—a difference of $1,454.

In contrast to the situations already described, there is a tendency to undervalue relatively productive land in areas where soils of lower productivity are dominant. Land class 3NE (average cropland) is intermingled with class 5 which is pasture land. A farm that would turn out 4,716 productivity units was valued at $12,526 in 1945 in subarea 3NE. This amount was $4,403 less than the valuation of a farm of equal productivity in subarea 1NW.

The value of a farm on low producing soil should be less than for an operating unit of equal productivity on more fertile soil. Even with the same crops on the two classes of land, production costs per unit of product on the low producing soils are higher than on the more fertile land. The higher costs leave less income to be capitalized into land values on the poorer soils.

Other factors that may be related to the productivity of land include the value of buildings and machinery and equipment. Data on these items are not available by townships for the year 1945. For this reason, only the 1940 data were used in the analysis presented in Tables 15 and 16.

Table 15.--Value of Buildings Per Acre and Per Farm in Relationship to Productivity as Shown by Analysis of Data From the 1940 United States Census.

	PER ACRE					PER FARM				
				Rank					Rank	
Land Class	Average value 1940	Relative value 1940 (1NW = 100)	Relative productivity (1NW = 100)	Value of buildings	Productivity	Average value 1940	Relative value 1940 (1NW = 100)	Relative productivity (1NW = 100)	Value of buildings	Productivity
1NW	$13.70	100	100	1	2	$2,607	100	100	1	1
1C	13.16	96	101	3	1	2,180	84	88	2	2
2WC	13.41	98	75	2	3	2,110	81	62	3	3
3NW	8.37	61	57	8	6	1,342	51	49	6	6
3SW	10.35	76	65	4	4	1,697	65	56	4	4
3NE	8.84	65	59	7	5	1,548	59	54	5	5
4SW	9.30	68	51	5	7	1,145	44	33	8	8
4EC	9.11	66	43	6	9	1,294	50	32	7	9
5	7.19	52	47	9	8	1,095	42	38	9	7
6	6.76	49	36	10	10	914	35	25	10	10
7	4.25	31	26	11	11	613	24	20	11	11
1SE	12.67	92	222	1	1	1,107	42	102	1	1
2SE	9.09	66	177	2	2	705	27	72	3	2
3SE	8.52	62	141	3	3	773	30	67	2	3
4SE	6.80	50	85	4	4	467	18	31	4	4

Table 16.--Value of Machinery Per Acre and Per Farm in Relationship to Productivity as Shown by Analysis of Data From the 1940 United States Census.

				Rank					Rank	
Land Class	Average value per acre of cultivated land	Relative value per acre of cultivated land (1NW=100)	Relative productivity per acre in farms (1NW=100)	Value of machinery per cultivated acre	Productivity per acre on farms	Average value per farm	Relative value per farm (1NW=100)	Relative productivity per farm (1NW=100)	Value of machinery per farm	Productivity per farm
1NW	$7.70	100	100	1	2	$811	100	100	1	1
1C	6.82	89	101	2	1	646	80	88	2	2
2WC	6.54	85	75	4	3	513	63	62	3	3
3NW	5.71	74	57	8	6	349	43	49	6	6
3SW	5.65	73	65	10	4	475	59	56	4	4
3NE	5.68	74	59	9	5	399	49	54	5	5
4SW	5.74	75	51	7	7	310	38	33	7	8
4EC	6.67	87	43	3	9	305	38	32	8	9
5	6.24	81	47	6	8	272	34	38	9	7
6	6.34	82	36	5	10	209	26	25	10	10
7	4.82	63	26	11	11	136	17	20	11	11
1SE	9.84	128	222	1	1	615	76	102	1	1
2SE	6.40	83	177	2	2	373	46	72	3	2
3SE	6.24	81	141	3	3	407	50	67	2	3
4SE	5.29	69	85	4	4	207	26	31	4	4

The value of buildings varied widely, both on a per acre and per farm basis. Separate determinations were made for the delta cotton and corn area and for the remainder of the state. In general, the analysis showed that there was a definite positive relationship between the value of buildings and the productivity of land. Outside of the cotton area, the value of buildings per acre ranged from $13.70 in subarea 1NW to $4.25 on land class 7. The value per farm varied from $2,607 in subarea 1NW to $613 in class 7. The value of improvements per farm was more closely related to productivity per farm than was the value improvements per acre to gross productivity per acre. Analysis of the data on a per acre basis, however, showed a correlation coefficient of .924. This r value indicated about 85 per cent of covariation between the value of buildings and the productivity of the land per acre. The relationship is shown graphically in Figure 9.

The value of buildings in southeastern Missouri was not as closely related to productivity per acre as in the rest of the state. The coefficient of correlation was .949. With two degrees of freedom, as in this case, the r value would have to be .950 to indicate a significant relationship at the five per cent point.

2. **Value of Machinery.**—The value of machinery per acre of cultivated land in farms, and per farm in each land class varied directly with productivity (Table 16). The investment per acre of cultivated land varied from $9.84 in subarea 1SE to $4.82 in class 7. The investment per farm varied from $811 in subarea 1NW to $136 in class 7 (Table 16).

The relationship between the value of machinery in 1940 and productivity per acre in farms, outside the delta cotton and corn area was found to be significant statistically. The coefficient of correlation was .966 indicating about 93 per cent of covariation. The relationship is shown graphically in Figure 9.

The relationship between value of machinery in 1940 and productivity per acre was not as close in southeastern Missouri as in the remainder of the state. The coefficient of correlation for the cotton area was .966 which falls between the one and five per cent point in terms of significance.

The coefficient of correlation between productivity and the value of machinery per acre of cultivated land outside the cotton producing area was .787. The covariation was about 62 per cent. This lower degree of relationship as compared to the 93 per cent of covariation between the value of machinery and productivity per acre of all land in farms appears to be caused by the high value of machinery and the low level of productivity per acre of cultivated land in productivity classes 4EC, 5, and 6.

The value of machinery was not closely related to the productivity per acre of cultivated land in the delta cotton and corn area. The coefficient of correlation was .915 which was below the five per cent point of .950. However, the value of machinery did tend to vary with productivity (Table 16).

3. **Tenure and Productivity.**—The form of property rights farmers hold in the land they operate is influenced by soil productivity. In 1945 the

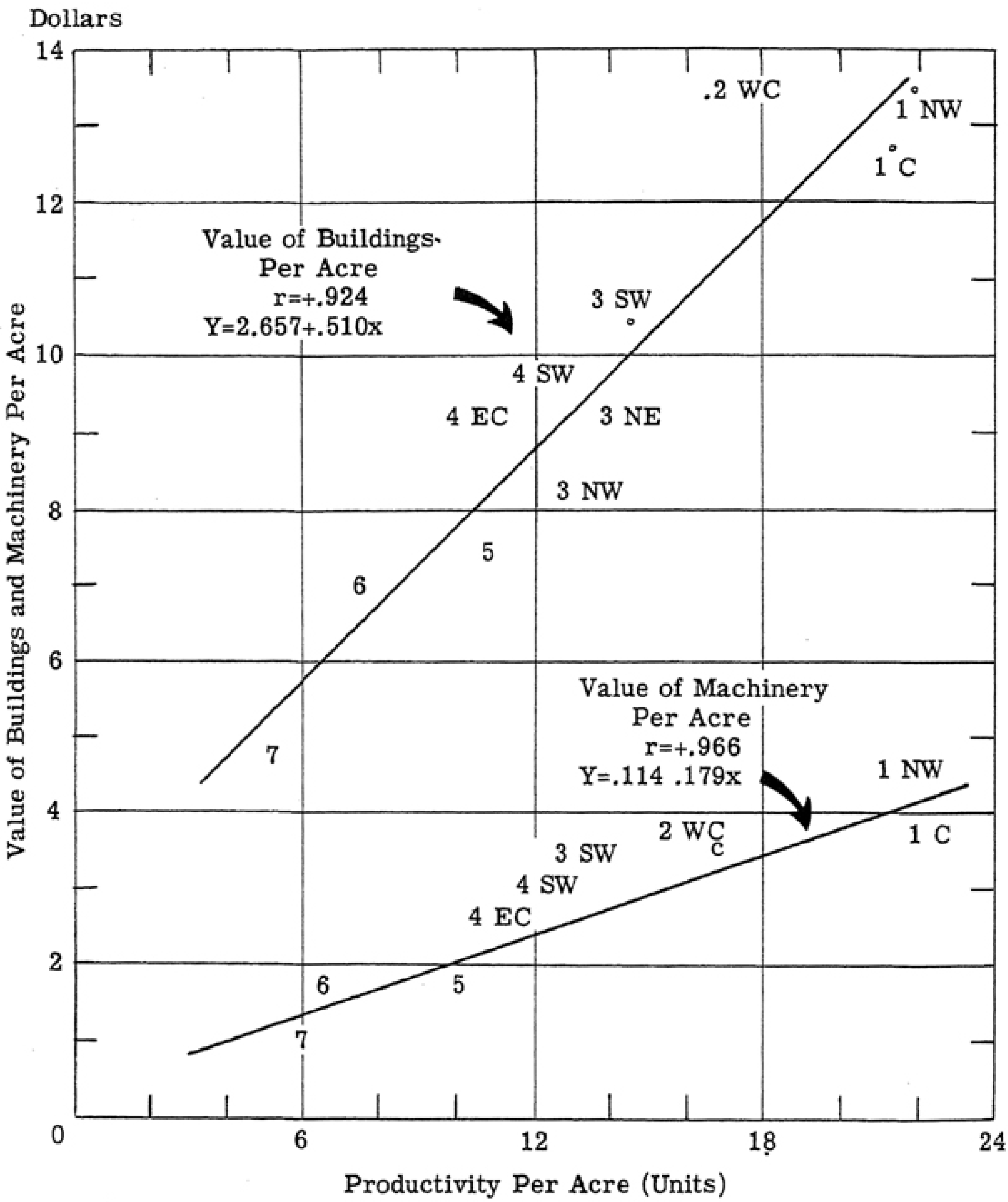

Figure 9.—Relationship of value of buildings and machinery and productivity of land per acre in 1944.

proportion of tenant operation varied directly and owner operation inversely with the productivity of the soil and the type of farming. In subarea 1SE, the most productive land in the state, 77.1 per cent of the farms were operated by tenants. The percentage was 79.3 in subarea 2SE which is somewhat less productive than is subarea 1SE. In subarea 4SE, 36.1 per cent of the farms were rented. Cotton is a major crop in these areas and the high percentage of tenancy reflects the share cropping arrangements that are in common use.

The proportion of tenancy in the land classes lying outside the delta cotton and corn area varied from 39.3 per cent in subarea 1NW to 16.1 per cent in class 7 (Table 17). The highest percentage was on the most productive land. In contrast to this situation, the percentage of full owner operators was highest on the low producing land. These relationships were statistically significant. For tenant operators the coefficient of correlation was .967 which indicates about 94 per cent of covariation. The coefficient of correlation was –.945 and the covariation approximately 89 per cent for full owners. These relationships are shown graphically in Figure 10. Similar results were obtained when the analysis was based upon productivity per farm. The results are shown graphically in Figure 11.

The relationship between the percentage of full owners and renters and total productivity per farm in southeastern Missouri was not statistically significant. The coefficient of correlation was –.934 for full owners and .919 for tenants. Both of these values are below the five per cent point.

The common belief that tenancy increases with productivity of land is supported by the findings, particularly outside the delta cotton and corn area. Highly productive land returns more income than operating costs and family living expenses. Rent can be paid out of this surplus. Competition for the right to collect this return has brought the cost of a farm on the most productive land above the savings and safe margin of credit of many young men who want to start farming. Land is much cheaper in low producing areas where the returns on the vast majority of farms are not adequate to support a farm family and pay rent that will bring a satisfactory rate of return to an investor. Although rent can be paid in good crop years and when commodity prices are high the returns are erratic. In some years no rent can be paid and the average return is very low. In these areas, people with small savings can become owner operators, with little or no

Table 17.--Tenure Status of Farm Operators in the Various Land Classes as Shown by Data From the 1945 United States Census.

Land Class	Tenure Status of Operators: Full owners (per cent)	Part owners (per cent)	Managers (per cent)	Renters (per cent)	Relative Gross Productivity: Per acre (1NW = 100)	Per farm (1NW = 100)
1NW	39.2	20.4	1.1	39.3	100	100
1C	41.8	20.0	.6	37.6	101	91
2WC	44.3	19.9	.4	35.4	75	63
3NW	55.3	17.2	.2	27.3	57	49
3SW	47.0	20.4	.2	32.4	65	55
3NE	51.9	20.3	.4	27.4	59	56
4SW	63.1	12.3	.4	24.2	51	31
4EC	66.2	14.8	.1	18.9	43	31
5	65.2	13.9	.2	20.7	47	37
6	71.3	10.2	.4	18.1	36	26
7	76.5	7.2	.1	16.2	26	21
1SE	17.0	5.4	.5	77.1	222	80
2SE	15.9	4.6	.2	79.3	177	64
3SE	22.4	4.0	.4	73.2	141	59
4SE	52.5	11.3	.1	36.1	85	29

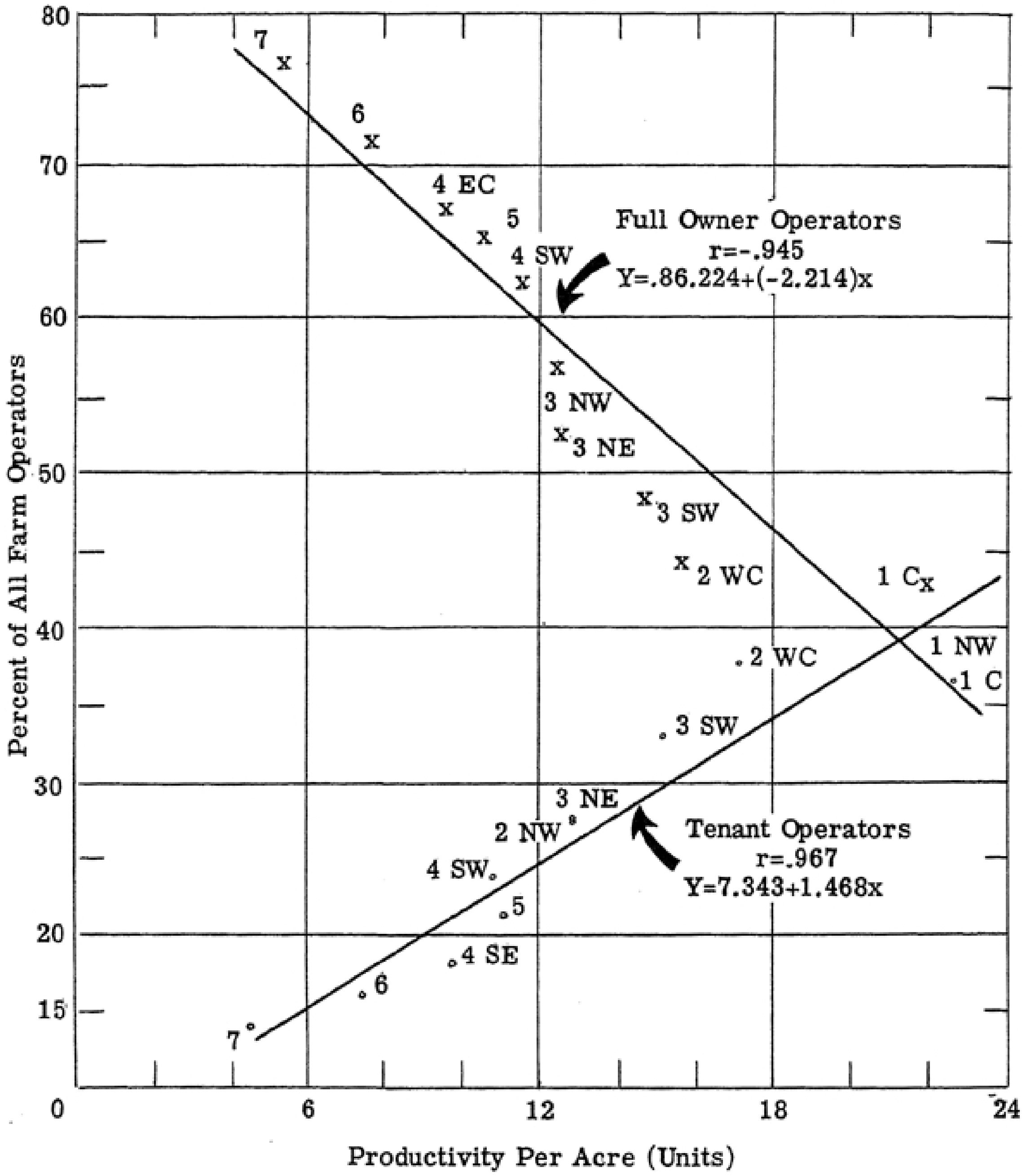

Figure 10.—Relationship of tenure status of farm operators and productivity of the land per acre.

debt. Their tenure status and their comparative freedom from debt, however, are not adequate measures of the level of living they can enjoy. In many instances the real incomes of owner operators on these low producing farms is much lower than that of renters on the most productive land. Farms with a gross productivity of not more than 979 units, as is the average situation in the sections of the state where class 7 land is dominant, cannot provide a satisfactory level of living for a farm family, even under owner operation.

The tenure status of operators in a given area is also influenced by the type of farming. In the delta cotton and corn area the method of holding rights in land such as fee simple ownership and lease is not closely

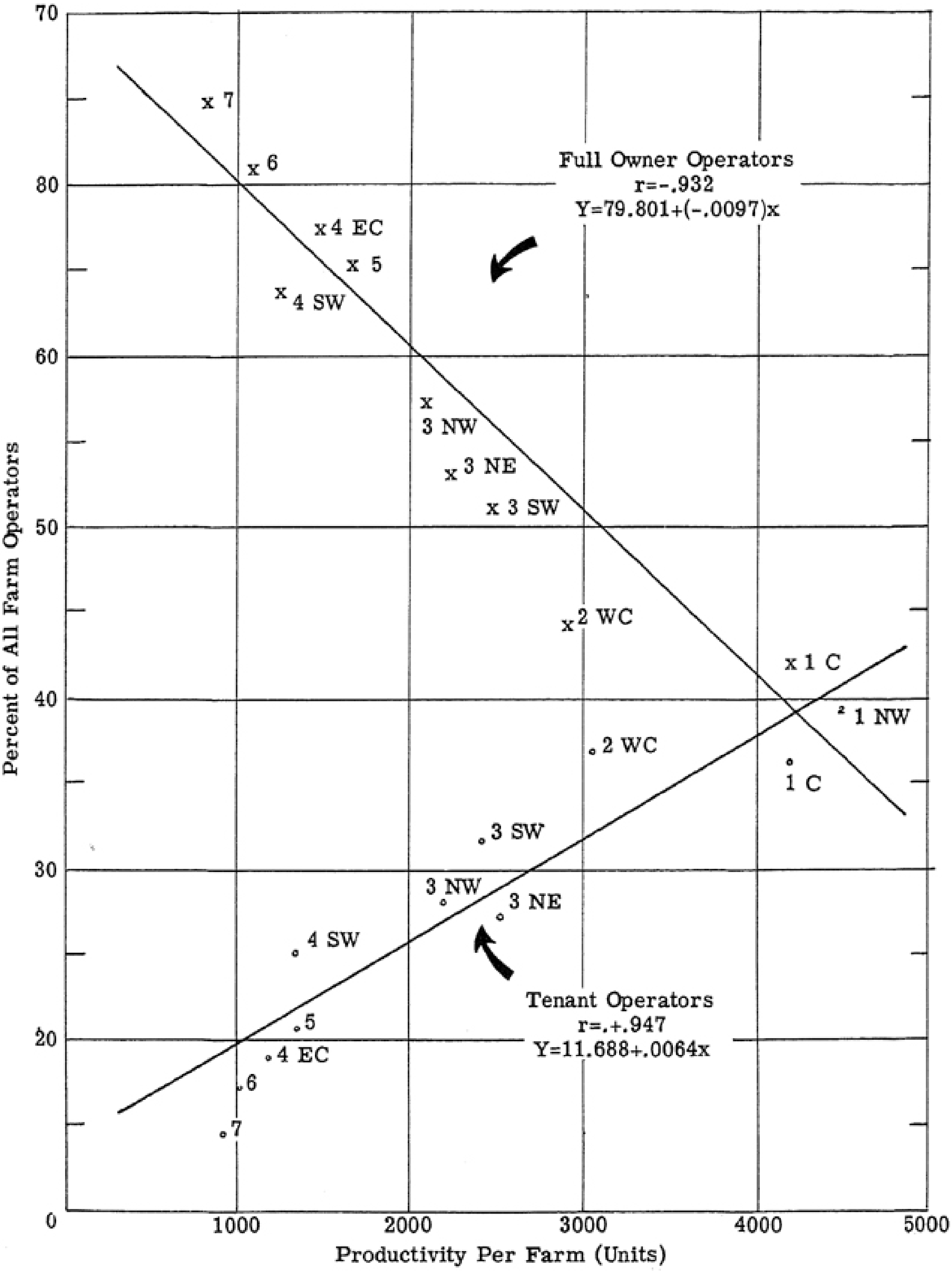

Figure 11.—Relationship of tenure status of farm operators and the productivity of farms.

related to productivity. In this section of the state, cotton is a major crop. A considerable part of the acreage is grown by share croppers.

4. **Distribution of Farm Population.**—The 1945 census shows the number of people living in dwelling units on farms, excluding persons in dwelling units rented to people who are not farming.

The number of persons per farm in 1945 did not vary with the productivity of the land (Table 18). The range was from 5.45 in subarea 3SE to 3.05 in subarea 3NW. Excluding southeastern Missouri, the number was greatest in land class 7 with 3.85 persons per farm and smallest in subarea 3NW with 3.05. In subarea 1NW where the average productivity per farm was the highest to be found in the state there were 3.73 persons per farm.

Table 18.--Distribution of the Farm Population and Its Relationship to Productivity and Farm Values for Each Land Class on January 1, 1945.

Land Class	Persons per farm (number)	Productivity per farm (units)	Productivity per person on farms (units)	Relative productivity per person (1NW = 100)	Acres in farms per person (number)	Value of land and buildings per person
1NW	3.73	4,716	1,264	100	56.5	$4,539
1C	3.47	4,282	1,234	98	54.5	4,104
2WC	3.42	2,993	875	69	53.4	3,311
3NW	3.05	2,316	758	60	58.5	2,362
3SW	3.25	2,605	802	63	55.2	2,315
3NE	3.08	2,580	854	66	64.9	2,269
4SW	3.30	1,478	448	35	39.3	1,423
4EC	3.32	1,474	444	35	46.5	1,350
5	3.17	1,767	557	44	53.0	1,516
6	3.53	1,212	343	27	43.2	1,036
7	3.85	979	254	20	44.0	759
1SE	5.38	3,776	702	56	14.2	1,748
2SE	5.18	3,031	585	46	14.7	1,472
3SE	5.45	2,773	509	40	18.3	1,424
4SE	4.41	1,375	312	25	13.7	834

The delta cotton and corn area contained the largest number of people per farm, but the concentration was not related either to productivity of soil or to total productivity per farm. The largest numbers (5.45 per farm) were in subarea 3SE where the productivity per farm was 2,773 units. In subarea 1SE, the most productive soil area, there were 5.38 persons per farm. The productivity per farm was 3,776 units.

There was no relationship between the number of acres per person on farms and productivity (Table 18). In many instances more acres of the highly productive soils were available per person than of the low producing land. The range was from 64.9 acres in subarea 3NE to 13.7 acres in subarea 4SE. Excluding southeastern Missouri, the range was from 64.9 in 3NE to 39.4 in 4SW.

The average number of productivity units per person on farms in each land class tended to vary directly with productivity per acre (Table 18). The range was from 1,264 units in subarea 1NW to 254 in class 7. On a relative basis productivity units per person ranged from 100 in 1NW to 20 in class 7. In other words, each farm person had five times as many units of products for his support on class 1NW land as were available per person on class 7 land. This relationship was statistically significant for the land classes outside the delta cotton and corn area. The coefficient of correlation was .939 and the covariation about 88 per cent. The relationship is shown graphically in Figure 12.

The relationship between productivity per acre and per person on farms was also statistically significant in southeastern Missouri (Figure 13). The coefficient of correlation was .994 which is above the one per cent point.

The findings in this analysis reveal clearly the basic cause for many

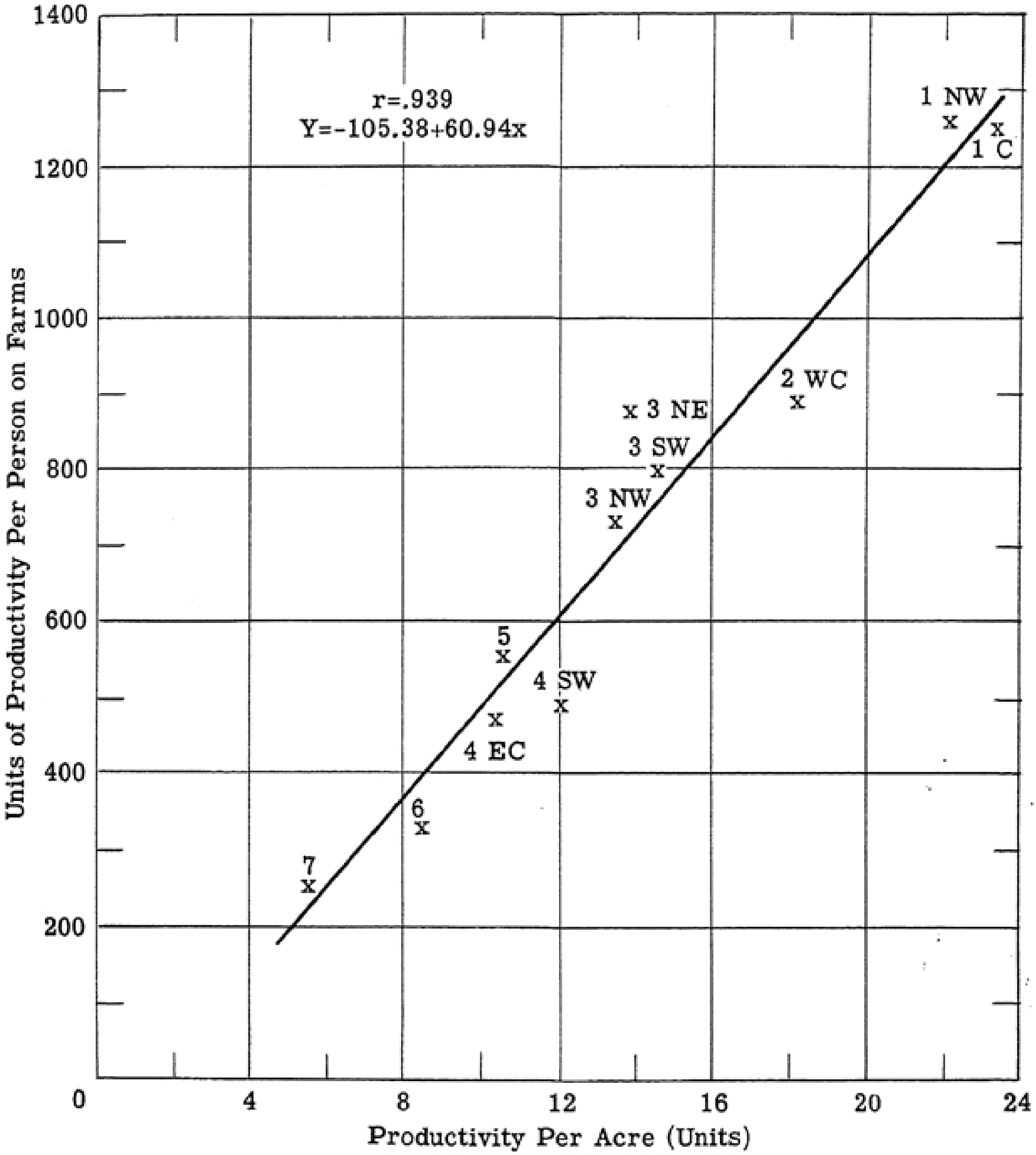

Figure 12.—Relationship of the units of productivity per person on farms to productivity per acre in sections of Missouri where cotton is not a principal crop, 1945.

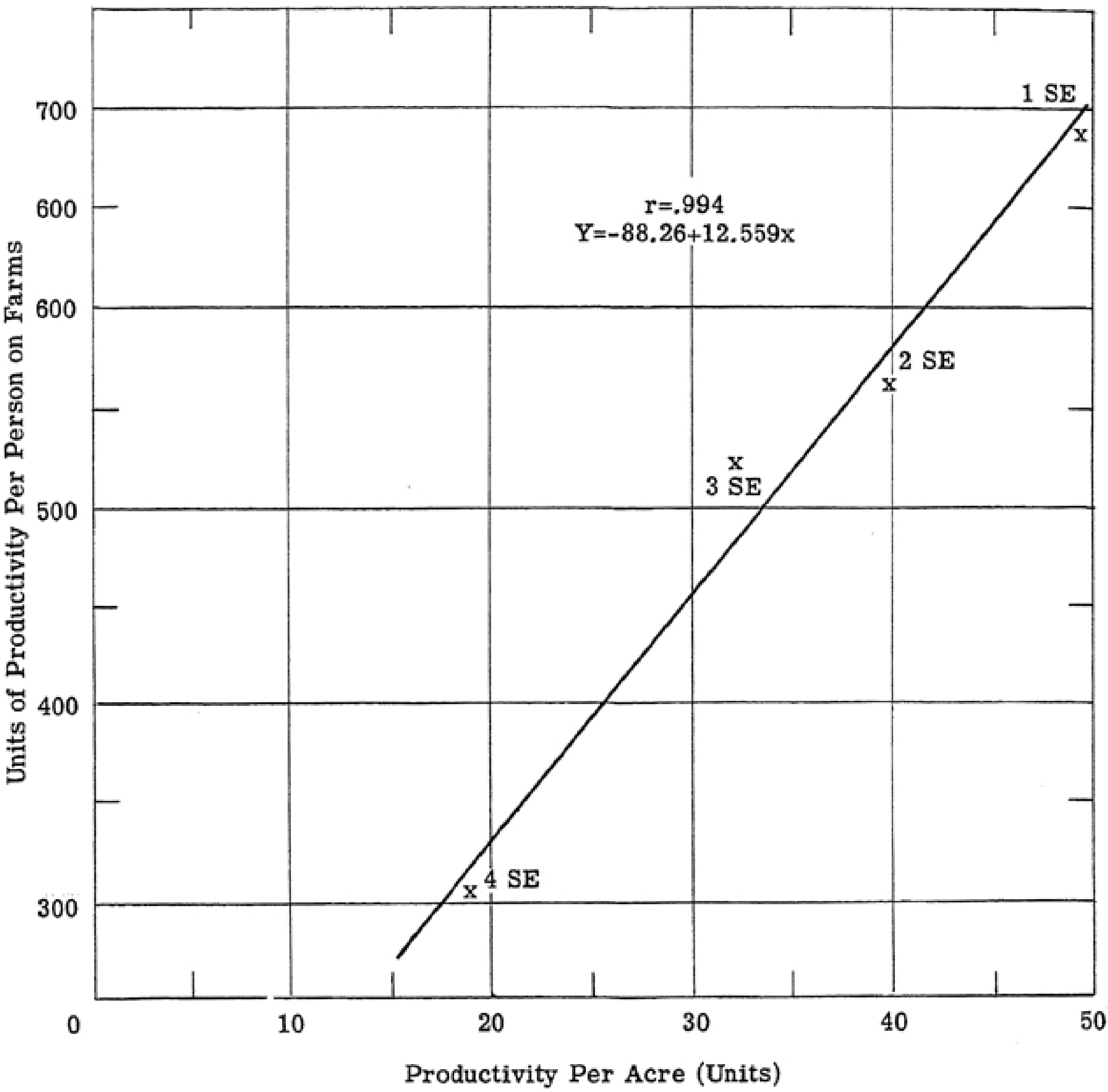

Figure 13.—Relationship of productivity per person on farms and productivity per acre in southeast Missouri where cotton is a principal crop, 1945.

of the rural problems in Missouri. The farm population is not well adjusted to the land resources. The number of persons per farm does not vary with the productivity of the land. Population density is related to type of farming rather than to productivity. In areas of low producing soils the principal enterprises are carried largely at the handcraft level, productivity per person on farms is small. In land class 7 it is only 254 units. It is 1,264 units or almost five times as much in subarea 1NW. These differences are the basic causes of low family income, inadequate housing, unsatisfactory educational opportunities, poorly financed churches and many other economic and social problems. It is possible that the difficulties can be corrected to some extent by changing the land use and operating unit pattern so the people who depend upon low producing land can have larger acreages from which income can be obtained under extensive uses—beef cattle raising or timber production for example.

There are, of course, opportunities for increasing the productivity per man by mechanizing processes which are at present carried on by hand. The hand labor required to grow cotton can be reduced materially. Yields of cotton and of other crops can be increased by the use of fertilizer, by systematic crop rotations, improved tillage procedure, the selection of high yielding varieties, effective pest control and by the application of many other known facts. These measures should not be forgotten in working out procedures that will help people to satisfy the greatest number of human wants. It should be kept in mind, however, that the response in terms of net economic benefits to the remedies applied are likely to be different on each of the fifteen productivity land classes in the state. The answer to the problem of low family income in one area may not apply in another area.

5. **Distribution of Farm Facilities.**—The relationship of land productivity to the use of modern farm equipment and conveniences was examined with the following results:

a. The percentage of farm telephones varied with the productivity of the land and the type of farming found in the various areas of the state. In 1945 six per cent of the farm homes were equipped with telephones in subarea 1SE where the land is highly productive and cotton is a principal crop. Only one per cent had telephones in subarea 4SE where similar crops are grown, but the land is less productive.

In subarea 1NW, where the soils are fertile and the productivity per farm is the highest in the state, 92 per cent of the farms had telephones. Only 13 per cent had this service in land class 7 where most of the soils are poor and productivity per farm is the lowest in the state. Here it appears that productivity of the soil was a major factor in the use of a modern convenience.

b. The percentage of farms equipped with running water also varied with the gross productivity of the land. The range in southeastern Missouri was from 13 per cent in subarea 1SE to 3 per cent in 4SE. In other parts of the state the range was from 21 per cent in subarea 1NW and 1C to 4 per cent in productivity classes 3NW, 5, and 7.

c. Farms equipped for electricity varied from 48 per cent in productivity class 1C to 12 per cent in class 7.

d. The type of road near the individual farm did not appear to be related to the gross productivity of the land. The proportion of all farms with hard surfaced roads ranged from 12 per cent in subarea 1SE to 2 per cent in class 5. For gravelled roads, the range was from 55 per cent in subarea 3SW and 4EC to 13 per cent in subarea 1NW. Improved dirt roads were available to 48 per cent of the farms in subarea 1NW and 13 per cent in 1C and 1SE. In the case of unimproved dirt roads, the range was from 48 per cent in productivity classes 3NE and 7 to 13 per cent in 3SE.

6. **Distribution of Livestock.**—The percentage of farmers carrying a hog enterprise varied directly with the gross productivity of the land, except in southeastern Missouri. In that section the relationship was inverse.

The number of hogs per farm also varied directly with productivity. The average acreage of land per head showed an inverse relationship to soil productivity.

Pork production is undoubtedly related to corn production, and the corn acreage is associated with the productivity of the land. The number of bushels grown on the average farm in 1945 varied directly with soil productivity, except in southeastern Missouri. The bushels produced per hog were fairly constant in all land classes.

Cattle enterprises were larger on the more productive lands than on soils of low productivity, except in southeastern Missouri. The number of acres per head varied inversely with productivity.

The distribution of chickens on farms showed little evidence of being related to productivity. The keeping of chickens probably is influenced more by the availability of labor and equipment for their care, location with respect to markets, and profits from other enterprises than by the productivity of the soil.

7. **Use of Lime and Fertilizer.**—The percentage of all farms using commercial fertilizer in 1939 varied inversely with the productivity of the cultivated land. Outside the cotton producing section, the proportion ranged from 36.9 per cent in subarea 4EC to 1.2 per cent in 1NW. In the cotton section, the highest percentage of farmers using commercial fertilizers was in subarea 3SE. Only .2 per cent of those on the most productive land used commercial fertilizer and 5.5 per cent on the poorest land. The use of fertilizer has increased materially in recent years. Good responses have been obtained on all grades of land. The proportion of farmers using it has increased in all land class areas.

The percentage of all farms applying lime in 1939 showed practically no tendency to vary with productivity. The range was from .1 per cent in subareas 1SE and 2SE to 16.2 per cent in 3NE. Factors such as consciousness of need growing out of failure of desirable crops to produce satisfactorily on untreated land, acreage in pasture, custom, and availability of funds probably influenced the use of lime more than did differences in productivity.

SUMMARY

The purposes of this study were two: (1) to measure the physical productivity of land in Missouri by areas and subareas where the crops grown and the yields that could be expected under customary farming practices were similar, and (2) to determine the relationship between the level of productivity found in these areas and subareas and some economic and social factors that influence the general welfare of farm people.

In order to reach these objectives, the land in the state was divided into fifteen areas and subareas for which separate determinations of productivity were made.

Productivity in each of these areas and subareas was based primarily upon the energy and protein equivalents of all primary products of the

land. The procedure was to select townships that were representative of each land class; find the acreage and average yield of crops as shown by data from the United States census; correct the yield determinations to the 1937-1946 ten-year average yields; reduce all feedstuffs, including pastures, to corn and cottonseed meal equivalents, and then to apply the 1928-1947 twenty-year average price of these two commodities to the totals. The value of cotton lint in the sections of the state where this crop is important was added to the dollar value of other products to get the total producivity. The productivity values which were obtained by this procedure were designated as productivity units per acre.

Productivity in the different land class areas and subareas varied greatly. The range when calculated on the basis of total acreage in farms was from 49.60 units per acre in subarea 1SE to 5.96 units in class 7. Productivity on cultivated land varied much less than for all land in farms. In the cotton growing section the range was from 58.83 units per acre in subarea 1SE to 32.28 in 4SE. Outside the cotton area productivity varied from 31.09 units per acre in subarea 1C to 16.78 units in class 7.

When analyzed on a per farm basis, the range in gross productivity was also wide. It varied from 4,716 units on the average farm in subarea 1NW to 979 units in class 7. In the cotton section the range was from 3,776 units in subarea 1SE to 1,375 in 4SE.

On a county basis, Pemiscot, with a relatively large acreage of class 1 land, was first in productivity. Reynolds and Taney counties with most of their acreage in land class 7, stood last.

The productivity determinations were tested statistically for homogeneity. Data from representative townships in subarea 3SW, where soil scientists believe productivity is more variable than in any other land class in the state, were used for this purpose. No significant difference was found in the productivity determinations of two groups of townships which were chosen at random to be representative of this subarea. The determinations for all land class areas and subareas were, therefore, judged to be representative of the actual results obtained by farmers.

Significant positive relationships were found between the following factors:

1. Productivity per acre and the value of land and buildings per acre.
2. Productivity of land and the value of buildings, except in southeastern Missouri.
3. Productivity and the value of machinery per acre. This relationship was less significant in southeastern Missouri than in other parts of the state.
4. Productivity per acre and the percentage of farms operated by renters, except in southeastern Missouri.
5. Productivity per farm and the percentage of farms rented.
6. Productivity per acre and the amount of gross product per person on farms. This relationship was also significant in the delta cotton and corn area, but the number of units of productivity per person on farms was smaller than for other land classes in the state.

7. The proportion of farms equipped with telephones, running water, and electricity showed some tendency to vary with the productivity of the land.

A significant inverse relationship was found between the productivity of land and the percentage of owner operators.

The analysis presents objective proof of the need for adjustments in land use and the size of operating units, particularly in the low producing classes. The findings should aid the following people:

1. Prospective buyers of land.
2. Rural appraisers, fire insurance companies, banks and other financial institutions that provide services or make loans to farmers.
3. Action agencies charged with the task of aiding low income farmers.
4. Research workers in crops, soils, credit, farm organization and tenure who want to make their work applicable to specific conditions that influence the welfare of farm people.
5. Government officials and business executives whose task it is to frame policies that will lead to large expenditures for adjustments in agricultural production, or public service facilities such as roads, telephones, electric power lines, school buildings and marketing facilities.
6. Business men who are planning sales campaigns for farm equipment, household appliances and other goods used by farmers.

REFERENCES

1. Classifying Land for Conservation Farming, Farmers Bulletin 1853, U. S. Department of Agriculture, Washington, D. C.
2. Brown R. Rawlings, Jr. and O. R. Johnson, Relationship of Productivity of Farm Units and Their Ability to Pay Rent, Missouri Agricultural Experiment Station Research Bulletin 308, November, 1939.
3. W. H. Pine, Measuring the Economic Productivity of Land, Journal of Farm Ecnomics, Vol. XXX, November, 1948, pp. 777-783.
4. R. Earl Storie, An Index for Rating the Agricultural Value of Soils, California Agricultural Experiment Station Bulletin 556, 1933.
5. Homer J. L'Hote, Measuring the Productive Value of Pasture, Missouri Agricultural Experiment Station Bulletin 443, May 1942.
6. R. R. Renne and H. H. Lord, Assessment of Montana Farm Lands, Montana Agricultural Experiment Station Bulletin 348, October 1937.
7. The corn equivalents were taken from Morrison, F. B., Feeds and Feeding, 20th Edition, Table VII, p. 1027. The protein value of each crop was converted to its equivalent in cottonseed meal.
8. Sixteenth Census of the United States, 1940, Vol. I, Part 2, including tables by minor civil divisions, Department of Commerce, Washington, D. C.

9. United States Census of Agriculture, 1945, Vol. I, Part 10, including tables by minor civil divisions, Department of Commerce, Washington, D. C.

10. Descriptions of the land classes are taken from a proposed scheme of land classification for Missouri made by the Department of Soils, University of Missouri.

11. Homer J. L'Hote, Measuring the Productive Value of Pastures, Missouri Agricultural Experiment Station Bulletin 443, p. 33.