FERTILITY CHARACTERIZATION OF OKLAHOMA SOIL ASSOCIATIONS BASED ON CHEMICAL SOIL TESTS

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CHAPTER I

INTRODUCTION

For decades soil scientists have, consciously or unconsciously, "classified" soils as to fertility, productivity, or inherent fertility - whichever term happened to be in vogue at the time. They found, through the process of trial and error, that their field classification was often wrong, sometimes drastically so.

At one time, the soil chemists also attempted to characterize soils as to their value for plant growth, based generally on the laboratory tests they made for plant nutrients - total and available. The chemist similarly found that his prophecies often proved erroneous.

Statistical methods were also applied in an attempt to evaluate the productivity of soils; these methods were generally based on a statistical treatment of yield data. This gave useful information when limited to the type vegetation, type soil and type management with which they dealt. Unfortunately this is merely a "soil rating" based on traditional or prevailing land use with an average level of management and contributes little to the real understanding of soils and soil potentials.

Each of the above investigators, and many others, contributed much to the contemporary knowledge of soils and the soil's relative ability to produce vegetation. Today it is realized that the potential of a soil cannot be found by using any one, or even the whole combination, of methods mentioned. Soil genesis, morphology, fertility and management, along with statistical treatment of yields and cropping history, leaves entirely too many variables for confident predictions. This is not to say that a knowledge of each does not narrow the possible error of prediction. It does.

It is generally agreed among agriculturists that soil tests within themselves are of limited value for making fertilizer recommendations on specific soils. This is due to the numerous other variables which greatly influence plant growth. If, on the other hand, a great deal is known about a soil's morphology and the climate under which it develops, soil testing becomes an invaluable aid in making useful fertilizer recommendations. Alert Extension Service technicians have consequently learned to support their recommendations with a general knowledge of the soils and environmental conditions which prevail in their areas.

This study deals with soil test data made over the entire State of Oklahoma. The writer realizes many of the limitations imposed upon soil testing results, whether used for fertilizer recommendations or for more general soil-plant predictions; consequently, no attempt has been made to rate soils as to their respective productivity. It is however, fervently hoped that this study will prove of some value - or perhaps even serve as a "stepping stone" - to future investigations of greater refinement, involving more exhaustive methods, which will bring us nearer an accurate means of evaluating soil potential.

At the present time, a soil association map and report of Oklahoma are being prepared which will show areas of principal soils and the relationship of these soils (associations) to the Problem Areas in Soil Conservation. The specific aim of this thesis is to characterize these soil associations as to fertility status based on laboratory analysis for total organic matter, available phosphorus, exchangeable potassium and soil reaction.

What would be the value of such information? It should be just as useful to agricultural leaders in a state or county as such information about his farm is to the progressive farmer. (1).[1]

1. The information would aid research workers in orienting their research.

2. It would give educational and action agencies, as well as fertilizer and lime industries, a basis for evaluating or promoting their programs.

3. A comparison of this study with earlier and later similar studies will reflect trends in soil fertility; trends in nutrient status would reflect the effectiveness of research, educational and action programs.

4. It would give the soil scientist mapping soils a more factual knowledge of the comparative fertility status of the soils he is classifying.

5. The results could be used by Extension Service technicians for correlative purposes, thereby giving support to their own soil testing results.

6. It could conceivably help "pilot" the work for a more detailed study on the fertility characterization of soil series and types, which is a necessary part of soil productivity investigations.

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[1]Figures in parenthesis refer to literature cited.

Background

In the State of Oklahoma thirteen Problem Areas in Soil Conservation are recognized. These are generally based on climate (rainfall being the major criterion), geology, physiography and vegetation. (2). A Problem Area might include numerous unlike soil series and types; however, the major soil associations within a Problem Area would have, at least, a "common denominator" which could be applied successfully to soil conservation needs and management requirements. Physically similar soil series and types were grouped into soil units which became the basis for a mapping system used by the Soil Conservation Service from 1943 till recent years.

The following description of a soil unit was used in this mapping system which was known as the Farm Planning Conservation Survey.

A soil unit will include all soils within a problem area in soil conservation that have similar profile characteristics such as depth, texture, structure, permeability and consistence of the various horizons. All variations of the unit under similar conditions should have similar crop adaptabilities, be about equally productive, and require and respond to the same conservation practices. Any soil unit may include several types or soil series providing there is a similarity as described above and regardless of whether or not they are adjoining or in close association.

Each soil unit was further classified into one of the eight land use capability classes, based on potentialities, limitations and needs.[1]

Delimitations

This study has been limited to the possible valid interpretations concerning the fertility of soils in Oklahoma soil associations which

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[1]Soil Conservation Surveys, Memo. #6, Second Revision, U. S. Dept. of Agri., Soil Conservation Service (Fort Worth, 1951), p. 1.

can be made from chemical soil tests of Farm Planning Conservation Survey soil units and Pawnee County soil types and phases. The soil unit tests numbering 11,831 cover the period from 1944 to 1954. The Pawnee County tests numbering 1,131 cover the period from 1944 to 1954.

Definitions

Soil association, as used here, means a group of geographically associated soils developing in a generally similar kind of parent material, under a similar type vegetation. Each soil association occupies a restricted climatic range.

CHAPTER II

REVIEW OF LITERATURE

Few studies concerning the nutrient status of defined soil units on a large area basis have been undertaken and reported in the literature. This is understandable when the large amount of field survey progress and laboratory testing that is necessary is considered. This, too, concerns only the inventory phase of fertility findings; interpretive work on large area studies is extremely rare.

Due, presumably, to the "pressure of time" several short cuts to rate soils numerically as to productivity have been ably attempted. These pressures could be defined as an urgent need for suitable classifications for such purposes as (1) taxation assessment, (2) conservation of agricultural land resources and (3) land appraisal. The Bureau of Chemistry and Soils, United States Department of Agriculture, is credited with pioneer work in rating soils numerically as to productivity. Such ratings are generally a part of the Federal Soil Survey Report. Some representative methods or approaches to various fertility and/or productivity classification schemes have been selected and will be presented by the writer.

Anderson et al. (3) presented a method for classifying and evaluating soils having reasonably similar productivity and use suitabilities. Using forty-three farms in Johnson County, Nebraska, the relative effect of slope and erosion on yield of corn, wheat, oats and alfalfa was estimated for forty-nine land types occurring within the county. A reference point was first established by estimating the yield of land types considered the most productive for corn, wheat, and oat production. The other land types having varying slope and erosion classes were then assigned yield values relative to the most productive type. These estimated yields on the representative types were then adjusted to the corresponding land types for the entire county. The actual acre yield estimates were so derived that when weighted according to the acreage allotted they equaled the estimate (county reports) for gross county production.

Anderson observed that various crops doubtless respond differently to soil conditions but there was a lack of data on which such yield responses could be based. No mention of chemical soil tests or nutrient status was made.

Parker et al. (1) demonstrated a method of using soil test data to show the nutrient status of soils in a state. Limitations of the data as well as limited interpretive material showing how the results of the tests reflect inherent differences in soils as well as differences in management were presented. The study was made on Tennessee and North Carolina soils and counties were characterized according to relative nutrient levels for available phosphorus, potassium, magnesium, calcium and degree of acidity.

Peech (4) presented a report on the nutrient status of potato-producing soils of the Atlantic and Gulf Coast area. It was apparent that the native nutrient levels of the soils studied were generally very low, but there had been a marked accumulation of readily soluble phosphorus and exchangeable potassium. The extent of this accumulation varied in different soils and areas depending upon the chemical characteristics of the soils and upon farm management, particularily upon the number of years that the field had been under the intense fertilization common in potato production. Potassium had apparently accumulated to a lesser degree than phosphorus due to the heavy leaching of fertilizer salts as indicated by the high levels of potassium found in the subsoils. The organic matter was found to be quite variable even among different soil types within the same series. Incident to the control of potato scab the soils were purposely maintained at a very acid reaction.

Using the results of 6200 surface and 1400 sub-surface chemical soil tests for easily soluble phosphorus, Harper (5) classified Oklahoma soils into five groups for available phosphorus - very low, low, medium, high and very high. These levels were derived after correlation with field response. The soils were studied and characterized by county groups and by geographic regions, i.e., northeast, southeast, north-central, south-central, northwest and southwest Oklahoma.

Harper's results showed that greater than fifty percent of the soils in eastern Oklahoma (roughly, from the west boundaries of Kay, Logan and Carter Counties eastward) contained less than fifty pounds of easily soluble phosphorus per acre. Many of the subsoils in eastern Oklahoma were extremely low in available phosphorus. Although many soils in western Oklahoma were classified as deficient in easily soluble phosphorus, most of these were only medium in deficiency. The bottomland soils were generally higher in available phosphorus than adjacent uplands, except where the sediments were washed in from local sources which were low in easily soluble phosphorus.

The State of Oklahoma was divided into thirteen soil areas based on variations in topography, rainfall, age, kind of soil material and the effect of vegetation on soil development. (6). An examination of these areas on a map show they closely approximate the Oklahoma Problem Areas in Soil Conservation. Chemical soil tests for total nitrogen, total and easily soluble phosphorus, and soil reaction were made on these thirteen soil areas. The results showed that the Black Waxy soils and Alluvial soils contained the highest total nitrogen and total phosphorus content; but with those two exceptions, the Prairie soils were higher in total nitrogen than the other areas.

Based on the analysis of 21,792 surface soils and a comparison of 3,259 surface and 3,259 subsurface soils Harper (7) classified Oklahoma soils as to seven levels of acidity. Specifically defined soil units, once again, were not considered in the results presented. Counties and geographical regions were characterized and the results of these soil reaction levels were interpreted as being due, primarily, to rainfall (leaching) and to a lesser extent, degree of slope, erosion and the effect of cultivation and natural vegetation. Moderately to strongly acid soils were found in eastern Oklahoma with a majority of these falling in the eastern fourth of the State.

Soil scientists analyzed 6,379 soil samples representing every county in Oklahoma to study the potassium content of these soils in relation to crop production. Tests were further made on eighty-five different soil types and twenty-eight pairs of samples from virgin soils and adjacent areas of cultivated land. The results of these tests showed eighteen percent were in the very low level of exchangeable potassium. (8). Most of these soils found to be very low were located in eleven eastern and southeastern Oklahoma counties. The causes of low exchangeable potassium content were shown to be related to texture and character of soil material. Harper concluded that "there was no indication that soil acidity was associated with potassium deficiency". It was further concluded that medium and fine textured soils usually contain more exchangeable potassium than sandy soils for two reasons: (1) leaching is most rapid on sandy soils; (2) the predominant type of clay mineral in Oklahoma soils (montmorillonite), has a high base exchange capacity and holds practically all of the exchangeable potassium. The possibility of Kaolinite being associated with low exchangeable potassium on some eastern Oklahoma soils was not excluded.

The results of the tests on eighty-five soil types were presented and four series were especially low in exchangeable potassium - Parsons, Bates, Bowie and Norfolk. The data presented indicated that up to that time (1950) the effect of cropping had not seriously reduced the exchangeable potassium content which was originally present in a sufficient quantity for the growth of crops having a high requirement for potassium.

CHAPTER III

METHOD AND PROCEDURE

Materials

Soil units within Oklahoma's thirteen Problem Areas in Soil Conservation were tested for total organic matter, exchangeable potassium, easily soluble phosphorus and acidity by the Soil Conservation Service Operations Laboratory at Stillwater, Oklahoma. Test results numbering 11,831 on each of the above nutrients and acidity were used in this study.

An unpublished soil association map and report of Oklahoma covering the above soil units and showing areas of principal soils and the relationship of these soils (associations) to the Problem Areas were used as a comprehensive basis for interpretive study.[1]

Soil tests numbering 1,131 for easily soluble phosphorus and acidity were made in Pawnee County by the Extension Service located at Pawnee, Oklahoma. These tests were related to specific soil types and phases by the use of field sheets for a recently completed detailed soil survey of Pawnee County. The Pawnee County tests were supplemented by complete analysis data made on many of Pawnee County's more important

[1]Unpublished manuscript map. Soil Conservation Service and Oklahoma Agricultural Experiment Station.

soil types.[1]

A report on fertilizer consumption in Oklahoma and a Preliminary Type-of-Farming Map of Oklahoma were studied for general interpretive possibilities. (9, 10).

Laboratory Procedures

The test methods used, ranges and final groupings of the nutrient and acidity levels for both groups of data were as follows:

I. Problem Area soil units (surface soil only)

A. Total organic matter. The "wet combustion process"[2] of organic carbon oxidation was utilized and results were grouped into five classes: very low (0- .8%), low (.81 - 1.3%), medium (1.31 - 1.80%), medium plus (1.81 - 2.40%) and high (2.41 +).

B. Exchangeable potassium. Each soil was extracted with two parts of neutral normal ammonium acetate at seventy degrees centigrade for one-half hour and the potassium in the filtrate determined with a Perkin-Elmer flame photometer. Results were grouped into five classes: very low (0 - 99 lbs/acre), low (100 - 124 lbs/acre), medium (125 - 149 lbs/acre), medium plus (150 - 200 lbs/acre), and high (200 + lbs/acre).

C. Easily soluble phosphorus. The Harper method[3] was used and results grouped as very low (0 - 3 lbs/acre), low (4 - 7 lbs/acre),

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[1]Soils analyzed by Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

[2]H. J. Harper. Methods for the Analysis of Soil and Plant Material, Soils Laboratory, Oklahoma Agricultural and Mechanical College, 1948.

[3]Ibid.

medium (8 - 13 lbs/acre), medium plus (14 - 20 lbs/acre), and high (20+ lbs/acre).

D. Soil reaction. The Beckman, glass electrode pH meter was employed and the degree of acidity defined as strongly acid (pH 0 - 4.9), moderately acid (pH 5.0 - 5.9), slightly acid (pH 6.0 - 6.4), neutral (pH 6.5 - 7.2), basic (pH 7.3 - 7.8) and strongly basic (pH 7.9+).

II. Pawnee County soil types (surface soil only)

A. Easily soluble phosphorus. .02 N H_2SO_4 was used as the extracting agent and groupings were the same as were used on the Problem Area soil units.

B. Soil reaction. The Comber colorimetric test was used and various levels reported as strongly acid (pH 4.9 - 5.4), moderately acid (pH 5.5 - 6.0), slightly acid (pH 6.1 - 6.4), very slightly acid (pH 6.5 - 6.7) and non-acid and alkaline (pH 6.8+).

III. Problem Area soil units and Pawnee County soil types were grouped for soil reaction indexing and correlative purposes in the following manner: strongly acid (pH 0 - 5.9), slightly acid (pH 6.0 - 6.4), and neutral (pH 6.5+).

Selection of Data

The soil tests made by the Extension Service at Pawnee, Oklahoma, were recorded by farmer's name, field on the farm and/or specific legal description when available. Those tests which could not be specifically related to a field shown on the soil survey field sheets were eliminated from the data. The tests on several series and types were not used due to the insignificant number of tests.

Numerous tests made on soil units by the Soil Conservation Operations Laboratory were discarded due either to the insignificant number of tests for that unit or to the uncertainty of the soil type by which it could be appropriately represented.

Treatment of the Data

In conference with other soil scientists the Farm Planning Conservation Survey soil units were converted to appropriate soil series.[1] It was realized that each soil unit would generally include more than one soil series, type or phase; consequently most soil units are represented by two or more series. The soil phase was interpreted from soil units in various capability classes when it was possible to have positive knowledge of the soil unit.

The soil type and phase was taken directly from the field sheets of the Pawnee County detailed soil survey when the field or pasture the test represented was located. These series, types and phases have undergone final correlation.[2]

Method of Calculation

Both the Pawnee County tests and the Soil Conservation Service Operations Laboratory tests were grouped into three classes. The very low and low tests were combined and designated as "low". The medium tests were designated as "medium". The medium-plus and high level tests

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[1]Harry Galloway, SCS and Exp. Sta. Soil Scientist; Dr. Fenton Gray, Assoc. Prof. of Soils; Louis Derr, formerly State Soil Scientist; Ray Marshall, Acting State Soil Scientist; Milton Gault, Area Conservationist.

[2]Final review was made in November, 1954, by A. R. Aandahl and E. H. Templin.

were grouped and designated as "high". The strong and moderate acidity levels were combined and designated "strong"; the slight acidity level remained "slight"; and the neutral and basic acidity levels were designated "neutral". The source of the samples from Pawnee County and the method used in converting Farm Planning Conservation Survey soil units to soil types and phases did not justify finer division.

A weighted average index was calculated for total organic matter, exchangeable potassium, easily soluble phosphorus and acidity. (1). In order to obtain a single index for each nutrient and acidity the percentage of samples in each of the three groups low, medium and high was multiplied by one, two and three respectively. The sum of the figures thus obtained divided by 100 gave the index, or weighted average, for the soil.

The weighted average index was calculated for (1) Pawnee County soil types and phases, (2) each soil unit within Problem Areas which had been converted to soil series and phases, and (3) for whole Problem Areas in Oklahoma.

In some cases it was suspected that a single soil unit within a Problem Area would include two or more series and types with contrasting fertility levels. Where separable geographically the tests on these soil units were calculated from data of individual counties and the index was figured on separate soil series.

Following a method used by Parker et al. (1) the indices were divided into eight ranges and a relative descriptive term for each range applied as follows:

Ave. Nutrient Index	Nutrient Designation	Acidity Designation
1.00 - 1.14	Very low	Very strong
1.15 - 1.42	Low -	Strong +
1.43 - 1.70	Low +	Strong -
1.71 - 1.99	Medium -	Slight +
2.00 - 2.28	Medium +	Slight -
2.29 - 2.57	High -	Neutral
2.58 - 2.85	High +	Neutral +
2.86 - 3.00	Very high	Very basic

CHAPTER IV

RESULTS AND DISCUSSION

The reliability of chemical soil tests, whether used as specific means by which to make fertilizer recommendations, or as an aid in predicting soil productivity, has been often discredited. Among different individuals varying degrees of skepticism can readily be detected; often this relative doubt can be proportionally related to the amount of experience along those lines which these individuals have had, or by their degree of familiarity with the experiences and investigations of others in fertility studies.

In fairness to most of the plant-soil investigators having extensive experience in fertility investigations, it must be admitted that these individuals generally agree that chemical soil tests are a valuable tool in making fertilizer recommendations when interpreted correctly. This is true when other soil factors as soil reaction, parent material, soil drainage, depth, slope, expected precipitation, and past history are known and considered. This acceptance points out a salient fact: that chemical soil tests, though far from perfect, are often in unjust disfavor. It is more than likely not the test results that are causing numerous miscalculations, but is rather a lack of fundamental knowledge about the soil factors involved.

The dilema could be attacked by two approaches. First, the relative influence which the various soil factors have on soil tests, as now per-formed in the laboratory, could be further studied and interpreted. Secondly, various new or modified soil testing methods could be applied in search for more reliable methods. The solution of either approach would greatly expedite mastering the other.

The writer hopes that these observations help to point out the value, as well as the limitations, of the data which are to be presented. In the first place, an inventory of the nutrient and acidity status (total organic matter, soil reaction, acid-soluble phosphorus and exchangeable potassium as determined by defined methods) of morphologically defined soil units, however broad, is of extreme importance within itself. Within this inventory presentation, as will be seen later, are enough specific instances sufficiently massed (or weighted with adequate repetition) to readily lend themselves as a basis for broad interpretive reasoning. The writer will attempt to develop the validity of this reasoning in the final portion of this paper. The ultimate value of this line of interpretive reasoning will have to stand on its own merits as determined by time.

Pawnee County Soil Types

Pawnee County soils were used in this study for the following reasons:

1. The field sheets for a recent detailed soil survey were available for use. The soil tests made could be directly located on these sheets (aerial photographs) and the soil type and phase was shown thereon.

2. The same technician had made the soil tests over the period of time evolved in this study, therefore the relative degree of accuracy should remain somewhat constant.

3. A suitable record had been kept which helped locate test sites.

4. Specific soil types and phases having a sufficient number of soil tests made on them were necessary to determine whether or not these soil types would show correspondingly different test levels. It is believed that the Pawnee County soil tests were the best available source.

The soils tested for easily soluble phosphorus and soil reaction by the Extension Service technician at Pawnee, Oklahoma, are shown in Table I. The soil types and phases were shown which had a sufficient number of tests to be considered significant or at least indicative of a defined range (low, medium, high) of easily soluble phosphorus and acidity.

The percentages of tests falling in low, medium and high, as well as the number of tests showing strong, slight and non-acid levels of acidity were shown on this table to enable the reader to observe the method utilized in calculating indices which were used throughout this study. The percentages shown for low, medium and high were multiplied by one, two and three respectively. The sum of the figures thus obtained divided by 100 gave the index, or weighted average, for the soil.

There is an inherent weakness which is unavoidable in the Pawnee County data. Although soil sampling sites were located on the survey field sheets as accurately as possible, it is impossible to state whether or not individual farmers followed directions for taking samples, or how well the area sampled represented the soil shown on the map area.

Another limitation which should be brought to the attention of the reader is the lack of information available pertaining to commercial fertilizer and lime usage on individual soils. This limitation applies to the entire study, not only to Pawnee County soils. While generalizations can be made from a knowledge of the soil's probable use and pre-

TABLE I

SOME PAWNEE COUNTY SOIL TYPES WITH EASILY SOLUBLE PHOSPHORUS* AND ACIDITY** PERCENTAGE LEVELS AND CALCULATED INDICES

			Phosphorus				Acidity			
			% of Samples Testing				% of Samples Testing			
Soil Type	Slope	No. Tests	Low	Medium	High	Index	Strong	Slight	Non-Acid	Index
UPLAND SOILS										
Bates fine sandy loam	2-5%	39	74.4	17.9	7.7	1.33	12.8	28.2	59.0	2.46
Dennis loam	2-5%	338	84.3	11.5	4.1	1.20	15.4	30.8	53.8	2.38
Dennis loam eroded	2-5%	27	92.6	7.4	0.0	1.08	11.2	33.3	55.5	2.44
Kirkland silt loam	0-3%	70	80.0	15.7	4.3	1.24	30.1	32.8	37.1	2.07
Norge silt loam	2-5%	70	82.8	4.3	12.9	1.30	11.4	40.0	48.6	2.37
Parsons complex	1-3%	27	70.4	29.6	0.0	1.30	29.6	40.7	29.6	2.00
Renfrow silt loam	1-3%	39	74.3	17.9	7.7	1.33	23.1	25.6	51.3	2.28
Renfrow silt loam	3-5%	57	92.9	1.8	5.3	1.12	8.7	28.1	63.2	2.54
Teller soils	2-5%	65	69.2	21.5	9.3	1.40	6.2	36.9	56.9	2.51
Vanoss silt loam	0-2%	52	59.6	23.1	17.3	1.58	9.6	38.5	51.9	2.42
Zaneis soils	2-5%	46	84.8	8.7	6.5	1.22	21.7	34.8	43.5	2.22
BOTTOMLAND SOILS										
Brewer silty clay loam	0-3%	14	43.0	28.5	28.5	1.85	0.0	7.2	92.8	2.93
Dale silt loam	0-3%	26	46.2	26.9	26.9	1.81	26.9	3.8	69.2	2.42
Lela soils	0-2%	15	46.6	40.0	13.3	1.67	6.8	26.6	66.6	2.60
Port silt loam	0-1%	194	54.6	28.9	16.5	1.62	8.3	22.2	69.5	2.61
Yahola fine sandy loam	0-3%	21	38.1	23.8	38.1	2.00	9.5	0.0	90.5	2.81
Yahola silt loam	0-2%	31	19.4	12.9	67.7	2.48	0.0	3.2	96.8	2.97

* Tests made by Extension Service, Pawnee, Oklahoma, on topsoils only. .02 N. H_2SO_4 extracting agent.
** Comber method.

vailing management levels for the region, it remains impossible to estimate past fertilizer application on any specific soil. This problem will be discussed more completely in the latter part of this chapter.

The relative degree of intensive utilization specific soils have undergone should be reflected in the nutrient status level. This will not always be apparent from the index level, because the "better" soils are generally the ones receiving the largest fertilizer increments.

The greater the number of tests per soil unit the less will be the effect of individual variation in past fertilizer and lime treatments, whether the treatment was unusually large or small.

From a study of Table I it can be seen that

1. Bottomland soils were considerably higher in available phosphorus than were the upland soils.

2. The bottomlands were somewhat higher in pH (more basic) than were the uplands.

3. The easily soluble phosphorus indices for the uplands were all "low", ranging from very low for Dennis loam, eroded, to low- for Bates sandy loam and Renfrow silt loam. The acidity levels for the uplands ranged from slight- for Kirkland silt loam to neutral for Renfrow silt loam, 3-5% slope, both of which occupy neutral to basic rocks in western Pawnee County.

4. Vanoss, a high terrace soil near through-flowing streams, formed on unconsolidated loams, was found to be intermediate in available phosphorus between bottomland soils and uplands. The phosphorus index for Vanoss was low+ and the soil reaction neutral. Vanoss in Pawnee County is cropped intensively.

5. Phosphorus indices for Pawnee County bottomland soils ranged

from low+ for Port silt loam to high- for Yahola silt loam.

The Arkansas River, forming the north and east boundaries for Pawnee County, has deposited sediments rich in plant nutrients along its flood bottoms. Yahola, Dale and Brewer developing here, as should be expected, are relatively high in available phosphorus and pH level.

Three Problem Areas in Soil Conservation - the Reddish Prairies, Cherokee Prairies and Cross Timbers - extend into Pawnee County. The Reddish Prairie soils - Kirkland, Norge, Renfrow, Teller, Vanoss and Zaneis - developed on clayey "red beds", silts and sandstones and had slightly higher nutrient indices than the Cherokee Prairie soils which developed on shales and sandstones just east of the Reddish Prairies. These Cherokee Prairie soils are Bates, Dennis and Parsons.

There is no representative soil shown for the Cross Timbers, because of a general lack of tests for these soils in the county. Physically, Teller comes nearer to representing some of the better Cross Timbers, but it has been strongly influenced by sediments of aeolian and/or alluvial origin. The relatively high index reflects this influence.

A complete chemical analysis of several major soil types mapped in Pawnee County appears in Appendix A.

Problem Area Soil Units

Soils within Oklahoma's thirteen Problem Areas in Soil Conservation were mapped by a system known as the Farm Planning Conservation Survey. Physically similar soil series and types were grouped into soil units throughout the State. A descriptive legend for those soil units used in this study is shown in Appendix B.

The same soil unit can appear in any or all Problem Areas, depending upon physical similarities. Generally, however, the soil unit will include different soil series when it appears in a different Problem Area, due to a difference in the interrelated influences exerted by the soil formation factors (climate, parent material, topography, vegetation and time) on soil development.

The chemical soil tests were made on these soil units. The samples were collected by soil scientists over a period of years and analyzed in the Soil Conservation Service Operations Laboratory at Stillwater, Oklahoma.

In some instances soil units which were somewhat similar morphologically were grouped in order to pool data which would have been insufficient in quantity to use alone. In each case, where this grouping was done, it was believed to increase the fertility probability of those units (when applied to this broad a study). The soil unit having the greatest number of tests made on it was always listed first in such groupings.

As previously stated, a soil unit in the Farm Planning Conservation Survey (Problem Area soil units) would generally be expected to include more than one series or type. This fact was one of the major drawbacks to this study. An attempt was made to name, at least, the major soil series that these various soil units include.

Some minor-occurring soil series which have been mapped and possibly even tested for available nutrients do not appear in this major soil series listing. Generally, the soil series believed to be most extensive was named first.

The soils shown in Table II and especially the number of tests shown for these soils, give no indication as to the area the soils occupy.

TABLE II

NUTRIENT AND ACIDITY INDICES OF OKLAHOMA PROBLEM AREA SOIL UNITS

Soil Unit	Land Class	Major Soils	Number Tests	Indices: Organic Matter*	Phos-phorus**	Potas-sium***	Acidity
High Plains Problem Area							
02 06	1-4 3-7	Richfield, Pull-man, Zita	20	2.05	2.90	3.00	3.00
07 70	1-7 3-4	Dalhart, Berthoud	20	1.25	2.95	3.00	2.95
09 04	1-2 1-2	Spur	4	2.75	3.00	3.00	3.00
12	1-7	Dalhart, Vona, Tivoli	5	1.40	3.00	3.00	3.00
17 18 20	3-4 1-4 3-7	Mansker, Potter, Regnier	6	2.00	3.00	3.00	3.00
		Totals	55	1.74	2.94	3.00	2.98
Rolling Red Plains Problem Area							
01 05	1-2 1-2	Foard, Hollister, Tillman, Lebos	130	2.18	2.87	2.97	2.72
01 05	3-4 3-4	Tillman	162	2.13	2.78	2.97	2.75
01 05	5-7 5-7	Eroded Tillman	8	1.88	2.62	3.00	2.25
02	1-7	Abilene, Kiowa, La Casa	114	2.21	2.90	2.96	2.84
03	1-7	Spur	19	2.31	2.95	3.00	3.00
04 08	1-7 1-7	Norwood, Port	128	2.22	2.96	3.00	2.86

*Total Organic Matter.
**Easily soluble Phosphorus.
***Exchangeable Potassium.

TABLE II (Continued)

Rolling Red Plains Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
06 60	1-7 1-4	Abilene, St.Paul, Carwile, Lawton	185	1.89	2.90	2.96	2.87
07	1-2	Dill, Carey, Tipton, Enterprise	102	1.50	2.74	2.86	2.76
07 70 07	3-4 1-7 5-7	Woodward, Miles, Farnum, Enterprise	215	1.33	2.55	2.87	2.77
09	1-7	Port, Yahola, Spur, Sweetwater	145	1.63	2.93	2.92	2.98
12	1-7	Pratt, Brownfield	89	1.12	1.94	2.70	2.85
13	3-7	Tivoli	5	1.00	2.00	1.80	2.80
15	3-7	Lincoln	8	1.00	3.00	2.00	3.00
20 19 17 25	1-7 3-4 3-7 1-7	Quinlan-Woodward complex	97	1.74	2.75	2.85	2.88
27 24	1-2 1-7	Vernon, rough brokenland-Vernon, Harmon	10	2.22	2.80	3.00	2.91
		Totals	1417	1.80	2.75	2.90	2.83

Reddish Prairies Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
01 01	1-2 3-4	Tabler, Renfrow	85	2.12	2.41	2.96	2.76
02 02	1-4 5-7	Fairview, Rusk	53	2.40	2.34	2.83	2.47
03	1-7	Lela, Roebuck, Miller	28	2.57	2.39	2.92	2.57
04 08	1-7 1-7	Port, Kay, Brewer	474	2.46	2.56	2.85	2.68
05	1-2	Tabler, Kirkland	270	2.23	1.78	2.82	1.85

TABLE II (Continued)

Reddish Prairies Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phosphorus	Potassium	Acidity
05	3-4	Renfrow, Kirkland	510	1.92	1.46	2.68	1.94
05 01	5-7 5-7	Eroded Renfrow	67	1.73	1.39	2.56	2.13
06	1-2	Pond Creek, Norge, Bethany, Kingfisher	160	1.99	2.54	2.89	2.20
06	3-7	Zaneis, Norge	215	1.71	1.49	2.68	2.09
07 70	1-2 1-2	Grant, Chickasha, Vanoss, Minco, Teller	495	1.71	2.12	2.82	2.18
07 70	3-7 3-7	Grant, Cobb, Teller, Minco	882	1.57	1.65	2.66	2.23
09 09	1-4 5-7	Port, Yahola, Reinach	616	1.72	2.59	2.74	2.64
12	1-7	Pratt, Cobb, Dougherty	93	1.14	2.34	2.55	2.58
13	3-7	Derby, Tivoli	4	1.50	2.00	2.50	3.00
15	1-7	Lincoln	35	1.31	2.47	2.46	2.78
16 17 19	3-4 3-4 3-7	Stamford	33	1.82	2.30	2.91	2.67
20 20	1-4 5-7	Lucien, Nash	100	1.46	1.96	2.79	2.42
24 25	3-7 1-7	Vernon, Lucien	45	2.11	2.02	2.85	2.69
		Totals	4165	1.83	2.03	2.75	2.31

Cherokee Prairies Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phosphorus	Potassium	Acidity
01 02	1-7 1-4	Okemah, Woodson	43	2.54	1.48	2.06	1.98

TABLE II (Continued)

Cherokee Prairies Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
03 04 08	1-7 1-7 1-7	Verdigris, Osage, Lightning	164	2.54	1.86	2.30	2.10
05	1-7	Parsons, Taloka, Cherokee	343	2.41	1.23	1.75	1.68
06	1-7	Dennis, Choteau	529	2.32	1.18	1.95	1.55
07 20	1-7 3-7	Bates	359	2.10	1.26	1.78	1.57
09	1-7	Verdigris, Cleora, Mason	109	2.42	1.80	2.37	2.25
17 18 19 24 25 27	3-7 3-4 5-7 3-7 3-7 3-4	Talihina, Collins-ville	45	2.69	1.22	2.62	1.76
		Totals	1592	2.33	1.33	1.95	1.70

Ouachita Highlands Problem Area
(Arkansas Valley, Boston Mts. and Ouachita Mts.)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
03	1-2 5-7	Atkins	5	3.00	2.00	3.00	1.40
05	1-7	Parsons, Taloka, Le Flore	49	1.69	1.06	1.95	1.32
06 19	1-7 3-7	Conway, Enders, Tyler	102	1.88	1.19	1.90	1.70
07 20	1-7 3-7	Linker, Cleburne, Waynesboro	280	1.60	1.22	1.83	1.82
08 04	1-7 1-4	Philo	87	2.33	1.22	2.26	1.71
09	1-7	Pope	64	2.00	1.33	2.22	1.75
12 70	3-7 1-7	Dougherty, Stid-ham, Teller	24	1.12	1.04	1.52	1.79

TABLE II (Continued)

Ouachita Highlands Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos- phorus	Potas- sium	Acidity
25 27	3-7 3-7	Hector, Potts- ville	15	2.40	1.00	2.43	1.60
		Totals	626	1.80	1.20	1.96	1.73
		Grand Prairie Problem Area					
02 01	1-7 1-7	Denton, San Saba	304	2.81	1.96	2.74	2.63
03	1-7	Kaufman, Trinity, Navasota, Bell	27	2.67	2.52	2.85	2.62
04 09 08	1-7 1-4 1-7	Gowen, Catalpa, May	314	2.68	2.39	2.84	2.72
05	1-7	Wilson, Irving	36	2.03	1.28	1.91	2.11
06	1-7	Durant	205	2.26	1.44	2.54	2.21
07	1-7	Choctaw, Newtonia	99	1.85	1.39	2.34	2.06
24 28 25 17	3-7 5-7 5-7 3-7	Tarrant, Ellis	23	2.91	1.39	2.84	2.48
		Totals	1008	2.53	1.91	2.68	2.49
		Bluestem Hills Problem Area					
02 05	1-7 1-2	Summit, Woodson	31	2.76	1.39	2.41	2.13
03 04	1-4 1-4	Osage, Muir, Verdigris	11	3.00	1.96	3.00	1.47
06	1-7	Labette	30	3.00	1.84	2.75	1.83
07	1-4	Newtonia	4	2.75	2.00	2.75	2.50
08 09	1-2 1-2	Verdigris, Mason	9	2.78	2.11	3.00	1.22

TABLE II (Continued)

Bluestem Hills Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos- phorus	Potas- sium	Acidity
20 28	3-4 5-7	Sogn	5	2.20	1.80	3.00	2.00
		Totals	90	2.83	1.73	2.69	1.84
		Ozark Highlands (Prairie) Problem Area					
01 17	1-4 3-7	Woodson	20	2.85	1.50	2.04	2.10
02	1-7	Summit	50	2.80	1.74	2.48	2.34
04	1-2 5-7	Muir	4	2.25	2.00	2.50	1.75
05	1-7	Parsons, Gerald	57	2.35	1.12	1.36	1.46
06	1-7	Dennis, Lawrence, Choteau	136	2.64	1.21	1.50	1.43
07 19 25	1-7 3-7 5-7	Newtonia, Craig, Cabanal, Riverton	134	2.38	1.19	1.70	1.67
08 09	1-2 1-7	Huntington	26	2.69	1.31	2.12	1.62
20	5-7	Bodine	50	2.66	1.20	1.74	1.58
		Totals	477	2.56	1.27	1.73	1.66
		Ozark Highlands Problem Area					
01 02 17	1-4 3-4 1-2	Summit	5	3.00	1.20	1.40	1.80
05	1-7	Guthrie	10	2.20	1.20	1.50	2.10
06 19	1-7 3-4	Lawrence	40	2.32	1.17	1.77	1.72
07	1-7	Nixa, Baxter, Cabanal	85	2.10	1.34	2.10	1.66

TABLE II (Continued)

Ozark Highlands Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
09 08	1-7 1-4	Huntington, Roane, Melvern	51	2.67	1.84	2.43	1.94
20 24 25	1-7 5-7 5-7	Bodine	26	2.77	1.50	2.20	1.65
		Totals	217	2.38	1.44	2.09	1.76

Granitic Soils Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
02 01	1-7 1-4	Garrett	78	2.38	2.12	2.83	2.46
05	1-7	Garrett	24	1.87	1.83	2.83	2.17
06 11	1-7 3-7	Lawton, Chigley, Roff, Gilson	29	2.06	1.20	2.61	1.96
07	1-7	Tishomingo	16	2.00	1.88	3.00	2.06
09	1-4	Port, Pulaski	13	1.92	2.38	2.83	2.28
		Totals	160	2.17	1.91	2.80	2.27

Cross Timbers Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
03	3-7	Roebuck, Lela	4	1.25	1.50	2.50	2.25
04 08	1-7 1-4	Miller	32	2.00	2.00	2.51	2.65
06 60 05 01 02	1-7 3-4 1-7 1-7 3-7	Nimrod, Windthorst, Parsons	95	1.40	1.47	2.20	2.17
07 70	1-4 1-4	Stephenville, Dougherty, Stid- ham, Noble, Teller	555	1.28	1.47	2.15	2.19
07 70 19 20	5-7 5-7 3-7 1-7	Stephenville, Windthorst Eroded and shallow phases	222	1.28	1.24	1.95	2.22

TABLE II (Continued)

Cross Timbers Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
09 15	1-7 1-7	Pulaski, Port, Gowen, Mason	214	1.38	1.86	2.23	2.65
12	1-7	Dougherty, Stid-ham	108	1.12	1.67	1.99	2.46
13	3-7	Eufaula, Derby	21	1.00	1.90	1.53	2.47
24 25 27	1-2 3-4 3-7	Darnell and rough sandstone lands	7	1.29	1.43	2.57	2.00
		Totals	1258	1.31	1.54	2.13	2.32

Forested Coastal Plain Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
04 08	1-4 1-7	Iuka, Bibb	10	1.50	1.00	1.40	2.00
05 01	1-7 5-7	Caddo, Lufkin, Myatt	14	1.42	1.07	1.92	1.50
06 10 11	1-7 1-2 5-7	Boswell, Kirvin, Sawyer, Susque-hanna	57	1.24	1.17	1.83	1.89
07 12 13	1-7 1-7 3-4	Bowie, Ruston, Norfolk	137	1.16	1.53	1.42	2.17
09	1-7	Ochlockonee	26	1.58	1.62	2.62	2.27
19 20	3-7 3-7	Cuthbert	13	1.30	1.23	1.40	2.00
		Totals	257	1.27	1.40	1.59	2.07

Bottomlands Problem Area

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
03	1-7	Pledger, Lela, Perry	30	2.73	2.50	2.97	2.67
04 08	1-7 1-7	Dale, McLain, Port, Miller, Norwood, Spur	251	2.46	2.75	2.81	2.72

TABLE II (Continued)

Bottomlands Problem Area (Continued)

Soil Unit	Land Class	Major Soils	Number Tests	Organic Matter	Phos-phorus	Potas-sium	Acidity
09	1-7	Yahola, Reinach, Canadian, Port	357	1.76	2.56	2.56	2.55
15	1-7	Lincoln	33	1.18	2.77	2.13	2.76
		Totals	671	2.03	2.65	2.64	2.63

There are relatively few tests for shallow, stony pasture land over the State. In areas where fertility is not considered a positive limiting factor to crop production (such as the High Plains in western Oklahoma), there were also few tests by which to characterize these soils. Soils showing the highest number of tests are the ones being used most intensively.

In Table II the thirteen Problem Areas were listed separately. Soil units were arranged in numerical order; the major soil series were named and the number of tests made for each nutrient and acidity was shown. The calculated index for each nutrient and acidity as well as the index for the entire Problem Area are also listed.

These same Problem Areas are shown in Appendix C arranged in different order: Problem Areas and soil units were listed according to their relative indices - the higher indices first. The indices for total organic matter, exchangeable potassium, easily soluble phosphorus and soil reaction were listed separately for the sake of convenience and simplicity.

From a study of Table II or Appendix C it can be seen that the bottomland soils were almost without exception higher in nutrient status and soil reaction (more basic) than were the upland soils.

The next group of soils which were generally relatively high in nutrient status and pH were the deep, fine textured, slowly or very slowly permeable soils.

In numerous instances that group of soils mapped as shallow, rough broken or rough stony land were found to be considerably higher in nutrient and acidity levels than might be expected from a knowledge of these soils' morphology or land use suitability.

The three general groups referred to above as having relatively high indices - indicating higher nutrient and pH levels - are not necessarily highly productive soils, nor are they physically ideal for average methods of management. For instance, some of the bottomland soils are subject to overflow hazards; some others could be abnormally high in soluble salts. Many of the fine textured, very slowly permeable soils are poorly drained and may have undesirable tilth. The shallow, rough, stony soils are, of course, unfit for economical crop production. These shallow soils are incapable of holding enough water to encourage vigorous vegetative growth, and are often located on steep topography, making them difficultly accessible and especially susceptible to accelerated erosion.

That group of soils which were notable low in nutrient levels are the coarse textured, permeable and freely permeable soil units. This is probably due to inherently low fertility and low ion exchange capacity. These soils are subject to intense leaching due to the open, permeable profiles. In some cases, due to the small number of soil tests made, these coarse textured permeable soils were grouped with other soils having somewhat less "open" profiles. This grouping affected the indices of the physically better soils only slightly, due to the comparatively greater number of tests. It tended to absorb and apparently enhance the nutrient status of the coarser textured soils.

The largest number of tests for the upland soils was made on those units which may be considered physically superior for the production of field crops (this is true when considered on a comparative acreage basis). Soil-water relationships and tilth are ideal on those soils which are deep, medium textured and moderately permeable. As can be seen in Table II, these were not, generally, among the soil units with the highest indices. This was anticipated by the writer and can be explained with reasonable justification. These soils, due to their lower ion exchange capacity, as compared with the fine textured soils, would be expected to hold less plant nutrients; permeability is freer and therefore suggestive of greater weathering and leaching. Being relatively higher in quartz and lower in weatherable minerals, these soils should be of lower original nutrient content than are the finer-textured soils.

As stated previously, these soils are used intensively and consequently the nutrients, as they become readily available to plants, are assimilated quite rapidly. These continuously cropped soils are being fertilized and limed as heavily as any other physical group of soils in Oklahoma. Generally, however, the amount of fertilizers being added to Oklahoma soils does not nearly approach the amount being removed by plants. (11).

The statements made above apply, generally, to the soils throughout the State, and the trends indicated are not restricted to any particular Problem Area, although some Problem Areas have fewer exceptions to these trends than others.

Effects of Climate

Indices were progressively lower, with the exception of those for organic matter, (indicating relatively lower available nutrient and pH levels), for soil series occurring west to east geographically. Both precipitation and temperature increase, generally, west to east. (12). One notable exception to this trend was bottomland soils, which had considerably higher indices due to the nutrient-enriched sediments deposited by the major streams (the available phosphorus levels for several bottomland soil series occurring in the Forested Coastal Plain, Ouachita Highlands and Ozark Highlands were in the low range).

The most variable indices were those representing total organic matter percentage. The most apparent trend was in reverse of the other indices i.e., they increase with increasing precipitation.

Effects of Parent Material

The effect of parent material was obviously noted on soil series occurring on granitic rocks in south central Oklahoma. Even though these soils have developed under an annual rainfall of approximately 35", relatively conducive to leaching, they showed high potassium indices. Another possible contributing factor was the comparative youth of these granatic soils. Granitic rock contains large amounts of potassium, and through the process of weathering, rather large amounts of exchangeable potassium become available. (13).

At the other extreme the potassium indices for soils developed on the unconsolidated sands, sandy clays and clays of the Forested Coastal Plain area were, generally, very low in exchangeable potassium. The geological formation, (marine deposits of the Eocene group), on which these soils developed was probably originally deficient in potassium content. (14).

Not only was potassium indicated as low on these Forested Coastal Plain soils; they also appeared to be low in total organic matter content. In accord with the theory that parent material is here exerting a strong influence, the Cross Timbers soils (also quite sandy morphologically) were similarly low in organic matter.

Increasing total organic matter is apparently not only correlative with increasing rainfall and temperature, but is apparently affected by the type parent material also. Those soils developing on limestones had considerably higher indices than other soils within a similar climate. Those series within the Bluestem Hills and Ozark Highlands were the highest in total organic matter within the State according to the tests employed. Waksman (15) considers the clay-humus complex which is held together by calcium ions as agriculturally more important than the clay-humus held together by iron, the apparent reason for this being the latter's less favorable influence on soil structure.

Effects of Vegetation, Topography and Time

Under a defined climate for any geographical area, roughness of topography and the physical state - or fineness - of the rock particles present depends upon the time exposed to the physical, chemical and biological weathering agents. In many places on the earth bare granite, gneiss or other igneous or metamorphic rock outcrops on the surface of the lithosphere. This rock has not yet had time to be transformed into a clastic state. (13).

The differential weathering of these rocks progresses with the lapse of time and land surfaces are smoothed by the active forces of erosion. The products of erosion are removed, transported and redeposited, selectively, over the land.

Soil scientists have learned to recognize the above geological processes as directly affecting soils pedologically. There is a positive relationship that exists between climax vegetation and the steepness of slope as well as physical and chemical constituents of soil parent material. This places vegetation in the dependent sense and neglects its independent influence on soil formation. It should perhaps be explained that after a climax type vegetation has been selected ecologically, the developing soil is genetically influenced by the resulting biosphere.

Various vegetative materials have different pH ranges, qualities and quantities of carbon and nitrogen compounds, and these differences give rise to specific soil faunas, the influences of which are reflected in soil development.

Trees dominantly comprise the native vegetation for five of Oklahoma's thirteen Problem Areas (FC, OH, ZH, CT, GS). From Table II it may be noted that these soils generally had low indices, with certain reservations. (The effects of vegetation are less apparent on level of acidity than on nutrient status. Even this exception is removed when those "sandier" soils of the Cross Timbers and Forested Coastal Plain are not considered.)

The organic matter levels for these soils are low even where they have developed under a comparatively high rainfall zone. The trend previously suggested, i.e., that organic matter, generally, shows an increase with increasing precipitation, does not completely hold true under all types of vegetation. For instance, the Ouachita Highlands soils are low in organic matter percentage even though they are not especially "sandy".

The Ozark Highlands in which the soils are relatively high in organic matter, have many areas of prairie where the soils have developed from limestone and cherty materials. (The limestone influence on organic matter has been mentioned earlier.)

The phosphorus and potassium levels were found, almost without exception, to be relatively low on those soils developed under a forest-type vegetation. The special case of the young, granitic soils has been discussed.

Comparison of Pawnee County Soil Types with Appropriate Problem Area Soil Units

The phosphorus and acidity indices for the two sources of data were difficult to compare for the following reasons:

1. The soil testing methods were different: the acids used for leaching had different normalities; and the soil reaction method used at Pawnee, Oklahoma, was colorimetric, whereas the Stillwater laboratory employed the glass electrode. (The glass electrode method should be considered the most exact of the two acidity methods.)

2. Soil units, which were the comparison units, generally contain more than one soil type. This being the case, the indices for a soil unit do not necessarily represent any one series or type, but rather the average of the series and types which were mapped (grouped) under that soil unit.

3. The soil units cover a much larger geographical area than the soil types in Pawnee County. Although grouped on physical similarities, the soil types within this grouping could have been used quite differently than are the soil types within Pawnee County. Traditional land use and management often prevail within geographic areas despite soil conservation recommendations to the contrary.

With these limitations in mind, it was still believed feasible to attempt to correlate the data from the above two sources. The soil types and their comparable soil units are shown on Table III. The number of tests and the indices for phosphorus and soil reaction are shown. Perhaps it should be stated, once again, that the topsoils only were tested; reliability increases with increasing number of tests.

The upland soils correlate well, considering the limitations men-

TABLE III

COMPARISON OF PAWNEE COUNTY SOIL TYPES WITH APPROPRIATE PROBLEM AREA UNITS

Pawnee County Soil Type	Slope	No. Tests	Comparable Units: Problem Area	Soil Unit	Capability Class	No. Tests	Phosphorus Index: Pawnee	Problem Area	Acidity Index: Pawnee	Problem Area
UPLAND SOILS										
Bates fine sandy loam	2-5%	39	CP	07,20	1-7	359	1.33	1.26	2.46	1.57
Dennis loam	2-5%	338	CP	06	1-7	529	1.20	1.18	2.38	1.55
Dennis loam eroded	2-5%	27	CP	06	5-7	17	1.08	1.12	2.44	1.88
Kirkland silt loam	0-3%	70	RP	05	3-4	510	1.24	1.46	2.07	1.94
Norge silt loam	2-5%	70	RP	06	3-7	215	1.30	1.49	2.37	2.09
Parsons complex	1-3%	27	CP	05	1-7	343	1.30	1.23	2.00	1.68
Renfrow silt loam	1-3%	39	RP	05	3-4	510	1.33	1.46	2.28	1.94
Renfrow silt loam	3-5%	57	RP	05,01	5-7	67	1.12	1.39	2.54	2.13
Teller soils	2-5%	65	CT	07,70	1-4	555	1.40	1.47	2.51	2.19
Vanoss silt loam	0-2%	52	RP	07,70	1-2	495	1.58	2.12	2.42	2.18
Zaneis soils	2-5%	46	RP	06	3-7	215	1.22	1.49	2.22	2.09
BOTTOMLAND SOILS										
Brewer silty clay loam	0-3%	14	RP	04,08	1-7	474	1.85	2.56	2.93	2.68
Dale silt loam	0-3%	26	BO	04,08	1-7	251	1.81	2.75	2.42	2.72
Lela soils	0-2%	15	RP	03	1-7	28	1.67	2.39	2.60	2.57
Port silt loam	0-1%	194	RP	09	1-7	616	1.62	2.59	2.61	2.64
Yahola fine sandy loam	0-3%	21	RP	09	1-7	616	2.00	2.59	2.81	2.64
Yahola silt loam	0-2%	31	BO	09	1-7	357	2.48	2.56	2.97	2.55

tioned and the knowledge that the Pawnee County samples were taken by many individual farmers. The indices for soil units were higher, in most cases, than were those for soil types. (The indices were an average of ten units higher for the Problem Area soil units than for Pawnee County soil types. This theoretical difference should indicate the average differences in the amounts of soluble phosphorus extracted by the two test methods employed.) This difference is in accord with the stronger acid normality used for leaching soil unit samples.

Since the .1 N acetic acid removed more soluble phosphorus than the .02 N H_2SO_4 from soils testing low in amount of acid soluble phosphorus, this difference would be expected to increase proportionally as the amount of soluble phosphorus within soils increased. The index levels for bottomland soils show this trend.

Considering the two methods, one or the other is probably more reliable for predicting response for most field crops. Grimes (16) made a study of three chemical methods for extracting soluble phosphorus from several soil types in Oklahoma. He found that acetic acid leaching gave extremely high results on the Pullman soil, which indicated that the method removed more phosphorus than was available for plant utilization.

From Table III it may be noted that the Pawnee County soil types generally have higher indices for pH than the comparable soil units. This trend could also be due to the different test methods used. There was a good correlation indicated considering the general, but varied, use of lime on agricultural soils in north-central Oklahoma.

Oklahoma Soil Associations

Any conclusions about the fertility of Oklahoma soil associations must, as was implied by the definition of a soil association, be general ones. The indices shown for various soil associations presented on Plate I must be interpreted with the following limitations considered:

1. The indices which are shown in Table IV were calculated from test data which represented many more soil series than are named in the forty-three soil associations.

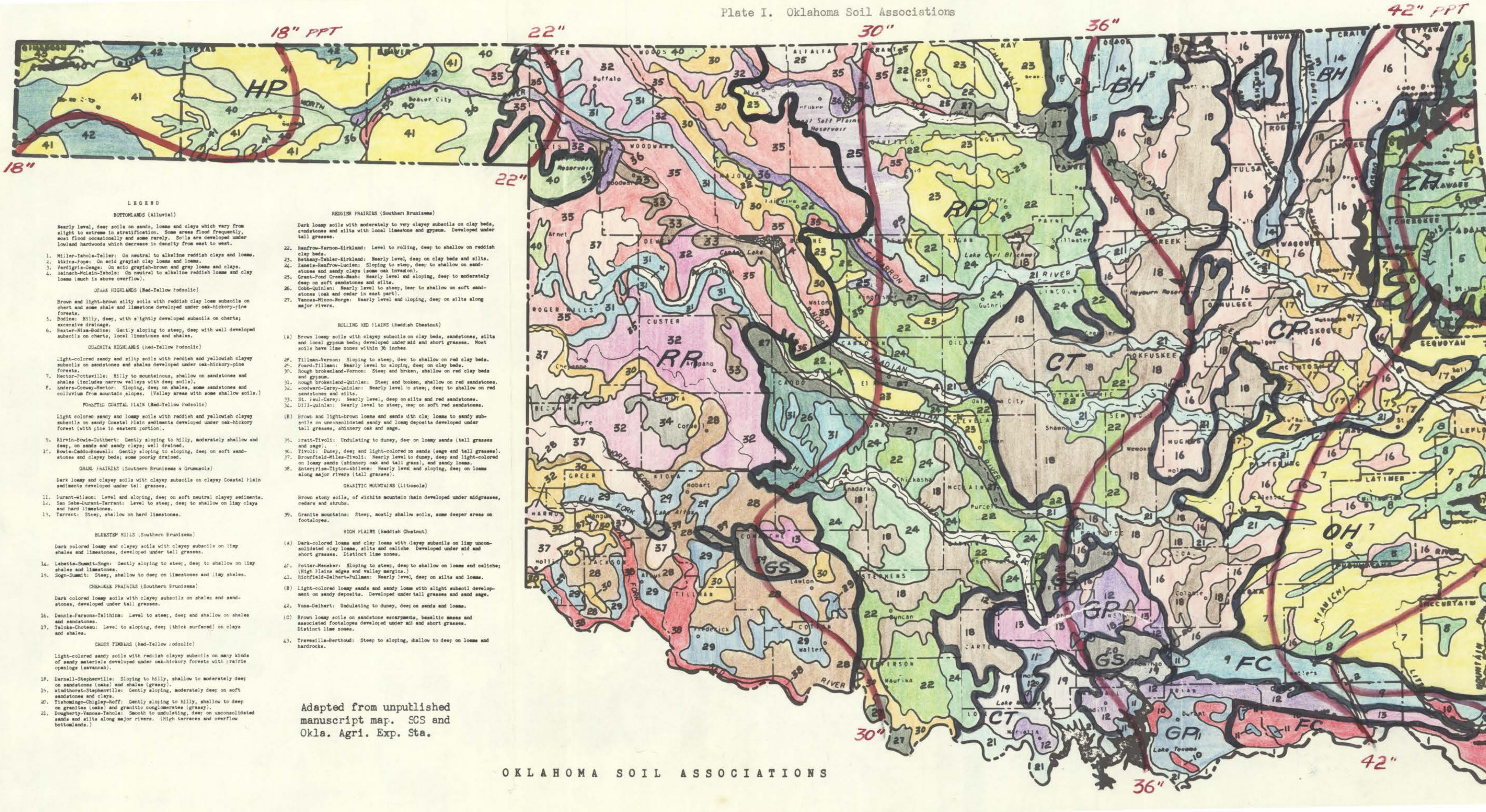
2. The indices are the averages of those for the several soil series included in a particular Problem Area soil unit and these do not represent a single soil series.

The best estimate of the principal soil series within any Problem Area soil unit was based on general knowledge of the occurrence and predominance of certain series in the several parts of Oklahoma.

3. Soil associations have varying degrees of "purity", i.e., various amounts of other minor-occurring soil series are included within the major series which are named.

4. There are only a small number of tests by which to characterize several soil associations.

In some instances, where it was known that a single Problem Area soil unit included two or more important series, the indices were calculated from data of individual counties, where those important series were known to predominate. Even though the number of tests representing each important series was thereby lessened, it was believed that these tests more nearly represented the major soils in the respective soil associations. These data from selected counties appear in Appendix C under the Problem Area in which they occur.



LEGEND

BOTTOMLANDS (Alluvial)

Nearly level, deep soils on sands, loams and clays which vary from slight to extreme in stratification. Some areas flood frequently, most flood occasionally and some rarely. Soils are developed under lowland hardwoods which decrease in density from east to west.

1. Miller-Yahola-Teller: On neutral to alkaline reddish clays and loams.
2. Atkins-Pope: On acid grayish clay loams and loams.
3. Verdigris-Osage: On acid grayish-brown and gray loams and clays.
4. Reinach-McLain-Yahola: On neutral to alkaline reddish loams and clay loams (much is above overflow).

OZARK HIGHLANDS (Red-Yellow Podzolic)

Brown and light-brown silty soils with reddish clay loam subsoils on chert and some shale and limestone developed under oak-hickory-pine forests.

5. Bodine: Hilly, deep, with slightly developed subsoils on cherts; excessive drainage.
6. Baxter-Nixa-Bodine: Gently sloping to steep, deep with well developed subsoils on cherts, local limestones and shales.

OUACHITA HIGHLANDS (Red-Yellow Podzolic)

Light-colored sandy and silty soils with reddish and yellowish clayey subsoils on sandstones and shales developed under oak-hickory-pine forests.

7. Hector-Pottsville: Hilly to mountainous, shallow on sandstones and shales (includes narrow valleys with deep soils).
8. Enders-Conway-Hector: Sloping, deep on shales, some sandstones and colluvium from mountain slopes. (Valley areas with some shallow soils.)

FORESTED COASTAL PLAIN (Red-Yellow Podzolic)

Light colored sandy and loamy soils with reddish and yellowish clayey subsoils on sandy Coastal Plain sediments developed under oak-hickory forest (with pine in eastern portion).

9. Kirvin-Bowie-Cuthbert: Gently sloping to hilly, moderately shallow and deep, on sands and sandy clays; well drained.
10. Bowie-Caddo-Boswell: Gently sloping to sloping, deep on soft sandstones and clayey beds; some poorly drained.

GRAND PRAIRIES (Southern Brunizems & Grumusols)

Dark loamy and clayey soils with clayey subsoils on clayey Coastal Plain sediments developed under tall grasses.

11. Durant-Wilson: Level and sloping, deep on soft neutral clayey sediments.
12. San Saba-Durant-Tarrant: Level to steep, deep to shallow on limy clays and hard limestones.
13. Tarrant: Steep, shallow on hard limestones.

BLUESTEM HILLS (Southern Brunizems)

Dark colored loamy and clayey soils with clayey subsoils on limy shales and limestones, developed under tall grasses.

14. Labette-Summit-Sogn: Gently sloping to steep, deep to shallow on limy shales and limestones.
15. Sogn-Summit: Steep, shallow to deep on limestones and limy shales.

CHEROKEE PRAIRIES (Southern Brunizems)

Dark colored loamy soils with clayey subsoils on shales and sandstones, developed under tall grasses.

16. Dennis-Parsons-Talihina: Level to steep, deep and shallow on shales and sandstones.
17. Taloka-Choteau: Level to sloping, deep (thick surfaced) on clays and shales.

CROSS TIMBERS (Red-Yellow Podzolic)

Light-colored sandy soils with reddish clayey subsoils on many kinds of sandy materials developed under oak-hickory forests with prairie openings (savannah).

18. Darnell-Stephenville: Sloping to hilly, shallow to moderately deep on sandstones (oaks) and shales (grassy).
19. Windthorst-Stephenville: Gently sloping, moderately deep on soft sandstones and clays.
20. Tishomingo-Chigley-Hoff: Gently sloping to hilly, shallow to deep on granites (oaks) and granitic conglomerates (grassy).
21. Dougherty-Vanoss-Yahola: Smooth to undulating, deep on unconsolidated sands and silts along major rivers. (High terraces and overflow bottomlands.)

REDDISH PRAIRIES (Southern Brunizems)

Dark loamy soils with moderately to very clayey subsoils on clay beds, sandstones and silts with local limestone and gypsum. Developed under tall grasses.

22. Renfrow-Vernon-Kirkland: Level to rolling, deep to shallow on reddish clay beds.
23. Bethany-Tabler-Kirkland: Nearly level, deep on clay beds and silts.
24. Zaneis-Renfrow-Lucien: Sloping to steep, deep to shallow on sandstones and sandy clays (some oak invasion).
25. Grant-Pond Creek-Nash: Nearly level and sloping, deep to moderately deep on soft sandstones and silts.
26. Cobb-Quinlan: Nearly level to steep, deep to shallow on soft sandstones (oak and cedar in east part).
27. Vanoss-Minco-Norge: Nearly level and sloping, deep on silts along major rivers.

ROLLING RED PLAINS (Reddish Chestnut)

(A) Brown loamy soils with clayey subsoils on clay beds, sandstones, silts and local gypsum beds; developed under mid and short grasses. Most soils have lime zones within 36 inches

28. Tillman-Vernon: Sloping to steep, deep to shallow on red clay beds.
29. Foard-Tillman: Nearly level to sloping, deep on clay beds.
30. Rough brokenland-Vernon: Steep and broken, shallow on red clay beds and gypsum.
31. Rough brokenland-Quinlan: Steep and broken, shallow on red sandstones.
32. Woodward-Carey-Quinlan: Nearly level to steep, deep to shallow on red sandstones and silts.
33. St. Paul-Carey: Nearly level, deep on silts and red sandstones.
34. Dill-Quinlan: Nearly level to steep, deep on soft red sandstones.

(B) Brown and light-brown loams and sands with clay loams to sandy subsoils on unconsolidated sandy and loamy deposits developed under tall grasses, shinnery oak and sage.

35. Pratt-Tivoli: Undulating to duney, deep on loamy sands (tall grasses and sage).
36. Tivoli: Duney, deep and light-colored on sands (sage and tall grasses).
37. Brownfield-Miles-Tivoli: Nearly level to duney, deep and light-colored on loamy sands (shinnery oak and tall grass), and sandy loams.
38. Enterprise-Tipton-Abilene: Nearly level and sloping, deep on loams along major rivers (tall grasses).

GRANITIC MOUNTAINS (Lithosols)

Brown stony soils, of Wichita mountain chain developed under midgrasses, cedars and shrubs.

39. Granite mountains: Steep, mostly shallow soils, some deeper areas on footslopes.

HIGH PLAINS (Reddish Chestnut)

(A) Dark-colored loams and clay loams with clayey subsoils on limy unconsolidated clay loams, silts and caliche. Developed under mid and short grasses. Distinct lime zones.

40. Potter-Mansker: Sloping to steep, deep to shallow on loams and caliche; (High Plains edges and valley margins.)
41. Richfield-Dalhart-Pullman: Nearly level, deep on silts and loams.

(B) Light-colored loamy sands and sandy loam with slight subsoil development on sandy deposits. Developed under tall grasses and sand sage.

42. Vona-Dalhart: Undulating to duney, deep on sands and loams.

(C) Brown loamy soils on sandstone escarpments, basaltic mesas and associated footslopes developed under mid and short grasses. Distinct lime zones.

43. Travesilla-Berthoud: Steep to sloping, shallow to deep on loams and hardrocks.

Adapted from unpublished manuscript map. SCS and Okla. Agri. Exp. Sta.

OKLAHOMA SOIL ASSOCIATIONS

TABLE IV

NUTRIENT AND ACIDITY INDICES OF OKLAHOMA SOIL ASSOCIATIONS

	Soil Associations			Indices			
Location and Parent Materials	No.	Name	No. Tests	Organic Matter*	Phos- phorus**	Potas- sium***	Acidity****
Alluvial soils: a. Red River west to Denison Dam.	1	Miller	30	2.70	2.87	2.93	2.93
		Yahola	25	1.52	2.76	2.40	2.84
		Teller	32	1.27	1.47	1.49	2.00
b. Southeastern Oklahoma. Forested areas.	2	Atkins	5	3.00	2.00	3.00	1.40
		Pope	64	2.00	1.33	2.22	1.75
c. Eastern Oklahoma. Prairie areas.	3	Verdigris	273	2.49	1.83	2.32	2.15
		Osage	164	2.54	1.85	2.29	2.09
d. Along through-flowing streams throughout rest of Oklahoma.	4	Reinach	357	1.76	2.56	2.56	2.55
		McLain	251	2.46	2.75	2.81	2.71
		Yahola	357	1.76	2.56	2.56	2.55
Ozark Highlands. Cherty materials, local limestones and shales.	5	Bodine	76	2.70	1.30	1.90	1.60
	6	Baxter	85	2.10	1.34	2.10	1.66
		Nixa	85	2.10	1.34	2.10	1.66
		Bodine	76	2.70	1.30	1.90	1.60

*Total Organic Matter.
**Easily soluble Phosphorus.
***Exchangeable Potassium.
****Glass electrode method.

TABLE IV (Continued)

Location and Parent Materials	Soil Associations No.	Name	No. Tests	Indices Organic Matter	Phos-phorus	Potas-sium	Acidity
Southeastern Oklahoma. Mountain and valley areas. Shales and sandstones.	7	Hector	15	2.40	1.00	2.42	1.60
		Pottsville	15	2.40	1.00	2.42	1.60
	8	Enders	102	1.88	1.19	1.90	1.70
		Conway	102	1.88	1.19	1.90	1.70
		Hector	15	2.40	1.00	2.42	1.60
Coastal plains. Sandy sediments and clayey beds.	9	Kirvin	57	1.24	1.17	1.83	1.89
		Bowie	137	1.16	1.53	1.42	2.17
		Cuthbert	13	1.30	1.23	1.40	2.00
	10	Bowie	137	1.16	1.53	1.42	2.17
		Caddo	14	1.42	1.07	1.92	1.50
		Boswell	57	1.24	1.17	1.83	1.89
Coastal plains. Clayey sediments, marls and limestones.	11	Durant	205	2.26	1.44	2.54	2.21
		Wilson	36	2.03	1.28	1.91	2.11
	12	San Saba	304	2.81	1.96	2.74	2.63
		Durant	205	2.26	1.44	2.54	2.21
		Tarrant	23	2.91	1.39	2.83	2.48
	13	Tarrant	23	2.91	1.39	2.83	2.48
Northeastern Oklahoma prairie. Limestones and limy shales.	14	Labette	30	3.00	1.84	2.75	1.83
		Summit	31	2.76	1.39	2.41	2.13
		Sogn	5	2.20	1.80	3.00	2.00

TABLE IV (Continued)

Location and Parent Materials	Soil Associations No.	Name	No. Tests	Indices: Organic Matter	Phos-phorus	Potas-sium	Acidity
	15	Sogn	5	2.20	1.80	3.00	2.00
		Summit	31	2.76	1.39	2.41	2.13
Eastern Oklahoma prairie. Shales and sandstones	16	Dennis	529	2.32	1.18	1.95	1.55
		Parsons	343	2.41	1.23	1.75	1.68
		Talihina	45	2.69	1.22	2.62	1.76
	17	Taloka	392	2.32	1.20	1.77	1.63
		Choteau	529	2.32	1.18	1.95	1.55
Central Oklahoma. Sandstones and clays.	18	Darnell	7	1.29	1.43	2.57	2.00
		Stephenville	555	1.28	1.47	2.15	2.19
	19	Windthorst	95	1.40	1.47	2.20	2.17
		Stephenville	555	1.28	1.47	2.15	2.19
South central Oklahoma. Granitic rocks and granite conglomerates.	20	Tishomingo	16	2.00	1.88	3.00	2.06
		Chigley	29	2.06	1.20	2.61	1.96
		Roff	23	2.13	1.22	2.67	1.99
Central Oklahoma. Unconsolidated loams and sandy loams near through-flowing streams.	21	Dougherty	555	1.28	1.47	2.15	2.19
		Vanoss	495	1.71	2.12	2.82	2.18
		Yahola	357	1.76	2.56	2.56	2.55
Central Oklahoma prairies. Clayey "Red beds" and silts.	22	Renfrow	510	1.92	1.46	2.68	1.94
		Vernon	55	2.12	2.16	2.87	2.73
		Kirkland	170	2.28	1.81	2.82	2.01

TABLE IV (Continued)

Location and Parent Materials	Soil Associations No.	Name	No. Tests	Indices: Organic Matter	Phos-phorus	Potas-sium	Acidity
	23	Bethany	20	2.40	2.85	2.94	1.85
		Tabler	55	2.71	1.94	3.00	1.25
		Kirkland	191	2.35	1.86	2.85	1.87
Central Oklahoma. Sandstones and sandy "Red beds".	24	Zaneis	215	1.71	1.49	2.68	2.09
		Renfrow	510	1.92	1.46	2.68	1.94
		Lucien	45	2.11	2.02	2.84	2.69
	25	Grant	79	1.76	2.88	2.84	2.08
		Pond Creek	11	2.18	3.00	3.00	1.82
		Nash	20	1.65	2.85	2.95	2.60
	26	Cobb	251	1.26	1.79	2.84	2.49
		Quinlan	96	1.74	2.75	2.85	2.82
Central Oklahoma. Unconsolidated loams near through-flowing streams.	27	Vanoss	495	1.71	2.12	2.82	2.18
		Minco	882	1.57	1.65	2.66	2.23
		Norge	375	1.83	1.94	2.77	2.13
Western Oklahoma prairies. Clayey "Red beds" and gypsum.	28	Tillman	170	2.12	2.78	2.97	2.72
		Vernon	55	2.12	2.16	2.87	2.73
	29	Foard	130	2.18	2.86	2.97	2.71
		Tillman	170	2.12	2.78	2.97	2.72
	30	Rough brokenland - Vernon	55	2.12	2.16	2.87	2.73

TABLE IV (Continued)

Location and Parent Materials	Soil Associations No.	Soil Associations Name	No. Tests	Indices Organic Matter	Indices Phosphorus	Indices Potassium	Indices Acidity
Western Oklahoma prairies. Red sandstones and silts.	31	Rough brokenland - Quinlan	97	1.74	2.75	2.85	2.88
	32	Woodward	215	1.33	2.55	2.87	2.77
		Carey	102	1.50	2.74	2.86	2.76
		Quinlan	97	1.74	2.75	2.85	2.88
	33	St. Paul	185	1.89	2.90	2.96	2.87
		Carey	102	1.50	2.74	2.86	2.76
	34	Dill	50	1.30	2.14	2.90	2.54
		Quinlan	97	1.74	2.75	2.85	2.88
Western Oklahoma plains. Duney sands and sandy loams.	35	Pratt	182	1.13	2.14	2.57	2.70
		Tivoli	9	1.22	2.00	2.11	2.88
	36	Tivoli	9	1.22	2.00	2.11	2.88
	37	Brownfield	28	1.00	1.79	2.68	2.95
		Miles	24	1.13	2.74	2.83	2.93
Western Oklahoma plains. Unconsolidated loams and clay loams near through-flowing streams.	38	Enterprise	317	1.38	2.60	2.86	2.77
		Tipton	102	1.50	2.74	2.86	2.76
		Abilene	114	2.21	2.90	2.96	2.84
Southwestern Oklahoma.	39	Granitic Mountains	---	----	----	----	----

TABLE IV (Continued)

Location and Parent Materials	Soil Associations No.	Name	No. Tests	Indices Organic Matter	Phos-phorus	Potas-sium	Acidity
Western Oklahoma high plains. a. Rolling "breaks" to the High Plains. Unconsolidated limy loams.	40	Potter	6	2.00	3.00	3.00	3.00
		Mansker	6	2.00	3.00	3.00	3.00
b. Unconsolidated limy loams and sands.	41	Richfield	20	2.05	2.90	3.00	3.00
		Dalhart	20	1.25	2.95	3.00	2.95
	42	Vona	5	1.40	3.00	3.00	3.00
		Dalhart	20	1.25	2.95	3.00	2.95
c. Hill and valley areas. Loams and hard rocks.	43	Travesilla	--	----	----	----	----
		Berthoud	20	1.25	2.95	3.00	2.95

The indices for each nutrient and acidity were averaged arithmetically for each soil association that appears on Plate I. An average of the averages was then calculated for those soil associations which occurred in each Problem Area. These average indices were plotted on a graph and compared with the indexed averages for all soils that occurred in each Problem Area. The indices for the soil associations and Problem Areas were close to identical. The relationship between these two groups might be enumerated:

1. Problem Areas include all the soils which were tested - minor-occurring soil units as well as the major soil units. Soil associations include only the major-occurring soils from the Problem Area group.

2. Soil associations are more specific than Problem Areas, i.e., not nearly so many indices must be considered in order to characterize them according to relative nutrient and acidity levels.

3. Soil associations are shown on the map and may be located specifically, whereas separate soil units can not be shown for Problem Areas.

Since the indices are relatively identical for soil associations and Problem Areas, the following statements seem reasonable:

The major factors which influenced the nutrient and acidity levels of Problem Area soil units similarly affected the nutrient and acidity levels of the soil associations.

The causes for these trends, as previously discussed, apply to soil associations as well as to Problem Area soil units. These causes were attributed to the interrelated effects of climate, parent material, vegetation, topography and time.

The soil series which comprise each soil association are the ultimate degree of morphological refinement possible in this study. As previously mentioned, even they are of varying degrees of "purity". These soils as distinct individuals would reflect the effects of soil management more strongly than would be detected when shown as soil associations. Generalities may be assumed, however, which can be of considerable value when attempting to characterize these soils.

Figure 10, Appendix D, shows the type farming (preliminary), or products produced, in the various counties in Oklahoma. Figure 11, Appendix D, shows the tons of fertilizer used in each Oklahoma county for the past year and the fifteen high counties in fertilizer consumption for the past five years. The percentages of nitrogen, phosphorus and potassium in the fertilizers applied were approximately 19, 70 and 11 respectively. No figures are readily available for lime used on Oklahoma soils. As previously mentioned, more fertilizer elements are being removed in the form of crops and livestock sales than are being added to Oklahoma soils. Some general observations concerning the usage of fertilizers are worth stating:

1. Fertilizers are used where an increased cash return may be realized. Generally, this would be confined to soils which are being utilized for cash crops and where moisture is ample to produce these crops.

2. Fertilizers are not commonly used where livestock and/or self-sufficing farming are prevalent.

3. Fertilizers are used on soils which require them for the economic production of valuable crops. These soils must have adequate moisture and be physically capable of producing a relatively large amount of crop growth.

4. Fertilizers are traditionally used more liberally in some geographical areas than in other areas which have similar fertility problems.

The above statements should give a positive clue to where the majority of the fertilizers sold in Oklahoma are being used. From a study of Figure 11, Appendix D, it can be seen that few fertilizers are being applied to the soils of the High Plains and Rolling Red Plains in western Oklahoma. Low tonnages of fertilizers are being applied to soils in the Ozark Highlands and Ouachita Highlands with the exception of a few counties.

Relatively higher indices might be expected for the soils which are physically good for high crop yields in those counties which are receiving the highest fertilizer increments. It can be seen that these high counties have adequate rainfall, during average years, to insure an increase in crop production.

CHAPTER V

SUMMARY AND CONCLUSIONS

The fertility characterization of Oklahoma soil associations is a necessary part of soil potential studies. The chemical soil test data accumulated over a period of ten years provided an excellent basis for a soil fertility inventory. A soil association map and report are being prepared for Oklahoma and these chemical soil tests have been related to these soil associations. The soil tests represented the previously interpreted levels for total organic matter as determined by the wet combustion method; exchangeable potassium as determined by extraction with ammonium acetate and reading with the Perkin-Elmer flame photometer; easily soluble phosphorus as determined by the Harper method; and soil reaction measured with the Beckman glass electrode.

In order to obtain a single index for each nutrient and acidity the percentages of samples in each of the three groups low, medium and high were multiplied by one, two and three respectively. The sum of the figures thus obtained divided by 100 gave the index, or weighted average, for the soil. The index was calculated for (1) Pawnee County soil types and phases which had a sufficient number of soil tests to be indicative of a defined phosphorus and acidity level, (2) each soil unit within Oklahoma's thirteen Problem Areas in Soil Conservation which could be converted to appropriate soil series, and (3) for entire Problem Areas in Oklahoma. Tables showing these soils and the calculated indices for each soil type, soil series and Problem Area were presented with the discussion.

The various nutrient and acidity levels for different soils as indicated by different indices were attributed to the effects of the interrelated influences of climate, parent material, vegetation, topography and time.

The effect of climate can best be observed when all soil units tested are considered as a group. This tends to absorb those soil units which strongly reflect the effect of parent materials on fertility levels. The indices for entire Problem Areas within Oklahoma are shown in Figures 1, 2 and 3. From a study of Plate I, on which are shown the Problem Areas and precipitation zones of Oklahoma, it can be seen that nutrient levels for potassium and phosphorus and the pH levels decrease, generally, west to east in Oklahoma. It is interesting to note that under any climate prevalent in Oklahoma the same relative levels for potassium, phosphorus and acidity occur for separate Problem Areas. In almost every case the phosphorus was the lowest of the three and potassium the highest. Acidity level was generally intermediate. These same relationships exist even when a single soil unit from each Problem Area is graphed. The exceptions can be attributed to parent material or known soil management practices. The levels of these nutrients as shown in Figures 1, 2, and 3 suggest that phosphorus is easily leached and that potassium is quite difficult to remove by solution. Considering the approximate percentages of the earth's crust for these two elements, i.e., 0.10% for phosphorus and 2.40% for potassium, this is not so apparent. (13).

The other elements which occur as bases (calcium, sodium and mag-

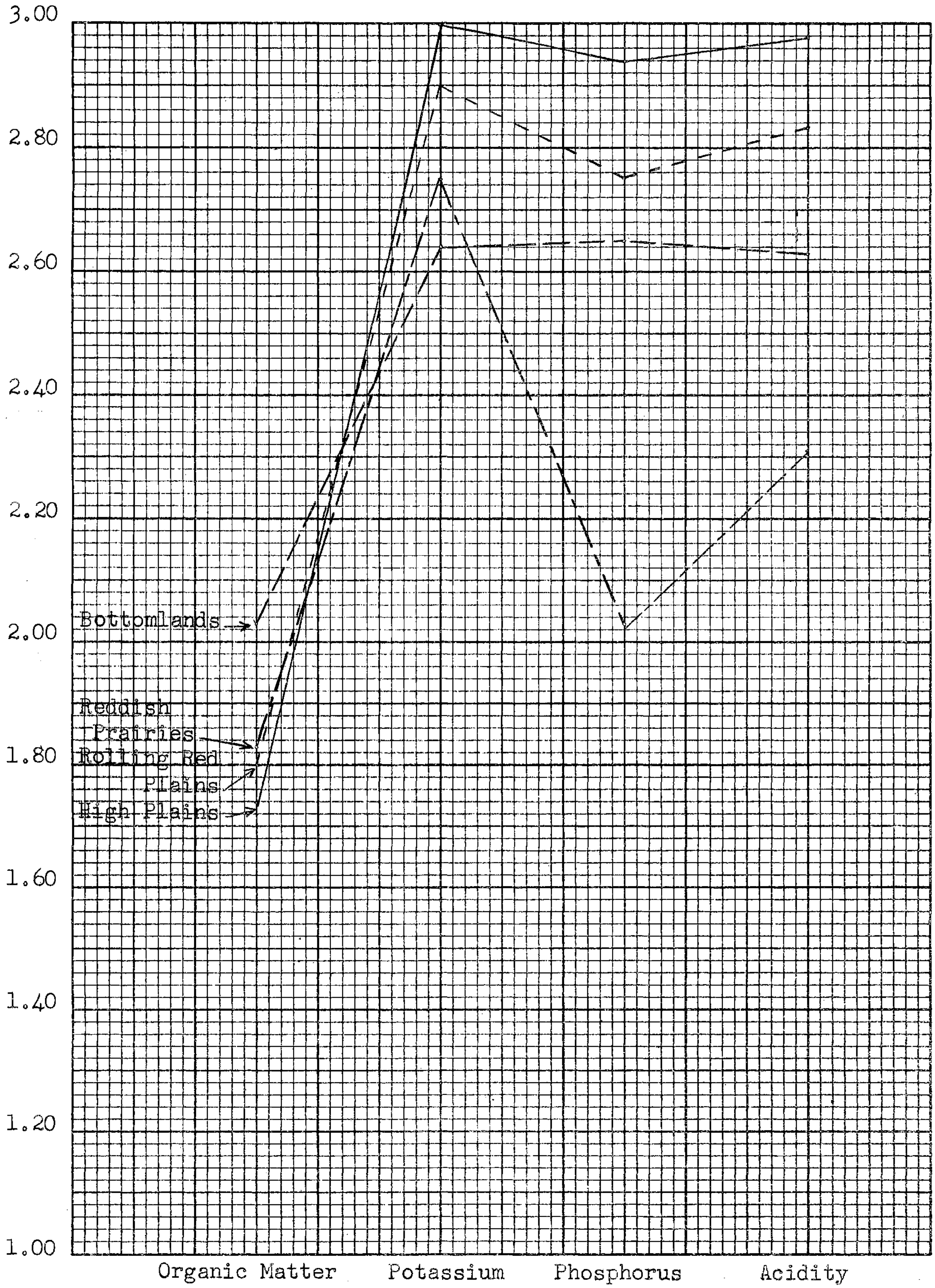


Figure 1. Problem Area Indices (HP, RR, BO, RP)

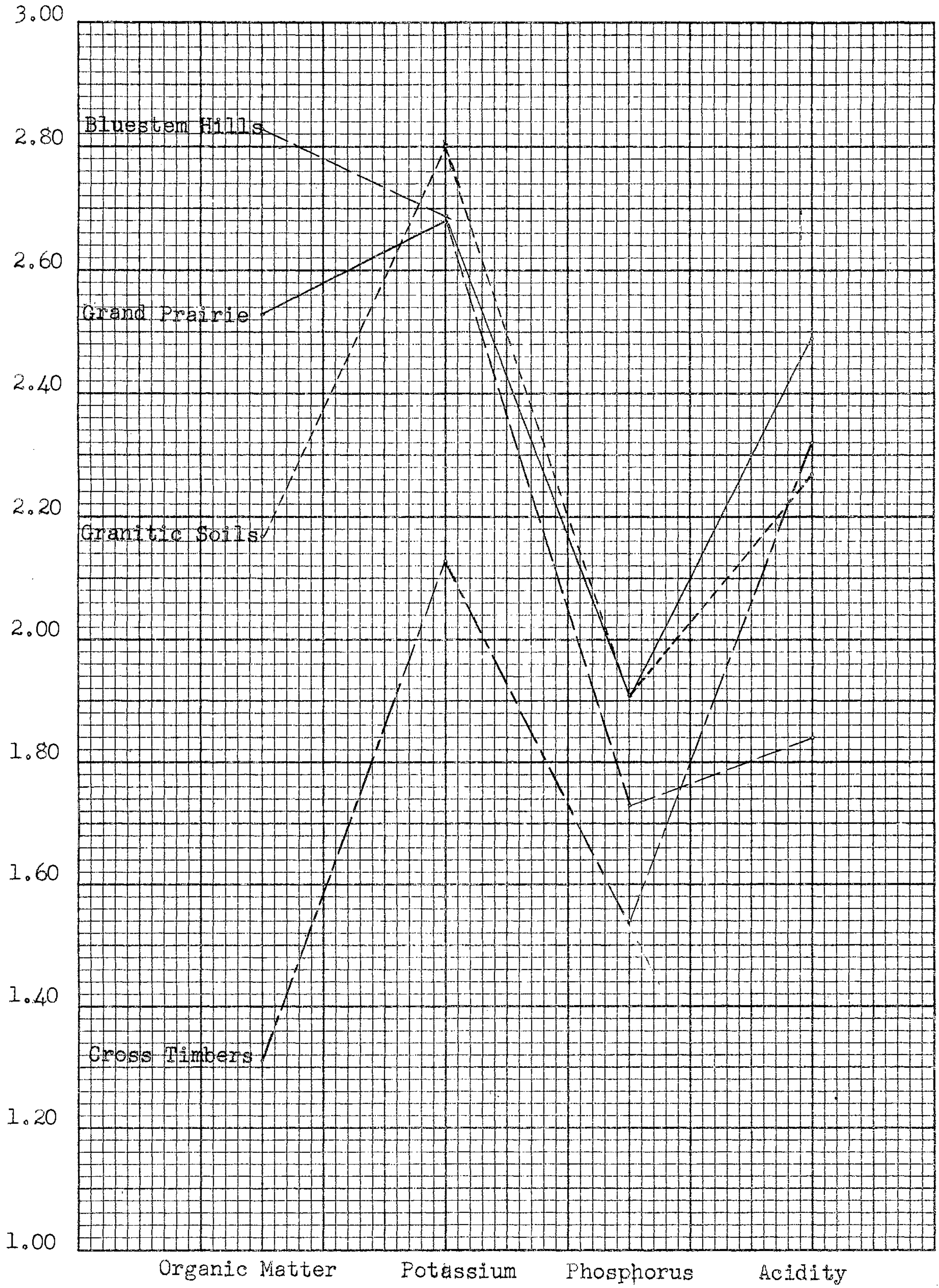


Figure 2. Problem Area Indices (GP, GS, BH, CT)

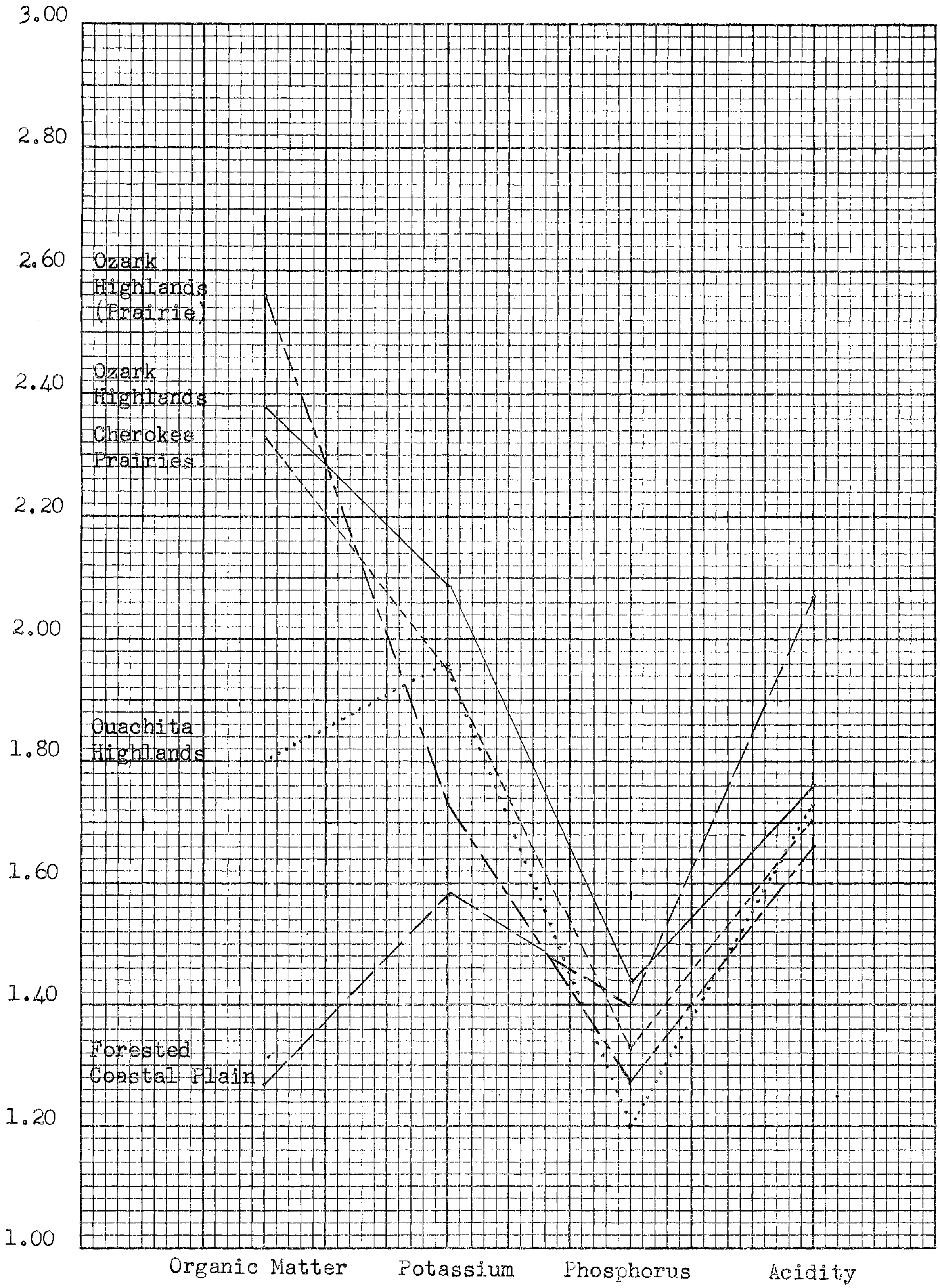


Figure 3. Problem Area Indices (ZH, FC, CP, ZHA, OH)

nesium) and consequently affect pH levels, are many times more soluble than potassium, as shown by the analysis of river and sea water. This might suggest a possible reason why potassium is relatively higher than pH for soils developing under the same climate.

The solubility of phosphorus is difficult to compare with that of potassium. Garretsen (17) demonstrated that the solubilization of difficultly soluble phosphates was greatly affected by microorganisms. Waksman (15) states that the formation by microorganisms of CO_2 and various organic acids results in a greater solubility of the soil minerals, particularly the carbonates and phosphates. This differing solubility would be particularly evident on newly cleared lands or perhaps on soils having quite different flora and fauna. The factors affecting this solubilization process are the nature and quality of root excretions, presence and number of phosphate-dissolving microorganisms in the soil, chemical composition of the phosphate, and pH and temperature of the soil. Several workers have reported the influence of microorganisms on the solubility of potassium, but no such positive relationship has been reported.

From a study of Figures 1, 2 and 3 three apparent trends affecting the levels of total organic matter are discernible. First, total organic matter apparently increases as rainfall increases. Secondly, soils which have developed on parent materials which were limy are relatively high in total organic matter, and thirdly, the soils developing under a forest-type vegetation (these soils are also somewhat "sandier" as compared with the others) are low in total organic matter.

As was previously discussed, several soil units within Oklahoma Problem Areas tended to show rather constant nutrient status levels.

An arithmetical average of the indices for these soils is shown in Figure 4. This shows the relative fertility levels which were discussed for these soil units in graphic form. Soil unit 01 and 05 were added as a matter of interest. These soils include the Planosols found in Oklahoma. The 02 and 06 units, which are deep, fine and medium textured slowly permeable soils are noticeably higher in potash, phosphorus and pH levels than are the 01 and 05 units which include the Planosols. This could be attributed to poor drainage, aeration and the other undesirable conditions which would accompany these limitations.

The comparison of Pawnee County soil types and phases with appropriate soil units from Oklahoma Problem Areas is shown graphically in Figures 5 and 6. The relative correlation of these soil test methods have been previously discussed. It should be mentioned that Port is relatively low in easily soluble phosphorus and pH as compared with the other bottomland soil types. This is due to the source of the sediments which have been deposited. Port soils are developed along local streams whereas these other bottomland soils occur along major streams. These local-occurring bottomland soils should reflect the fertility status of the uplands from which they received their products of erosion. For graphing purposes Vanoss was considered a bottomland soil since it is developed in old alluvium of through-flowing streams, and its index more nearly conformed to the bottomland soils pattern.

The Problem Area soil units represent all the soil series which have been mapped and tested for nutrient and acidity levels in Oklahoma. The soil associations represent all the major-occurring soil series mapped and tested in Oklahoma; consequently, many minor-occurring soil units shown in Problem Areas have been dropped by this process of re-

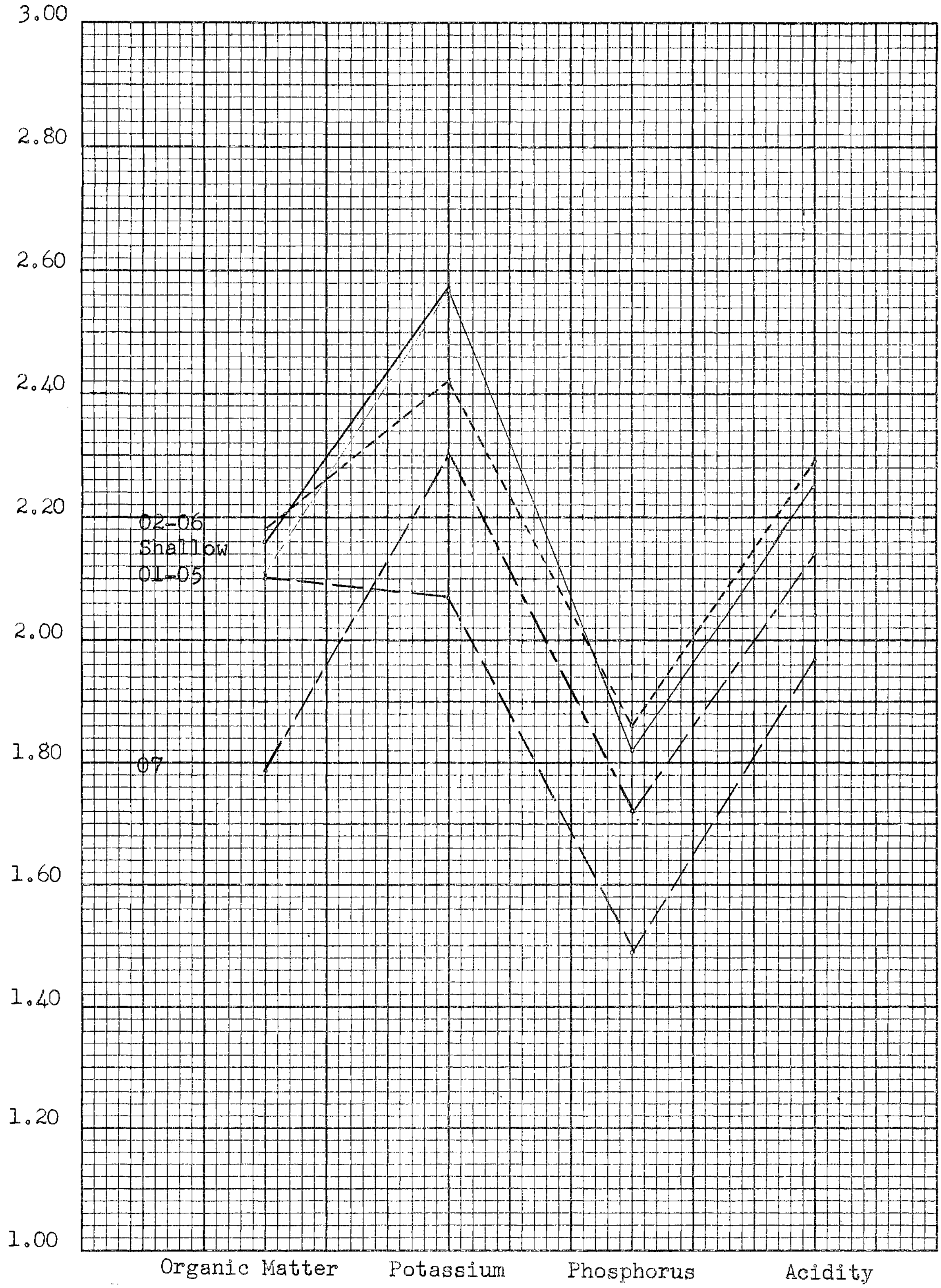


Figure 4. Indices for Problem Area Soil Units 07, 02-06, 01-05, and Shallow Soils

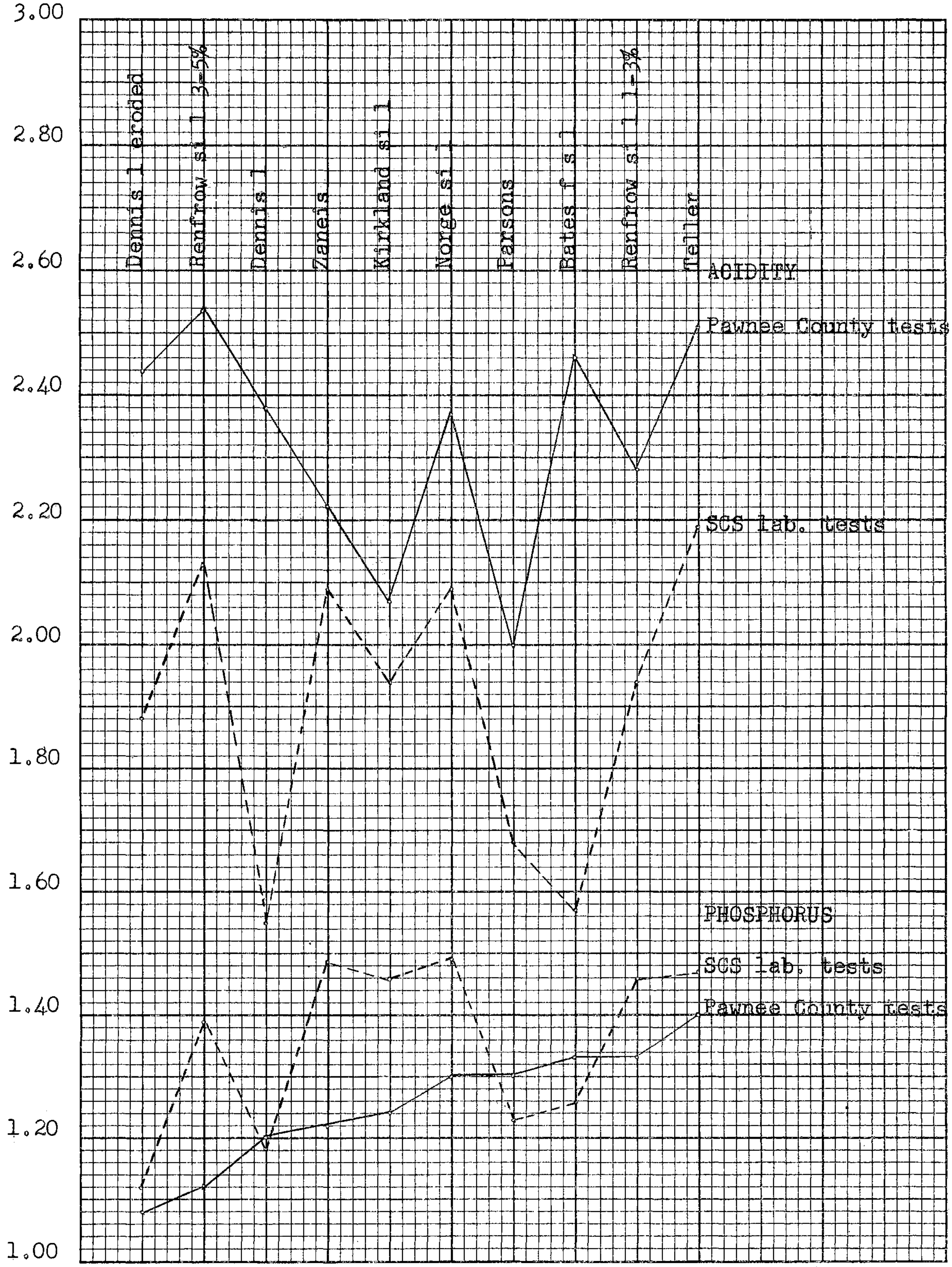


Figure 5. Comparison of Indices for Pawnee County Upland Soil Types and Phases with Appropriate Problem Area Soil Units

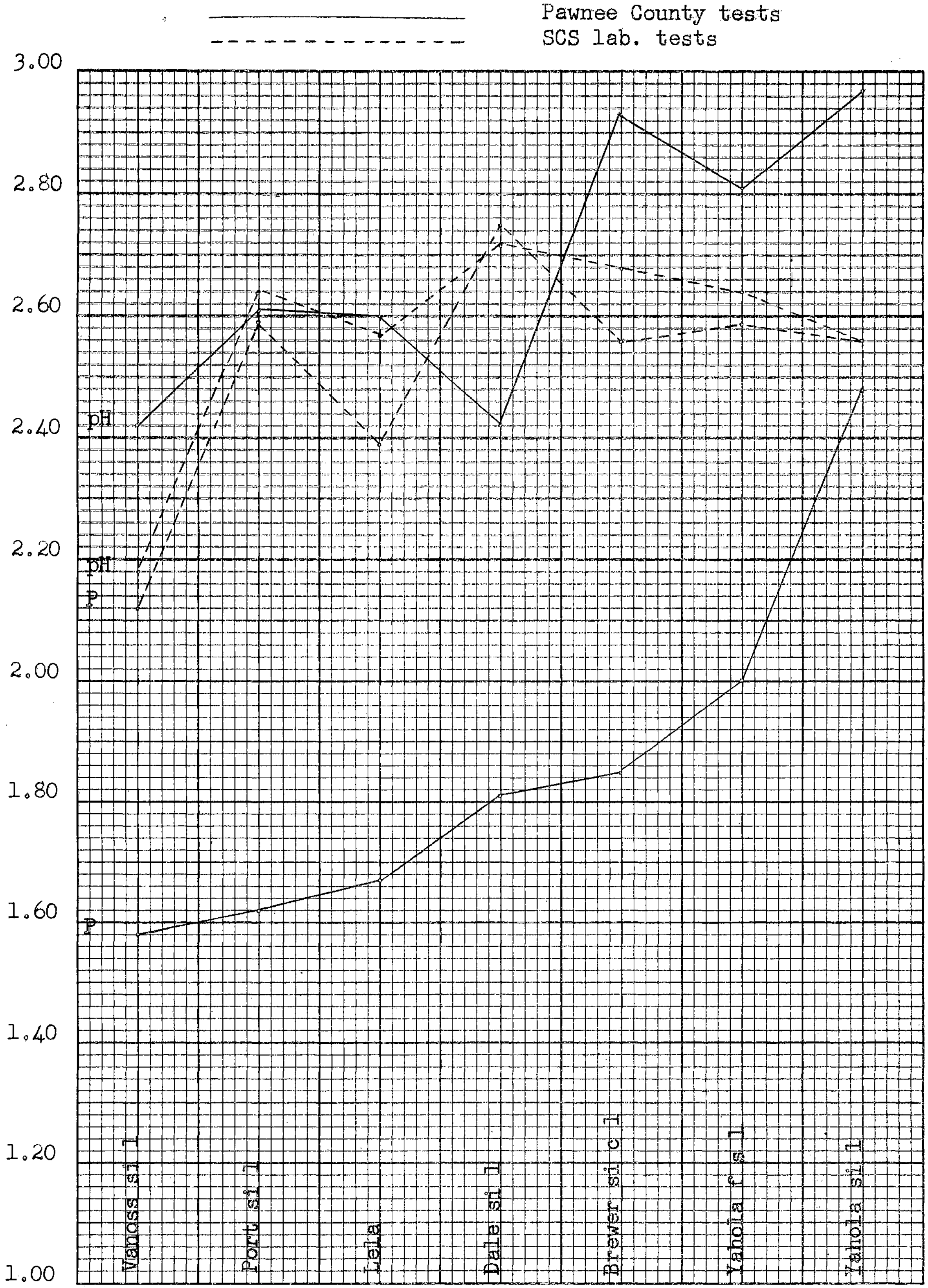


Figure 6. Comparison of Indices for Pawnee County Bottomland and Terrace Soil Types with Appropriate Problem Area Soil Units

finement. Since these soil associations do represent all major-occurring soil series, the indices for these associations should be similar and relative to those indices calculated for Problem Area soil units. If this were true, the same fertility trends and problems attributed to Problem Areas should apply to soil associations.

An arithmetical average of the indices for the named soil series (which were represented by a Problem Area soil unit) in each soil association was calculated and these averages were then averaged for the soil associations occurring in each Problem Area. The indices which were thus derived were then plotted graphically and appear in Figures 7, 8 and 9. If the reader compares these graphs with the graphs shown on Figures 1, 2 and 3, he will find that they are similar and relative.

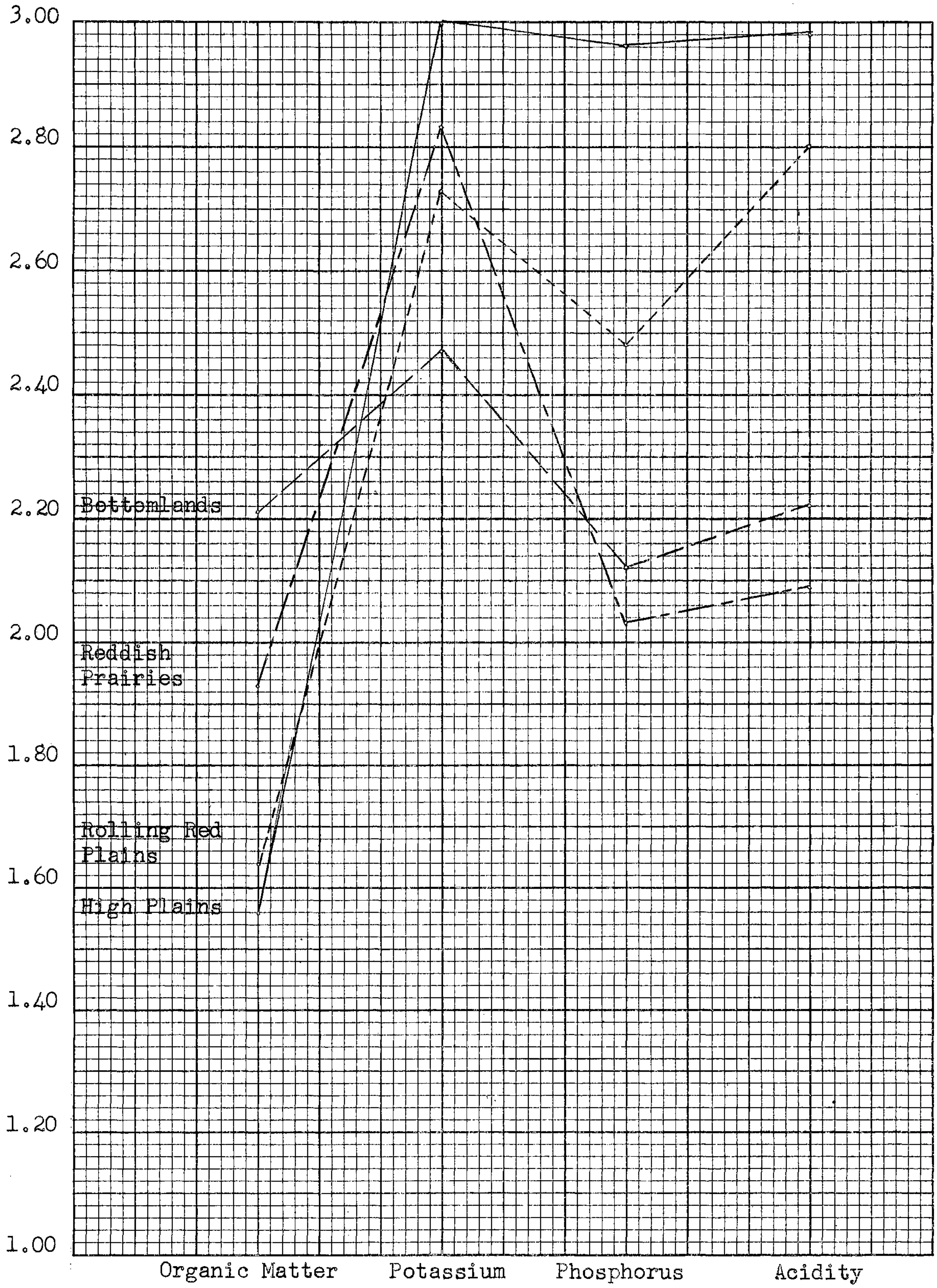


Figure 7. Averaged Indices for Oklahoma Soil Associations by Problem Areas (HP, RR, BO, RP)

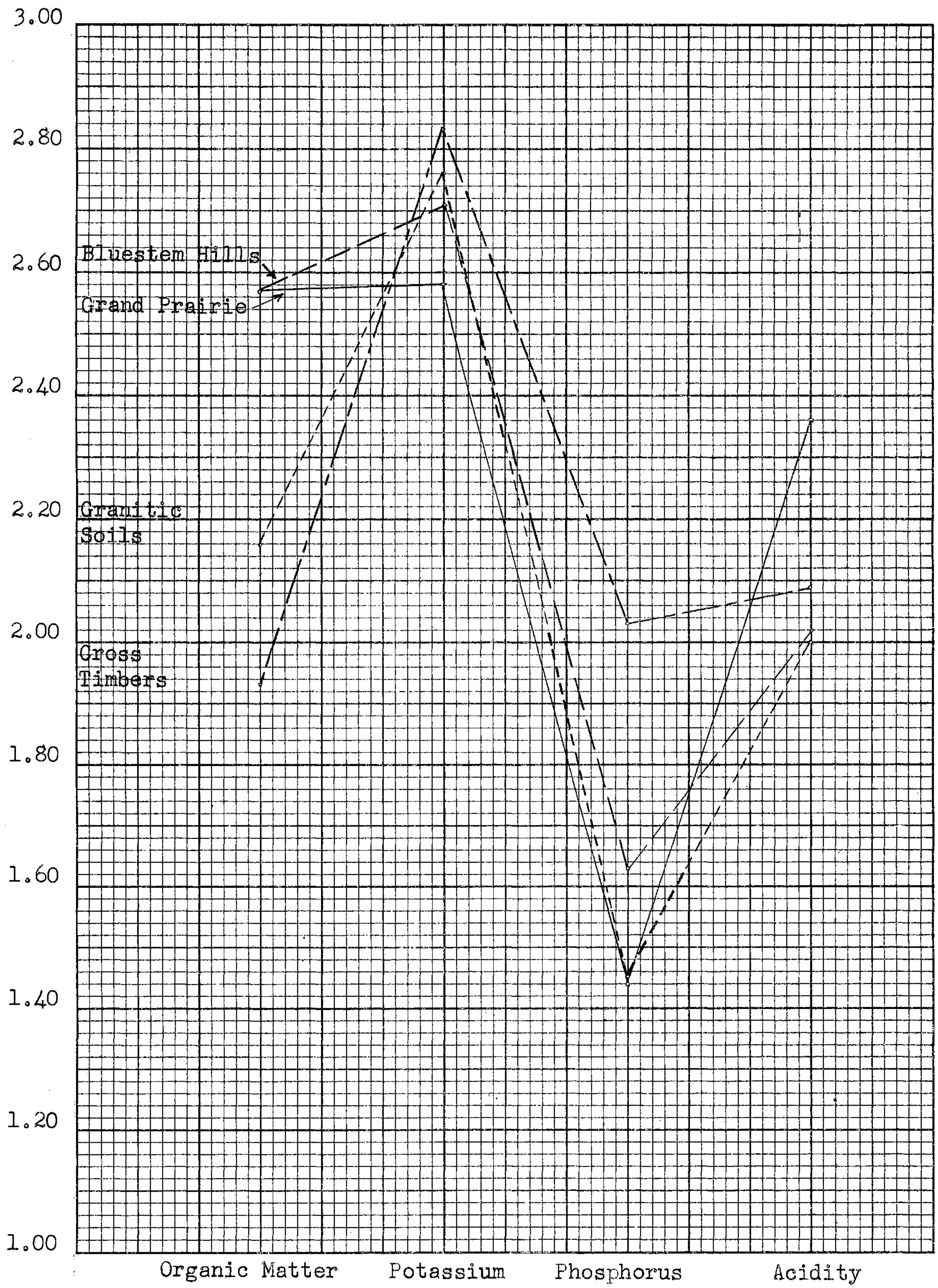


Figure 8. Averaged Indices for Oklahoma Soil Associations by Problem Areas (GP, GS, BH, CT)

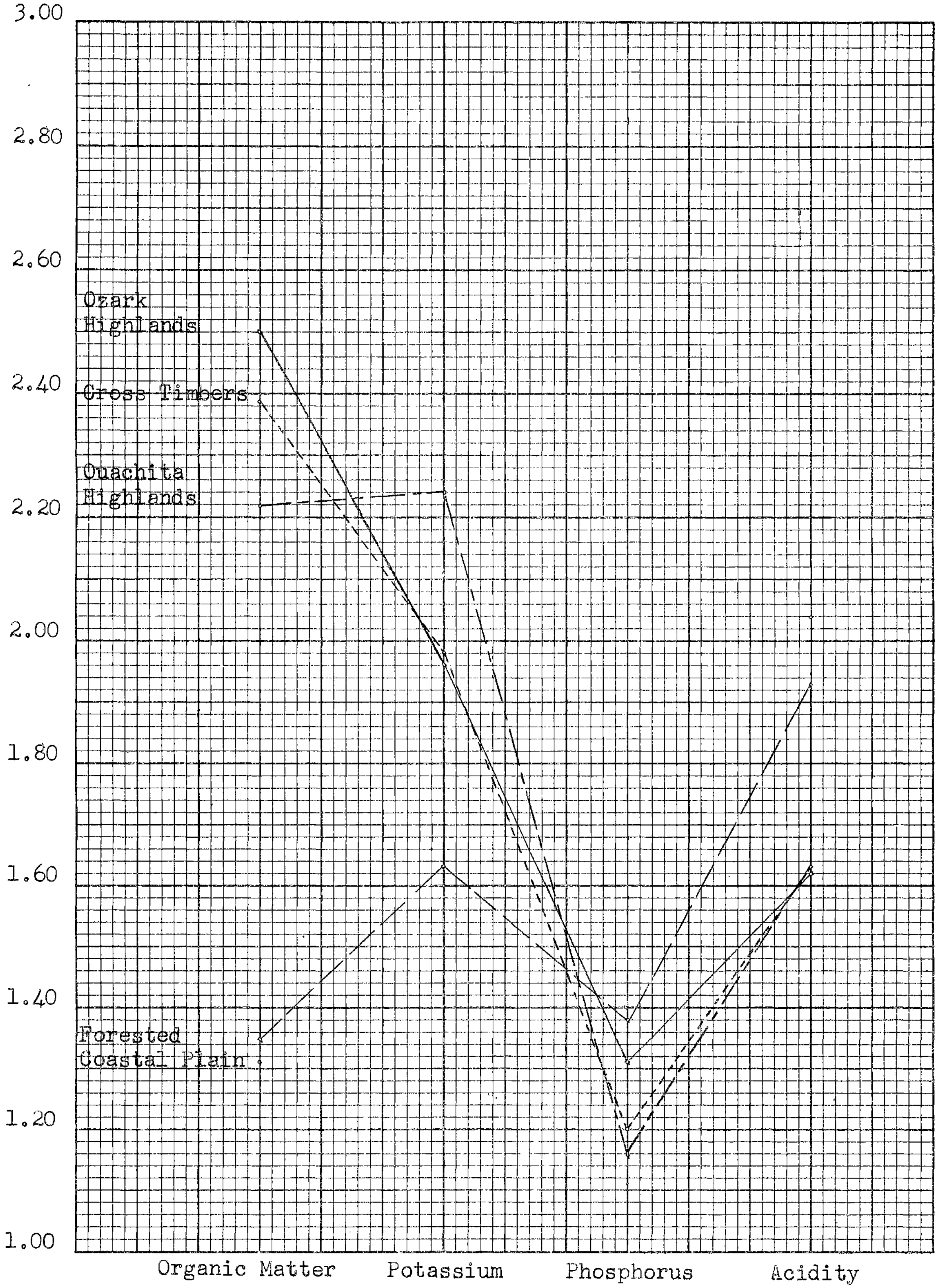


Figure 9. Averaged Indices for Oklahoma Soil Associations by Problem Areas (ZH, FC, CP, OH)

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APPENDIX A

TABLE V

TOTAL CHEMICAL ANALYSIS FOR SOME MAJOR SOIL TYPES IN PAWNEE COUNTY, OKLAHOMA

Soil Type	Depth	Horizon	Base Exchange Capacity ME/100 Grams	Exchange Na	Exchange K
Bates fine sandy loam	0- 8	A1P*	5		.459
	0- 8V**	A1	9		.229
	8-20V	B1	7		.229
	20-30V	B2	9		.229
	30-44V	C1	13		.229
Brewer silty clay loam	0-10	A1P	21		.663
	10-26	B2	22		.459
	26-46	B-C	25	5.394	.561
	46-80	C	23	1.827	.561
Cleora fine sandy loam	0-18	A1	5		.229
	18-30	A12	7		.229
	30-46	AC	6		.331
	46-80	C	18		.459
Dale silt loam	0-30	A	6		.331
	30-50	A-C	7		.331
	50-80	C	8		.102
Dennis loam V	0- 6	A1P	17	.174	.561
	0- 9	A1-1	19	.174	.459
	9-18	A1-2	22	.174	.459
	18-30	B1	25	.348	.561
	30-44	B2	18	.348	.561
	44-52	B3	21	.348	.561
	52-70	C	19		
Dennis silt loam	0- 8V	A1	19		.229
	0- 8	A1P	15		.229
	8-16	B1	20		.331
	16-26	B2	26		.331
	26-44	B3	25		.459
	44-60	C1	21		.229
Kirkland silt loam	0-10V	A1	20		.561
	0- 9	A1P	21	.174	.459
	9-17	B21	28	.348	.561
	17-30	B22	31	.348	.765
	30-42	B3	30	.522	.663
	42-86	C	22	.522	.561

* Plowed
** Virgin

pH	C/N Ratio	Total N %	Organic Matter	Total Phosphorus	Easily Soluble Phosphorus Parts per Million	Easily Soluble Phosphorus Pounds per Acre
5.8		.060	1.1	.0127	3.2	6.4
5.7		1.400	2.9	.0127	3.2	6.4
5.7		.093	1.9	.0166	0.0	0.0
5.3		.061	1.1	.0153	0.0	0.0
5.1		.055	.9	.0140	0.0	0.0
5.9	12.4	.148	3.5	.0294	32.0	64.0
6.5	20.0	.061	1.8	.0193	32.0	64.0
7.8	11.3	.030	.8	.0127	32.0	64.0
7.4	9.4	.017	.3	.0153	32.0	64.0
6.0		.043	.9	.0232	1.6	3.2
5.9		.002	.8	.0180	1.6	3.2
6.1		.055	.5	.0193	1.6	3.2
7.0		.040	1.1	.0280	32.0	64.0
6.8		.042	.7	.0127	30.4	60.8
6.5		.028	.3	.0264	12.8	25.6
5.8		.103	2.2	.0212	1.6	3.2
5.8	12.2	.189	4.4	.0200	1.6	3.2
5.7	9.4	.134	3.1	.0193	1.6	3.2
5.8	6.0	.112	1.8	.0160	0.0	0.0
6.4	5.5	.069	.5	.0134	1.6	3.2
6.1	2.9	.079	.03	.0120	1.6	3.2
6.4			.14	.0134	4.8	9.6
5.5		.170	4.7	.0206	1.6	3.2
5.4		.130	2.8	.0220	0.0	0.0
5.4		.118	2.8	.0200	0.0	0.0
5.8		.072	1.2	.0140	0.0	0.0
7.0		.015	.7	.0106	0.0	0.0
7.7		.053	.1	.0226	0.0	0.0
6.3		.135	4.1	.0220		
6.1	11.1	.090	2.9	.0140	0.0	0.0
6.1	6.3	.106	2.4	.0127	0.0	0.0
6.6	12.0	.034	1.2	.0099	0.0	0.0
7.2	11.0	.017	.6	.0092	0.0	0.0
7.8	4.1	.027	.4	.0078	0.0	0.0

TABLE V (Continued)

Soil Type	Depth	Horizon	Base Exchange Capacity ME/100 Grams	Exchange Na	Exchange K
Miller clay	0- 8	A11	26	.622	1.224
	8-20	A12	23	.609	1.020
	20-36	AC	24	1.392	.816
	36-52	C1	17	1.218	.561
	52-78	C2	6	.870	.229
Norge fine sandy loam	0-10V	A1	8		.765
	0-10	A1P	6		.561
	10-18	B1	9		.331
	18-42	B2	10		.331
	42-52	B3-C1	10		.459
Norge silt loam	0-12	A1P	12		.663
	0-12V	A1	13		.229
	12-20V	B2	15		.561
	20-46V	B3	17		.331
	46-72V	C1	16		.459
Port silt loam	0-10	A11	11		.459
	10-28	A12	15		.331
	28-60	C	18		.459
Renfrow silt loam	0-12	A1P	15		.561
	0-12V	A1	18		.561
	12-24V	B1	10		.765
	24-36V	B2	23	6.090	.561
	36-52V	C	11	2.175	.331
Teller very fine sandy loam	0-10V	A1	9		.459
	0-10	A1P	9		.561
	10-18	B1	11		.459
	18-30	B2	13		.331
	30-60	C	10		.561
Vanoss silt loam	0-14V	A1	14		.561
	0-14	A1P	14		.331
	14-24	B1	16		.331
	24-42	B2	17		.331
	42-84	C	14		.459
Yahola fine sandy loam	0-10	A	6		.331
	10-22	AC	7		.331
	22-60	C	3		.102
Yahola fine sandy loam	0-14	A	6		.561
	14-60	AC	4		.229

pH	C/N Ratio	Total N %	Organic Matter	Total Phos-phorus	Easily Soluble Phosphorus Parts per Million	Pounds per Acre
7.3		.111	2.4	.0520	32.0	64.0
7.3		.131	2.2	.0500	32.0	64.0
7.5		.089	1.7	.0534	32.0	64.0
7.5		.080	1.0	.0455	32.0	64.0
7.7		.025	.4	.0187		
6.0	3.5	.173	3.6	.0085	3.2	6.4
5.9		.074	1.5	.0071	0.0	0.0
5.6	5.6	.133	1.7	.0153	0.0	0.0
6.1	7.6	.046	.7	.0134	0.0	0.0
6.1	6.3	.027	.6	.0099	0.0	0.0
5.9		.090	2.2	.0260	3.2	6.4
6.2	14.8	.120	3.3	.0180	3.2	6.4
5.9	13.8	.106	1.8	.0180	0.0	0.0
5.8	12.7	.066	1.1	.0153	0.0	0.0
5.8	2.7	.051	.6	.0115	0.0	0.0
6.5		.078	1.9	.0085	28.8	57.6
6.4		.034	1.6	.0092	9.6	19.2
6.2		.068	1.3	.0092	8.0	16.0
5.8		.088	2.6	.0147	0.0	0.0
5.7	12.5	1.280	3.4	.0180	0.0	0.0
6.7	8.5	.098	2.4	.0127	0.0	0.0
7.6	6.4	.070	2.9	.0147	0.0	0.0
7.6	5.4	.033		.0244	0.0	0.0
5.5	11.6	.080	2.7	.0256	3.2	6.4
6.5		.080	1.6	.0212	4.8	9.6
5.9	11.6	.085	1.3	.0187		
5.8	7.7	.057	1.0	.0270		
5.6	4.3	.049	.7	.0160		
6.0		.110	2.6	.0226	1.6	3.2
5.9	8.5	.100	2.1	.0238	1.6	3.2
6.1	11.9	.082	1.8	.0244	1.6	3.2
5.9	5.6	.084	1.3	.0226	0.0	0.0
6.5	3.0	.057	.5	.0206	0.0	0.0
7.4		.050	.9	.0350	32.0	64.0
7.4		.042	1.3	.0312	32.0	64.0
7.7		.009	.2	.0212	32.0	64.0
7.4		.050	1.2	.0264	32.0	64.0
7.1		.032	.07	.0147	32.0	64.0

TABLE V (Continued)

Soil Type	Depth	Horizon	Base Exchange Capacity ME/100 Grams	Exchange Na	Exchange K
Yahola silt loam	0-14	A1	8		.561
	14-26	C1	11		.331
	26-60	C2	6		.229
Zaneis loam and fine sandy loam	0-10	A1P	9		.459
	0-10V	A1	10		.459
	10-18V	B1	11		.459
	18-34V	B2	13		.459
	34-42V	C	12		

pH	C/N Ratio	Total N %	Organic Matter	Total Phosphorus	Easily Soluble Phosphorus Parts per Million	Easily Soluble Phosphorus Pounds per Acre
6.9		.090	.46	.0400	32.0	64.0
7.0		.061	.81	.0332	32.0	64.0
7.7		.034	.26	.0280	32.0	64.0
5.6		.990	2.4	.0226	3.2	6.4
5.9		1.060	3.2	.0166	3.2	6.4
5.6		.074	2.1	.0160	0.0	0.0
5.7		.065	1.5	.0120	0.0	0.0
6.0		.057	.7	.0099	0.0	0.0

APPENDIX B

SOIL CONSERVATION SERVICE PROBLEM AREA AND SOIL UNIT LEGEND

Problem Areas*

HP..................High Plains
RR...........Rolling Red Plains
RP.............Reddish Prairies
CP............Cherokee Prairies
OH...........Ouachita Highlands
(Arkansas Valley, Boston Mts. and Ouachita Mts.)
GP................Grand Prairie
ZHA....Ozark Highlands (Prairie)
ZH..............Ozark Highlands
GS...............Granitic Soils
CT................Cross Timbers
FC.......Forested Coastal Plain
BO..................Bottomlands

Soil Units**

01...Deep, fine textured, very slowly permeable soils
02...Deep, fine textured, slowly permeable soils
03...Deep, fine textured, very slowly permeable bottomland soils
04...Deep, fine textured, slowly permeable bottomland soils
05...Deep, medium textured, very slowly permeable soils
06...Deep, medium textured, slowly permeable soils
07...Deep, medium textured, permeable soils
08...Deep, medium textured, slowly permeable bottomland soils
09...Deep, medium textured, permeable bottomland soils
10...Deep, coarse textured, very slowly permeable soils
11...Deep, coarse textured, slowly permeable soils
12...Deep, coarse textured, permeable soils
13...Deep, coarse textured, freely permeable soils
15...Deep, coarse textured, permeable bottomland soils
16...Shallow, fine textured, very slowly permeable soils
17...Shallow, fine textured, slowly permeable soils
18...Shallow, fine textured, permeable soils
19...Shallow, medium textured, very slowly or slowly permeable soils
20...Shallow, medium textured, permeable or freely permeable soils
24...Very shallow, fine textured soils
25...Very shallow, medium textured soils
27...Rough broken or rough stony land, non-calcareous materials
28...Rough broken or rough stony land, calcareous materials
60...Deep, medium (coarser textured members) textured, slowly permeable soils
70...Deep, medium (coarser textured members) textured, permeable soils

*Problem Areas used in this thesis
**Soil units used in this thesis. Soil Conservation Surveys, Memo. #6, Second Revision

Depth, Texture and Permeability Legend

Soil Depth	Description
Deep	20" plus
Shallow	10" to 20"
Very shallow	10"

Soil Texture	Description
Fine	Clay, silty clay, sandy clay, silty clay loam, clay loam, sandy clay loam
Medium	Silt loam, loam, very fine sandy loam, fine sandy loam, sandy loam
Coarse	Loamy fine sand, loamy sand, sand, coarse sand

Soil Permeability	Description
Very slowly permeable	Characterized by dense clays or semi-clay pans. Structure massive or irregular angular blocky.
Slowly permeable	Characterized by crumbly or granular clays, silty clays, clay loams. Structure fine to medium irregular angular blocky. Some granulation.
Permeable (moderate)	Characterized by sandy clay loam or highly granular silty clays, clays, or clay loams. Nuciform structure.
Freely permeable (rapid)	Characterized by fine sandy loam or coarser textures. Crumb to single grain structure.

APPENDIX C

TABLE VI

ORGANIC MATTER INDICES OF OKLAHOMA PROBLEM AREA SOIL UNITS

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		Bluestem Hills Problem Area		
03 04	1-4 1-4	Osage, Muir, Verdigris	11	3.00
06	1-7	Labette	30	3.00
08 09	1-2 1-2	Verdigris, Mason	9	2.78
02 05	1-7 1-2	Summit, Woodson	31	2.76
07	1-4	Newtonia	4	2.75
20 28	3-4 5-7	Sogn	5	2.20
		Totals	90	2.83
		Ozark Highlands (Prairie) Problem Area		
01 17	1-4 3-7	Woodson	20	2.85
02	1-7	Summit	50	2.80
08 09	1-2 1-7	Huntington	26	2.69
20	5-7	Bodine	50	2.66
06	1-7	Dennis, Lawrence, Choteau	136	2.64
07 19 25	1-7 3-7 5-7	Newtonia, Craig, Cabanal, Riverton	134	2.38
05	1-7	Parsons, Gerald	57	2.35
04	1-2 5-7	Muir	4	2.25
		Totals	477	2.56

TABLE IV (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		Grand Prairie Problem Area		
24 28 25 17	3-7 5-7 5-7 3-7	Tarrant, Ellis	23	2.91
02 01	1-7 1-7	Denton, San Saba	304	2.81
03	1-7	Kaufman, Trinity, Navasota, Bell	27	2.67
04 09 08	1-7 1-4 1-7	Gowen, Catalpa, May	314	2.68
06	1-7	Durant	205	2.26
05	1-7	Wilson, Irving	36	2.03
07	1-7	Choctaw, Newtonia	99	1.85
		Totals	1008	2.53
		Ozark Highlands Problem Area		
01 02 17	1-4 3-4 1-2	Summit	5	3.00
20 24 25	1-7 5-7 5-7	Bodine	26	2.77
09 09	1-7 1-4	Huntington, Roane, Melvern	51	2.67
06 19	1-7 3-4	Lawrence	40	2.32
05	1-7	Guthrie	10	2.20
07	1-7	Nixa, Baxter, Cabanal	85	2.10
		Totals	217	2.38

TABLE VI (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
Cherokee Prairies Problem Area				
17 18 19 24 25 27	3-7 3-4 5-7 3-7 3-7 3-4	Talihing, Collinsville	45	2.69
01 02	1-7 1-4	Okemah, Woodson	43	2.54
03 04 08	1-7 1-7 1-7	Verdigris, Osage, Lightning	164	2.54
09	1-7	Verdigris, Cleora, Mason	109	2.42
05	1-7	Parsons, Taloka, Cherokee	343	2.41
06	1-7	Dennis, Choteau	529	2.32
07 20	1-7 3-7	Bates	359	2.10
		Totals	1592	2.33
Granitic Soils Problem Area				
02 01	1-7 1-4	Garrett	78	2.38
06 11	1-7 3-7	Lawton, Chigley, Roff, Gilson	29	2.06
07	1-7	Tishomingo	16	2.00
09	1-4	Port, Pulaski	13	1.92
05	1-7	Garrett	24	1.87
		Totals	160	2.17
Bottomlands Problem Area				
03	1-7	Pledger, Lela, Perry	30	2.73

TABLE VI (Continued)

Bottomlands Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
04 08	1-7 1-7	Dale, McLain, Port, Miller, Norwood, Spur	251	2.46
09	1-7	Yahola, Reinach, Canadian, Port	357	1.76
15	1-7	Lincoln	33	1.18
		Totals	671	2.03
04	1-7	Miller (McCurtain, Choctaw and Bryan Counties)	30	2.70
09	1-7	Yahola (McCurtain, Choctaw and Bryan Counties)	25	1.52
		Reddish Prairies Problem Area		
03	1-7	Lela, Roebuck, Miller	28	2.57
04 08	1-7 1-7	Port, Kay, Brewer	474	2.46
02 02	1-4 5-7	Fairview, Rusk	53	2.40
05	1-2	Tabler, Kirkland	270	2.23
01 01	1-2 3-4	Tabler, Renfrow	85	2.12
24 25	3-7 1-7	Vernon, Lucien	45	2.11
06	1-2	Pond Creek, Norge, Bethany, Kingfisher	160	1.99
05	3-4	Renfrow, Kirkland	510	1.92
16 17 19	3-4 3-4 3-7	Stamford	33	1.82
05 01	5-7 5-7	Eroded Renfrow	67	1.73

TABLE VI (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
09 09	1-4 5-7	Port, Yahola, Reinach	616	1.72
06	3-7	Zaneis, Norge	215	1.71
07 70	1-2 1-2	Grant, Chickasha, Vanoss, Minco, Teller	495	1.71
07 70	3-7 3-7	Grant, Cobb, Teller, Minco	882	1.57
13	3-7	Derby, Tivoli	4	1.50
20 20	1-4 5-7	Lucien, Nash	100	1.46
15	1-7	Lincoln	35	1.31
12	1-7	Pratt, Cobb, Dougherty	93	1.14
		Totals	4165	1.83
05	1-2	Tabler (Grant, Kay and Garfield Counties)	55	2.71
06	1	Bethany (Canadian, Cleveland, Noble, Kingfisher, Logan, Oklahoma, Grant, Kay and Garfield Counties)	20	2.40
05	2;1-2	Kirkland (Grant, Kay and Garfield; Canadian, Cleveland, Kingfisher, Logan and Oklahoma Counties)	191	2.35
05	1-2	Kirkland (Canadian, Cleveland, Grady, Kingfisher, Logan, Oklahoma, Pawnee, Payne and Noble Counties)	170	2.28
07	1	Pond Creek (Alfalfa, Grant, Garfield and Woods Counties)	11	2.18
07	2-3	Grant (Alfalfa, Grant, Garfield and Woods Counties)	79	1.76

TABLE VI (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
20	3-4	Nash (Alfalfa, Grant, Garfield and Woods Counties)	20	1.65
07	1-4	Dill (Washita and Beckham Counties)	50	1.30
12; 07,70	2-3; 1-4	Cobb (Caddo County)	251	1.26

Rolling Red Plains Problem Area

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
03	1-7	Spur	19	2.31
04 08	1-7 1-7	Norwood, Port	128	2.22
27 24	1-2 1-7	Vernon and rough, brokenland-Vernon, Harmon	10	2.22
02	1-7	Abilene, Kiowa, La Casa	114	2.21
01 05	1-2 1-2	Foard, Hollister, Tillman, Lebos	130	2.18
01 05	3-4 3-4	Tillman	162	2.13
06 60	1-7 1-4	Abilene, St. Paul, Carwile, Lawton	185	1.89
01 05	5-7 5-7	Eroded Tillman soils	8	1.88
20 19 17 25	1-7 3-4 3-7 1-7	Quinlan-Woodward complex	97	1.74
09	1-7	Port, Yahola, Spur, Sweetwater	145	1.63
07	1-2	Dill, Carey, Enterprise, Tipton	102	1.50

TABLE VI (Continued)

Rolling Red Plains Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
07 70 07	3-4 1-7 5-7	Woodward, Miles, Farnum, Enterprise	215	1.33
12	1-7	Pratt, Brownfield	89	1.12
13	3-7	Tivoli	5	1.00
15	3-7	Lincoln	8	1.00
		Totals	1417	1.80
07;70	3-4;1-7	Miles (Beckham, Greer and Harmon Counties)	24	1.13
12	1-7	Brownfield (Beckham, Greer and Harmon Counties)	28	1.00
		Ouachita Highlands Problem Area (Arkansas Valley, Boston Mts. and Ouachita Mts.)		
03	1-2 5-7	Atkins	5	3.00
25 27	3-7 3-7	Hector, Pottsville	15	2.40
08 04	1-7 1-4	Philo	87	2.33
09	1-7	Pope	64	2.00
06 19	1-7 3-7	Conway, Enders, Tyler	102	1.88
05	1-7	Parsons, Taloka, Le Flore	49	1.69
07 20	1-7 3-7	Linker, Cleburne, Waynesboro	280	1.60
12 70	3-7 1-7	Dougherty, Stidham, Teller	24	1.12
		Totals	626	1.80

TABLE VI (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		High Plains Problem Area		
09 04	1-2 1-2	Spur	4	2.75
02 06	1-4 3-7	Richfield, Pullman, Zita	20	2.05
17 18 20	3-4 1-4 3-7	Mansker, Potter, Regnier	6	2.00
12	1-7	Dalhart, Vona, Tivoli	5	1.40
07 70	1-7 3-4	Dalhart, Berthoud	20	1.25
		Totals	55	1.74
		Cross Timbers Problem Area		
04 08	1-7 1-4	Miller	32	2.00
06 60 05 01 02	1-7 3-4 1-7 1-7 3-7	Nimrod, Windthorst, Parsons	95	1.40
09 15	1-7 1-7	Pulaski, Port, Gowen, Mason	214	1.38
24 25 27	1-2 3-4 3-7	Darnell and rough sandstone lands	7	1.29
07 70	1-4 1-4	Stephenville, Dougherty, Stidham, Noble, Teller	555	1.28
07 70 19 20	5-7 5-7 3-7 1-7	Stephenville, Windthorst Eroded and shallow phases	222	1.28
03	3-7	Roebuck, Lela	4	1.25

TABLE VI (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
Cross Timbers Problem Area (Continued)				
12	1-7	Dougherty, Stidham	108	1.12
13	3-7	Eufaula, Derby	21	1.00
		Totals	1258	1.31
Forested Coastal Plain Problem Area				
09	1-7	Ochlockonee	26	1.58
04 08	1-4 1-7	Iuka, Bibb	10	1.50
05 01	1-7 5-7	Caddo, Lufkin, Myatt	14	1.42
19 20	3-7 3-7	Cuthbert	13	1.30
06 10 11	1-7 1-2 5-7	Boswell, Kirvin, Sawyer, Susquehanna	57	1.24
07 12 13	1-7 1-7 3-4	Bowie, Ruston, Norfolk	137	1.16
		Totals	257	1.27
07	1-7	Teller	32	1.27

TABLE VII

POTASSIUM INDICES OF OKLAHOMA PROBLEM AREA SOIL UNITS

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		High Plains Problem Area		
02 06	1-4 3-7	Richfield, Pullman, Zita	20	3.00
09 04	1-2 1-2	Spur	4	3.00
07 70	1-7 3-4	Dalhart, Berthoud	20	3.00
12	1-7	Dalhart, Vona, Tivoli	5	3.00
17 18 20	3-4 1-4 3-7	Potter, Regnier	6	3.00
		Totals	55	3.00
		Rolling Red Plains Problem Area		
01 05	5-7 5-7	Eroded Tillman soils	8	3.00
03	1-7	Spur	19	3.00
04 08	1-7 1-7	Norwood, Port	128	3.00
27 24	1-2 1-7	Vernon and rough brokenland-Vernon Harmon	10	3.00
01 05	1-2 1-2	Foard, Hollister, Tillman, Lebos	130	2.97
01 05	3-4 3-4	Tillman	162	2.97
02	1-7	Abilene, Kiowa, La Casa	114	2.96
06 60	1-7 1-4	Abilene, St. Paul, Carwile, Lawton	185	2.96
09	1-7	Port, Yahola, Spur, Sweetwater	145	2.92

TABLE VII (Continued)

Rolling Red Plains Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
07 70 07	3-4 1-7 5-7	Woodward, Miles, Farnum, Enterprise	215	2.87
07	1-2	Dill, Carey, Enterprise, Tipton	102	2.86
20 19 17 25	1-7 3-4 3-7 1-7	Quinlan-Woodward complex	97	2.85
12	1-7	Pratt, Brownfield	89	2.70
15	3-7	Lincoln	8	2.00
13	3-7	Tivoli	5	1.80
		Totals	1417	2.90
07;70	3-4;1-7	Miles (Beckham, Greer and Harmon Counties)	24	2.83
12	1-7	Brownfield (Beckham, Greer and Harmon Counties)	28	2.68
		Granitic Soils Problem Area		
07	1-7	Tishomingo	16	3.00
02 01	1-7 1-4	Garrett	78	2.83
05	1-7	Garrett	24	2.83
09	1-4	Port, Pulaski	13	2.83
06 11	1-7 3-7	Lawton, Chigley, Roff, Gilson	29	2.61
		Totals	160	2.80
		Reddish Prairies Problem Area		
01 01	1-2 3-4	Tabler, Renfrow	85	2.96

TABLE VII (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
03	1-7	Lela, Roebuck, Miller	28	2.92
16 17 19	3-4 3-4 3-7	Stamford	33	2.91
06	1-2	Pond Creek, Bethany, Kingfisher	160	2.89
04 08	1-7 1-7	Port, Kay, Brewer	474	2.85
24 25	3-7 1-7	Vernon, Lucien	45	2.85
02 02	1-4 5-7	Fairview, Rusk	53	2.83
05	1-2	Tabler, Kirkland	270	2.82
07 70	1-2 1-2	Grant, Chickasha, Vanoss, Minco, Teller	495	2.82
20 20	1-4 5-7	Lucien, Nash	100	2.79
09 09	1-4 5-7	Port, Yahola, Reinach	616	2.74
05	3-4	Renfrow, Kirkland	510	2.68
06	3-7	Zaneis, Norge	215	2.68
07 70	3-7 3-7	Grant, Cobb, Teller, Minco	882	2.66
05 01	5-7 5-7	Eroded Renfrow	67	2.56
12	1-7	Pratt, Cobb, Dougherty	93	2.55
13	3-7	Derby, Tivoli	4	2.50
15	1-7	Lincoln	35	2.46
		Totals	4165	2.75

TABLE VII (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
05	1-2	Tabler (Grant, Kay and Garfield Counties)	55	3.00
07	1	Pond Creek (Alfalfa, Grant, Garfield and Woods Counties)	11	3.00
20	3-4	Nash (Alfalfa, Grant, Garfield and Woods Counties)	20	2.95
06	1	Bethany (Canadian, Cleveland, Noble, Kingfisher, Logan, Oklahoma, Grant, Kay and Garfield Counties)	20	2.94
07	1-4	Dill (Washita and Beckham Counties)	50	2.90
05	2;1-2	Kirkland (Grant, Kay and Garfield Counties; Canadian, Cleveland, Kingfisher, Logan, Oklahoma Counties)	191	2.85
07	2-3	Grant (Alfalfa, Grant, Garfield and Woods Counties)	79	2.84
12; 07,70	2-3; 1-4	Cobb (Caddo County)	251	2.84
05	1-2	Kirkland (Canadian, Cleveland, Grady, Kingfisher, Logan, Oklahoma, Pawnee, Payne and Noble Counties)	170	2.82
		Bluestem Hills Problem Area		
03 04	1-4 1-4	Osage, Muir, Verdigris	11	3.00
08 09	1-2 1-2	Verdigris, Mason	9	3.00
20 28	3-4 5-7	Sogn	5	3.00

TABLE VII (Continued)

Bluestem Hills Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
06	1-7	Labette	30	2.75
07	1-4	Newtonia	4	2.75
02 05	1-7 1-2	Summit, Woodson	31	2.41
		Totals	90	2.69
		Grand Prairie Problem Area		
03	1-7	Kaufman, Trinity, Navasota, Bell	27	2.85
04 09 08	1-7 1-4 1-7	Gowen, Catalpa, May	314	2.84
24 28 25 17	3-7 5-7 5-7 3-7	Tarrant, Ellis	23	2.84
02 01	1-7 1-7	Denton, San Saba	304	2.74
06	1-7	Durant	205	2.54
07	1-7	Choctaw, Newtonia	99	2.34
05	1-7	Wilson, Irving	36	1.91
		Totals	1008	2.68
		Bottomlands Problem Area		
03	1-7	Pledger, Lela, Perry	30	2.97
04 08	1-7 1-7	Dale, McLain, Port, Miller, Norwood, Spur	251	2.81
09	1-7	Yahola, Reinach, Canadian, Port	357	2.56
15	1-7	Lincoln	33	2.13
		Totals	671	2.64

TABLE VII (Continued)

Bottomlands Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
04	1-7	Miller (McCurtain, Choctaw and Bryan Counties)	30	2.93
09	1-7	Yahola (McCurtain, Choctaw and Bryan Counties)	25	2.40
		Cross Timbers Problem Area		
24 25 27	1-2 3-4 3-7	Darnell and rough sandstone lands	7	2.57
04 08	1-7 1-4	Miller	32	2.51
03	3-7	Roebuck, Lela	4	2.50
09 15	1-7 1-7	Pulaski, Port, Gowen, Mason	214	2.23
06 60 05 01 02	1-7 3-4 1-7 1-7 3-7	Nimrod, Windthorst	95	2.20
07 70	1-4 1-4	Stephenville, Dougherty, Stidham, Noble, Teller	555	2.15
12	1-7	Dougherty, Stidham	108	1.99
07 70 19 20	5-7 5-7 3-7 1-7	Stephenville, Windthorst Eroded and shallow phases	222	1.95
13	3-7	Eufaula, Derby	21	1.53
		Totals	1258	2.13
		Ozark Highlands Problem Area		
09 08	1-7 1-4	Huntington, Roane, Melvern	51	2.43

TABLE VII (Continued)

Ozark Highlands Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
20 24 25	1-7 5-7 5-7	Bodine	26	2.20
07	1-7	Nixa, Baxter, Cabanal	85	2.10
06 19	1-7 3-4	Lawrence	40	1.77
05	1-7	Guthrie	10	1.50
01 02 17	1-4 3-4 1-2	Summit	5	1.40
		Totals	217	2.09
		Ouachita Highlands Problem Area (Arkansas Valley, Boston Mts. and Ouachita Mts.)		
03	1-2 5-7	Atkins	5	3.00
25 27	3-7 3-7	Hector, Pottsville	15	2.43
08 04	1-7 1-4	Philo	87	2.26
09	1-7	Pope	64	2.22
05	1-7	Parsons, Taloka, Le Flore	49	1.95
06 19	1-7 3-7	Conway, Enders, Tyler	102	1.90
07 20	1-7 3-7	Linker, Cleburne, Waynesboro	280	1.83
12 70	3-7 1-7	Dougherty, Stidham, Teller	24	1.52
		Totals	626	1.96

TABLE VII (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		Cherokee Prairies Problem Area		
17	3-7	Talihina, Collinsville	45	2.62
18	3-4			
19	5-7			
24	3-7			
25	3-7			
27	3-4			
09	1-7	Verdigris, Cleora, Mason	109	2.37
03	1-7	Verdigris, Osage, Lightning	164	2.30
04	1-7			
08	1-7			
01	1-7	Okemah, Woodson	43	2.06
02	1-4			
06	1-7	Dennis, Choteau	529	1.95
07	1-7	Bates	359	1.78
20	3-7			
05	1-7	Parsons, Taloka, Cherokee	343	1.75
		Totals	1592	1.95
		Ozark Highlands (Prairie) Problem Area		
04	1-2	Muir	4	2.50
	5-7			
02	1-7	Summit	50	2.48
08	1-2	Huntington	26	2.12
09	1-7			
01	1-4	Woodson	20	2.04
17	3-7			
20	5-7	Bodine	50	1.74
07	1-7	Newtonia, Craig, Cabanal, Riverton	134	1.70
19	3-7			
25	5-7			

TABLE VII (Continued)

Ozark Highlands (Prairie) Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
06	1-7	Dennis, Lawrence, Choteau	136	1.50
05	1-7	Parsons, Gerald	57	1.36
		Totals	477	1.73
		Forested Coastal Plain Problem Area		
09	1-7	Ochlockonee	26	2.62
05 01	1-7 5-7	Caddo, Lufkin, Myatt	14	1.92
06 10 11	1-7 1-2 5-7	Boswell, Kirvin, Sawyer, Susquehanna	57	1.83
07 12 13	1-7 1-7 3-4	Bowie	137	1.42
04 08	1-4 1-7	Iuka, Bibb	10	1.40
19 20	3-7 3-7	Cuthbert	13	1.40
		Totals	257	1.59
07	1-7	Teller	32	1.49

TABLE VIII

PHOSPHORUS INDICES OF OKLAHOMA PROBLEM AREA SOIL UNITS

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index*
		High Plains Problem Area		
09 04	1-2 1-2	Spur	4	3.00
12	1-7	Dalhart, Vona, Tivoli	5	3.00
17 18 20	3-4 1-4 3-7	Mansker, Potter, Regnier	6	3.00
07 70	1-7 3-4	Dalhart, Berthoud	20	2.95
02 06	1-4 3-7	Richfield, Pullman, Zita	20	2.90
		Totals	55	2.94
		Rolling Red Plains Problem Area		
15	3-7	Lincoln	8	3.00
04 08	3-7 1-7	Norwood, Port	128	2.96
03	1-7	Spur	19	2.95
09	1-7	Port, Yahola, Spur, Sweetwater	145	2.93
02	1-7	Abilene, Kiowa, La Casa	114	2.90
06 60	1-7 1-4	Abilene, St. Paul, Carwile, Lawton	185	2.90
01 05	1-2 1-2	Foard, Hollister, Tillman, Lebos	130	2.87
27 24	1-2 1-7	Vernon and rough brokenland-Vernon, Harmon	10	2.80

*Easily soluble Phosphorus. Extracting agent used was acetic acid.

TABLE VIII (Continued)

Rolling Red Plains Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
20 19 17 25	1-7 3-4 3-7 1-7	Quinlan-Woodward complex	97	2.75
07	1-2	Dill, Carey, Enterprise, Tipton	102	2.74
01 05	5-7 5-7	Eroded Tillman soils	8	2.62
07 70 07	3-4 1-7 5-7	Woodward, Miles, Farnum, Enterprise	215	2.55
13	3-7	Tivoli	5	2.00
12	1-7	Pratt, Brownfield	89	1.94
		Totals	1417	2.75
07;70	3-4;1-7	Miles (Beckham, Greer and Harmon Counties)	24	2.74
12	1-7	Brownfield (Beckham, Greer and Harmon Counties)	28	1.79
		Bottomlands Problem Area		
15	1-7	Lincoln	33	2.77
04 08	1-7 1-7	Dale, McLain, Port, Miller, Norwood, Spur	251	2.75
09	1-7	Yahola, Reinach, Canadian, Port	357	2.56
03	1-7	Pledger, Lela, Perry	30	2.50
		Totals	671	2.65
04	1-7	Miller (McCurtain, Choctaw and Bryan Counties)	30	2.87
09	1-7	Yahola (McCurtain, Choctaw and Bryan Counties)	25	2.76

TABLE VIII (Continued)

Reddish Prairies Problem Area				
SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
09 09	1-4 5-7	Port, Yahola, Reinach	616	2.59
04 08	1-7 1-7	Port, Kay, Brewer	474	2.56
06	1-2	Pond Creek, Norge, Bethany, Kingfisher	160	2.54
15	1-7	Lincoln	35	2.47
01 01	1-2 3-4	Tabler, Renfrow	85	2.41
03	1-7	Lela, Roebuck, Miller	28	2.39
02 02	1-4 5-7	Fairview, Rusk	53	2.34
12	1-7	Pratt, Cobb, Dougherty	93	2.34
16 17 19	3-4 3-4 3-7	Stamford	33	2.30
07 70	1-2 1-2	Grant, Chickasha, Vanoss, Minco, Teller	495	2.12
24 25	3-7 1-7	Vernon, Lucien	45	2.02
13	3-7	Derby, Tivoli	4	2.00
20 20	1-4 5-7	Lucien, Nash	100	1.96
05	1-2	Tabler, Kirkland	270	1.78
07 70	3-7 3-7	Grant, Cobb, Teller, Minco	882	1.65
06	3-7	Zaneis, Norge	215	1.49
05	3-4	Renfrow, Kirkland	510	1.46
05 01	5-7 5-7	Eroded Renfrow	67	1.39

TABLE VIII (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		Totals	4165	2.03
07	1	Pond Creek (Alfalfa, Grant, Garfield and Woods Counties)	11	3.00
07	2-3	Grant (Alfalfa, Grant, Garfield and Woods Counties)	79	2.88
06	1	Bethany (Canadian, Cleveland, Noble, Kingfisher, Logan, Oklahoma, Grant, Kay and Garfield Counties)	20	2.85
20	3-4	Nash (Alfalfa, Grant, Garfield and Woods Counties)	20	2.85
07	1-4	Dill (Washita and Beckham Counties)	50	2.14
05	1-2	Tabler (Grant, Kay and Garfield Counties)	55	1.94
05	2;1-2	Kirkland (Grant, Kay and Garfield Counties; Canadian, Cleveland, Kingfisher, Logan, and Oklahoma Counties)	191	1.86
05	1-2	Kirkland (Canadian, Cleveland, Grady, Kingfisher, Logan, Oklahoma, Pawnee, Payne and Noble Counties)	170	1.81
12; 07,70	2-3; 1-4	Cobb (Caddo County)	251	1.79
		Grand Prairie Problem Area		
03	1-7	Kaufman, Trinity, Navasota, Bell	27	2.52

TABLE VIII (Continued)

Grand Prairie Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
04 09 08	1-7 1-4 1-7	Gowen, Catalpa, May	314	2.39
02 01	1-7 1-7	Denton, San Saba	304	1.96
06	1-7	Durant	205	1.44
07	1-7	Choctaw, Newtonia	99	1.39
24 28 25 17	3-7 5-7 5-7 3-7	Tarrant, Ellis	23	1.39
05	1-7	Wilson, Irving	36	1.28
		Totals	1008	1.91
		Granitic Soils Problem Area		
09	1-4	Port, Pulaski	13	2.38
02 01	1-7 1-4	Garrett	78	2.12
07	1-7	Tishomingo	16	1.88
05	1-7	Garrett	24	1.83
06 11	1-7 3-7	Lawton, Chigley, Roff, Gilson	29	1.20
		Totals	160	1.91
		Bluestem Hills Problem Area		
08 09	1-2 1-2	Verdigris, Mason	9	2.11
07	1-4	Newtonia	4	2.00
03 04	1-4 1-4	Osage, Muir, Verdigris	11	1.96

TABLE VIII (Continued)

Bluestem Hills Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
06	1-7	Labette	30	1.84
20 28	3-4 5-7	Sogn	5	1.80
02 05	1-7 1-2	Summit, Woodson	31	1.39
		Totals	90	1.73

Cross Timbers Problem Area

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
04 08	1-7 1-4	Miller	32	2.00
13	3-7	Eufaula, Derby		
09 15	1-7 1-7	Pulaski, Port, Gowen, Mason	214	1.86
12	1-7	Dougherty, Stidham	108	1.67
03	3-7	Roebuck, Lela	4	1.50
06 60 05 01 02	1-7 3-4 1-7 1-7 3-7	Nimrod, Windthorst, Parsons	95	1.47
07 70	1-4 1-4	Stephenville, Dougherty, Stidham, Noble, Teller	555	1.47
24 25 27	1-2 3-4 3-7	Darnell and rough sandstone lands	7	1.43
07 70 19	5-7 5-7 3-7	Stephenville, Windthorst, eroded and shallow phases	222	1.24
20	1-7	Totals	1258	1.54

Ozark Highlands Problem Area

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
09 08	1-7 1-4	Huntington, Roane, Melvern	51	1.84

TABLE VIII (Continued)

Ozark Highlands Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
20 24 25	1-7 5-7 5-7	Bodine	26	1.50
07	1-7	Nixa, Baxter, Cabanal	85	1.34
01 02 17	1-4 3-4 1-2	Summit	5	1.20
05	1-7	Guthrie	10	1.20
06 19	1-7 3-4	Lawrence	40	1.17
		Totals	217	1.44
		Forested Coastal Plain Problem Area		
09	1-7	Ochlockonee	26	1.62
07 12 13	1-7 1-7 3-4	Bowie, Ruston, Norfolk	137	1.53
19 20	3-7 3-7	Cuthbert	13	1.23
06 10 11	1-7 1-2 5-7	Boswell, Kirvin, Sawyer, Susquehanna	57	1.17
05 01	1-7 5-7	Caddo, Lufkin, Myatt	14	1.07
04 08	1-4 1-7	Iuka, Bibb	10	1.00
		Totals	257	1.40
07	1-7	Teller (McCurtain, Choctaw, Bryan Counties)	32	1.47

TABLE VIII (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
Cherokee Prairies Problem Area				
03 04 08	1-7 1-7 1-7	Verdigris, Osage, Lightning	164	1.86
09	1-7	Verdigris, Cleora, Mason	109	1.80
01 02	1-7 1-4	Okemah, Woodson	43	1.48
07 20	1-7 3-7	Bates	359	1.26
05	1-7	Parsons, Taloka, Cherokee	343	1.23
17 18 19 24 25 27	3-7 3-4 5-7 3-7 3-7 3-4	Talihina, Collinsville	45	1.22
06	1-7	Dennis, Choteau	529	1.18
		Totals	1592	1.33
Ozark Highlands (Prairie) Problem Area				
04	1-2 5-7	Muir	4	2.00
02	1-7	Summit	50	1.74
01 17	1-4 3-7	Woodson	20	1.50
08 09	1-2 1-7	Huntington	26	1.31
06	1-7	Dennis, Lawrence, Choteau	136	1.21
20	5-7	Bodine	50	1.20
07 19 25	1-7 3-7 5-7	Newtonia, Craig, Cabanal, Riverton	134	1.19

TABLE VIII (Continued)

Ozark Highlands (Prairie) Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
05	1-7	Parsons, Gerald	57	1.12
		Totals	477	1.27
		Ouachita Highlands Problem Area (Arkansas Valley, Boston Mts. and Ouachita Mts.)		
03	1-2 5-7	Atkins	5	2.00
09	1-7	Pope	64	1.33
08 04	1-7 1-4	Philo	87	1.22
07 20	1-7 3-7	Linker, Cleburne, Waynesboro	280	1.22
06 19	1-7 3-7	Conway, Enders, Tyler	102	1.19
05	1-7	Parsons, Taloka, Le Flore	49	1.06
12 70	3-7 1-7	Dougherty, Stidham, Teller	24	1.04
25 27	3-7 3-7	Hector, Pottsville	15	1.00
		Totals	626	1.20

TABLE IX

ACIDITY INDICES OF OKLAHOMA PROBLEM AREA SOIL UNITS

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		High Plains Problem Area		
02 06	1-4 3-7	Richfield, Pullman, Zita	20	3.00
04 09	1-2 1-2	Spur	4	3.00
12	1-7	Dalhart, Vona, Tivoli	5	3.00
17 18 20	3-4 1-4 3-7	Mansker, Potter, Regnier	6	3.00
07 70	1-7 3-4	Dalhart, Berthoud	20	2.95
		Totals	55	2.98
		Rolling Red Plains Problem Area		
03	1-7	Spur	19	3.00
15	3-7	Lincoln	8	3.00
09	1-7	Port, Yahola, Spur, Sweetwater	145	2.98
27 24	1-2 1-7	Vernon, rough brokenland-Vernon, Harmon	10	2.91
20 19 17 25	1-7 3-4 3-7 1-7	Quinlan-Woodward complex	97	2.88
06 60	1-7 1-4	Abilene, St. Paul, Carwile, Lawton	185	2.87
04 08	1-7 1-7	Norwood, Port	128	2.86
12	1-7	Pratt, Brownfield	89	2.85
02	1-7	Abilene, Kiowa, La Casa	114	2.84
13	3-7	Tivoli	5	2.80

TABLE IX (Continued)

Rolling Red Plains Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
07 70 07	1-2 1-7 5-7	Woodward, Miles, Farnum, Enterprise	215	2.77
07	1-2	Dill, Carey, Enterprise, Tipton	102	2.76
01 05	3-4 3-4	Tillman	162	2.75
01 05	1-2 1-2	Foard, Hollister, Tillman, Lebos	130	2.72
01 05	5-7 5-7	Eroded Tillman soils	8	2.25
		Totals	1417	2.83
12	1-7	Brownfield (Beckham, Greer and Harmon Counties)	28	2.95
07;70	3-4;1-7	Miles (Beckham, Greer and Harmon Counties)	24	2.93
		Bottomlands Problem Area		
15	1-7	Lincoln	33	2.76
04 08	1-7 1-7	Dale, McLain, Port, Miller, Norwood, Spur	251	2.72
03	1-7	Pledger, Lela, Perry	30	2.67
09	1-7	Yahola, Reinach, Canadian, Port	357	2.55
		Totals	671	2.63
04	1-7	Miller (McCurtain, Choctaw and Bryan Counties)	30	2.93
09	1-7	Yahola (McCurtain, Choctaw and Bryan Counties)	25	2.84
		Grand Prairie Problem Area		
04 09 08	1-7 1-4 1-7	Gowen, Catalpa, May	314	2.72

TABLE IX (Continued)

Grand Prairie Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
02 01	1-7 1-7	Denton, San Saba	304	2.63
03	1-7	Kaufman, Trinity, Navasota, Bell	27	2.62
24 28 25 17	3-7 5-7 5-7 3-7	Tarrant, Ellis	23	2.48
06	1-7	Durant	205	2.21
05	1-7	Wilson, Irving	36	2.11
07	1-7	Choctaw, Newtonia	99	2.06
		Totals	1008	2.49
		Cross Timbers Problem Area		
04 08	1-7 1-4	Miller	32	2.65
09 09 15	1-4 5-7 1-7	Pulaski, Port, Gowen, Mason	214	2.65
13	3-7	Eufaula, Derby	21	2.47
12	1-7	Dougherty, Stidham	108	2.46
03	3-7	Roebuck, Lela	4	2.25
07 70 19 20	5-7 5-7 3-7 1-7	Stephenville, Windthorst Eroded and shallow phases	222	2.22
07 70	1-4 1-4	Stephenville, Doutherty, Stidham, Noble, Teller	555	2.19
06 60 05 01 02	1-7 3-4 1-7 1-7 3-7	Nimrod, Windthorst, Parsons	95	2.17

TABLE IX (Continued)

Cross Timbers Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
24 25 27	1-2 3-4 3-7	Darnell and rough sandstone lands	7	2.00
		Totals	1258	2.32

Reddish Prairies Problem Area

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
13	3-7	Derby, Tivoli	4	3.00
15	1-7	Lincoln	35	2.78
01 01	1-2 3-4	Tabler, Renfrow	85	2.76
24 25	3-7 1-7	Vernon, Lucien	45	2.69
04 08	1-7 1-7	Port, Kay, Brewer	474	2.68
16 17 19	3-4 3-4 3-7	Stamford	33	2.67
09 09	1-4 5-7	Port, Yahola, Reinach	616	2.64
12	1-7	Pratt, Cobb, Dougherty	93	2.58
03	1-7	Lela, Roebuck, Miller	28	2.57
02 02	1-4 5-7	Fairview, Rusk	53	2.47
20 20	1-4 5-7	Lucien, Nash	100	2.42
07 70	3-7 3-7	Grant, Cobb, Teller, Minco	882	2.23
06	1-2	Pond Creek, Norge, Bethany, Kingfisher	160	2.20
07 70	1-2 1-2	Grant, Chickasha, Vanoss, Minco, Teller	495	2.18

TABLE IX (Continued)

Reddish Prairies Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
05 01	5-7 5-7	Eroded Renfrow	67	2.13
06	3-7	Zaneis, Norge, Lawton	215	2.09
05	3-4	Renfrow, Kirkland	510	1.94
05	1-2	Tabler, Kirkland	270	1.85
		Totals	4165	2.31
20	3-4	Nash (Alfalfa, Grant, Garfield and Woods Counties)	20	2.60
07	1-4	Dill (Washita and Beckham Counties)	50	2.54
12; 07,70	2-3 1-4	Cobb (Caddo County)	251	2.49
07	2-3	Grant (Alfalfa, Grant, Garfield and Woods Counties)	79	2.08
05	1-2	Kirkland (Canadian, Cleveland, Grady, Kingfisher, Logan, Oklahoma, Pawnee, Payne and Noble Counties)	170	2.01
05	2;1-2	Kirkland (Grant, Kay and Garfield Counties; Canadian, Cleveland, Kingfisher, Logan, Oklahoma and Grant Counties)	191	1.87
06	1	Bethany (Canadian, Cleveland, Kingfisher, Logan, Oklahoma, Grant, Kay, Garfield and Noble Counties)	20	1.85
07	1	Pond Creek (Alfalfa, Grant, Garfield and Woods Counties)	11	1.82
05	1-2	Tabler (Grant, Kay and Garfield Counties)	55	1.25

TABLE IX (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
		Granitic Soils Problem Area		
01 02	1-4 1-7	Garrett	78	2.46
09	1-4	Port, Pulaski	13	2.28
05	1-7	Garrett	24	2.17
07	1-7	Tishomingo	16	2.06
06 11	1-7 3-7	Lawton, Chigley, Roff, Gilson	29	1.96
		Totals	160	2.27
		Forested Coastal Plain Problem Area		
09	1-7	Ochlockonee	26	2.27
07 12 13	1-7 1-7 3-4	Bowie, Ruston, Norfolk	137	2.17
04 08	1-4 1-7	Iuka, Bibb	10	2.00
19 20	3-7 3-7	Cuthbert	13	2.00
06 10 11	1-7 1-2 5-7	Boswell, Kirvin, Sawyer, Susquehanna	57	1.89
05 01	1-7 5-7	Caddo, Lufkin, Myatt	14	1.50
		Totals	257	2.07
07	1-7	Teller (McCurtain, Choctaw and Bryan Counties)	32	2.00
		Bluestem Hills Problem Area		
07	1-4	Newtonia	4	2.50
02 05	1-7 1-2	Summit, Woodson	31	2.13

TABLE IX (Continued)

Bluestem Hills Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
20 28	3-4 5-7	Sogn	5	2.00
06	1-7	Labette	30	1.83
03 04	1-4 1-4	Osage, Muir, Verdigris	11	1.47
08 09	1-2 1-2	Verdigris, Mason	9	1.22
		Totals	90	1.84
		Ozark Highlands Problem Area		
05	1-7	Guthrie	10	2.10
08 09	1-4 1-7	Huntington, Roane, Melvern	51	1.94
01 02 17	1-4 3-4 1-2	Summit	5	1.80
06 19	1-7 3-4	Lawrence	40	1.72
07	1-7	Nixa, Baxter, Cabanal	85	1.66
20 24 25	1-7 5-7 5-7	Bodine	26	1.65
		Totals	217	1.76
		Ouachita Highlands Problem Area (Arkansas Valley, Boston Mts. and Ouachita Mts.)		
07 20	1-7 3-7	Linker, Cleburne, Waynesboro	280	1.82
12 70	3-7 1-7	Dougherty, Stidham, Teller	24	1.79
09	1-7	Pope	64	1.75

TABLE IX (Continued)

Ouachita Highlands Problem Area (Continued)

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
08 04	1-7 1-4	Philo	87	1.71
05 06 19	1-7 1-7 3-7	Conway, Enders, Tyler	102	1.70
25 27	3-7 3-7	Hector, Pottsville	15	1.60
03 03	1-2 5-7	Atkins	5	1.40
05	1-7	Parsons, Taloka, Le Flore	49	1.32
		Totals	626	1.73

Cherokee Prairies Problem Area

SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
09	1-7	Verdigris, Cleora, Mason	109	2.25
03 04 08	1-7 1-7 1-7	Verdigris, Osage, Lightning	164	2.10
01 02	1-7 1-4	Okemah, Woodson	43	1.98
17 18 19 24 25 27	3-7 3-4 5-7 3-7 3-7 3-4	Talihina, Collinsville	45	1.76
05	1-7	Parsons, Taloka, Cherokee	343	1.68
07 20	1-7 3-7	Bates	359	1.57
06	1-7	Dennis, Choteau	529	1.55
		Totals	1592	1.70

TABLE IX (Continued)

Ozark Highlands (Prairie) Problem Area				
SCS Soil Unit	Land Capability Class	Major Soils	No. Tests	Index
02	1-7	Summit	50	2.34
01 17	1-4 3-7	Woodson	20	2.10
04 04	1-2 5-7	Muir	4	1.75
07 19 25	1-7 3-7 5-7	Newtonia, Craig, Cabanal, Riverton	134	1.67
08 09	1-2 1-7	Huntington	26	1.62
20	5-7	Bodine	50	1.58
05	1-7	Parsons, Gerald	57	1.46
06	1-7	Dennis, Lawrence, Choteau	136	1.43
		Totals	477	1.66

APPENDIX D

L E G E N D

AREA DESCRIPTION BY TYPE-OF-FARMING

AREA 1

1. Cash grain and livestock.
1A. Largely range livestock.

AREA 2

2. Somewhat broken topography-some small grains, feed crops, livestock.
2A. Cash wheat primarily.
2B. Cash wheat primarily.
2C. Sandy area, general farming.

AREA 3

3. Cash grain, general farming.
3A. A wooded area of sandy soil, general farming, some cotton produced on this strip.

AREA 4

4. Range livestock-some general farming.

AREA 5

5. General farming, livestock, dairy, poultry, and self-sufficing.

AREA 6

6. Cash grain, general farming, cotton, livestock.
6A. Rough, sandy area, scarcely any farming, some range livestock.
6B. Wooded area, general farming, and cotton.

AREA 7

7. General farming, cotton, livestock, dairy, and poultry.

AREA 8

8. Cotton, general farming, self-sufficing, dairy (an area of generally poor soil, except on small bottoms).

AREA 9

9. Cotton, some dairy, potatoes, commercial vegetables, self-sufficing.

AREA 10

10. Some fruit, general farming, dairy and poultry, self-sufficing (rough wooded land).

AREA 11

11. Cotton, supplemented with cash grain, livestock, dairy, and poultry.

AREA 12

12. Cotton, cash grain, livestock, some dairy and poultry.
12A. Range livestock.
12B. Sandy, wooded section, cotton, general farming.

AREA 13

13. Cotton, livestock, general farming, broomcorn.

AREA 14

14. Cotton, self-sufficing, livestock (rough mountain and wooded area).

AREA 15

15. Range livestock, general farming, self-sufficing.
15A. Cotton.

AREA 16

16. Cotton, general farming.

Figure 10. Preliminary Type-of-Farming Map of Oklahoma

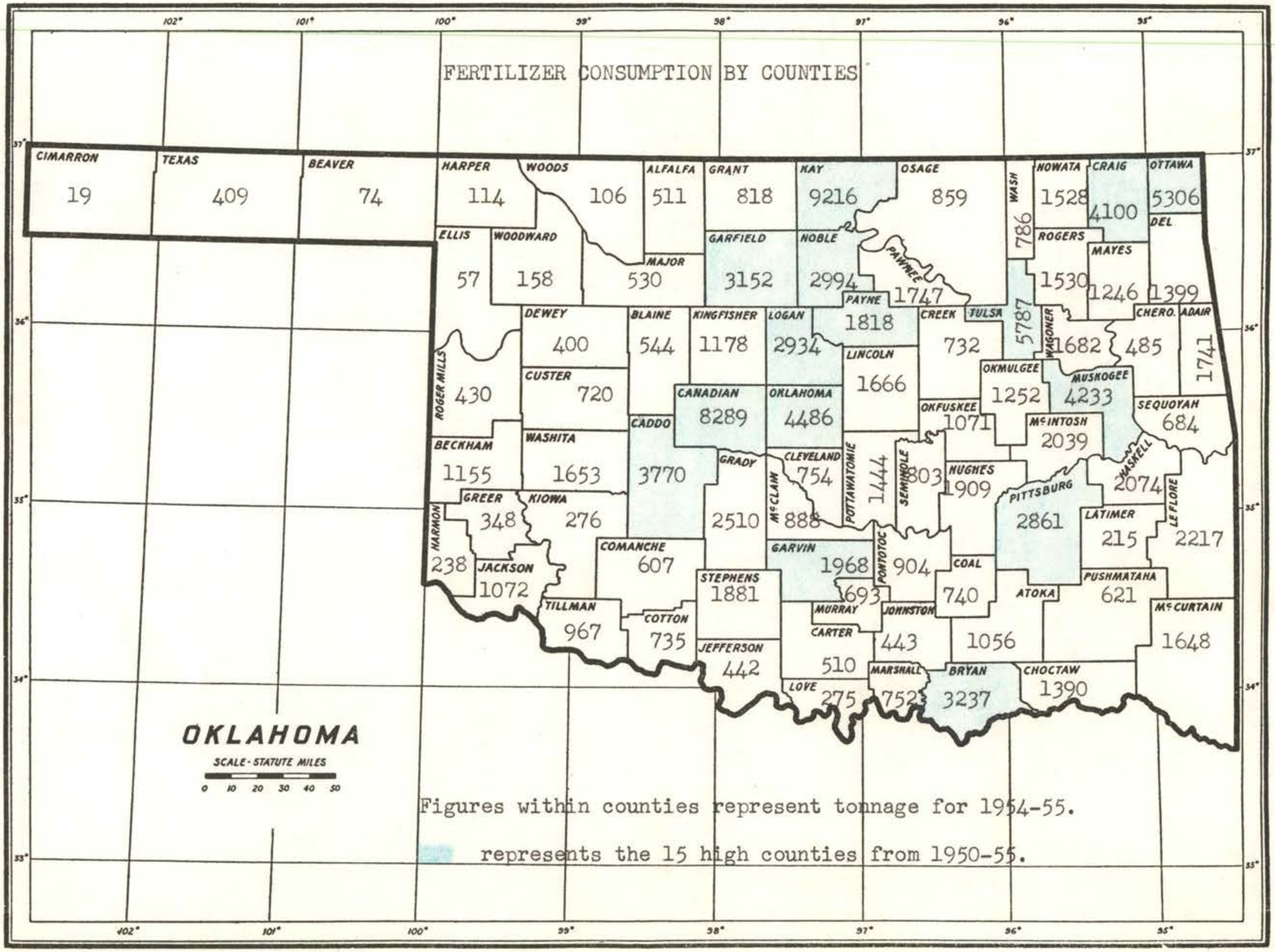

Figure 11. Fertilizer Consumption by Counties

VITA

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