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To the Graduate Council:

I am submitting herewith a thesis written by Oliver W. Rice, Jr. entitled "Relationship of pH, Phosphorus and Potassium of Soil Layers Among Fifty Soil Series in Tennessee." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

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RELATIONSHIP OF pH, PHOSPHORUS AND POTASSIUM OF SOIL LAYERS
AMONG FIFTY SOIL SERIES IN TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Oliver W. Rice, Jr.

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CHAPTER I

INTRODUCTION

Recommendations for the use of lime and fertilizer in Tennessee are based on soil tests made on samples from the top 6 or 7 inches. Values of pH and "available"¹ phosphorus and potassium for the surface layer may vary greatly because of past fertilization and cropping, and may not be related to values for soil layers below. These subsoil layers are well within the rooting depth of most crops and are, therefore, a potential source of nutrients.

Since it is likely that the pH and phosphorus and potassium levels of subsoil layers of Tennessee soils influence plant growth, and because there is little information on the levels in subsoils, a portion of this study was devoted to this problem. The information obtained could improve interpretations of observed responses to fertilization and lead to more accurate fertilizer recommendations.

Although fertility status, per se, is not a criterion for differentiation of soil series, it is often a clue to less easily measured differences. Together, these may be phase-differentiating criteria. The relationship of fertility status to certain soil horizons is of interest to the pedologist as well as to those interested only in fertilizer recommendations. Three problems important to soil classification and soil test interpretation were a part of this study.

¹Phosphorus and potassium levels as determined by the chemical soil tests used in this study. These tests are outlined in Methods and Procedures. References hereafter will omit the "available."

In Iowa, phosphorus in the B horizon of soils from loess decreased as the distance of the soil from the source of loess increased (14). Wascher, et al. (43) showed that loess in Tennessee thins with distance from the Mississippi River bottoms and that along the eastern edge of the loess area where the total loess was less than 4 feet thick, Peorian loess could not be distinguished from the older, more highly weathered loess. Loess thickness over material of marine, alluvial, or residual origin, distance from loess source, and landscape features associated with loess differences can be consistently recognized by soil scientists and could be recorded in mapping if needed. It was therefore desirable to test the hypothesis that observable differences in loess in which the Memphis soils have developed are associated with subsoil acidity and phosphorus and potassium levels. This would clarify the classification of these soils and aid in understanding the soil test characteristics.

West Tennessee Plateau Slope bottom soils whose parent materials are alluvium from either loess or loess and Coastal Plains may reflect in their soil test values the dissimilarity in parent material. Soils formed in alluvium from Coastal Plains formations and loess have been classified in the Hyman catena and those from alluvium predominantly from loess have been classified in the Collins catena. Hyman and Collins are moderately well-drained. Ina and Falaya are somewhat poorly-drained. Both catenas were mapped until 1961, when the Hyman was inactivated due to uncertainty that alluvium from the two sources could be consistently separated in mapping, and because of evidence that there were few, if

any, mineralogical differences in medium textured alluvium from the two sources.² Some of the medium textured types of the Hymon catena overlapped with and are presently classified in the Collins catena. New soil series descriptions of the soils now classified in the Collins catena are not complete. If differences in the phosphorus and potassium content of the bottom soils are associated with the alluvium source, as represented by soil series and location, they could have implications in classification as well as fertilization.

Soils in a catena have formed from similar parent materials but have different properties associated with differences in drainage. The drainage differences have influenced the processes of development in these soils, resulting in characteristic morphology used by soil scientists to differentiate series. These processes may also have resulted in characteristic soil test values for these soils.(3). The 12 to 24 inch subsoil fertility values of soils of the Collins, Mountview, and Huntington catenas were studied to determine what soil test differences, if any, were in soils of the same catena and to see if there were similarities in soil test values of catena analogues.

Throughout its history, the state soil testing laboratory has analyzed air-dry samples. This procedure is convenient for soil testing laboratories; however, it has become increasingly evident that testing air-dry soil may not give the same values as testing field-moist soil. Therefore, it was desirable to compare soil test values obtained from air-dry samples with values obtained from samples maintained at field

²Soil Survey Staff. SCS, USDA. Tentative descriptions of bottom soils of West Tennessee. 1961.

moisture level until analysis, and to interpret the difference, if any, in terms of lime and fertilizer recommendations.

The objectives of the study were to:

- 1) Characterize the profiles of several representative Tennessee soils in relation to pH and phosphorus and potassium levels.
- 2) Make certain soil test comparisons of interest in soil classification and soil test interpretations.
- 3) Find soil test relationships among soils in each sampling area and between sampling areas.
- 4) Compare the test values of pH and the levels of phosphorus and potassium of soil samples maintained at field-moisture level until analysis with the values of paired samples air dried before analysis.

The data for this study were obtained through a cooperative program of the Agricultural Extension Service and the Agricultural Experiment Station, University of Tennessee, and the Soil Conservation Service, United States Department of Agriculture.

CHAPTER II

LITERATURE REVIEW

The pH and nutrient levels of the soil layers below the top 6 or 7 inches have received relatively little attention in the soil fertility literature. Many of the reports of chemical properties have been for determining the genesis and classification of soils. Some of the information is difficult to interpret in terms of soil-plant relationships.

Winters and Simonson (45) have summarized the information on the kinds, characteristics, and behavior of subsoils by soil groups. They pointed out the growing interest in what lies beneath the surface soil and also in the effects of the subsoil on plant growth responses. They further suggested that the quantity of mineral plant nutrients in the subsoil of many soils is deserving of more study.

For many states, soil testing summaries and soil fertility maps (2,4,31,39) have been prepared. In general, these summaries have been limited to results of surface soil samples analyzed by soil testing laboratories. They give little information about soil fertility levels in the remainder of the profile. Except in areas where little lime and fertilizer have been used, these summaries do not give an estimate of pH and phosphorus and potassium levels which is independent of the soils use and management. For this reason, surface sample results may vary as widely within a soil series as among soil series.

I. CORRELATION OF SOIL TESTS WITH SOIL SERIES

A relationship between soil series and surface soil test values, if established at all, would most likely be found in areas where fertilizers have not been used extensively.

Rouse and Bertramson (34) determined the potassium supplying power of the surface soil of 23 Indiana soil types. The exchangeable potassium levels were affected by the previous cropping and fertility practices and were not correlated with the supplying power or with soil type. Supplying power appeared to remain rather constant within a soil series and type from one location to another. They stated that these findings confirm and emphasize that potassium supplying power is a soil type characteristic. They concluded that both exchangeable potassium and the supplying capacity, as chemical characteristics of the soil type, are needed to outline the best potassium fertilization program.

Olson et al. (28,29) classified the major Nebraska soil series into definite categories with regard to pH, phosphorus and potassium status. These soils had received little lime or commercial fertilizer during 50 to 100 years of cropping. The pH, phosphorus and potassium values of the subsoil were closely correlated with the values of the topsoil. Soluble phosphorus, exchangeable potassium and pH were relatively uniform within a soil series, but varied greatly among soil series. In 62 fertility experiments in which soluble phosphorus levels of the 0 to 6 inch layer of certain soils were correlated with crop yield responses to fertilization, the soil series had a highly significant soil fertility connotation with respect to pH and soluble phosphorus.

II. SUBSOIL REACTION AND FERTILITY LEVELS AND THEIR USE

In areas where use of lime and fertilizer has been appreciable, surface soil values may have serious limitations in estimating the fertility status of a soil series. If subsoils do not have this limitation, an alternative is to show that the subsoil reaction and fertility levels have a predictable influence on plant nutrition. It would then be possible to determine the reaction and fertility level of the subsoils of soil series and to use the information in conjunction with surface soil tests to recommend fertilizer.

Fitts and Nelson (13), in a review of soil testing, discussed the usefulness of information about the lower profile characteristics relative to plant nutrient availability and to acidity. They pointed out that under most farming conditions the fertility characteristics of the soil profile below the surface soil do not change materially in a short time.

Winters and Simonson (45), in discussing the differences between fertility levels of the A and B horizons, stated that the movement of amendments into the deeper horizons is slow except for nitrates and sulfates. Therefore, the original relationship of nutrient level between these horizons may be obscured under cultivation because of fertility changes in the A horizon.

Brown et al. (7) reported the profile distribution of pH of a fine sandy loam (50 percent clay plus silt) at intervals over a 23 year period in Connecticut after having various rates of limestone applied to

permanent sod. Limestone at the rates of 2, 4, 8 and 16 tons per acre on the surface in 1930 increased the pH to depths of 6, 12, 15 and 24 inches, respectively, 9 years later. The pH, 23 years after liming, had increased to depths of 8, 10, 24 and 30 inches, respectively. The greatest difference in pH in the subsoil after 23 years was 0.2 pH units. The pH, 2 years after liming, showed that even the unusually high rates of limestone had not affected the pH values nearly as deeply as had much less limestone after longer periods of time.

Wells and Parks (44) reported the vertical distribution of soil phosphorus and potassium on established alfalfa stands on Maury, Dunmore, Dewey and Dickson silt loams in Tennessee. Three soils received annual K_2O at rates of 400 pounds or less per acre per year for 4 years. One soil received annual P_2O_5 at rates of 180 pounds or less per acre for 4 years. Maury is naturally rich in phosphorus and received no phosphorus fertilizer. In these soils, added phosphorus was retained in the 0 to 3 inch soil layer and the added potassium was retained predominantly in the 0 to 6 inch layer. Only at the higher rates of fertilization was there significant movement of potassium to depths below 6 inches.

Even though fertilizer additions remain predominantly within the plow layer, it is generally agreed (13) that the nature of the profile below this layer influences the growth of plants and the yields obtained.

In Nebraska, Olson et al. (27), in 88 experiments, measured the response of corn and grain sorghum to phosphorus starter fertilizer. They found equal numbers of positive and negative responses to the

starter and concluded that subsoil phosphorus contributed substantially to the crops' nutrition, especially when the surface soil phosphorus level was low, but that blanket recommendations of starter could not be made for Nebraska.

In assessing the importance of subsoil phosphorus to corn, Murdock and Engelbert (26) found that in 2 of 4 soils studied, corn recovered more fertilizer phosphorus from the 6 to 12 inch layer than from the plow layer. Recovery in the other 2 soils was almost as great from the 6 to 12 inch layer as from the plow layer. Recovery from any layer below 12 inches was considerably less than from the top 12 inches. However, the combined recovery from the lower layers was appreciable. The conclusion was that subsoil as well as topsoil levels of phosphorus should be considered when fertilizer recommendations were made.

Fitts and Nelson (13), in stressing the importance of characterizing the fertility level of the subsoil, suggested a general soil map giving the characteristics of the lower profile relative to acidity and to nutrient availability. With this map and topsoil sample results, recommendations and interpretations could be made.

Subsoil fertility and reaction levels for soil series have been established in Nebraska and Michigan. Olson et al. (28,29) reported that the important Nebraska soil series have been established in definite categories with regard to pH and potassium and phosphorus levels. Michigan (42) has classified each soil type into one of 5 subsoil fertility classes and uses this information in conjunction with surface soil tests

and other data to arrive at lime and fertilizer recommendations.

When soil tests are not made, Tennessee (1) makes a different fertilizer recommendation for crops grown on soils in the Mississippi River Bottoms and the phosphatic soils of the Central Basin than for the rest of the state. The soils in these regions are designated "high phosphate soils." When surface soil tests are made, there is no distinction between recommendation for these regions and the rest of the state.

III. ROOTING DEPTHS OF TENNESSEE FARM CROPS

To make inferences about the possible effects on crops of subsoil reaction and nutrient levels, it would be helpful to know the depth to which crops root and the amount of roots in subsoil layers.

The depth of rooting and weight of roots of a few important agricultural crops growing on the major soil series of Tennessee have been determined by Long (23). Alfalfa was found to have root systems as deep as 7 feet on a Pembroke silt loam and as shallow as $22\frac{1}{2}$ inches on a Dickson silt loam. This range was the greatest of the crops studied. Cotton was found to have root systems as deep as 37 inches and as shallow as 18 inches at maturity. Of root systems studied, cotton was the least extensive and alfalfa was the most extensive.

Corn was found to root slightly deeper than cotton on the poorly drained Calhoun and the well drained Lintonia in a dry year. In a year of more abundant rainfall, corn rooted about twice as deeply as cotton on the poorly drained Almo. The most general rooting pattern was one in which root weight consistently declined with depth. This pattern was

observed for cotton and corn on red and brown well drained soils. However, on some gray and yellow soils of restricted drainage, the root weights of cotton were lower in the surface 6 inches than in the 6 to 12 inch and the 12 to 18 inch layers. Within the 16 to 24 inch zone, the weight of corn roots was greater than in the layer immediately above, but less than in the surface 6 inch layer.

Long did not establish a consistent relationship between rooting depth and fertility status of the subsoil. He found roots in soil both low and high in pH and levels of phosphorus and potassium. High cotton yields were explained in part by a favorable fertility status of the deeper soil horizons. However, the study indicated that high levels of phosphorus and potassium in the subsoil did not in themselves promote root development.

Peace³ determined the rooting depth of well fertilized corn on three soils in Putnam County, Tennessee, in a year of ample rainfall. The average rooting depths of 6 sites for each soil were 37 inches for Huntington silt loam, 33 inches for Waynesboro silt loam, and 21 inches for Dickson silt loam.

Smith,⁴ using the moisture extraction pattern to estimate the depth of active root distribution, reported evidence of corn, cotton and

³Peace, R. A. The productivity of Huntington, Waynesboro, and Dickson soils for corn under high levels of management. Unpub. M. S. thesis, University of Tennessee, Knoxville, Tennessee, 1961.

⁴Smith, H. B. Soil moisture extraction pattern of different soil-crop combinations as determined by a neutron meter. Unpub. M. S. thesis, University of Tennessee, Knoxville, Tennessee, 1961.

soybean roots in the upper 2 feet of the profile during early growth. In later stages of growth, roots appeared to move into deeper layers. Established perennial crops such as alfalfa, Bermudagrass and fescue had extraction patterns indicating active rooting to depths of approximately 42 to 60 inches. There is ample evidence from these studies that roots of many Tennessee crops penetrate subsoils to depths sufficient for the reaction and fertility to significantly affect the crop.

IV. EFFECTS OF DRYING ON SOIL TEST VALUES

The effect of drying on the results of routine soil tests has received much attention in recent years. A point of interest has been the change in soil test values resulting from testing field-moist, air-dry, or oven-dry samples and the correlation of these results with crop responses to fertilization.

Almost all laboratories have made routine analyses on air-dry samples (13). Should the results obtained with this procedure be discredited, methods of handling samples and making interpretations would need to be re-examined.

Fitts and Nelson (13) reviewed the procedure used by soil testing laboratories for conditioning samples before analysis. They indicated that potassium values may change due to drying but they did not discuss whether or not drying may affect the phosphorus soil test values or pH.

Chapman et al. (8) studied the change of pH in composite samples stored moist. These samples were from 4 soils that ranged in field-moist pH from 3.8 to 7.8. They also studied the effects of air drying and oven

drying. The storage of moist samples in cans at room temperature for as long as 5 days did not materially alter the pH value. Air drying and rewetting gave a value for one sample definitely lower than the corresponding field-moist sample. Further studies were made on a large group of soils sampled by 6 inch layers to a depth of 36 inches. The greatest difference in pH between field-moist and air-dry samples was less than 0.2 pH among 40 samples from 10 soils. The pH values obtained immediately after wetting the soil to the sticky point or wetter were not significantly different from those obtained after the soils had been moist for longer periods. They further concluded that tests of air-dry samples gave values not significantly different from pH values determined on field-moist samples.

Few references on the effect on phosphorus of drying soil samples were found. Grava et al. (15) reported that topsoil samples of a Nicollet clay loam in Minnesota that received various fertilizer additions increased slightly in extractable phosphorus by air drying. The greatest increase was 18 percent where no phosphate was applied, contrasted with 11 and 10 percent where 240 and 480 pounds P_2O_5 were applied, respectively. Keogh⁵ found that temperatures around 100°C. could not be used for drying fine-textured soils of Minnesota because the amount of phosphorus subsequently extracted was increased considerably over results obtained with air drying.

⁵Keogh, J. L. A study of soil testing methods for Minnesota soils. Unpub. Ph. D. thesis, University of Minnesota, Minneapolis. 1953.

Jackson (20) stated that freshly taken field-moist samples are best for measurement of the chemical conditions existing in the field. Storage in the moist state may decrease the dilute acid extractable phosphorus; air drying samples, especially of acid soil, may increase it by 10 to 30 percent. Oven drying samples, especially of acid soils, may increase the extractable phosphorus by over 100 percent; with limed and fertilized soil, drying may decrease it.

The extensive literature on the effects of drying on potassium in soils generally shows that if a change occurs, drying tends to decrease the content of exchangeable potassium in soils treated with soluble potassium salts, and to increase it in soils not so treated. The release or fixation of exchangeable potassium upon drying is related to the initial level of exchangeable potassium and the degree of drying (33). Takyi and Caldwell (41) found that addition of potassium to three Minnesota soils before air drying or oven drying resulted in a fixation of some of the applied potassium. The amount of applied potassium fixed increased with increasing intensity of drying. Fixation occurs when the initial level of exchangeable and soluble potassium is high, while release occurs when the level of these forms is relatively low (35). The clay minerals, especially the 2 to 1 types, influence potassium fixation and release in soils (33). In 6 Kentucky soils that Dowdy and Hutcheson (11) studied, there appeared to be an association of illite with release of potassium on drying, vermiculite with fixation in the moist state, and montmorillonite with fixation at low moisture levels.

The release of potassium to the exchangeable form upon drying is paralleled by increased uptake of potassium by plants. Scott (36) found that potassium uptake with soybean plants was always greater from previously dried soil than from that kept continuously moist. Leubs et al. (22) observed variable increases in exchangeable potassium content upon air drying 13 Iowa soils, and found corresponding increases in potassium uptake by corn plants grown in the greenhouse. Dowdy and Hutcheson (12) observed similar results with Sudangrass. Leubs et al. (22) demonstrated that under field conditions, the fluctuation in soil moisture levels in the surface one inch layer was accompanied by marked changes of exchangeable potassium over an 11-week period. Below this layer, exchangeable potassium remained nearly constant since moisture content did not drop as low as in the surface.

Because fixation and release are related to the equilibrium of exchangeable and fixed potassium, perhaps potassium commonly would be released to the exchangeable form by subsoils, and fixation would occur with fertilized surface soils. This expectation was partially substantiated by Hanway and Scott (16). Both the subsoil and surface soil of 4 Iowa soils released potassium upon drying but the subsoil released greater amounts.

On 10 Iowa soils, Hanway and Scott (17) determined potassium release in 0 to 6 inch samples and in 18 to 24 inch samples. The increase of extracted potassium by oven drying of samples was much greater for subsoils than for surface soils.

Whether air-dry or field-moist sample results are most closely correlated with the potassium available to crops is still questionable (5). There is not yet a consensus of opinion as to the best method of handling samples before testing.

As an example of the data supporting conflicting views, Jones et al. (21) showed better correlation of crop yields with results from air-dry samples than from field-moist samples. Matthews and Sherrell (25) found a close correlation between the potassium supplying power of the soil and exchangeable potassium measured in oven-dry soil. It was postulated that results from the oven-dry samples should, therefore, give a closer correlation with yield than results from field-moist samples. On the other hand, Luebs et al. (22), working with surface soil materials of 13 Iowa soils series studied in the greenhouse, found the potassium supplying power was better correlated with the exchangeable potassium content of the undried soil than with the air-dried soil.

CHAPTER III

METHODS AND PROCEDURES

Profiles of fifty series were sampled at 4 to 39 sites for each series (Appendix A). Sampling was according to "Procedure for Taking Soil Samples for the Soil Fertility Inventorying Program," Appendix B, prepared jointly by the Agricultural Extension Service and the Agricultural Experiment Station, University of Tennessee, and the Soil Conservation Service, United States Department of Agriculture.

I. FIELD AND LABORATORY PROCEDURES

Soil series were selected for sampling because they were important agriculturally, were representative of a large group of soils of an area, or were not well characterized in relation to soil fertility.

The need for soil fertility information for a particular soil series was considered in determining the number of sampling sites. Series for which most accurate estimates were desired, and those whose subsoil fertility was thought to vary considerably, were sampled most intensively.

For sampling purposes, the state was divided into 7 sampling areas along physiographic boundaries shown in Figure 1. The names of the sampling areas follow those assigned by Pond (32). The number of sample sites of each soil, the sampling area in which the soils were sampled, and an identifying symbol for each soil are given in Appendix A.

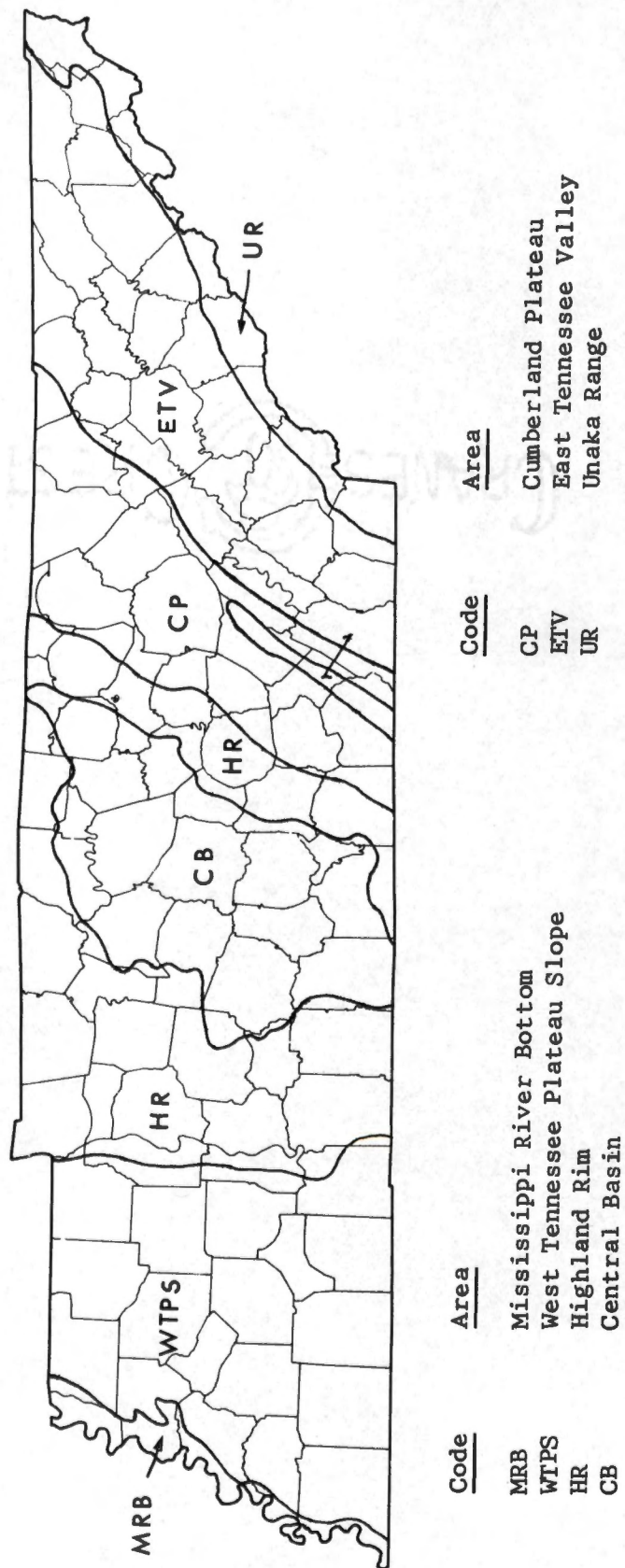


Figure 1. Map of Tennessee showing areas in which soils were sampled.

The general area for sampling was assigned according to the known distribution of the soils. The exact sites were determined by local soil scientists of the SCS. Each selected site was similar to the central concept of a series and was more than one mile from other sites of the same series. At each site, samples of individual layers of the profile were collected with a bucket auger or post hole digger to a depth of 42 inches or rock. Some samples were taken in the winter of 1959; others in the early spring of 1962. A short profile description for each site was prepared by the soil scientist at the time of sampling. An example of this information is in Appendix C.

The soil from each layer was mixed before being placed in containers. Each sample to be analyzed in field-moist condition was put in a plastic bag and sealed before being placed in a quart ice cream carton. Samples to be analyzed in the air-dry condition were placed directly in quart cartons and mailed to the State Soil Testing Laboratory. After arrival at the laboratory, some samples were prepared for testing by air drying the soil and grinding to pass a 2 mm. sieve. Field-moist samples were kept sealed in the containers until tested.

Five grams of soil were weighed from the field-moist samples on a torsion balance. The air-dried samples were measured volumetrically to give approximately 5 grams of air-dried soil as is done routinely in the State Soil Testing Laboratory.

The soil extracting solution used for both phosphorus and potassium was 0.05 N. H_2SO_4 containing 1 percent of $(\text{NH}_4)_2\text{SO}_4$. The soil-solution ratio was 1 to 4. Phosphorus and potassium extracted by this

solution are commonly referred to as "available" phosphorus and "available" potassium because of correlation with crop yields.⁶ This test is currently being used by the Extension Service as a basis for recommending fertilizer to Tennessee farmers. The directions for preparation and for routine use of the extracting solution for phosphorus and potassium are given in Appendix D.

Phosphorus was determined colorimetrically with a spectrophotometer after having ammonium molybdate added and being reduced with aminonaphthol-sulfonic acid reagent to develop the blue color. Potassium was determined directly with a Perkin-Elmer flame photometer.

The pH for both air-dry and field-moist samples was determined on a suspension prepared with equal parts soil and distilled water. The suspension was allowed to stand 30 minutes with periodic mixing. At the end of 30 minutes, this suspension was again stirred and the pH determined with a Beckman glass electrode pH meter.

Air-dried samples were tested by the method used by the Extension Service for routine analysis of samples sent in by farmers.

Because of difficulty of handling, the field-moist samples were not treated in the routine way used for air-dry samples. Five grams of the field-moist soil were taken from the bulk sample and placed in a mixing cup. Twenty milliliters of the extracting solution were added to the sample. The soil and extracting solution were stirred from 2 to 3 minutes

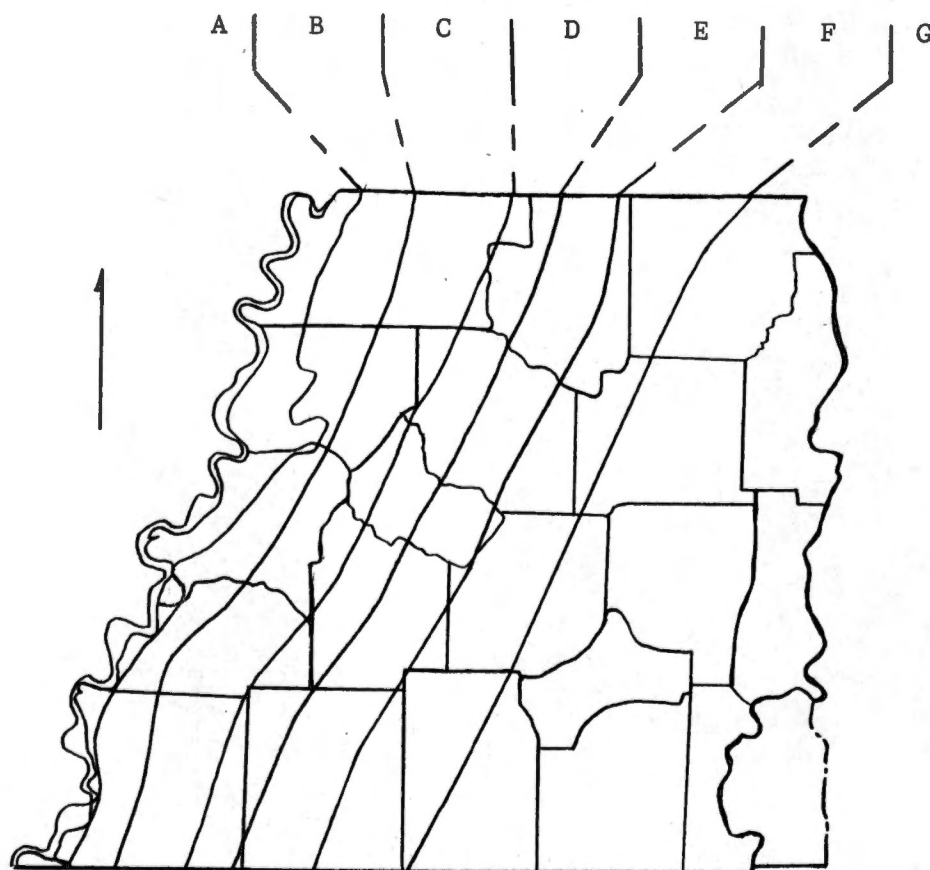
⁶Bishop, W. D. Prediction accuracy evaluation of five soil test methods. Unpub. M. S. thesis, University of Tennessee, Knoxville, 1954.

with a milk-shake mixer. This mixing time was sufficient for most samples. The analysis from this step forward was identical to the routine analysis.

II. METHODS AND STATISTICAL PROCEDURES FOR COMPARING SOILS AND SOIL TESTS

Soil Test Values of Memphis in Relation to Loess Areas

For purposes of the study, each of the 39 Memphis sites was designated as to location by (a), (b) and (c). These are referred to as "bands" in the discussion. The Memphis sites in band (a), referred to as Memphis (a), etc., were sampled in an area where the Peorian loess was described by Wascher et al. (43) (Figure 2) as being more than 15 feet in thickness and calcareous at some depth. The total thickness of loess in this area ranged from 15 to 70 feet. Memphis (b) sites were sampled in the areas described by Wascher et al. as having a Peorian loess sheet from 5 to 15 feet thick and designated by them as C, D, and E.. Memphis (c) samples came from an area designated by Wascher et al. as area F and as having a Peorian loess sheet 4 to 5 feet thick. In addition to being identified as to loess band, an estimate was made of the loess thickness at each sample site. Memphis (a) sites were sampled where the loess was a near-maximum thickness and the landscape strongly dissected; Memphis (b) where the loess thickness was estimated to be 6 feet or thicker; and Memphis (c) where the loess thickness was estimated to be from 42 inches to 6 feet.



Legend:

- Loess Area A - Major bottomlands (probable source of loess)
- Loess Area B - Peorian loess mostly more than 15 feet thick (calcareous loess present)
- Loess Area C - Peorian loess mostly 10 to 15 feet thick
- Loess Area D - Peorian loess mostly 7 to 10 feet thick
- Loess Area E - Peorian loess mostly 5 to 7 feet thick
- Loess Area F - Peorian loess mostly 4 to 5 feet thick
- Loess Area G - Total loess mostly 3 to 4 feet thick

Figure 2. Loess areas of the West Tennessee Plateau Slope (after Wascher et al. (43)).

Tests of differences in the pH and phosphorus and potassium values of the B2 horizons of the three groups of Memphis samples were made by the analysis of variance.

Soil Test Values Among Bottom Soils of the West Tennessee Plateau Slope

The relationship between parent material and fertility status of 4 West Tennessee Plateau Slope bottom soils of the Hyman and Collins catenas was studied to help in classifying the soils and in recommending fertilizer for them. Hyman and Ina are members of the Hyman catena and Collins and Falaya are members of the Collins catena. The catena into which sample sites were placed was an indication of parent material source. An indication of the relative contribution of alluvium from loess and Coastal Plains was made by 4 bands approximately parallel to the Mississippi River and lettered (w), (x), (y), and (z), eastward to the north-flowing traverse of the Tennessee River. These bands were used to identify loess areas. There are more Coastal Plains outcrops as loess thickness decreases and a larger local supply of Coastal Plains sediments as the Tennessee River is approached. Loess areas on uplands (43) were clues to the probable supply and source of loess. Band (w) corresponds generally to areas B and C of Wascher et al.; band (x) to areas D and E; band (y) to area F and the western one-fourth of area G; and band (z) to the remaining three-fourths of area G eastward to the Tennessee River (see Figure 2).

Two series of each of these catenas were sampled at sites located in these bands with these exceptions: Hyman and Ina were not sampled in band (w) and Collins and Falaya were not sampled in band (z). These soils have not been mapped in these bands.

The analysis of variance of phosphorus and potassium of the 12 to 24 inch layer for soils and bands was made by the method of unequal number of observations (40).

Soil Test Values of the Subsoil Among Soils in a Catena

Differences in values of pH and levels of phosphorus and potassium of the 12 to 24 inch layer of three soils of each of three catenas were tested by the analysis of variance. Soils of the Collins, Mountview and Huntington catenas were used in these analyses.

Soil Characteristics of Fifty Soil Series

Soil test means ($\bar{x}$) and the sample standard deviations (s) of the 50 soils were calculated for layers 0 to 8, 0 to 12, 12 to 24, 24 to 36, and 36 to 42 inches, or to the maximum depth sampled if less than 42 inches.

The number of observations for some soil series was quite small. In addition, the population distribution may not be normal. This should be kept in mind in making interpretations of means and of sample population standard deviations. Within these limitations, the results can be applied with some confidence to soils similar in characteristics to those sampled (9, 10).

Soil Test Values of Air-Dry and Field-Moist Samples Compared

The results of soil tests on air-dry and field-moist samples were placed in one of 5 groups depending on the texture of the horizons and whether they were surface soil or subsoil samples. Each surface soil result was placed in one of two groups. One group, referred to as the loamy group, contained results of samples which had textures of silt loam, loam, sandy loam, sandy clay loam, clay loam, and silty clay loam. Another textural group, referred to as the clayey group, contained results of samples which had textures of silty clay, sandy clay, or clay. Subsoil results were divided into 3 groups. The third textural group, referred to as sandy, had textures of sand and loamy sand. These groups will hereafter be referred to as loamy, clayey and sandy.

The statistical analyses of the pH, phosphorus and potassium values determined on the air-dry and field-moist samples were made according to the procedure for paired observations (40).

CHAPTER IV

RESULTS AND DISCUSSION

I. SOIL TEST VALUES OF MEMPHIS IN RELATION TO LOESS AREAS

In the analysis of variance (Table 1) for the Memphis results, the soil test values of samples from the B₂ horizon were used. Some profiles had more than one layer of the B₂ sampled. In cases where 2 layers were sampled, the deeper layer was used. Where 3 layers were sampled, the middle layer was used. The average thickness of all the layers of B₂ horizons used was 10 inches. The average depth to the B₂ layers was 17, 15, and 20 inches for Memphis (a), (b), and (c) respectively. All sample sites were on 2 to 5 percent slopes except Memphis (a). Five of the 10 Memphis (a) sites were on 5 to 8 percent slopes. There was no difference in soil test means of samples from sites having different slopes.

Comparisons of mean soil test values for the three groups of Memphis soils are in Table 2. At the 0.05 level of probability, the mean pH of Memphis (a) was significantly lower than for the Memphis (c). All phosphorus means were significantly different, ranging from a low of 5 ppm. in Memphis (c) to a high of 32 ppm. in Memphis (a). Potassium means in B₂ layers of Memphis (a) were significantly higher, with 86 ppm., than in corresponding layers of Memphis (b) and (c).

The low pH in the Memphis (a) may have been due to more complete leaching of the solum because of the deeper permeable loess beneath.

Table 1--Analysis of variance of pH and phosphorus and potassium levels in Memphis B₂ horizons sampled in three loess bands

Source of variation	Degrees of freedom	Mean squares	F
pH			
Loess bands	2	0.54	4.53*
Error	36	0.12	-
Phosphorus			
Loess bands	2	2117.44	36.36**
Error	36	58.23	-
Potassium			
Loess bands	2	4385.66	9.95**
Error	36	440.90	-

*Significant at probability level equal to or less than 0.05.

**Significant at probability level equal to or less than 0.01.

Table 2--Comparisons of pH and phosphorus and potassium means of Memphis B₂ horizons sampled in three loess bands

No. of sites	Duncan's New Multiple Range Test		
	Memphis (a) 10	Memphis (b) 15	Memphis (c) 14
pH	5.40	5.58	5.82
Phosphorus (ppm)	31.5	15.1	4.6
Potassium (ppm)	86.0	55.3	48.9

Means not underlined by same line are significantly different at 0.05 level of probability.

The Memphis (c) is underlain at shallower depths by material of contrasting texture, and although a well drained soil has developed, water movement through the soil may not be as free as in thicker layers of permeable loess. In the Memphis (a), where profiles were sampled to a depth of 42 inches, a depth was not reached at which the pH increased appreciably (see page 54). In the deepest layer sampled, the highest pH of an individual sample was 5.9. The apparent anomaly in pH decrease as loess thickness increases should be investigated further.

The cause of the decrease in phosphorus and potassium associated with loess bands could not be determined from this study. There is agreement in these findings with those of Godfrey and Riecken (14) who found a decrease in the total phosphorus in soils as the distance from the loess source increased. A suggested explanation was the possible sorting of phosphorus minerals during the loess deposition; however, no data were presented on this. They recognized a decrease in phosphorus content of the profile as the degree of profile development increased. It was assumed that the major soil formation variable in the soils studied was the time of weathering. The relationships observed in the Memphis soil may have a similar explanation. In addition, Wascher et al. (43) presented evidence that showed the unweathered Peorian loess has more weatherable feldspar, mica and heavy minerals than the older loess sheets. He attributed the lower levels in the earlier loess layers to more weathering of these layers. However, the deeper late Sangamon was weathered less than the soil profiles developed from Peorian. In only a few places was the late Sangamon calcareous.

It appears likely that in areas from which the Memphis (c) samples came, the soil profile has developed in the total thickness of Peorian loess and portions, or all, of the older loess layers. In a part of loess band (c), Wascher et al. found the individual sheets could not be distinguished. Results for Memphis and those reported by Wascher and by Godfrey and Riecken could be interpreted to indicate that all Memphis have developed in loess that was similar when first deposited; however, the Memphis which has developed in loess a greater distance from the source has undergone soil formation for a longer period, is more highly weathered, and contains less available potassium and phosphorus than Memphis soils closer to the source where the loess is thicker, soil formation has proceeded for a shorter period, and the soil is less weathered. It is likely that these soils have differences in properties which this study was not designed to detect. The results do, however, indicate a classification problem.

The difference in subsoil pH and phosphorus and potassium levels in Memphis soils of three loess bands was striking. There is evidence to indicate (23) that the differences in subsoil fertility of this size may be detected in crop yield responses to fertilizer. The differences might be the deciding factor in whether a soil whose topsoil tested medium needed phosphorus and potassium fertilizers. Correlation of subsoil tests with crop response to fertilizer is needed to clarify this question.

II. RELATIONSHIP OF SOIL TEST VALUES AMONG BOTTOM SOILS OF THE WEST TENNESSEE PLATEAU SLOPE

The analysis of variance for the 12 to 24 inch layers is in Table 3. Disproportionate subclass numbers of observations required constants to be fitted to obtain unbiased estimates of soil and band effects. Significant differences between soil and band adjusted means and constants are presented in Table 4. The phosphorus mean of 3.7 ppm. for Collins, adjusted for band effects, was not significantly different from phosphorus means of the other soils. The phosphorus means for Falaya, at 4.7 ppm., was significantly higher than the means for Hymon and Ina. Potassium means for the 4 soils were not significantly different.

The phosphorus means for bands (x), (y) and (z) were not significantly different from each other, but the phosphorus mean for band (w), at 5.4 ppm., was significantly different from that for each of the other bands. Potassium means for the 4 bands were not significantly different.

Field textural estimates of the samples showed that approximately equal numbers of the Hymon 12 to 24 inch samples were loam and silt loam. Slightly more than half of the Ina samples were silt loam. In the remaining Ina samples, the texture was loam. Two Hymon samples had a sandy loam texture. The texture of all Collins and Falaya samples was silt loam.

These results agreed with those of Bell.⁷ In Haywood County, he sampled many profiles of Hymon, Ina and Falaya and found no differences

⁷Bell, F. F. Characteristics and productive capacity of Grenada and related soils in West Tennessee. Unpub. Ph. D. thesis, Iowa State College, Ames. 1956.

Table 3--Analysis of variance of phosphorus and potassium levels in 12 to 24 inch layers of 4 West Tennessee Plateau Slope bottom soils and 4 loess bands by method for disproportionate subclass number

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F
Phosphorus				
Soils and bands	6	154.12	-	-
Soils (adjusted for bands)	3	26.83	8.94	2.93*
Bands (adjusted for soils)	3	54.35	18.12	5.95***
Interaction (adjusted for soils and bands)	5	5.68	1.14	0.35 NS
Error	59	189.93	3.22	-
Potassium				
Soils and bands	6	1542.64	-	-
Soils (adjusted for bands)	3	1118.14	372.71	1.68 NS
Bands (adjusted for soils)	3	1440.70	480.23	2.17 NS
Interaction (adjusted for soils and bands)	5	1345.34	269.07	1.21 NS
Error	59	13076.80	221.64	-

*Significant at probability level equal to or less than 0.05.

***Significant at probability level equal to or less than 0.005.

Table 4--Comparisons of adjusted means of phosphorus and potassium of the 12 to 24 inch layers of 4 West Tennessee Plateau Slope bottom soils and 4 loess bands

	Phosphorus (ppm)		Potassium (ppm)	
	Constants	Adjusted means	Constants	Adjusted means
Overall soils and bands	-	3.5	-	27.8
<u>Soil</u>				
Hymon	-0.80	2.7 a	-0.98	26.8 a
Ina	-0.59	2.9 a	-3.39	24.4 a
Collins	0.18	3.7 ab	3.14	30.9 a
Falaya	1.21	4.7 b	11.22	29.0 a
<u>Band</u>				
(w)	1.93	5.4 a	-1.87	25.9 a
(x)	-0.85	2.6 b	-1.38	26.4 a
(y)	-0.37	3.1 b	-2.72	25.1 a
(z)	-0.71	2.8 b	5.96	33.7 a

Adjusted means for soils and bands not followed by same letter are significantly different at 0.05 level of probability according to Duncan's New Multiple Range Test.

in exchangeable potassium of the 18 to 24 inch layers of Falaya, Ina and Hyman at the 0.05 level of probability. At the same level of probability, however, he found that the 12 to 18 inch layer of Ina had 33 and 37 pounds more potassium per acre 6-inch than Falaya and Hyman, respectively. There were no significant differences in phosphorus levels in these layers.

In bands (x), (y), and (z), the evidence presented supports the concept that soils of essentially the same texture from alluvium have no significant differences in chemical properties. In band (w), however, compared to bands (x), (y), and (z), there were significant differences in amount of available phosphorus between soils of the same texture. Between bands (x) and (y), where both catenas were mapped, there were no significant differences. The significant differences were between soils of different catenas.

The subsoil layers of Coastal Plains upland soils were lower in phosphorus and potassium than soils from loess (Table 11). Alluvium from Coastal Plains would be expected to have different phosphorus contents. The predominant direction of stream flow in West Tennessee is northwestward into areas containing more loess. The streams may distribute the phosphorus-poor Coastal Plains sediments along the major streams to the Mississippi River. Memphis (c), Grenada, and Henry were also low in phosphorus, and the alluvium from these soils may also have contributed to the differences. Sediments from relatively unweathered loess sources, as well as the relatively phosphorus-rich Memphis (a) and Memphis (b), may have contributed to the increase of the phosphorus in bottom soils in loess band (b) and (c).

The small amounts of potassium may have been due to factors other than source of parent material. Bell,⁸ noting the low amounts of potassium in the bottom soils in comparison to the uplands, stated that the bottoms had a lower clay content and that smaller amounts of potassium would be released from the clay present.

The results indicated a relationship between source of alluvium and phosphorus levels in Falaya, Hymon and Ina. Falaya, a soil predominantly from loess, had significantly more phosphorus than the soils formed from alluvium from Coastal Plains materials and loess.

The implications to mapping are that the difference in parent material estimates for the catena members was valid (substantiated). In areas where both catenas were mapped, estimates of source of alluvium furnished more fertility information than was furnished by potential supply of parent material from the upland (represented by bands). In addition, that only the Collins catena was mapped in band (w) is evidence that the parent material was also correctly estimated in band (w).

The data support the source of parent material criterion for mapping both the Hymon and Collins catenas. However, other differences as well as the magnitude in phosphorus differences in the soil, should be considered. Only the magnitude of the significant phosphorus differences could be discussed here. The difference between 3 and 5 ppm. subsoil phosphorus for both soils and bands is probably inconsequential to management of these soils for most crops. If these were the only differences to be considered in the decision to map these soils in one or two catenas, the recommendation would be to map one catena. The slightly

⁸Ibid.

higher available phosphorus in the soils in band (w) could be used as information on subsoil fertility in addition to that supplied by soil series.

III. RELATIONSHIP OF SOIL TEST VALUES OF THE SUBSOIL AMONG SOILS IN A CATENA

The analysis of variance of the pH and phosphorus and potassium levels in soils of different drainage classes in each of three catenas is presented in Tables 5, 6 and 7. The Collins, Mountview and Huntington catenas of western, central, and eastern Tennessee, respectively, were studied. Collins, Falaya and Waverly are moderately well-drained, somewhat poorly-drained, and poorly drained members, respectively, of the Collins catena. They have formed from mixed alluvium predominantly from loess. These soils are excellent for many Tennessee crops. Waverly must be drained for most crops. Drainage is sometimes difficult; hence, a much smaller proportion of Waverly is cropped than of Collins or Falaya.

In central Tennessee, Mountview, Dickson and Lawrence were studied. They are soils of the Highland Rim. Mountview is well drained, Dickson well or moderately well-drained and Lawrence is somewhat poorly-drained. Dickson has fragipans weakly or well developed and Lawrence has strongly developed fragipans. Repeated observations have shown that among these soils, those less well drained are less productive and less responsive to management, especially to applications of fertilizer. Perhaps these observations are related to the fertility of the subsoil as well as to other chemical and physical properties of these soils.

Table 5--Analysis of variance of pH and phosphorus and potassium levels
in 12 to 24 inch layers of Collins, Falaya and Waverly

Source of variation	Degrees of freedom	Mean squares	F
pH			
Soils	2	0.36	3.84*
Error	38	0.09	-
Total	40	-	-
Phosphorus			
Soils	2	15.64	2.19 NS
Error	38	7.13	-
Total	40	-	-
Potassium			
Soils	2	1561.11	3.94*
Error	38	395.64	-
Total	40	-	-

*Significant at probability level equal to or less than 0.05.

Table 6--Analysis of variance of pH and phosphorus and potassium levels in 12 to 24 inch layers of Dickson, Mountview and Lawrence

Source of variation	Degrees of freedom	Mean squares	F
pH			
Soils	2	0.65	3.71*
Error	22	0.17	-
Total	24	-	-
Phosphorus			
Soils	2	0.68	5.28*
Error	22	0.13	-
Total	24	-	-
Potassium			
Soils	2	187.71	1.41 NS
Error	22	133.20	-
Total	24	-	-

*Significant at probability level equal to or less than 0.05.

Table 7--Analysis of variance of pH and phosphorus and potassium levels in 12 to 24 inch layers of Huntington, Lindside and Melvin

Source of variation	Degrees of freedom	Mean squares	F
pH			
Soils	2	0.04	0.26 NS
Error	12	0.17	-
Total	14	-	-
Phosphorus			
Soils	2	3.08	0.58 NS
Error	12	5.35	-
Total	14	-	-
Potassium			
Soils	2	5625.40	7.28**
Error	12	772.76	-
Total	14	-	-

**Significant at probability level equal to or less than 0.01.

In eastern Tennessee, Huntington, Lindside and Melvin were studied. These bottom soils are members of the Huntington catena. Huntington and Melvin are well drained and poorly drained, respectively. Lindside is moderately well-drained or somewhat poorly-drained. All have formed from mixed alluvium predominantly from shale, limestone and sandstone. They are excellent soils for most Tennessee crops. Melvin is less often used for row crops than the other two.

Comparison of mean pH and phosphorus and potassium levels are given in Table 8. Mean pH and potassium in Waverly were significantly higher than in Collins and Falaya. The means for phosphorus were not significantly different.

In the analysis for the central Tennessee soils, 4 significant differences were found. The 12 to 24 inch layers of Mountview had higher pH values and contained slightly more phosphorus than corresponding layers of Dickson and Lawrence.

Means of pH and phosphorus values were not significantly different among the three soils of the Huntington catena. Potassium values of Melvin were significantly higher than for Huntington and Lindside.

Table 8 shows that in the Collins and Mountview catenas, mean pH increased as drainage improved, although not all differences were statistically significant. The reason for the increase is uncertain. The large amount of water moving through the profile of the more poorly drained soils may have resulted in a more thoroughly leached soil. If all the soils were highly leached, a higher cation exchange capacity in Waverly

Table 8--Comparisons of pH and phosphorus and potassium means of 12 to 24 inch layers of three soils in each of three catenas

	pH	Phosphorus (ppm)	Potassium (ppm)	No. of sites
Collins catena				
Collins	5.79 a	3.9 a	28.9 a	18
Falaya	5.75 a	4.9 a	27.0 a	18
Waverly	5.34 b	6.6 a	54.5 b	5
Mountview catena				
Mountview	5.80 a	1.9 a	40.2 a	5
Dickson	5.30 b	1.3 b	36.4 a	15
Lawrence	5.12 b	1.5 b	28.4 a	5
Huntington catena				
Huntington	6.69 a	3.2 a	55.8 a	5
Lindside	6.87 a	2.0 a	33.6 a	5
Melvin	6.81 a	3.5 a	99.5 b	5

Means in one catena not followed by same letter are significantly different at the 0.05 level of probability according to Duncan's New Multiple Range Test.

could have resulted in a lower base saturation and lower pH. The relatively higher potassium levels in Waverly could be explained by release of potassium from clay and/or weathering of potassium minerals replenishing the potassium lost through leaching. A weatherable source of calcium would not be present. In Dickson and Lawrence, the subsoil pH was below the optimum for most Tennessee crops and may partially explain observed response differences between these soils and Mountview. When crops are being selected for Dickson, Lawrence and Waverly, consideration of the low subsoil pH should be made.

The small differences in phosphorus levels between Mountview and the soils with fragipans have few, if any, implications to fertilizer use. If these were surface soil results, the same amount of phosphorus fertilizer would be recommended. Although there are no implications to fertilizer use in the results, the significant differences may be indicative of processes within the soil which are more significant to productivity than are the small differences in phosphorus, such as processes promoting stronger horizon development, slower internal drainage and poorer aeration. As pointed out by Godfrey and Riecken (14), slow internal drainage and poor aeration are associated with lower phosphorus values in loess. Phosphorus was also found to decrease as loess thickness decreased. The results of the present study may indicate that lower values of phosphorus are associated with stronger horizon development in loess of essentially the same thickness. The small differences among phosphorus levels of the 12 to 24 inch layer of these soils gave little

indication that low crop response to fertilizer on Highland Rim soils with fragipans is related to subsoil phosphorus.

Evidently poor drainage, or associated factors, is related to high available potassium in the subsoils of the bottom soils studied. A low potassium test in the better drained soils could result because more frequent cropping reduced the exchangeable potassium in the 12 to 24 inch layer. The exchangeable potassium in Melvin and Waverly could be higher because these soils have not been cropped or because they contain more clay. Other possible causes could be that the crops growing on these soils did not penetrate the layer or because the roots which did penetrate did not extract the potassium. It is also possible that the potassium values for the bottom soils are an accurate indication of the available potassium and that differential penetration or removal by roots are not factors.

IV. COMPARISON OF SOIL TEST VALUES AMONG FIFTY SOILS IN SEVEN SAMPLING AREAS

Tables 9 through 15 present means and sample standard deviations of pH and phosphorus and potassium levels among the 0 to 8, 0 to 12, 12 to 24, 24 to 36, and 36 to 42 inch soil layers of 50 soil series. Each table contains the results of soils sampled in one sampling area. The soils in each table are grouped by a common property such as source or kind of parent material. In addition, some soils are grouped according to texture. For a description of each soil, see the Soil Series Descriptions, SCS, USDA.

The discussion of the soil test value relationships among the soils of each group concerns largely the soil test values of the 12 to 24 inch layer and to a lesser extent, deeper layers. Because the surface soil is influenced by management and can be easily sampled, this layer receives relatively minor consideration.

Mississippi River Bottom Sampling Area

Table 9 shows that the pH and fertility levels of the Mississippi River Bottom soils varied considerably. Dundee, a high bottom, had a pH greater than 5.7 below 12 inches. Of the medium textured soils, Dundee was lowest in phosphorus, with 30 ppm. or less, compared to 36 to 52 ppm. in Robinsonville and Commerce. Sharkey clay had a pH somewhat higher than Dundee, and a phosphorus content of 13 to 16, compared to 18 to 29 ppm. for Dundee in the 12 to 42 inch zone. The pH values of Dundee and Sharkey were suggestive of older bottom soils. In the 12 to 42 inch layer, Commerce and Robinsonville had a pH above 7.3 and a phosphorus content greater than 35 ppm. The soil with the least amount of potassium was Robinsonville, with a low of about 53 ppm. in the 12 to 42 inch zone. This soil also has the least amount of clay. The highest potassium level was about 130 ppm. for Sharkey, the soil with the highest percentage of clay. Other soils had intermediate values of potassium and clay content. These soils have developed in sediments from the Mississippi River that have come from many kinds of soils over the watershed of the Mississippi River. The fertility levels of the soils in this group apparently have been influenced by the high fertility level of the sediments and nutrients transported in the water.

Table 9--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some Mississippi River Bottom soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Loamy Bottom</u>								
Robinsonville	0-8	6.9	0.63	71	30.1	112	41.5	5
	0-12	7.0	0.56	62	27.0	102	33.8	5
	12-24	7.3	0.33	36	17.1	71	17.1	5
	24-36	7.3	0.27	39	30.0	59	16.2	5
	36-42	7.4	0.20	49	38.3	53	14.0	5
Commerce	0-8	7.2	0.28	87	25.5	139	19.1	5
	0-12	7.2	0.26	78	21.2	121	16.0	5
	12-24	7.3	0.32	52	23.4	80	21.4	5
	24-36	7.4	0.38	46	25.5	70	20.8	5
	36-42	7.4	0.30	51	33.4	69	22.3	5
<u>Clayey Bottom</u>								
Sharkey	0-8	6.3	0.37	28	11.4	197	81.7	4
	0-12	6.3	0.38	25	12.1	187	72.0	4
	12-24	5.9	0.26	16	7.4	130	45.2	4
	24-36	5.9	0.41	13	1.2	126	18.4	4
	36-42	5.7	0.48	13	5.3	136	36.4	4
<u>High Loamy Bottom</u>								
Dundee	0-8	5.9	0.38	22	13.0	104	60.1	5
	0-12	5.9	0.30	21	13.3	99	61.4	5
	12-24	5.7	0.54	18	11.2	77	32.0	5
	24-36	5.5	0.48	30	22.4	72	21.8	5
	36-42	5.5	0.55	29	21.2	76	31.9	5

Central Basin Sampling Areas

Bottom soils. The phosphatic phases of Huntington and Lindside are bottom soils formed in mixed alluvium, parts of which have washed from areas high in phosphorus. Table 10 gives the soil test means and sample standard deviations for these soils.

The subsoil layers of Huntington and Lindside had pH means of 5.6 to 6.7, phosphorus levels of 89 to 120 ppm., and potassium levels of 43 to 52 ppm. The sample standard deviations of the values were large, except the standard deviation of potassium for Huntington.

Terrace and colluvial soils. The values for these soils can best be interpreted with reference to the source of parent material. Armour has developed in material coming predominantly from phosphatic areas. Captina has a fragipan and has developed in transported material coming largely from limestone. Captina is phosphatic or non-phosphatic depending on its parent material. Dellrose is on steep slopes and is underlain by residuum from phosphatic limestone, but the major part of the solum is in material that came from up-slope, non-phosphatic cherty limestone material.

The range in pH in subsoil layers of Dellrose and Armour was 5.8 to 6.2. The Captina pH values were somewhat lower.

Phosphorus was highest in Armour and Captina. It varied between 50 and 68 ppm. The phosphorus content of Armour varied widely from sample to sample. The mean phosphorus content would have been higher except that phosphorus values above 150 were recorded only as 150+ ppm.

Table 10--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some Central Basin soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Bottom-phosphatic</u>								
Huntington	0-8	6.6	0.32	124	45.9	56	14.0	10
	0-12	6.7	0.32	124	40.3	54	12.4	10
	12-24	6.8	0.33	120	34.3	46	10.2	10
	24-36	6.7	0.32	114	41.0	43	9.6	10
	36-42	6.6	0.25	119	44.9	45	12.3	10
Lindside	0-8	6.5	0.34	111	50.6	63	17.3	15
	0-12	6.5	0.32	120	50.7	58	16.9	15
	12-24	6.6	0.39	98	50.4	45	24.4	15
	24-36	6.6	0.47	96	58.3	51	45.4	15
	36-42	6.6	0.50	89	55.2	52	49.8	15
<u>Terrace and Col- luvial-phosphatic</u>								
Dellrose	0-8	5.8	0.31	16	17.2	74	32.2	10
	0-12	5.9	0.29	15	16.3	66	26.1	10
	12-24	6.1	0.33	16	14.7	41	11.1	10
	24-36	6.1	0.37	29	43.6	48	12.6	10
	36-42	6.0	0.42	26	44.6	53	13.4	10
Armour	0-8	6.2	0.38	47	45.6	66	18.7	9
	0-12	6.2	0.32	51	48.3	62	13.9	9
	12-24	6.2	0.29	59	57.3	52	12.5	9
	24-36	6.0	0.32	59	58.4	60	26.3	9
	36-42	5.8	0.36	64	59.0	65	31.4	9
Captina	0-8	5.7	0.32	62	49.4	150	214.0	5
	0-12	5.7	0.32	59	38.4	128	170.0	5
	12-24	5.6	0.42	48	11.0	63	48.4	5
	24-36	5.6	0.44	50	16.9	82	85.6	5
	36-42	5.9	0.52	68	57.8	99	101.3	5

Table 10 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Upland-phosphatic</u>								
Mimosa	0-8	6.0	0.38	75	50.6	108	60.0	5
	0-12	6.0	0.41	83	49.8	111	71.7	5
	12-24	5.9	0.46	118	56.3	109	87.2	5
	24-36	6.0	0.79	107	50.8	90	44.4	5
	36-42	5.7	0.76	150	00.0	78	15.3	3
Stiversville	0-8	6.0	0.29	76	55.7	52	16.2	5
	0-12	6.1	0.27	77	51.9	50	15.8	5
	12-24	6.1	0.27	88	54.8	48	14.7	5
	24-36	6.0	0.27	90	55.8	53	17.1	5
	36-42	5.8	0.35	84	48.5	58	22.6	4
Maury	0-8	6.2	0.31	54	41.9	76	26.4	8
	0-12	6.2	0.27	51	36.0	72	23.6	8
	12-24	6.2	0.34	48	45.2	62	14.7	8
	24-36	5.9	0.43	47	43.7	73	31.4	8
	36-42	5.8	0.50	50	43.1	86	45.7	8
<u>Upland</u>								
Talbott	0-8	5.9	0.49	3.1	2.28	64	21.8	5
	0-12	5.9	0.55	2.5	1.59	61	16.5	5
	12-24	5.7	0.57	1.4	0.41	53	7.0	5
	24-36	6.0	0.28	2.3	1.56	55	5.2	5
	36-42	5.8	0.30	2.6	1.65	60	12.2	4

Three Armour samples had 150+ ppm. phosphorus. Dellrose had 16 ppm. phosphorus in the upper subsoil. The Dellrose topsoil and upper subsoil have a medium texture. The lower subsoil is limestone residuum with a clay texture and had 26 to 29 ppm. phosphorus. There was considerable variation from sample to sample in the lower subsoil. Cycling of nutrients and mixing of residuum with transported material are processes probably responsible for the appreciable phosphorus in the upper parts of the solum. The contrast of phosphorus levels of the material from the two sources is distinct.

The large sample standard deviations of phosphorus values for Armour subsoils were probably due to their variable parent materials. The soil profiles high in phosphorus probably differ enough in morphology from those low in phosphorus to be separate series. If they are separate series, apparently mappers have not been able to consistently separate the two soils. Of the 9 Armour profiles sampled, the subsoil of one had phosphorus values of 2 ppm. Two of the samples had an average of 10 to 25 ppm. and 6 had more than 50 ppm.

The Dellrose soils also varied considerably in phosphorus content of the subsoil. Of the 10 samples, two had phosphorus levels of nearly 5 ppm., and the remaining had levels distributed upward to 150+ ppm. The phosphorus content of Dellrose and Armour is, therefore, not predictable within a narrow range; however, there is a high probability that a sample from one of these soils will contain appreciable phosphorus.

In potassium, Dellrose was lowest with 40 to 50 ppm. Armour had 50 to 65 ppm. and was lower than Captina, which had 65 to 100 ppm. A potassium distribution characteristic that was common to these soils was

an increase from the 12 to 24 inch layer downward through the 36 to 42 inch layer. Perhaps this was due to root extraction in the 12 to 24 inch layer.

Upland-phosphatic soils. The soils of the Central Basin developed from phosphatic limestone have often been referred to as the most fertile soils of Tennessee. Sampled series were Mimosa, Stiversville, and Maury.

As shown in Table 10, the mean pH of these soils in the zone below 12 inches varied between 5.7 and 6.2. As indicated by the sample standard deviation, the pH was more variable in the deeper layers of Mimosa than in Maury and Stiversville.

The phosphorus levels varied considerably among soils; however, the level in every layer of each soil was very high as evaluated by surface soil test criteria. Maury, often used as an example of a soil high in phosphorus developed from phosphatic parent material, had an available phosphorus level of about 50 ppm. This was about half the level for Mimosa and Stiversville. Three of 8 samples of the 12 to 24 inch layer had less than 25 ppm. phosphorus. All soils had a fairly large sample standard deviation but the relative variation in Maury was greater than in the other upland soils. Characterization data for Maury indicate that the upper solum of Maury has developed in loess over limestone residuum.⁹ The intermediate phosphorus levels of the subsoil could have resulted through

⁹"Seventh Congress of the International Society of Soil Science, Tour II" guide booklet. Unpub. Page 31. 1960.

mixing of the loess and phosphatic limestone residuum. Potassium content also varied considerably among soils. Stiversville, which had about 50 ppm., has more sand and a coarser subsoil texture than Maury, which had from 62 to 86 ppm. Mimosa subsoil contains more clay than Maury and was higher in potassium.

Upland soils. Talbott, although a Central Basin soil on similar landscape to Maury, Stiversville and Mimosa, is not closely associated with them geographically. Talbott is found in the Inner Central Basin, and is developed in residuum from non-phosphatic limestone. The limestone is older and lower in phosphorus than that in which Maury, Stiversville and Mimosa have developed.

Talbott had a mean pH of 5.7 to 5.9, which was similar to the phosphatic soils. The phosphorus was 1 to 3 ppm. and potassium was 53 to 60 ppm. Talbott subsoil has a similar clay content to Mimosa but had less potassium than the phosphatic soils with a similar amount of clay.

Soil Test Summary of Central Basin Soils

In the subsoil, the sampled upland and terrace soils of the Central Basin had a range in pH between 5.6 to 6.2. The pH in all these soils decreased with depth except in Captina, where the pH increased from 5.6 in the upper subsoil to 5.9 in the lower subsoil. The bottom soils had a subsoil pH from 6.6 to 6.9.

The phosphorus content of the Central Basin soils varied considerably from soil to soil and from sample to sample within soils. The variation in Talbott is not important to management because of the low mean

ppm. phosphorus. The variation in Armour, Dellrose, and Maury is important because a sample from these soils cannot always be assumed high in phosphorus.

The potassium level of bottom soils and soils with less than well-developed profiles (Huntington, Lindsides, Armour, and Dellrose) was 40 to 65 ppm. in the subsoil. Also in this range were Stiversville and Talbott. Average potassium values for the Captina, Maury and Mimosa soils ranged from 60 to 110 ppm.

West Tennessee Plateau Slope Sampling Area

Bottom soils. The bottom soils of the West Tennessee Plateau Slope have formed in materials washed from soils developed in Coastal Plains materials and loess. Collins, Falaya and Waverly, progressively more poorly drained soils, were mapped where the alluvium was assumed to have been from loess. In areas where the alluvium was assumed to have come from Coastal Plains materials and loess, Hyman and Ina were mapped. The Hyman and Ina are moderately well-drained and somewhat poorly-drained soils, respectively. The classification of these soils is discussed on pages 35 and 36. A previous analysis (Table 5) has shown that the 12 to 24 inch layer of Collins, Falaya and Waverly did not differ significantly in phosphorus. Waverly was almost twice as high in potassium as either Collins, Falaya, Hyman or Ina. The pH values for the five soils did not vary greatly, except that Waverly was somewhat lower in pH than either of the other soils.

Silty upland soils. The thickness and chemical characteristics of the loessial parent materials of the upland soils of this area vary according to distance from the Mississippi River bottoms (43). The soil test values of Memphis also varied according to loess bands (Table 2). Grenada was sampled over the same area as Memphis except for loess band (c). No difference was found in soil test values of Grenada in loess bands (a) and (b). Henry was not sampled in the loess bands (a) or (c). Therefore, the values for Henry and Grenada are not applicable to the eastern edge of the West Tennessee Plateau Slope, nor Henry values to band (a).

As seen in Table 11, the pH for Memphis (b) was about 5.5. In soils of progressively poorer drainage, the pH was slightly lower. The same relationship was true for phosphorus but there were greater differences between soils. Memphis (b) had 14 ppm. and Henry had means of from 3 to 8 ppm. phosphorus in the zone below 12 inches.

The potassium values for Memphis (b) were 55 and 65 ppm. This was about 10 ppm. greater than for either Grenada or Henry.

As shown in Table 11, the Memphis (a) means for phosphorus were 4 and 6 times as large as the means for Grenada and Henry, respectively. Potassium means were almost twice as large as the 40 to 50 ppm. for Grenada and Henry. The mean pH of Memphis (a) was similar to the pH values for Grenada and Henry. The mean pH of Memphis (c) was 5.8. This was approximately 0.5 pH units higher than the pH for Grenada and Henry. The 4 to 6 ppm. phosphorus means for Memphis (c) were in the same range as for Henry and somewhat lower than the means of about 8 ppm. for Grenada. Potassium values for Memphis (c) were slightly higher than the 42 to 52 ppm.

Table 11--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some West Tennessee Plateau Slope soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Bottom</u>								
Collins	0-8	5.8	0.27	6	3.6	47	16.2	18
	0-12	5.8	0.24	5	2.8	43	13.8	18
	12-24	5.8	0.29	3.9	2.48	29	9.3	18
	24-36	5.8	0.29	4.9	3.42	27	12.7	18
	36-42	5.7	0.28	5	3.9	24	10.8	18
Hymon	0-8	5.7	0.43	7	11.3	45	16.6	15
	0-12	5.7	0.41	5	7.5	41	14.5	15
	12-24	5.6	0.46	2.0	0.94	29	14.0	15
	24-36	5.5	0.31	2.3	0.62	28	11.2	15
	36-42	5.4	0.28	2.5	1.06	34	20.1	15
Falaya	0-8	6.0	0.49	7	6.8	43	25.2	18
	0-12	5.9	0.40	7	5.0	37	20.0	18
	12-24	5.8	0.35	5	2.4	27	21.9	18
	24-36	5.8	0.41	5	2.6	25	12.0	18
	36-42	5.8	0.50	5	3.4	26	11.8	18
Ina	0-8	5.6	0.37	10	23.1	45	27.0	20
	0-12	5.7	0.37	7	15.5	39	19.6	20
	12-24	5.7	0.38	2.3	1.29	27	10.6	20
	24-36	5.7	0.34	2.6	1.17	25	9.3	20
	36-42	5.7	0.30	3.0	1.60	25	10.5	20
Waverly	0-8	5.3	0.21	5	2.2	82	45.5	5
	0-12	5.3	0.20	5	2.1	79	45.5	5
	12-24	5.3	0.10	7	4.0	54	36.7	5
	24-36	5.3	0.20	8	4.5	42	18.2	5
	36-42	5.3	0.13	10	5.4	44	24.1	5
<u>Silty Upland</u>								
Memphis (a)	0-8	5.6	0.34	19	4.7	92	25.5	10
	0-12	5.6	0.31	23	9.0	86	23.0	10
	12-24	5.4	0.29	34	11.9	84	19.3	10
	24-36	5.4	0.27	32	13.0	84	23.8	10
	36-42	5.3	0.30	33	14.0	80	20.2	10

Table 11 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
Memphis (b)	0-8	6.0	0.42	11	5.3	87	26.3	15
	0-12	5.9	0.40	12	4.5	71	22.1	15
	12-24	5.6	0.38	14	3.8	55	21.3	15
	24-36	5.6	0.41	14	2.0	60	21.8	15
	36-42	5.5	0.20	15	3.3	64	23.3	15
Memphis (c)	0-8	6.0	0.28	7	8.5	87	37.8	14
	0-12	6.0	0.28	6	5.8	76	26.8	14
	12-24	5.8	0.32	3.9	2.03	53	13.4	14
	24-36	5.8	0.31	5	2.7	54	17.4	14
	36-42	5.8	0.30	6	2.6	56	21.5	14
Grenada	0-8	5.8	0.34	6	3.3	54	20.3	13
	0-12	5.7	0.31	7	2.9	50	16.7	13
	12-24	5.4	0.23	8	3.1	43	12.0	13
	24-36	5.4	0.41	7	3.3	45	16.3	13
	36-42	5.5	0.61	8	5.3	48	17.7	13
Henry	0-8	5.5	0.48	14	16.5	55	12.0	5
	0-12	5.5	0.56	10	11.3	49	10.5	5
	12-24	5.4	0.59	2.6	1.02	42	7.0	5
	24-36	5.3	0.16	4.1	1.78	50	2.4	5
	36-42	5.2	0.20	8	5.0	52	5.7	5
<u>Silty Soils on Coastal Plains</u>								
Lexington	0-8	5.8	0.55	14	12.7	153	101.4	5
	0-12	5.9	0.54	10	8.5	161	136.6	5
	12-24	5.9	0.39	1.9	0.59	149	158.3	5
	24-36	5.8	0.33	2.4	1.26	99	49.6	5
	36-42	5.7	0.41	2.6	1.51	92	41.9	5
Silerston	0-8	5.5	0.47	8	10.1	83	30.3	5
	0-12	5.4	0.41	6	6.7	81	24.2	5
	12-24	5.3	0.31	1.1	0.30	72	19.9	5
	24-36	5.3	0.28	1.0	0.07	68	29.7	5
	36-42	5.2	0.17	1.2	0.56	65	35.1	5

Table 11 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
Dulac	0-8	5.5	0.46	4.1	1.92	70	9.0	5
	0-12	5.4	0.33	3.0	1.28	65	10.5	5
	12-24	5.3	0.11	1.1	0.13	54	15.2	5
	24-36	5.2	0.11	1.2	0.27	45	8.8	5
	36-42	5.2	0.19	1.2	0.25	38	5.6	5
<u>Sandy Coastal Plains</u>								
Ruston	0-8	5.5	0.28	2.0	1.70	59	19.4	10
	0-12	5.5	0.26	1.8	1.29	61	19.4	10
	12-24	5.5	0.27	1.3	0.62	57	25.0	10
	24-36	5.4	0.25	1.4	0.78	54	32.5	10
	36-42	5.4	0.25	1.4	0.80	48	35.3	10
<u>Clayey Coastal Plains</u>								
Shubuta	0-8	5.4	0.14	1.2	0.35	55	23.2	8
	0-12	5.4	0.14	1.2	0.34	58	22.9	8
	12-24	5.3	0.17	1.1	0.19	71	27.7	8
	24-36	5.3	0.19	1.0	0.00	60	26.7	8
	36-42	5.2	0.19	1.0	0.00	52	18.1	8

means for Grenada and Henry.

Coastal Plains--silty, sandy and clayey soils. Lexington, Silerton, Dulac, Ruston and Shubuta soil test values are shown in Table 11. Lexington, Silerton and Dulac have developed in shallow loess about 2 to 3 feet thick and underlying materials of marine origin. Ruston and Shubuta have developed entirely in Coastal Plains materials.

Lexington has formed in the thickest loess which may account for the higher pH and phosphorus and potassium levels in the subsoil.

Silerton and Dulac had pH and phosphorus and potassium mean values very similar to Ruston and Shubuta. All of these values are noticeably lower than in the Lexington. Silerton had a higher pH and more potassium than Dulac.

Ruston and Shubuta have developed in material of marine sediments like those underlying Lexington and Silerton, respectively. In the layers below 12 inches, the pH was below 5.5, the phosphorus was a little over 1 ppm, and the potassium was from 50 to 70 ppm. These low values, along with the low values in the deeper layers of Silerton and Dulac, indicate the extremely low fertility level of the highly weathered Coastal Plains soils.

The surface values of Ruston and Shubuta were not greatly different from those in the subsoil. This may be evidence that they have not been farmed, or, if farmed, not fertilized.

In general, the loess component of Dulac and Silerton has not resulted in subsoil test values greatly different from soil test values of

Ruston and Shubuta, soils developed entirely in Coastal Plains materials. Shubuta, a soil high in clay below 12 inches, was somewhat higher in potassium than Dulac, a soil with a fragipan, but was not higher than Silerton nor appreciably higher than Ruston, both of which contain much less clay in the 12 to 36 inch zone.

Soil Test Summary of West Tennessee Plateau Slope Soils

The soil test values of the subsoils of the West Tennessee Plateau Slope cannot be estimated best from knowledge of the soil series only. Apparently there are factors, such as location, that can be used to improve the estimates. This was shown for the bottom soils and the Memphis series. The relationships found for these soils might also be in other soils not sampled.

Waverly, silty upland soils with fragipans, Memphis (a), and all the Coastal Plains soils except Lexington had a subsoil pH between 5.2 and 5.3. All other soils had pH values in the range from 5.4 to 5.9. The bottom soils had higher pH values than any Coastal Plains soil except Lexington.

The subsoils best supplied with phosphorus were those of Memphis (a) and Memphis (b), with averages of 34 and 14 ppm. phosphorus, respectively, in the 12 to 24 inch layer. In the remaining silty upland subsoils, phosphorus levels ranged from 3 to 8 ppm. The range in phosphorus levels was from 2 to 10 ppm. in the bottom soils and from 1 to 3 ppm. in the Coastal Plains soils.

The subsoils of all bottom soils except Waverly were considerably lower in potassium than either the Coastal Plains or silty upland soils. The potassium levels ranged from 24 to 34 ppm. Waverly had means of 44 to 54 ppm, a range which is similar to the range for Ruston, Dulac, Memphis (b) and Memphis (c). The soils with the highest potassium means were Memphis (a) and Lexington. Potassium means of these subsoils were 80 to 150 ppm. The means for Lexington were high because one site was very high in potassium; thus, these values may not be representative of this series.

East Tennessee Valley Sampling Area

Bottom soils. The statistics for Huntington, Lindside, and Melvin are given in Table 12. The subsoil pH means were between 6.7 and 6.9. Lindside and Melvin had considerably more variation from site to site than Huntington. Lindside was lower in both phosphorus and potassium than Huntington and Melvin. Huntington was lower in potassium, with 40 to 55 ppm, than Melvin, with 80 to 100 ppm. The reason for these variations is not apparent. Generally, Melvin contains more clay than either Huntington or Lindside. This may be associated with the higher potassium level. Another possible reason is that Melvin is poorly drained and not usually cropped. When cropped, roots do not penetrate very deeply because of poor aeration. Under these conditions, potassium would not be removed from the subsoil. Perhaps if drained and intensively cropped, potassium values would be lower.

Table 12--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some East Tennessee Valley soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Bottom</u>								
Huntington	0-8	6.6	0.19	9	6.3	82	88.6	5
	0-12	6.7	0.21	8	5.9	81	90.3	5
	12-24	6.7	0.23	3.2	2.12	56	35.3	5
	24-36	6.7	0.15	3.2	2.57	41	16.7	5
	36-42	6.7	0.23	4.1	3.19	37	18.2	5
Lindside	0-8	6.6	0.57	3.9	3.12	55	35.5	5
	0-12	6.6	0.57	3.9	3.12	54	34.4	5
	12-24	6.9	0.53	2.0	0.86	34	15.0	5
	24-36	6.9	0.49	2.2	1.07	21	2.4	5
	36-42	6.9	0.64	2.5	2.03	19	4.2	5
Melvin	0-8	6.7	0.58	4.1	2.68	84	29.6	5
	0-12	6.7	0.53	4.0	2.62	89	27.1	5
	12-24	6.8	0.41	3.5	3.29	100	29.1	5
	24-36	6.7	0.62	3.8	2.40	84	32.2	5
	36-42	6.6	0.73	4.2	2.46	78	33.3	5
<u>Loamy Terrace</u>								
Etowah	0-8	6.2	0.71	7	6.5	55	34.6	3
	0-12	6.2	0.70	6	5.4	52	28.2	3
	12-24	5.9	0.69	2.9	1.67	40	8.9	3
	24-36	6.0	0.48	3.0	1.32	45	8.7	3
	36-42	6.0	0.09	3.2	1.61	45	5.0	3
Sequatchie	0-8	5.8	0.24	2.4	0.77	45	13.9	5
	0-12	5.8	0.28	2.0	0.46	43	10.2	5
	12-24	5.8	0.45	1.3	0.36	37	6.0	5
	24-36	5.5	0.20	1.4	0.42	39	13.8	5
	36-42	5.5	0.50	1.4	0.66	57	30.8	5

Table 12 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Clayey Upland and Terrace</u>								
Cumberland	0-8	6.2	0.48	4.8	1.70	90	25.3	7
	0-12	6.2	0.44	3.9	1.35	84	23.1	7
	12-24	6.1	0.44	1.9	0.68	64	16.6	7
	24-36	5.8	0.29	2.4	0.70	60	12.2	7
	36-42	5.7	0.24	3.1	1.27	70	40.8	7
Decatur	0-8	6.2	0.54	4.2	3.60	105	71.2	5
	0-12	6.2	0.50	3.5	2.46	92	49.6	5
	12-24	6.1	0.36	1.9	0.09	64	9.7	5
	24-36	5.8	0.27	2.0	0.36	70	21.5	5
	36-42	5.8	0.13	2.0	0.58	69	27.5	4
Waynesboro	0-8	5.9	0.36	6	6.6	99	42.1	5
	0-12	5.9	0.38	4.3	4.66	88	29.2	5
	12-24	5.9	0.41	1.6	0.81	69	21.7	5
	24-36	5.5	0.43	1.8	0.83	71	33.6	5
	36-42	5.4	0.38	1.9	0.82	71	34.2	5
Dunmore	0-8	5.9	0.55	15	17.9	68	25.5	5
	0-12	5.8	0.48	10	12.0	64	15.7	5
	12-24	5.5	0.56	1.4	0.42	56	10.8	5
	24-36	5.6	0.37	1.9	0.82	63	19.3	5
	36-42	5.5	0.26	1.6	0.75	64	22.3	5
Fullerton	0-8	5.8	0.46	9	25.0	46	16.6	15
	0-12	5.7	0.41	6	16.9	44	16.7	15
	12-24	5.5	0.53	1.2	0.30	46	11.6	15
	24-36	5.4	0.59	1.5	1.12	54	16.0	15
	36-42	5.3	0.49	1.7	2.01	58	22.1	14
Sequoia	0-8	6.1	0.39	2.6	3.02	55	29.9	5
	0-12	6.0	0.43	2.5	3.05	56	29.3	5
	12-24	5.8	0.48	1.1	0.26	55	22.7	5
	24-36	5.6	0.43	1.3	0.55	57	26.9	5
	36-42	5.5	0.50	1.4	0.66	57	30.8	5

Table 12 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Cherty Upland</u>								
Clarksville	0-8	5.1	0.34	1.6	0.65	27	10.4	5
	0-12	5.1	0.33	1.6	0.69	26	9.9	5
	12-24	4.9	0.34	1.4	0.55	27	10.2	5
	24-36	4.9	0.31	1.2	0.27	30	13.4	5
	36-42	4.8	0.30	1.1	0.25	30	16.8	4
<u>Shallow Upland</u>								
Dandridge	0-8	6.6	0.36	10	9.4	57	10.2	5
	0-12	6.6	0.49	9	10.6	55	8.7	3
Litz	0-8	5.4	0.45	9	17.1	60	34.8	5
	0-12	5.3	0.34	6	12.0	63	35.4	5
	12-16	5.2	0.16	3.6	3.58	144	76.4	5

Loamy terrace soils. The soil test values of the loamy terrace soils, Etowah and Sequatchie, are listed in Table 12. These soils are medium in texture throughout. Other terrace soils, Waynesboro and Cumberland, are listed and described with the clayey upland soils because they contain high percentages of clay in the subsoil.

Etowah and Sequatchie had similar soil test values in the subsoil although the values were somewhat higher in the Etowah. In these soils, the subsoil pH ranged from 5.5 to 6.0, the phosphorus from 1 to 3 ppm., and the potassium from 37 to 57 ppm.

Clayey upland and terrace soils. All of these soils are essentially chert free to the depth sampled except Fullerton, which contains appreciable chert. In the layers below 12 inches, the pH ranged from 5.3 to 6.1. Phosphorus and potassium values were similar for these soils. Fullerton and Sequoia tended to have lower values for potassium. Phosphorus means were 1.1 to 3.1 ppm. and potassium means were about 50 to 70 ppm. Phosphorus and potassium means tended to increase with depth, whereas pH decreased with depth.

Cherty upland soils. Clarksville and Fullerton developed in cherty limestone residuum; however, Fullerton subsoil is a clay texture and Clarksville is a silt loam or silty clay loam. Fullerton is grouped with the clayey upland soils in Table 12. The sampled profiles of Clarksville and Fullerton contained up to 50 percent by volume chert fragments larger than 2 mm. The pH, and values of phosphorus and potassium apply only to the fine earth portion of the sample. Some of the Fullerton profiles were

relatively chert-free; however, no difference could be detected in pH and phosphorus and potassium levels between chert-free and cherty Fullerton.

Table 12 shows that Clarksville samples had a mean pH of 4.8 to 4.9 in the subsoil below 12 inches. Corresponding layers of Fullerton had a pH of 5.3 to 5.5. Of the two soils, Clarksville had lower mean values of phosphorus and potassium.

Shallow upland soils. Because raw shale or hard rock was encountered at a depth of less than 18 inches at every site, Table 12 does not give mean values for Litz and Dandridge for layers below 16 and 12 inches, respectively. It is probable that these soils have not been appreciably fertilized, but it cannot be stated definitely that the soil test values reported for the upper 12 inches are the natural fertility levels.

The difference in the parent materials of these soils was reflected in the pH. Dandridge has formed in material from calcareous shale. As indicated in Table 12, the pH of Dandridge was above 6.5 while that of Litz was less than 5.5. The phosphorus means varied from 4 to 10 ppm., and had large standard deviations. The potassium levels of both soils were about 55 to 60 ppm. in the top foot but increased to 144 ppm. in the 12 to 16 inch layer of Litz.

General Relationships of Soil Test Values Among the Soils in the East Tennessee Valley

Bottom soils had pH means in the layer below 12 inches from 6.6 to 6.9, whereas the means of the other soils were from 4.8 to 6.0. The pH means of soils formed in residuum from cherty limestone were lower

than terrace and other upland soils. Dandridge had a pH of about 6.6 to a depth of 12 inches. Dandridge overlies calcareous shale. The high mean pH of this soil may be due to the influence of shale or past management. The soil with the lowest pH was Clarksville, with a pH of 4.8 to 4.9 in the zone 12 to 42 inches. The cherty materials underlying this soil are similar to its parent materials. The materials are very low in calcium, very permeable, and have a low content of clay, which allow leaching to proceed rapidly and progress to a very low base saturation level.

The phosphorus levels in all of the soils in the layer below 12 inches were relatively low. The bottom soils, Cumberland, Etowah and Litz, were relatively higher, with 2 to 4 ppm. phosphorus, than the remaining soils with 1 to 2 ppm. This is fairly convincing evidence that the major soils in the East Tennessee Valley which developed from parent materials represented here can be expected to contain low amounts of phosphorus.

Potassium differences among certain soils were enough to be important to management. Litz and Melvin had the greatest amount of potassium. In Melvin, the potassium level in the upper subsoil was 100 ppm. but dropped to 78 ppm. in the deepest layer. Litz had 144 ppm. in the layer 12 to 16 inches. This is the layer grading into parent material and the drop may indicate a parent material rich in minerals containing potassium.

Other soils high in potassium were Cumberland, Waynesboro, Decatur and Dunmore. These soils are also high in clay. Fullerton and Sequoia had less potassium than the other soils with clayey subsoil. In Fullerton,

an average of 14 percent by volume coarse chert was discarded. There was no relationship between the levels of potassium and chert content of the sample.

Lindside and Clarksville, with 20 to 30 ppm. potassium, were notably lower in potassium than the other soils. Etowah, Sequatchie and Huntington were intermediate in potassium content with 35 to 50 ppm.

In all of these soils, potassium content had little relationship to any property except clay content, and this relationship was not well expressed.

Highland Rim Sampling Area

The bottom soils of the Highland Rim are mapped in two catenas and are in somewhat different landscapes. Ennis and Lobelville are most common where there is no fresh limestone in the surrounding landscape. Huntington and Lindside are browner and are more nearly neutral in reaction. They are most often in a landscape dissected by streams cutting through fresh limestone. These are possible explanations of the higher pH of Huntington and Lindside shown in Table 13.

The pH of the Huntington and Lindside soils was approximately one-half pH unit higher than for Ennis and Lobelville at corresponding depths. For all of the bottom soils, phosphorus values were generally 3 ppm. or less and the potassium values 25 ppm. or less.

The soil test means of Cumberland were considerably higher than for Etowah, due to one Cumberland sample that had high values. The standard deviations of the layers of Cumberland were also very large.

Table 13--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some Highland Rim soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Bottom</u>								
Ennis	0-8	5.9	0.58	6	4.5	34	15.2	8
	0-12	5.9	0.60	5	3.4	33	14.3	8
	12-24	5.8	0.57	2.5	1.32	24	7.5	8
	24-36	5.7	0.54	2.5	1.29	23	5.8	8
	36-42	5.7	0.47	2.6	1.11	26	8.4	7
Huntington	0-8	6.5	0.24	7	12.3	28	7.6	5
	0-12	6.5	0.26	7	5.2	26	6.3	5
	12-24	6.4	0.35	3.4	4.19	21	9.0	5
	24-36	6.2	0.33	2.1	0.32	22	12.9	5
	36-42	6.2	0.25	2.6	1.56	21	12.4	5
Lobelville	0-8	5.9	0.36	4.5	2.43	54	27.6	7
	0-12	5.9	0.35	4.0	1.97	48	22.0	7
	12-24	5.7	0.29	2.7	1.59	25	9.4	7
	24-36	5.7	0.42	3.6	3.59	25	8.9	7
	36-42	5.7	0.41	4.0	2.84	26	9.4	7
Lindside	0-8	6.2	0.21	9	9.3	42	18.6	6
	0-12	6.2	0.22	8	7.6	39	14.5	6
	12-24	6.1	0.43	1.8	0.99	24	4.7	6
	24-36	6.2	0.44	1.8	0.40	20	5.1	6
	36-42	6.2	0.42	1.6	0.49	19	5.8	6
<u>Terrace</u>								
Cumberland	0-8	5.9	0.21	42	24.7	222	168.5	3
	0-12	6.0	0.37	36	18.2	203	145.7	3
	12-24	5.9	0.80	7	9.4	136	102.2	3
	24-36	5.8	0.84	6	7.3	139	98.9	3
	36-42	5.9	0.80	6	7.1	140	98.5	3
Etowah	0-8	6.0	0.43	3.8	2.57	64	16.7	5
	0-12	6.0	0.45	3.2	2.00	60	14.8	5
	12-24	5.7	0.10	1.5	0.57	44	17.8	5
	24-36	5.5	0.09	2.1	0.02	41	16.0	5
	36-42	5.3	0.06	2.6	0.55	44	13.4	5

Table 13 (Continued)

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Upland</u>								
Bodine	0-8	5.6	0.44	12	22.7	44	10.2	5
	0-12	5.6	0.46	9	15.2	44	5.0	5
	12-24	5.5	0.35	1.4	0.39	50	13.8	5
	24-36	5.3	0.16	1.5	0.31	68	15.9	3
	36-42	5.4	0.21	2.0	0.71	75	7.1	2
Baxter	0-8	6.3	0.45	8	7.7	94	29.0	5
	0-12	6.4	0.46	6	5.2	82	21.5	5
	12-24	6.2	0.64	1.7	1.23	60	14.6	5
	24-36	5.6	0.26	1.7	0.65	63	15.0	4
	36-42	5.4	0.07	1.8	1.06	60	0.0	2
Bewleyville	0-8	6.0	0.55	10	9.4	69	29.4	5
	0-12	5.9	0.52	8	6.3	68	27.8	5
	12-24	5.7	0.42	1.7	0.32	68	21.2	5
	24-36	5.6	0.23	1.5	0.28	73	12.0	5
	36-42	5.5	0.13	2.0	0.61	70	13.6	5
Mountview	0-8	6.0	0.45	12	10	41	28.2	5
	0-12	6.0	0.51	9	7	41	25.2	5
	12-24	5.8	0.56	1.9	0.41	40	11.4	5
	24-36	5.3	0.16	1.6	0.49	45	12.1	5
	36-42	5.3	0.16	1.4	0.65	45	14.6	5
Dickson	0-8	5.6	0.58	8	10.8	53	45.7	15
	0-12	5.6	0.57	6	7.3	48	33.0	15
	12-24	5.3	0.41	1.3	0.35	36	11.4	15
	24-36	5.3	0.15	1.2	0.43	34	8.9	15
	36-42	5.2	0.21	1.3	0.58	33	7.0	14
Lawrence	0-8	5.3	0.28	1.7	0.57	29	9.1	5
	0-12	5.3	0.28	1.7	0.38	28	9.5	5
	12-24	5.1	0.23	1.5	0.35	28	12.2	5
	24-36	5.2	0.20	1.6	0.35	31	16.7	5
	36-42	5.2	0.18	1.7	0.48	30	17.7	5

These terrace soils are along streams cut into limestone whereas leached cherty limestone residuum underlies the upland soils of the Highland Rim. Some of the deeper limestones through which the streams cut are phosphatic, which may account for the higher phosphorus content of Cumberland.

Baxter and Bodine are formed from cherty limestone residuum. The percentage by volume coarse chert discarded from subsoil samples was 20 and 40 percent for Baxter and Bodine, respectively. Soil tests are made only on the fine earth portion of a sample. In these soils, the subsoil layers were similar in soil test values. The pH decreased progressively with depth from the surface. The 12 to 24 inch layer of Baxter had a pH more nearly like that of the surface layer than of the underlying layers which may show the effect of having been cropped and fertilized more often than Bodine.

In both soils, phosphorus values were 2 ppm. or less in the subsoil below 12 inches and potassium values were from 50 to 75 ppm.

Bewleyville, Mountview, Dickson and Lawrence are upland soils developed in loess and underlying cherty limestone residuum. In these soils, the pH decreased with both depth and drainage. Potassium values were similar for the Dickson and Lawrence subsoils and were slightly lower than in the Mountview and Bewleyville subsoils. The decrease corresponds to the decrease in clay content, cation exchange capacity and base saturation of these soils (19).

The Highland Rim bottom soils were higher in pH and phosphorus levels than the surrounding upland soils. Also, Huntington and Lindside were higher in pH than Ennis and Lobelville. The terrace and loess capped

upland soils were similar in pH and available phosphorus with the exception of Cumberland. In all upland soils, phosphorus had a value of 2 ppm. or less in the subsoil below 12 inches. The potassium levels in the bottom soils were somewhat lower than they were for Dickson and Lawrence soils and considerably lower than for the brown and redder upland Mountview, Etowah and Bewleyville soils.

Unaka Range Sampling Area

Congaree and Porters are not always close geographic associates, but they are similar in that their parent materials are derived from igneous and metamorphic rocks. Congaree is a bottom soil receiving sediments from a range of upland soils, including a dominant portion from Porters and associated soils, and is found along streams flowing in and from the Unaka Range.

The pH and potassium relationships for these soils were similar to those observed for upland and alluvial soils of most other areas, i.e., the bottom soil was higher in pH and lower in potassium than the upland soil. Congaree was considerably higher in phosphorus than the Porters, possibly due to the influence of alluvium from shaly soils such as Dandridge. (See Table 14.)

Cumberland Plateau Sampling Area

Below 12 inches, the pH values of Hartsells and Muskingum were, without exception, less than 5.5, the phosphorus less than 2 ppm., and the potassium less than 50 ppm. These soils are developed in similar parent material; however, the Muskingum is on steeper slopes and the profile is

Table 14--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some Unaka Range soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
<u>Bottom</u>								
Congaree	0-8	6.4	0.20	33	24.5	98	84.3	5
	0-12	6.4	0.17	32	24.5	90	69.2	5
	12-24	6.4	0.36	14	8.1	47	24.5	5
	24-36	6.5	0.29	8	4.3	29	6.5	5
	36-42	6.5	0.27	8	4.8	22	4.5	5
<u>Upland</u>								
Porters	0-8	5.7	0.14	2.5	1.05	66	33.8	5
	0-12	5.8	0.11	2.3	0.85	60	31.6	5
	12-24	5.8	0.18	1.8	0.67	53	31.6	4

shallow to rock. The low pH and phosphorus and potassium levels of these soils are due to the base- and nutrient-poor sandstone and shale from which the parent materials of these soils have formed. (See Table 15.)

V. COMPARISON OF SOIL GROUP SOIL TEST CHARACTERISTICS OF THE 12
TO 24 INCH LAYER AMONG AND WITHIN SEVEN SAMPLING AREAS

Tables 16 through 18 contain the class distribution of pH and phosphorus and potassium levels for individual 12 to 24 inch samples of groups of soils within a sampling area. Soils within a group are related by source and kind of parent material. In certain areas, those soils having common textural characteristics have been grouped. Groups were made so that a person who is relatively unfamiliar with soil names could recognize groups of soils in a sampling area. Appendixes E, F and G give the class distribution of soil test values for individual 12 to 24 inch samples by soil series.

The pH of samples from most sampling areas varied widely (Table 16). The East Tennessee Valley sampling area had samples in every pH class. The pH of samples within a soil group of the East Tennessee Valley sampling area had a smaller range. Groups such as the bottom and very cherty upland soils had samples in only three pH classes. Samples from both the Unaka Range and the Cumberland Plateau sampling areas had a narrow pH range; however, there were few samples within these groups.

Bottom soils had a greater proportion of samples in high pH classes than terrace and upland soils of the same sampling area (Table 16). Also, the terrace and colluvial soils had a slightly greater proportion of

Table 15--Means and sample standard deviations of pH and phosphorus and potassium levels for layers of some Cumberland Plateau soils

	Depth in inches	pH		Phosphorus (ppm)		Potassium (ppm)		No. of sites
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	
		<u>Upland</u>						
Muskingum	0-8	5.4	0.41	1.3	0.53	42	15.4	8
	0-12	5.3	0.29	1.3	0.49	42	13.0	8
	12-24	5.1	0.12	1.8	0.71	42	10.4	3
	24-36	5.2	0.07	1.5	0.00	49	3.5	2
Hartsells	0-8	5.7	0.37	2.8	3.38	49	35.5	10
	0-12	5.6	0.38	2.3	2.31	46	27.8	10
	12-24	5.5	0.48	1.2	0.27	39	10.1	10
	24-36	5.3	0.10	1.4	0.46	35	14.2	7
	36-42	5.3	0.08	1.2	0.50	43	23.2	4

Table 16--Class distribution of pH for individual 12 to 24 inch samples of certain soil groups in sampling areas

Sampling area and soil group	Soils in group	pH classes						
		4.5 and less	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.3	7.4-7.8
<u>Mississippi River Bottom</u>								
Loamy Bottom	Cm,Rb						5	5
Clayey Bottom	Sk				2	2		
Loamy High Bottom	Dd	2			2		1	
<u>Central Basin</u>								
Bottom, phosphatic Terrace and Colluvial, phosphatic	Hp,Lp				1	13	10	1
Upland, phosphatic	Ar,Cp,Ds		1	2	8	12	1	
Upland, non-phosphatic	Mm,Mr,Sv			1	7	8	2	
	Ta	1			3	1		
<u>West Tennessee Plateau Slope</u>								
Bottom	Cl,Fa,Hm,In,Wa		4	22	37	13		
Silty Upland	Gr,Hr,Mb(a,b,c)		3	28	21	4	1	
Silty soils on Coastal Plains	Dl,Lx,Sl		1	9	3	2		
Sandy Coastal Plains	Rt		1	5	4			
Clayey Coastal Plains	Sb		1	7				

Table 16 (Continued)

Sampling area and soil group	Soils in group	pH classes						
		4.5 and less	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.3	7.4-7.8
<u>East Tennessee Valley</u>								
Bottom	Ht, Ls, Mv					6	8	1
Loamy Upland	Et, Se			3	3	1	1	
Clayey Upland and Terrace	Cb, Dt, Dm							
	Fu, Sq, Wb		4	13	14	9	2	
Very Cherty Upland	Ck	1	2	2				
<u>Highland Rim</u>								
Bottom	Ht, Ls, En, Lv		2	3	9	9	3	
Terrace	Cb, Et			3	3	1	1	
Upland	Bo, Bw, Bx, Dk, Lw, Mt		3	25	6	4	2	
<u>Unaka Range</u>								
Bottom	Cg					2	3	
Upland	Pt				4			
<u>Cumberland Plateau</u>								
Upland	Hs, Mk		1	11			1	

samples in high pH classes than upland soils. Within a sampling area, the bottoms were about one pH class higher than terrace and upland soils. One exception was in the East Tennessee Valley where the bottoms were two classes higher than the upland soils. The soils of the Mississippi River loamy bottoms, the Central Basin bottoms and East Tennessee Valley bottoms had a greater proportion of their samples in high pH classes than did the Highland Rim and West Tennessee Plateau Slope bottoms.

The Central Basin phosphatic upland group, with 15 to 18 samples within the pH interval 5.6 to 6.5, had a higher proportion of samples in high pH classes than upland soils of other areas. All the upland soils of West Tennessee Plateau Slope, Highland Rim and Cumberland Plateau had the highest proportion of their samples in the pH class 5.1 to 5.5. In the Mississippi River Bottom, West Tennessee Plateau Slope and the East Tennessee Valley sampling areas, the low pH classes contained a higher proportion of samples from clayey soils than from silty soil groups.

As seen from Table 17, a high proportion of the samples from the Central Basin and Mississippi River Bottom areas were in classes with more than 7 ppm.phosphorus while a high proportion of samples of all other groups were in classes with less than 7 ppm.phosphorus.

Bottom soils, in general, had a higher proportion of samples in high phosphorus classes than did upland, and colluvial and terrace soils. This relationship was most pronounced in the Central Basin. One exception was bottom soils of the West Tennessee Plateau Slope which had a smaller proportion of samples in high phosphorus classes than the silty upland group but had a greater proportion than did the Coastal Plains

Table 17--Class distribution of phosphorus levels for individual 12 to 24 inch samples of certain soil groups in sampling areas

Sampling area and soil group	Soils in group	ppm. phosphorus						
		0-1.5	1.6-3	4-6	7-12	13-24	25-48	49+
<u>Mississippi River Bottom</u>								
Loamy Bottom	Cm,Rb					2	4	4
Clayey Bottom	Sk				2	1	1	1
Loamy High Bottom	Dd			1	1	1	2	2
<u>Central Basin</u>								
Bottom, phosphatic Terrace and Colluvial, phosphatic	Hp,Lp				1	2		22
Upland, phosphatic	Ar,Cp,Ds		1	3	5	2	6	7
Upland, non-phosphatic	Mm,Mr,Sv				2	5	6	5
	Ta	3	2					
<u>West Tennessee Plateau Slope</u>								
Bottom	Cl,Fa,Hm, In,Wa	13	31	20	11	1		
Silty Upland	Gr,Hr, Mb(a,b,c)							
Silty Soils on Coastal Plains	Dl,Lx,Sl	1	11	8	15	13	7	2
Sandy Coastal Plains	Rt	10	5					
Clayey Coastal Plains	Sb	9	1					
		8						

Table 17 (Continued)

Sampling area and soil group	Soils in group	ppm. phosphorus						
		0-1.5	1.6-3	4-6	7-12	13-24	25-48	49+
<u>East Tennessee Valley</u>								
Bottom	Ht, Ls, Mv	3	8	3	1			
Loamy Upland	Et, Se	5	2	1				
Clayey Upland and Terrace	Cb, Dt, Dm,							
	Fu, Sq, Wb	26	16					
Very Cherty Upland	Ck	4	1					
<u>Highland Rim</u>								
Bottom	Ht, Ls, En,	9	13	3	1			
	Lv							
Terrace	Cb, Et	4	3			1		
Upland	Bo, Bw, Bx,							
	Dk, Lw, Mt	24	16					
<u>Unaka Range</u>								
Bottom								
Upland	Cg	2	2	1	1	3		
	Pt							
<u>Cumberland Plateau</u>								
Upland	Hs, Mk	11	2					

soils. This may have resulted because the bottom soils have formed from materials washed from both the phosphorus-poor Coastal Plains and relatively phosphorus-rich silty upland soils. The Mississippi River Bottom soils were not all high in phosphorus. Of the soils sampled in this area, the high bottom and clayey bottom had some samples with less than 12 ppm. phosphorus. For the number of samples, there was considerable variation in these groups.

Terrace and upland soils were rather similar in the number of samples falling within each phosphorus class.

Samples of the silty soils of the West Tennessee Plateau Slope fell within every phosphorus class. As discussed on pages 26-30, the West Tennessee Plateau Slope soils of the Memphis series did not have a distribution of values that was centered on one phosphorus class. Samples of the terrace and colluvial phosphatic soils of the Central Basin were also very variable in phosphorus level, indicating that the subsoil phosphorus level cannot be predicted accurately for soils of this area.

Excluding the Central Basin phosphatic groups, bottom groups, and the West Tennessee Plateau Slope silty upland group, all of the samples except one, had less than 3 ppm. phosphorus. Samples with the most consistently low phosphorus values were from the Coastal Plains groups, the Cumberland Plateau area, and the East Tennessee Valley very cherty group, with a predominance having less than 1.5 ppm.

Although there were fewer classes for potassium than for either pH or phosphorus, in general, potassium values for a given soil group were spread over a wider range of classes (Table 18).

Table 18--Class distribution of potassium levels for individual 12 to 24 inch samples of soil groups in sampling areas

Sampling area and soil group	Soils in group	ppm. potassium				
		0-40	41-60	61-90	91-130	131+
<u>Mississippi River Bottom</u>						
Loamy Bottom	Cm,Rb		3	5	2	
Clayey Bottom	Sk			1	1	2
Loamy High Bottom	Dd		3		1	1
<u>Central Basin</u>						
Bottom, phosphatic Terrace and Colluvial, phosphatic	Hp,Lp	11	13		1	
Upland, phosphatic	Ar,Cp,Ds	8	14	1		1
Upland, non-phosphatic	Mm,Mr,Sv Ta	2	5 4	10 1		1 1
<u>West Tennessee Plateau Slope</u>						
Bottom	Cl,Fa,Hm, In,Wa	67	5	4		
Silty Upland	Gr,Hr, Mb(a,b,c)	13	28	13	3	
Silty Soils on Coastal Plains	Dl,Lx,Sl	1	6	4	3	1
Sandy Coastal Plains	Rt	2	5	2		1
Clayey Coastal Plains	Sb		4	2	1	1

Table 18 (Continued)

Sampling area and soil group	Soils in group	ppm. potassium				
		0-40	41-60	61-90	91-130	131+
<u>East Tennessee Valley</u>						
Bottom	Ht, Ls, Mv	5	4	3	1	2
Loamy Upland	Et, Se	4	4			
Clayey Upland and Terrace	Cb, Dt, Dm,					
	Fu, Sq, Wb	10	17	14	1	
Very Cherty Upland	Ck	5				
<u>Highland Rim</u>						
Bottom	Ht, Ls, En, Lv	26				
Terrace	Cb, Et	3	2	1	1	1
Upland	Bo, Bw, Bx, Dk, Lw, Mt	16	19	4	1	
<u>Unaka Range</u>						
Bottom	Cg	3		2		
Upland	Pt	2	1		1	
<u>Cumberland Plateau</u>						
Upland	Hs, Mk	6	6	1		

In contrast to pH and available phosphorus, bottom soils had more samples in low potassium classes than the upland soils. Bottom soils of the West Tennessee Plateau Slope and Highland Rim had a predominance of samples in the 0 to 40 ppm. class. As discussed previously, Waverly, a West Tennessee Plateau Slope bottom soil, had mean potassium values higher than other bottom soils associated with it. Of all groups, with the exception of East Tennessee Valley and Mississippi River Bottom soils, bottom soils had the greatest proportion of samples in classes with less than 60 ppm. potassium. The Mississippi River Bottom soils had the greatest proportion of samples in the 61 to 90, 91 to 130 and 131+ ppm. classes. Areas with the next higher proportion of samples in the high potassium classes were the Central Basin upland phosphatic group, followed closely by the East Tennessee Valley clayey upland group. Shubuta, a Coastal Plains soil with as much clay as the Central Basin upland phosphatic soils and the East Tennessee Valley upland soils, had the greatest number of its samples in the 41 to 60 ppm. class with a scattering in higher classes.

Clayey groups had a higher proportion of samples in high potassium classes than medium textured groups in the same sampling area. The bottom soils in the East Tennessee Valley sampling area did not have a potassium distribution that is centered on one potassium class. In this area, Melvin, as discussed on page 40, contained significantly more potassium than the other bottom soils associated with it.

VI. RELATIONSHIPS AMONG SOILS WITHIN CLASSES OF pH,
PHOSPHORUS AND POTASSIUM

Tables 19 through 21 are summary tables showing the soils that have 12 to 24 inch sample means of pH and phosphorus and potassium levels in certain soil test classes. The purpose of these tables is to help show relationships among soils having similar soil test means. Appendixes E, F and G give the distribution of individual 12 to 24 inch samples in soil test classes, and number of observations per soil.

Only means of bottom soils fell in the pH class 6.6 to 7.3 (Table 19). All soils except Commerce and Robinsonville are from areas having abundant limestone. All of these soils are flooded intermittently. The waters that flood them are probably high enough in calcium content to maintain the high level of pH. Other bottom soils had means in pH class 6.1 to 6.5. These are the Huntington and Lindside from the Highland Rim area and the Congaree from the Unaka Range and adjacent areas. Other soils with means in this pH class are well drained soils of limestone areas. These soils have few other common properties except good drainage. They are neither similar in texture nor degree of development. The poorest soil for agricultural use is Baxter. The high mean of pH of the Baxter may indicate that the pH has been considerably altered through farming.

The pH class 5.6 to 6.0 contained the most sample means of any class. In this class were Dundee and Sharkey, a high-bottom soil and a clayey-bottom soil, respectively, of the Mississippi River Bottom. Other

Table 19.--Means of 12 to 24 inch layers of soils within sampling areas distributed among pH classes

Sampling area	Classes of pH			
	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5
Mississippi River Bottom			Dd,Sk	Cm,Rb
Central Basin			Cp,Mm,Ta	Ar,Ds,Mr,Sv
West Tennessee Plateau Slope		Dl,Gr,Hr, Mb(a),Rt, Sl,Wa	Cl,Fa,Hm, In,Lx, Mb(b),Mb(c)	Hp,Lp
East Tennessee Valley	Ck	Dm,Fu	Et,Se, Sq,Wb	Ht,Ls,Mv
Highland Rim		Bo,Dk,Lw	Bw,Cb,En, Et,Lv,Mt	Bx,Ht,Ls
Unaka Range			Pt	Cg
Cumberland Plateau		Hs,Mk		

bottom soils in this class were Ennis and Lobelville soils of the Highland Rim and all the bottom soils of the West Tennessee Plateau Slope, except Waverly.

In pH class 5.1 to 5.5 were silty soils with fragipans, soils of the Coastal Plains (except Lexington), highly weathered clayey soils of the East Tennessee Valley and Highland Rim, and soils of the Cumberland Plateau. The only silty well drained soils in this group were Memphis in loess band (a) and Silerton.

Clarksville, an East Tennessee Valley soil, was the only soil in the pH class 4.6 to 5.0.

Sample means of all West Tennessee Plateau Slope soils were in the pH interval 5.1 to 6.1. All soils developed entirely or partly in Coastal Plains material, except Lexington, were in the interval 5.1 to 5.5.

Sample means of phosphorus cover a wide range (Table 20). All soils in the Mississippi River Bottom and Central Basin except Talbott, had sample means in a class with more than 12 ppm. phosphorus. In addition, Memphis in loess bands (a) and (b), and Congaree had means greater than 12 ppm. Soils with phosphorus means from 3 to 12 ppm. were largely West Tennessee Plateau Slope soils. These include bottoms of the Collins catena, and upland soils formed from loess. Soils of other groups with means in this phosphorus range were Melvin and Cumberland.

The remaining soils, or those in classes 0 to 1.5 and 1.6 to 3.0 ppm., represent more than half of the soils sampled. The largest proportion of sampled soils in the West Tennessee Plateau Slope, East Tennessee

Table 20-- Means of 12 to 24 inch layers of soils within sampling areas distributed among phosphorus classes

Sampling area	ppm.phosphorus						
	0-1.5	1.6-3.0	4-6	7-12	13-24	25-48	49+
Mississippi River Bottom							
Central Basin	Ta				Dd,Sk	Rb	Cm
West Tennessee Plateau Slope	Dl,Rt, Sb,Sl	Hm,Hr, In,Lx	Cl,Fa, Mb(c)	Gr,Wa	Mb(b)	Mb(a)	Ar, Hp, Lp, Mm, Sv
East Tennessee Valley	Ck,Dm,Fu, Se,Sq	Cb,Dt,Et, Ht,Ls,Wb	Mv				
Highland Rim	Bo,Dk Et,Lw	Bx,Bw, En,Ht,Ls, Lv,Mt		Cb			
Unaka Range		Pt			Cg		
Cumberland Plateau	Hs	Mk					

Valley, Highland Rim and Cumberland Plateau sampling areas had phosphorus means in these two classes. In the West Tennessee Plateau Slope area, only Memphis in loess bands (a) and (b) had means greater than 12 ppm.

A number of Tennessee soils contained large amounts of phosphorus in the subsoil, but in comparison with the other soils in the state, they are a minority in number and areal distribution.

The distribution of potassium means of the 12 to 24 inch layer of soils within sampling areas is presented in Table 21.

The soils of the Mississippi River Bottom, Unaka Range, and Cumberland Plateau areas had a narrower range of potassium mean values than other areas. The means of soils in other areas were in a number of potassium classes.

Excluding Melvin and the Mississippi River Bottom soils, all bottom soils had means less than 61 ppm potassium and a majority had less than 41 ppm. The potassium mean for Melvin was in the 91 to 130 ppm class. The Mississippi River Bottom soils means fell between 61 and 130 ppm.

No consistent relationship between clay content and potassium mean values was evident. However, soils high in clay, such as Sharkey, Mimosa, Shubuta, Waynesboro, Cumberland and Decatur had means well above the average of the majority of other soils in their respective areas.

Dunmore, Sequoia, Fullerton and Baxter, with means in potassium class 41 to 60 ppm, had the lowest means of all the soils with clayey subsoils.

The two soils with sample means for potassium in the class 131+ ppm. were small samples and their high means were due to one high observation in each soil.

Table 21--Means of 12 to 24 inch layers of soils within sampling areas distributed among potassium classes

Sampling area	ppm. potassium			
	0-40	41-60	61-90	91-130
Mississippi River Bottom				131+
Central Basin		Ar, Ds, Hp, Lp, Sv, Ta	Cm, Dd, Rb Cp, Mr	Sk Mm
West Tennessee Plateau Slope	Cl, Fa, Hm, In	Dl, Gr, Hr, Mb(b), Mb(c), Rt, Wa	Mb(a), Sb, Sl	Lx
East Tennessee Valley	Ck, Et, Ls, Se	Dm, Fu, Ht, Sq	Cb, Dt, Wb	Mv
Highland Rim	Dk, En, Ht, Ls, Lv, Lw, Mt	Bo, Bx, Et	Bw	Cb
Unaka Range		Cg, Pt		
Cumberland Plateau	Hs	Mk		

The majority of upland and terrace soils are Alfisols and Ultisols according to the Comprehensive System of Soil Classification.^{10,11} One of the major criteria differentiating soils of these orders is base saturation. A soil qualifying in other ways is classified an Alfisol, if at a depth of 30 or 50 inches below the upper boundary of the fragipan or argillic horizons, respectively, the base saturation exceeds 35 percent. To qualify as an Ultisol, the base saturation must be less than 35 percent at these depths.

It has been stated¹² that the relatively high base saturation requirement limits the Alfisols to soils through which little water has moved or to soils formed in young, relatively unweathered basic parent materials usually no older than late Pleistocene. Ultisols are on old land surfaces, or on land surfaces of late Pleistocene Age if the parent materials were highly weathered before being deposited.

If soil test values are related to the concept of soil formation of these soils, the Alfisols should have higher pH than the Ultisols and probably should contain more phosphorus and potassium.

An examination of mean soil test values of the 12 to 24 inch layer of the soils of these 2 orders shows that both Ultisols and Alfisols were in pH classes 5.1 to 5.6 and 5.6 to 6.0, but that only Ultisols were in

¹⁰Principal Soil Correlator's Office, SCS, USDA. Placement of Soils of the Southern States in the New Classification System. Knoxville, Tennessee. October 1, 1964.

¹¹Tennessee Soil Survey Staff, SCS, USDA. Proposed Placement of Certain Soil Series in Tennessee. Nashville, Tennessee. March 1965.

¹²Soil Survey Staff, SCS, USDA. Soil Classification: A Comprehensive System, 1960, and June 1964 Supplement.

pH class 6.1 to 6.5. Soils in this class were Armour, Maury, Dellrose, Stiversville, Cumberland, Decatur and Baxter.

Alfisols were in every phosphorus class except 0 to 1.5. Ultisols Armour, Captina, Stiversville and Maury were in phosphorus classes 25 to 48 and 49+. All other Ultisols were in phosphorus classes 1.6 to 3.0.

Soils of both orders were well distributed among most potassium classes. However, only Ultisols were in the class 0 to 40.

The depth at which base saturation must exceed 35 percent to qualify as an Alfisol is not 12 to 24 inches, but if the base saturation at lower depths is high, it is reasonable to expect some correlation between pH values of this layer and order. In this study, there was little relationship between pH and phosphorus or potassium levels in the 12 to 24 inch layer and order.

VII. SOIL TEST VALUES OF AIR-DRY AND FIELD-MOIST SAMPLES COMPARED

The results of the statistical comparison of the pH, phosphorus and potassium levels determined on air-dry and field-moist samples are given in Tables 22 and 23. In the groups where there was a significant difference between soil test values of air-dry and field-moist samples, a large difference indicates a need for examining correlation of field-moist results with crop yield response to fertilizer and lime. For air-dry sample results, correlations have been made by Bishop.¹³

¹³Bishop, W. D., op. cit.

There was no significant difference between average pH values of field-moist and air-dry samples in the surface soil groups or the subsoil sandy textured group (Table 22). Significant mean differences for subsoil means were found in the loamy and clayey groups. The loamy group contained 835 paired samples, or 1,670 individual subsoil samples. In this group, the field-moist samples had an average pH value of 0.03 less than the air-dry samples.

In the subsoil clayey group, 208 pairs, the average pH for the field-moist samples was 0.08 more than for the air-dry samples. The sample standard deviation was 0.1797.

A difference in pH for air-dry and field-moist samples could be caused by a net removal from the soil solution of basic or acid ions or by accumulation of salts. Removal of basic ions could result from fixation in minerals or microorganisms. Additions of bases could be caused by release of basic ions by minerals or by mineralization. Salts could accumulate through organic matter breakdown and lower pH. The results obtained indicate that if these occurred, their net effect on pH was very small.

The significant mean differences in the two subsoil groups, although statistically significant at the 0.001 level of probability, were too small to be of importance in a soil testing program. The largest difference in the pH of a pair of samples was 1.1 pH units. This pair was in a group in which the mean difference was not significant.

Interpretation of the results for phosphorus and potassium in Tables 22 and 23 must take into consideration two possible errors intro-

Table 22--Mean differences, sample standard deviations, and standard errors of pH, phosphorus, and potassium of air-dry versus field-moist paired surface soil samples of two textural groups

Soil test	No. of pairs	Sample means		Mean difference	Sample standard deviation	Standard error
		Field-moist	Air-dry			
<u>Loamy Textural Group</u>						
pH	435	5.94	5.94	<-0.01 NS	0.2492	0.0120
P	435	19.3	20.4	-1.1**	8.48	0.41
K	435	67.3	68.9	-1.6 NS	29.84	1.43
<u>Clayey Textural Group</u>						
pH	6	6.30	6.20	0.10 NS	0.2364	0.0966
P	6	21.4	22.9	-1.5 NS	4.22	1.72
K	6	150.8	168.3	-17.5 NS	30.12	12.30

Phosphorus and potassium values expressed in ppm.

**Significant at probability level equal to or less than 0.01.

Table 23--Mean differences, sample standard deviations, and standard errors of pH, phosphorus, and potassium of air-dry versus field-moist paired subsoil samples of three textural groups

Soil test	No. of pairs	Sample means		Mean difference	Sample standard deviation	Standard error
		Field-moist	Air-dry			
<u>Loamy Textural Group</u>						
pH	835	5.69	5.72	-0.03****	0.1664	0.0058
P	835	15.6	17.2	-1.6****	8.00	0.28
K	835	43.8	53.6	-9.8****	14.38	0.50
<u>Clayey Textural Group</u>						
pH	208	5.79	5.71	0.08****	0.1797	0.0125
P	208	19.8	21.3	-1.5**	6.64	0.46
K	208	53.0	75.9	-22.9****	26.27	1.82
<u>Sandy Textural Group</u>						
pH	8	5.57	5.56	0.01 NS	0.1245	0.0440
P	8	1.6	2.2	-0.6*	0.58	0.21
K	8	25.6	19.4	6.2**	4.44	1.57

Phosphorus and potassium values expressed in ppm.

*Significant at probability level equal to or less than 0.05.

**Significant at probability level equal to or less than 0.01.

****Significant at probability level equal to or less than 0.001.

duced in the field-moist determination of phosphorus and potassium levels due to weighing the field-moist samples. The first would be due to obtaining less than 5 grams of soil, since part of the weight of the 5 gram sample was water. Because a smaller amount of soil was being extracted, the 5 gram field-moist sample might have given a lower reading in ppm. phosphorus and potassium. The magnitude by which the values might be reduced depends upon the moisture percentage by weight of the sample.

The second possible error would be due to changes in soil solution ratio and dilution. Data presented by Bishop,¹⁴ showed that the phosphorus and potassium extracted with a soil solution ratio of 1 to 8 was 58 and 10 percent greater, respectively, than the amount extracted with a ratio of 1 to 4. In samples containing moisture at 2 atmospheres of tension, the maximum moisture estimated for the samples, the widest ratio with field-moist samples would be 1 to 5 for the clayey group. In the sandy group, the widest ratio would be 1 to 4.2. The moisture content at 2 atmospheres of tension for soil with the texture of these samples was estimated from data presented by Longwell, et al. (24). The probable error for potassium would be rather small for the ratio used in this study and would probably be negligible. The probable error in phosphorus would be larger and not negligible.

The statistically significant differences most meaningful are those for textural groups having a higher value of potassium for field-moist

¹⁴Ibid.

samples, and those that show such a high or low value for either phosphorus or potassium in the field-moist samples that it cannot be accounted for by the errors introduced in weighing the field-moist samples.

The use of less than 5 grams of soil may have accounted for the lower values of phosphorus and potassium in the field-moist samples in all groups in which there was a significant difference except in the case of the sandy subsoil group. The positive mean difference for potassium in the sandy group could not be accounted for by soil sample weight. It is also doubtful that the difference was due to a wider soil solution ratio caused by moisture in the samples, because sandy samples were relatively dry. The positive mean difference indicated more available potassium in the field-moist samples than in the air-dried samples. Fixation of potassium in coarse textured soils due to drying has not been reported in the literature. An adequate explanation of the apparent fixation of potassium upon drying is not known.

The potassium mean difference between loamy and clayey subsoil groups was considerably larger than corresponding values for the surface soil. This may be evidence of greater release of potassium upon drying of the subsoil samples or greater fixation on the part of surface soil samples, or both. Release of non-exchangeable potassium by air drying in some Tennessee soils was suggested by data presented by Seatz and Winters (37); however, this may not be the case here.

Because of drying at the surface, the field-moist subsoil samples probably contained a greater percentage of moisture than the surface soil samples. This may account for the observed differences. These data do not supply an adequate explanation.

The mean differences in pH were too small to be important to recommendations in a soil testing program. The paired analysis pointed toward no appreciable difference in extraction of phosphorus from air-dry compared to field-moist samples of the textural groupings of Tennessee soils used in this study. The potassium values did not indicate appreciable fixation of potassium by air drying. How much, if any, of the lower amounts of potassium in field-moist samples was due to release of potassium upon drying and/or smaller samples due to weighing the samples field moist could not be determined from these data.

CHAPTER V

SUMMARY AND CONCLUSIONS

Fifty Tennessee soils were sampled by horizon to a depth of 42 inches or to rock. Each series was sampled at from 4 to 39 sites. The pH and phosphorus and potassium levels were determined by soil tests. The pH, phosphorus and potassium values for subsoil layers of certain soils were statistically compared for classification and fertility interpretation purposes. The soil test values were calculated by 0 to 8, 0 to 12, 12 to 24, 24 to 36, and 36 to 42 inch depths. Means and sample standard deviations of these layers by series were used to study the fertility with depth and to compare soils within sampling areas. The 12 to 24 inch means and individual sample values of series were distributed into soil test classes by sampling areas so that relationships could be observed. The pH, phosphorus and potassium levels of air-dry and field-moist samples were compared after grouping by texture and position in the profile.

Soil test values of Memphis B₂ horizons from 39 sites were studied in relationship to thickness and characteristics of loess. Loess bands corresponding to upland thicknesses of more than 15, 5 to 15, and 4 to 5 feet, were lettered (a), (b), and (c), respectively, eastward from the Mississippi River. Among these bands, Memphis had significantly different pH, phosphorus and potassium means. In bands (a), (b), and (c), pH values

were 5.4, 5.6 and 5.8, respectively. Values for phosphorus were 31, 15, and 5 ppm., and for potassium were 86, 55, and 49 ppm., respectively. These differences suggest the likelihood of other soil differences and point up a classification problem in the Memphis series. The subsoil fertility differences were large and should be related to the management of these soils.

Fertility of the 12 to 24 inch layer of 4 West Tennessee Plateau Slope bottom soils was studied in relation to source of parent material. For purposes of comparing bottom soils, loess bands were lettered (w), (x), (y), and (z) eastward from the Mississippi River corresponding to upland loess thicknesses of more than 10, 5 to 10, 4 to 5, and less than 4 feet, respectively. Collins and Falaya, soils formed in alluvium from loess, were sampled in loess bands (w), (x), and (y). Hyman and Ina, soils formed in alluvium from Coastal Plains and loess, were sampled in loess bands (x), (y), and (z).

Falaya had significantly more phosphorus than the other three soils. The difference between bands (x) and (y), where all soils were sampled, was not significant. Among soils and bands, the low and high phosphorus values were 3 and 5 ppm., respectively. Although these differences were significant and support differences in parent material, they are too small, excluding other soil differences, to justify mapping more than one catena. In managing the soils, the differences probably have little practical significance.

Soil test values of the 12 to 24 inch layer were compared among three soils of the Collins catena from West Tennessee Plateau Slope,

the Mountview catena from the Highland Rim, and the Huntington catena from East Tennessee Valley.

✓ In the bottom land Huntington and Collins catenas, potassium was significantly higher in the poorly drained members. The pH of the poorly drained member was significantly lower than the better drained soils of the Collins catena. Phosphorus differences were not significant in either catena.

In the Mountview catena, pH and phosphorus levels were significantly lower in the soils with fragipans. Potassium differences were not significant.

Comparisons of the soil test means and standard deviations of the 0 to 8, 0 to 12, 12 to 24, 24 to 36, and 36 to 42 inch layers of 50 soils showed higher values for the 0 to 8 inch layer than for the subsoil layers. The high topsoil values were probably due to management. Soil test variations in the 36 to 42 inch layers in many soils were larger than in the 12 to 24 and 24 to 36 inch layers. This greater variation may have been because the 36 to 42 inch layer was in or near the C horizon in many of the soils.

Soils with sola thinner than 42 inches, such as Dellrose and the bottom soils, had more variation at shallow depths than soils with thicker sola. The mean pH generally decreased from the surface downward. However, phosphorus and potassium values were often lower in the 12 to 24 or 24 to 36 inch layer than in layers above or below.

Within the Central Basin, East Tennessee Valley and Highland Rim areas, the proportion of individual 12 to 24 inch bottom samples in the

high pH classes was greater than the proportion of terrace and colluvial soil samples in these classes. In turn, terrace and colluvial soils had a greater proportion in high pH classes than upland soils. The pH difference between bottom and upland soils was about one-half pH unit, except in East Tennessee Valley where it was about 1 pH unit.

In general, the Mississippi River Bottom samples had the highest pH values, followed by the Central Basin, Unaka Range, West Tennessee Plateau Slope, East Tennessee Valley, Highland Rim, and the Cumberland Plateau, in that order. However, among sampling areas, sample distributions overlapped among classes.

The pH class 5.6 to 6.0 contained the most soil means of any class. This class contains largely bottom soils and well drained upland soils. In pH classes above 6.0 were other bottom soils and well drained upland and terrace soils. In pH class 5.1 to 5.5, there was a variety of soils, most of which have fragipans or are highly weathered.

In the Central Basin, East Tennessee Valley, Highland Rim, and Unaka Range sampling areas, the proportion of individual 12 to 24 inch samples in the high phosphorus classes was greater for the bottoms than for the upland, colluvial and terrace soils.

On a sampling area basis, the Central Basin had the greatest proportion of observations in high phosphorus classes, followed by the Mississippi River Bottom, West Tennessee Plateau Slope, East Tennessee Valley, Highland Rim, Unaka Range, and Cumberland Plateau, in that order. In the latter four groups, excluding the bottoms and one upland sample, all of the samples had less than 3 ppm. phosphorus.

The sample means of all Mississippi River Bottom soils and Central Basin phosphatic soils were greater than 12 ppm. phosphorus. There were large variations in the subsoil phosphorus values of the Armour, Dellrose, and Maury soils. Of the soils, the variation in Maury was least. Soils with means between 3 to 13 ppm. were predominantly West Tennessee Plateau Slope soils. Of these, Memphis was the only one that did not have a phosphorus distribution centered on one class.

The individual observations of potassium within a soil sampling area were more variable than were pH and phosphorus. Bottom soils, other than those in the Mississippi River Bottom, had in general a greater proportion of samples in low potassium classes than associated terrace and upland soils. Most of the bottom samples had potassium values between 20 to 60 ppm. compared to upland and terrace values between 30 and 131+ ppm.

Within sampling areas, clayey groups of soils had a greater proportion of samples in high potassium classes than medium textured soil groups. Both of the poorly drained bottom soils had higher potassium values than the better drained bottom soils associated with them.

Soil means of the 12 to 24 inch layer of all Mississippi River Bottom soils were in potassium classes 61 to 90 and 91 to 130 ppm. All soil means of the Unaka Range and Cumberland Plateau were in the classes 0 to 40 and 41 to 60. Most soil means of all sampling areas except the Mississippi River Bottom were in potassium classes 0 to 40 and 41 to 61.

There was little relationship between pH, and phosphorus or potassium levels in the 12 to 24 inch layer and the orders Alfisol and Ultisol of the Comprehensive System of Soil Classification.

There were some substantial differences in soil test values among areas and among soils in an area. These differences may be large enough to justify more or less lime and fertilizer than is presently recommended from surface soil test results. The adjustments in recommendations because of differences in soil test values of the subsoil should be determined from studies of crop yield responses to additions of fertilizer and lime.

The mean differences between air-dry and field-moist pH and phosphorus values of loamy and clayey surface soils and loamy, clayey, and sandy subsoils were small and could be neglected in a soil testing program. The potassium mean differences for the clayey samples were considerably larger than for the loamy and sandy groups. In loamy and clayey groups, field-moist samples had the lowest means. Mean differences were significant in each subsoil group but not significant in the surface soil groups. The differences can be attributed largely to variations in amount of soil tested. No appreciable potassium was fixed on air-drying. There is a possibility that potassium was released on drying but this could not be established with the laboratory procedures used.

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APPENDIXES

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APPENDIX A

LEGEND OF SOIL SYMBOLS, NUMBER OF SITES SAMPLED, AND AREAS IN WHICH SAMPLED

<u>Soil Name</u>	<u>Soil Symbol</u>	<u>Number of Sites Sampled</u>	<u>Areas in Which Sampled</u>
Armour silt loam, 2 to 5% slopes, eroded	Ar	9	CB
Baxter cherty silt loam, 5 to 12% slopes, eroded	Bx	5	HR
Bewleyville silt loam, 2 to 5% slopes	Bw	2	HR
5 to 12% slopes, eroded	Bw	3	HR
Bodine cherty silt loam, 20 to 40% slopes	Bo	5	HR
Captina silt loam, phosphatic 2 to 5% slopes, eroded	Cp	5	CB
Clarksville cherty silt loam, 20 to 30% slopes	Ck	5	ETV
Collins silt loam, 0 to 2% slopes	Cl	18	WTPS
Commerce silt loam, 0 to 2% slopes	Cm	5	MRB
Congaree loam, 0 to 2% slopes	Cg	5	UR
Cumberland silt loam, 2 to 5% slopes, eroded	Cb	10	ETV and HR
Dandridge silt loam, 20 to 30% slopes, eroded	Dr	5	ETV
Decatur silt loam, 2 to 5% slopes, eroded	Dt	5	ETV

<u>Soil Name</u>	<u>Soil Symbol</u>	<u>Number of Sites Sampled</u>	<u>Areas in Which Sampled</u>
Dellrose cherty silt loam, 12 to 30% slopes	Ds	10	CB
Dickson silt loam, 2 to 5% slopes, eroded	Dk	15	HR
Dulac silt loam, 2 to 5% slopes, eroded	Dl	5	WTPS
Dundee loam and silty clay loam, 0 to 2% slopes	Dd	5	MRB
Dunmore silt loam, 5 to 12% slopes	Dm	5	ETV
Ennis silt loam, 0 to 2% slopes	En	8	HR
Etowah silt loam, 2 to 5% slopes, eroded	Et	8	ETV and HR
Falaya silt loam, 0 to 2% slopes	Fa	18	WTPS
Fullerton silt loam and cherty silt loam, 5 to 12 and 20 to 30% slopes eroded	Fu	15	ETV
Grenada silt loam, 2 to 5% slopes, eroded	Gr	13	WTPS
Hartsells loam, 2 to 5% slopes, eroded	Hs	10	CP
Henry silt loam, 0 to 2% slopes	Hr	5	WTPS
Huntington silt loam, 0 to 2% slopes	Ht	10	ETV and HR
Huntington silt loam, 0 to 2% slopes, phosphatic	Hp	9	CB
Hymon loam and silt loam, 0 to 2% slopes	Hm	15	WTPS

<u>Soil Name</u>	<u>Soil Symbol</u>	<u>Number of Sites Sampled</u>	<u>Areas in Which Sampled</u>
Ina loam and silt loam, 0 to 2% slopes	In	20	WTPS
Lawrence silt loam, 0 to 2% slopes	Lw	5	HR
Lexington silt loam, 2 to 5% slopes	Lx	5	WTPS
Lindside silt loam, 0 to 2% slopes	Ls	11	ETV and HR
Lindside silt loam, 0 to 2% slopes, phosphatic	Lp	15	CB
Litz silt loam, 5 to 12% slopes	Lz	5	ETV
Lobelville silt loam, 0 to 2% slopes	Lv	7	HR
Maury silt loam, 2 to 5% slopes, eroded	Mr	8	CB
Melvin silt loam, 0 to 2% slopes	Mv	5	ETV
Memphis (a) silt loam, 2 to 5% slopes, eroded	Mb (a)	5	WTPS
Memphis (a) silt loam, 8 to 12% slopes, eroded	Mb (a)	5	WTPS
Memphis (b) silt loam, 2 to 5% slopes, eroded	Mb (b)	15	WTPS
Memphis (c) silt loam, 2 to 5% slopes, eroded	Mb (c)	14	WTPS
Mimosa silt loam, 12 to 20% slopes, eroded	Mm	5	CB
Mountview silt loam, 2 to 5% slopes, eroded	Mt	5	HR

<u>Soil Name</u>	<u>Soil Symbol</u>	<u>Number of Sites Sampled</u>	<u>Areas in Which Sampled</u>
Muskingum loam, 12 to 30% slopes	Mk	8	CP
Porters silt loam, 20 to 30% slopes, eroded	Pt	5	UR
Robinsonville loam and silt loam, 0 to 2% slopes	Rb	5	MRB
Ruston sandy loam, 8 to 25% slopes, eroded	Rt	10	WTPS
Sequatchie sandy loam, 2 to 5% slopes, eroded	Se	5	ETV
Sequoia silt loam, 2 to 5% slopes, eroded	Sq	5	ETV
Sharkey clay, 0 to 2% slopes	Sk	4	MRB
Shubuta sandy loam, 5 to 8% slopes, eroded	Sb	8	WTPS
Silerton silt loam, 5 to 12% slopes, eroded	Sl	5	WTPS
Stiversville silt loam, 2 to 5% slopes, eroded	Sv	5	CB
Talbott silt loam, 2 to 5% slopes, eroded	Ta	5	CB
Waverly silt loam, 0 to 2% slopes	Wa	5	WTPS
Waynesboro loam, 2 to 5% slopes	Wb	5	ETV

APPENDIX B

PROCEDURE FOR TAKING SOIL SAMPLES FOR THE SOIL FERTILITY

INVENTORYING PROGRAM

1. Select an area where the soil is somewhat extensive. A review of previously mapped terrain can help to expedite finding likely sites and assist in routing more efficient collection of the samples.
2. A site is suitable for sampling if the soil profile is near the central concept of the soil as mapped in your area. It should not be more than moderately eroded, i.e., 1 or 2 erosion.
3. Its land use can be either pasture, idle or cropland, if the crops are such crops as corn, cotton, small grain or soybeans. However, it should not be sampled if used for special crops such as tobacco, truck crops, or gardens, where high fertility measures have been employed. Where the soil is largely in forest, sampling is acceptable under forest conditions.
4. Each assigned soil should be sampled at as many sites as indicated on the "Soil Sampling Schedule." Individual sites of one soil series should not be sampled closer than one mile apart.
5. The soil profile at each individual site is to be sampled to a depth of 42 inches or to bedrock if shallower than 42 inches.
6. Only principal horizons of the soil profile are to be sampled. The master surface horizon (A1 or A2) or plow layer (AP) will constitute the first sampled horizon.

No horizon less than 5 inches thick is to be sampled. Transition layers, A3 or B1, if less than 5 inches thick should not be sampled.

No one sample will represent a layer or horizon thicker than 12 inches. Where a horizon or layer is more than 12 inches and less than 24 inches thick, take two samples, one from the upper part and one from the lower part: where 24 to 36 inches thick, take three samples, one to represent the upper part, one from the middle, and one from the lower part.

For any horizon containing coarse fragments: remove the larger fragments from the sample and record their estimated percent by volume before discarding.

7. Sampling can be done with any tool that will be convenient such as a bucket auger, post hole digger, etc.
8. The plastic bags and the large cartons you received are to be used for the samples.
9. Mix the sample before putting it in the bag. Avoid contamination.
10. The soil taken to represent each horizon should be enough to fill the carton about two-thirds full. Insert the plastic bag into the carton before filling.
11. It is important that the plastic bags be tied with fasteners before drying occurs. The samples will be tested at the laboratory in the field moisture condition and also in the air-dry condition. If possible, samples should be taken when the soil is not extremely wet.
12. Use the county highway map to locate the site. Use the form to describe location (within one-half mile) from some common landmark such as a town, church, school, etc. Use numbers or names of roads wherever possible.
13. When possible, you should ship all of the samples at one time, in a securely tied box, by Motor Express, COD, to:

The University of Tennessee Soil Testing Laboratory
810 Broadway
Nashville 3, Tennessee

Sampling and shipping all of the samples within about two days is desirable. However, if your schedule or weather conditions make it necessary to take longer than a week to complete the sampling, follow the procedure that collected samples should not be withheld from shipping any longer than a period of one week.

APPENDIX C

EXAMPLE OF INFORMATION SHEET PREPARED FOR EACH SAMPLE SITE

SOIL SAMPLE INFORMATION

Cooperative Soil Fertility Inventory

SCS - UT, 1962

Soil type Dickson silt loam

Associated soils Lawrence, Guthrie

Date sampled 11-10-62 Sampler's name B. C. Smith

Slope of sampled soil B Erosion of sampled soil 2

Present land use Grass - legume meadow

County Coffee Location 4.3 miles north of Hillsboro
on the Hillsboro-McMinnville road (in SE part of county)

Site No.	Horizon No.	Horizon Symbol	Depth to upper boundary and to lower boundary inches	Texture	Coarse Fragments discarded % by volume
15	1	Ap	0 - 6	sil	0
15	2	B2	10 - 16	sil	0
15	3	B2	16 - 23	sic1	0
15	4	B3m	27 - 35	sic1	0
15	5*	B3m	35 - 42	sic1	0

APPENDIX D

REAGENTS AND PROCEDURE FOR PHOSPHORUS AND POTASSIUM DETERMINATION IN SOILS

Reagents

1. Extracting solution. Prepare 0.05 N. H_2SO_4 containing 1% $(\text{NH}_4)_2\text{SO}_4$.
2. Activated carbon (phosphate free).
3. Molybdic acid solution. Dissolve 25 grams ammonium molybdate $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ in 200 ml. distilled water heated to 60°C and filter. Dilute 275 ml. conc. H_2SO_4 to 750 ml.; after both solutions have cooled, add the ammonium molybdate solution, slowly with stirring, to the sulfuric acid solution. Cool and dilute to 1000 ml.
4. Reducing agent (amino-naphthol-sulfonic acid). Mix thoroughly 2.5 grams 1-amino-2-naphthol-4-sulfonic acid (Eastman), 5.0 grams sodium sulfite (Na_2SO_3) and 146.25 grams sodium bisulfite (meta, $\text{Na}_2\text{S}_2\text{O}_5$) and grind the mixture to a fine powder. Dissolve 8.0 grams of the powder mixture in 50 ml. of warm distilled water. If possible, allow to stand overnight before using and filter before using, to remove any crystals formed.

Procedure

1. Weigh 5 grams of soil into a 125 ml. flask.
2. Add small amount of activated carbon and mix.
3. Add 20 ml. of extracting solution.
4. Shake for 5 minutes.
5. Filter, using Whatman No. 1 filter paper, collecting entire filtrate.
6. Pipette 10 ml. of filtrate into 25 ml. flask. Use remainder of filtrate for potassium determination. (For blank use 10 ml. extracting solution.)
7. Add 1/2 ml. of molybdic acid solution and mix.
8. Add 5 drops (3 drops to blank) of reducing agent and mix immediately.

9. Read in spectrophotometer at 650 wave length 15 minutes after adding reducing reagent.
10. Convert readings to ppm. Phosphorus from standard curve plotted from readings obtained from phosphorus standards run in a similar manner.
11. Use remaining filtrate for determining potassium with Perkin-Elmer Model 52C flame photometer by direct method.

APPENDIX E

CLASS DISTRIBUTION OF pH FOR INDIVIDUAL 12 TO 24 INCH LAYERS OF SAMPLED SOILS

Soil	No. of sites	Mean	Classes of pH						
			4.5 or less	4.6- 5.0	5.1- 5.5	5.6- 6.0	6.1- 6.5	6.6- 7.3	7.4- 7.8
Robinsonville	5	7.3						2	3
Commerce	5	7.3						3	2
Lindside (ETV)	5	6.9					2	3	
Melvin	5	6.8					2	2	1
Huntington-P	10	6.8					4	5	1
Huntington (ETV)	5	6.7					2	3	
Lindside-P	15	6.6				1	9	5	
Congaree	5	6.4					2	3	
Huntington (HR)	5	6.4					3	2	
Maury	8	6.2				3	3	2	
Armour	9	6.2				3	6		
Baxter	5	6.2			1	2	1	1	
Dellrose	10	6.1			1	2	6	1	
Lindside (HR)	6	6.1			1	1	4		
Cumberland (ETV)	7	6.1			1	2	3	1	
Decatur	5	6.1				3	2		
Stiversville	5	6.1				1	4		
Sharkey	4	5.9				2	2		
Lexington	5	5.9			1	2	2		
Etowah (ETV)	3	5.9			1	1		1	
Cumberland (HR)	3	5.9			1	1		1	
Mimosa	5	5.9			1	3	1		
Waynesboro	5	5.9			1	3	1		
Ennis	8	5.8		2		3	2	1	
Memphis (c)	14	5.8			4	7	3		
Mountview	5	5.8			3		2		
Collins	18	5.8			3	12	3		
Porters	4	5.8				4			
Sequoia	5	5.8			2	2		1	
Sequatchie	5	5.8			2	2	1		
Falaya	18	5.8		1	4	10	3		
Lobelville	7	5.7			2	5			
Ina	20	5.7		1	5	9	5		
Bewleyville	5	5.7			2	2	1		
Etowah (HR)	5	5.7			2	2	1		

Soil	No. of sites	Mean	Classes of pH						
			4.5 or less	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.3	7.4-7.8
Talbott	5	5.7		1		3	1		
Dundee	5	5.7			2	2		1	
Captina	5	5.6		1	1	3			
Hymon	15	5.6		2	5	6	2		
Memphis (b)	15	5.6		1	7	6		1	
Dunmore	5	5.5		1	2	1	1		
Fullerton	15	5.5		3	7	3	2		
Ruston	10	5.5		1	5	4			
Hartsells	10	5.5			9			1	
Bodine	5	5.5			3	2			
Henry	5	5.4		1	3		1		
Memphis (a)	10	5.4		1	4	5			
Grenada	13	5.4			10	3			
Silerton	5	5.3		1	3	1			
Waverly	5	5.3			5				
Shubuta	8	5.3		1	7				
Dickson	15	5.3		1	13			1	
Dulac	5	5.3			5				
Muskingum	3	5.1		1	2				
Lawrence	5	5.1		2	3				
Clarksville	5	4.9	1	2	2				

APPENDIX F

CLASS DISTRIBUTION OF PHOSPHORUS FOR INDIVIDUAL 12 TO 24 INCH LAYERS
OF SAMPLED SOILS

Soil	No. of sites	Mean	ppm available phosphorus						
			0-1.5	1.6-3	4-6	7-12	13-24	25-48	49+
Huntington-P	10	120							10
Mimosa	5	118						1	4
Lindside-P	15	98				1	2		12
Stiversville	5	88						2	3
Armour	9	59		1		2		2	4
Commerce	5	52					1	1	3
Maury	8	48				1	2	3	2
Captina	5	48						2	3
Robinsville	5	36						2	3
Memphis (a)	10	34					1	7	2
Dundee	5	18			1	1	1	2	
Sharkey	4	16					2	2	
Dellrose	10	16			3	3	2	2	
Memphis (b)	15	14				4	11		
Congaree	5	14			1	1	3		
Grenada	13	8				10	3		
Cumberland (HR)	3	7		2			1		
Waverly	5	7		1	2	1	1		
Falaya	18	5		3	9	6			
Memphis (c)	14	3.9		8	3	3			
Collins	18	3.9	4	4	7	3			
Melvin	5	3.5		4		1			
Huntington (HR)	5	3.4	2	2		1			
Huntington (ETV)	5	3.2	1	2	2				
Etowah (ETV)	3	2.9		1	1	1			
Lobelville	7	2.7	2	3	2				
Henry	5	2.6	1	2	2				
Ennis	8	2.5	2	5	1				
Ina	20	2.3	6	12	1	1			
Hymon	15	2.0	3	11	1				
Lindside (ETV)	5	2.0	2	2	1				
Cumberland (ETV)	7	1.9	2	5					
Decatur	5	1.9		5					
Mountview	5	1.9	2	3					
Lexington	5	1.9	1	4					

Soil	No. of sites	Mean	ppm. available phosphorus						
			0-1.5	1.6-3	4-6	7-12	13-24	25-48	49+
Lindside (HR)	6	1.8	3	3					
Muskingum	3	1.8	2	1					
Porters	4	1.8	2	2					
Baxter	5	1.7	1	4					
Bewleyville	5	1.7	2	3					
Waynesboro	5	1.6	3	2					
Etowah (HR)	5	1.5	4	1					
Lawrence	5	1.5	4	1					
Talbott	5	1.5	3	2					
Bodine	5	1.4	3	2					
Dunmore	5	1.4	4	1					
Clarksville	5	1.4	4	1					
Ruston	10	1.3	9	1					
Sequatchie	5	1.3	4	1					
Dickson	15	1.3	12	3					
Fullerton	15	1.2	13	2					
Hartsells	10	1.2	9	1					
Silerton	5	1.1	4	1					
Sequoia	5	1.1	4	1					
Shubuta	8	1.1	8						
Dulac	5	1.1	5						

APPENDIX G

CLASS DISTRIBUTION OF POTASSIUM FOR INDIVIDUAL 12 TO 24 INCH LAYERS OF
SAMPLED SOILS

Soil	No. of sites	Mean	ppm. available potassium				
			0-40	41-60	61-90	91-130	131+
Lexington	5	149		1	2	1	1
Cumberland (HR)	3	136		1		1	1
Sharkey	4	130			1	1	2
Mimosa	5	109			4		1
Melvin	5	100			3		2
Memphis (a)	10	84		2	5	3	
Commerce	5	80		1	3	1	
Dundee	5	77		3		1	1
Silerton	5	72		3		2	
Shubuta	8	71		4	2	1	1
Robinsonville	5	71		2	2	1	
Waynesboro	5	69		2	2	1	
Bewleyville	5	68		3	1	1	
Cumberland (ETV)	7	64	1	2	4		
Decatur	5	64		2	3		
Captina	5	63	2	2			1
Maury	8	62	1	2	5		
Baxter	5	60		3	2		
Ruston	10	57	2	5	2		1
Huntington (ETV)	5	56	1	3		1	
Dunmore	5	56		4	1		
Memphis (b)	15	55	5	5	5		
Sequoia	5	55	2	1	2		
Waverly	5	54	3		1	1	
Dulac	5	54	1	2	2		
Memphis (c)	14	53	2	9	3		
Porters	4	53	2	1		1	
Talbott	5	53		4	1		
Armour	9	52		8	1		
Bodine	5	50	1	3	1		
Stiversville	5	48	1	3	1		
Congaree	5	47	3		2		
Fullerton	15	46	7	6	2		
Huntington-P	10	46	3	7			
Lindside-P	15	45	8	6		1	
Etowah (HR)	5	44	3	1	1		

Soil	No. of sites	Mean	ppm. available potassium				
			0-40	41-60	61-90	91-130	131+
Grenada	13	43	5	8			
Henry	5	42	1	4			
Muskingum	3	42	1	2			
Dellrose	10	41	6	4			
Etowah (ETV)	3	40	1	2			
Mountview	5	40	2	3			
Hartsells	10	39	5	4	1		
Sequatchie	5	37	3	2			
Dickson	15	36	9	6			
Lindside (ETV)	5	34	4	1			
Hymon	15	29	12	2	1		
Collins	18	29	16	2			
Lawrence	5	28	4	1			
Falaya	18	27	17			1	
Clarksville	5	27	5				
Ina	20	27	19		1		
Lobelville	7	25	7				
Lindside (HR)	6	24	6				
Ennis	8	24	8				
Huntington (HR)	5	21	5				