SOIL ANALYSIS AT THE ROBITAILLE SITE

Part II: A Method Useful in Determining the Location of Longhouse Patterns*

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INTRODUCTION

As work proceeded on the delimitation of the village site through soil chemical analysis, the authors became increasingly aware that although the P, Mg and pH readings were consistently high within the village area, there were marked differences in chemical concentrations over fairly short distances. The problem we set ourselves was to discover whether the spatial variation in chemical anomalies had any pattern that might be ascribed to the cultural behaviour of the people occupying the site. In fact, we formulated a hypothesis that the highest readings in pH, P and Mg should be found in the middens and the central areas of the former longhouses.

In our previous work we have shown that middens are essentially a complex mixture of decomposed organic refuse and woodash, rich in P, Ca and Mg, with a soil reaction usually well above 6.5 (Hurley and Heidenreich, 1971). On the basis of previous archaeological work and the ethnohistoric accounts (Heidenreich, 1970: 154-171), we reasoned that the longhouse areas should produce high chemical anomalies similar to the middens. Some of the garbage in the middens originated in the longhouses. Even though the longhouses were cleaned periodically, some of the organic residues, particularly near the hearths, would have found their way into the soil. From descriptions of Huron village life we know that the villages were most actively occupied from the late fall to the spring. During that time most activities took place in the longhouses. In the summer the villages stood virtually deserted as women and children worked in the fields, while the men were off hunting, fishing, trading or on raiding expeditions. Since the villages were therefore most actively used in the winter, it stands to reason that the longhouses were the most intensively occupied areas of the village and potentially the areas where one might expect the greatest degree of soil modification. The most common residues that must have found their way into the soil were food remains, wood ash and urine. Among other elements, food remains, urine and excrement are rich in P and Ca while woodash is high in Mg. From archaeological work and the ethnohistoric descriptions we know that the typical Huron longhouse had a series of long, oval, centrally located hearth areas as well as smaller peripheral cooking fires. One would expect these areas to be high in Mg from the woodash and high in P and Ca from spilled food, animal and fish bone. The ethnohistoric accounts also mention that the Huron children and dogs freely urinated on the house floors, a habit that caused comment from some of the early observers. It would not be unreasonable to suppose that excrement, at least from the multitude of dogs that lived within the longhouses, would also have been deposited on the house floors. Since the longhouses at the Robitaille site were built on a loose structureless sand, one would expect that due to the activity in the houses these materials would be quickly mixed into the soil surface. Following the same line of reasoning, the intensity of soil modification should gradually drop off from the central area of the longhouses toward the walls. Except for midden deposits one would expect the village area between the houses to be quite variable in P, Mg and pH, but that the concentrations would not be as high as in the centre of the houses.

Due to the digging of storage pits and perhaps trenches for a palisade one could well expect to find low soil chemical anomalies in a Huron village. Such areas might indicate places where digging had brought subsoil to the surface.

In summary, it was our intention to see if soil chemical analysis can be used to detect contiguous areas of high and low P, Mg and pH anomalies, and to explore the possibility that these anomalies reflected the positioning of the longhouses, palisade and other features.

FIELD PROCEDURE

In designing the sampling procedure we decided to sample at a standard depth along transects run at right angels to the Robitaille longhouse, and parallel to a trench, both excavated by the University of Toronto (Figure 11). There is some evidence to suggest that the Huron grouped their longhouses within the village and that longhouses within such groups were parallel to each other (Heidenreich, 1970). For this reason we decided to run our transects at right angles to the excavated longhouse, believing that such a procedure would lessen the chances of missing a house altogether. It was hoped that the trench excavated by the archaeologists would furnish some data useful for interpreting the results of our transects. Unfortunately backdirt from the archaeological excavations prevented us from beginning the transects immediately adjacent to the longhouse.

The spacing of the sample points along the transects was a real problem because we had no idea how far apart samples should be taken for maximum results. Knowing the enormous soil variations that can occur over short distances we decided to sample at one foot intervals. Another consideration was the minimum width of the features we were looking for; which in the case of longhouses is about twenty feet. Our samples therefore had to be taken close enough together to enable us to distinguish linear features which could be as little as twenty feet wide. We finally decided to sample along five transects (A to E), running south to north for 120 feet. Transect A and B were spaced one foot apart, B to C three feet, C to D three feet and D to E one foot. The width of our sample grid was therefore five transects covering eight feet, while the length of the grid was 120 feet.

From our previous work on the village area we decided that a sample taken with a soil auger at a standard depth of 10" below the A horizon should probe the area of maximum concentration of leached elements (Part I this report). In order to minimize sampling error and attempt to overcome local variations in the depth at which elements have been redeposited, samples should have been taken at several intervals below the soil surface such as 5", 10" and 15". The results of such a sampling procedure would have been 1,800 samples for chemical analysis. Such a number is well above the capacity of our laboratory facilities. We felt that for a preliminary study such as this, one sample at the average level of maximum concentration of leached elements should be sufficient.

In summary then, our sample design was a grid 8 x 120 feet running at right angles north south from an excavated longhouse, furnishing 600 soil samples all taken at a depth of 10". Each sample was examined for pH, P, Mg and soil colour. During the field and laboratory work, notes were made on the presence of features such as rock, pottery, bits of bone, ash deposits and charcoal. The procedures used in the chemical analysis were the same as those used in the previous work on the Robitaille site (Hurley and Heidenreich, 1971). At a future date the authors hope to examine the 600 samples for calcium.

MAPPING PROCEDURE AND DESCRIPTION OF RESULTS

Once the data had been obtained for each of the 600 samples (each sample was processed at least twice to reduce error) the problem arose how to map it. This was essentially a problem in determining *significant* differences between the samples; differences that are attributable to the Indian occupation of the site.

For the purposes of determining the extent of the village, all sample points were mapped that were one and two standard deviations above the mean of the natural soils (Part I, this report). This seemed logical in view of the fact that we were trying to separate modified from natural soils. Since the $X + 1\sigma$, and even the $X + 2\sigma$, of the natural soils are close to the X of the transect soils for the three indicators (P, Mg and pH), one can conclude that the majority of the transect soils have been modified in some form (Tables 1 and 2). A mapping of the soil profiles based on the mean and standard deviations of the natural soils would simply point out that the transects were located within the village.

Since the purpose of mapping the data was to delineate the most intensely modified areas along the transects, we thought it best to base our criteria as to what was significantly modified, on the means of the transect soils. In all, an attempt was made to map the data in four slightly different ways:

1) The simplest solution was to calculate the mean for pH, P and Mg of the 600 samples and map all samples that were one and two standard deviations above and below the mean. Such maps were made for pH, P and Mg. A summary of these maps was prepared for this report by showing the distribution of all samples that had two or all three indicators (pH, P and Mg) one standard deviation or more above and below the mean (Figure 12). Included on this map were all samples with two indicators, two standard deviations above the mean of the natural soils. The results show a clustering of positive anomalies in the five to twenty-five foot areas of the A, B and C transects.

The problem with this method of analysis is that some extraordinarily high values of P and Mg in the A and B transects raise the mean for the entire set of data and obscure some high and low values in the C, D and E transects.

2) In an attempt to overcome the problems inherent in the first line of analysis, the means and standard deviations of the three sets of data were calculated separately for each transect (Table 3). Maps were prepared for the distribution of pH, P and Mg which are summarized in Figure 13. The results show an increase in the clustering of positive anomalies in the D and E transects adjacent to the anomalies in the A, B and C transects. Negative anomalies begin to appear, particularily in the area between 93 and 102 feet along the transects.

The principal problem with the two analytical procedures described so far is that they assume the data have a normal frequency distribution. In view of the nature of the data normal curves should not be expected. Since some of the soils in the village area have been strongly modified through chemical additives one would expect the frequency distribution of pH, P and Mg to be skewed toward the higher values. That this is the case can be seen from the histograms constructed for Figure 14. In every case, particularly Mg, the data are positively skewed, ie. the distribution is extended to the right, toward the higher values.

3) In order to normalize the data (ie: get rid of skewness) so that statistical inferences may be drawn from the results, all pH, P and Mg values were logarithmically transformed. At the same time the data were standardized (reduced to a mean of zero and expressed in units of standard deviations) in order to make the results from different scales of measurement comparable. This procedure is advisable if one wishes to formulate an index of chemical disturbance through the combination of pH, P and Mg, all of which involve different units and magnitudes of measurement.

The results of the standardized and transformed data were mapped separately for pH (Figure 15), P (Figure 16) and Mg (Figure 17). All three maps show an essentially similar pattern which is summarized in Figure 18. The area of greatest chemical disturbance in terms of positive anomalies is in the soils along all transects between the five and thirty foot intervals, while the negative anomalies are mainly north of the 85 foot interval.

4) A fourth approach to the problem of analyzing and mapping the data was to formulate an index of pH + P + Mg out of the standardized and transformed data and subject it to trend surface analysis. Trend surface analysis is a method whereby a three dimensional mathematical surface is fitted to data that have been collected for points on a bounded surface. In our case the height and depth of the surface is provided by the positive and negative index values which were plotted in terms of tenths of a standard deviation. The bounded area within which the three dimensional surface was calculated is the 8 x 120 foot sample grid. The end result is in fact a "best fit" contour map calculated from the index values much like a regression line,

except that a regression line is a best fit for a two dimensional data surface, while a trend surface is best fit for a three dimensional surface. The method is explained in some detail in Cole and King (1968: 375-379). In computing a best fit surface, the computer will print out increasingly more complex surfaces, until, theoretically at least, the original data is reproduced. Of the surfaces computed from the index values, the first simply indicated the general trend of the data running from the high values in the south east segment of the sample grid to the negative anomalies in the north west area. Succeeding surfaces were more complicated. Of these, the fifth degree surface was included in this report (Figure 19). This surface accounted for 29% of the variability of the data, while the fourth degree surface accounted for 23% and the sixth degree surface for 31% of the variability of the data. The sixth degree surface was already too complicated for easy mapping and analysis. The main reason for using trend surface analysis was to overcome the great variations of the data from the sample points. While the result is a smoothing of the data, 71% of the variance in the surface is lost. For this reason the residuals from the fifth degree surface were plotted and included as Figure 20. Figures 19 and 20 should therefore be considered together as the residuals indicate the degree to which the index values deviate from the best fit surface.

Both Figures 19 and 20 reinforce the observations made earlier. High positive values are located in the sample grid between the five and thirty foot intervals, while the negative anomalies are located north of about 95 feet along the transects. The map of residuals pinpoints the area of highest positive anomalies in the ten foot area between the 15 and 25 foot intervals, angling slightly to the north west, while the highest negative anomalies are concentrated over a five foot spread between the 95 and 100 foot intervals slanting towards the north east (Figure 20).

INTERPRETATION OF RESULTS

In interpreting the results it is important not to place too much reliance on the occurrence of isolated anomalies along the transects. The close spacing of the sample points must be kept in mind, both along and between transects. Strong variations in pH, P and Mg can also occur in natural soils over short distances. In order for an anomaly to be considered significant it should therefore extend at least three feet along and across transects.

A summary of the results from the first three methods of data analysis are presented in Figure 21. The largest contiguous area of high anomalies stretches across a 20 foot span between the 10 and 30 foot intervals along the transects. One small area of high anomalies occurs outside the primary area near the fifty foot interval along the A and B transects. This anomaly appears to be associated with a small midden. There are no other major positive anomalies in the sample grid. Similarily the trend surface analysis (Figure 19) and map of residuals (Figure 20) disclose only one major area of positive anomalies.

Within the area of high anomalies there are two areas of extremely high values. The southern one is located in the A, B and C transects between the 15 and 20 foot intervals while the northern one is in the A and B transects between 17 and 20 feet (Figure 21). An examination of the sieved soil material from the samples in these areas reveals a high ash content, some charcoal and minute fragments of fish and animal bone. Samples 17, 18 and 19 in the A and B transects are almost pure woodash, as are samples 23 and 24 in the B transect and sample 15 in the C transect. What we appear to have here is a large hearth area centered in the 17 and 19 foot area with a possible peripheral fire place at about 24 feet along the A and B transects.

Judging from the above results one could hypothesize that a longhouse occupied the area between the ten and thirty foot intervals and ran roughly parallel to the longhouse excavated by the University of Toronto. The post and hearth features in the trench to the east of the transects seemed to confirm our hypothesis (Figure 22). The southern longhouse wall lies somewhere between the five and ten foot interval (probably the latter), while the northern wall passes across the transects somewhere between 30 and 35 feet. The longhouse- is therefore somewhere between 20 and 30 feet in width, but most likely not more than 20 to 25 feet. Its orientation is similar to the one excavated in 1969.

The large negative anomalies in the latter half of the transects presents a problem. Some of the lowest values are well below the means of even the natural soils (Figures 20 and 21). By and large the contiguous areas of negative anomalies appear to be areas where subsoil has been brought to the surface, areas where considerable digging has taken place. Because the five foot wide negative anomaly, running across the transects between the 95 and 100 foot intervals, coincides with the edge of the village as defined earlier in this paper (Figure 11), we suspect that this is possibly where a palisade passed through the transects. This hypothesis requires archaeological confirmation.

There appears to be no other major features passing across the five transects.

EVALUATION OF TECHNIQUES

From the evidence presented in this paper it seems fair to conclude that the spatial distribution of pH, P and Mg are useful indicators for determining the location of longhouses and perhaps also palisades. In evaluating the usefulness of the technique, one must keep in mind that the soils at the Robitaille site have undergone very little disturbance since the Indian occupation. Future work at other sites must determine to what extent plowing and fertilization have obliterated the earlier chemical patterns. A related question is the extent to which multiple occupations of a site or the burning and rebuilding of houses can be distinguished. On the whole, taking the above problems into consideration, we feel that soil chemical methods are useful in delineating the size of a site and. determining the areas of most intensive occupation within the site.

The advantages of a soil chemical survey of a site are that a great deal of general information can be gathered in a short time. Two people can gather over 100 auger samples in the field per day while the rapidity of the lab analysis by the same two people is limited only the instruments at their disposal. With a colorimeter (Spectronic 20, Bausch and Lomb) and a spectrophotometer (Evans Model 140), we were able to do about 20 P and Mg samples per day. However, with an Autoanalyzer (Technicon Instruments Corp.) several hundred samples can be processed in a day The data can be punched on computer cards as the analysis proceeds. Standard computer programmes exist for the logarithmic transformation and standardization of data as well as the calculation and printing of trend surface maps.

In re-evaluating our field procedures we find that it would have been sufficient to take samples every two or three feet along the transects. Similarily the transects could be spaced two to three feet apart. We would however recommend taking more than one sample from each auger hole. Two samples should be sufficient, taken at two different levels within the area of maximum accumulation (5 to 15 inches). An average of two readings should provide a more reliable assessment of the chemical conditions of a particular soil section than one sample taken at the average depth of maximum chemical accumulation.

CONCLUSIONS

Soil chemical methods can be used with fair success to delineate a village and the most intensely occupied parts of a village. In a site that has undergone little soil disturbance or multiple occupation, the method shows promise in the detection of house patterns. Two of the advantages of soil chemical methods are the rapidity with which data can be gathered on a village site and the relative lack of disturbance to the site through soil augering.

We see the major use of this method in determining the size of a village and the major areas of intensive occupation prior to a detailed excavation. The soil survey could be used to pinpoint areas of potential archaeological interest as well as to provide a rough indicator of house concentrations in the unexcavated parts of a village.

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TABLE 1

MEANS (X) AND STANDARD DEVIATIONS (o-) OF NATURAL SOILS

	pH	P(ppm)	Mg(ppm)
X	5.59	1348	382
X + 1 o-	5.89	1711	545
X + 2 o-	6.19	2074	708
X - 1 o-	5.29	985	219
X - 2 o-	4.99	622	56

TABLE 2

MEANS (X) AND STANDARD DEVIATIONS (o-) OF TRANSECT SOILS (X based on all samples)

	pH	P(ppm)	Mg(ppm)
X	6.04	2029	571
X + 1 o-	6.37	2714	2269
X + 2 o-	6.70	3399	3967
X - 1 o-	5.71	1344	-
X - 2 o-	5.38	659	-

TABLE 3

MEANS (X) AND STANDARD DEVIATIONS (o-) OF TRANSECT SOILS (X based on each transect)

Transect	X	X + lo-	X + 2o-	X - lo-	X - 2o-
			pH		
A	6.02	6.43	6.84	5.61	5.20
B	6.02	6.34	6.66	5.70	5.38
C	5.99	6.30	6.61	5.68	5.37
D	6.01	6.33	6.65	5.69	5.37
E	5.97	6.24	6.51	5.60	5.33
			P(pprn)		
A	2307	3231		1383	459
B	2091	2810	3529	1372	653
C	1865	2408	2951	1322	779
D	1909	2423	2937	1395	881
E	1899	2405	2911	1393	887
			Mg(ppm)		
A	880	4149	7418	-	-
B	720	2373	4026	-	-
C	449	1143	1819	-	-
D	379	557	735	201	23
E	396	625	854	167	-

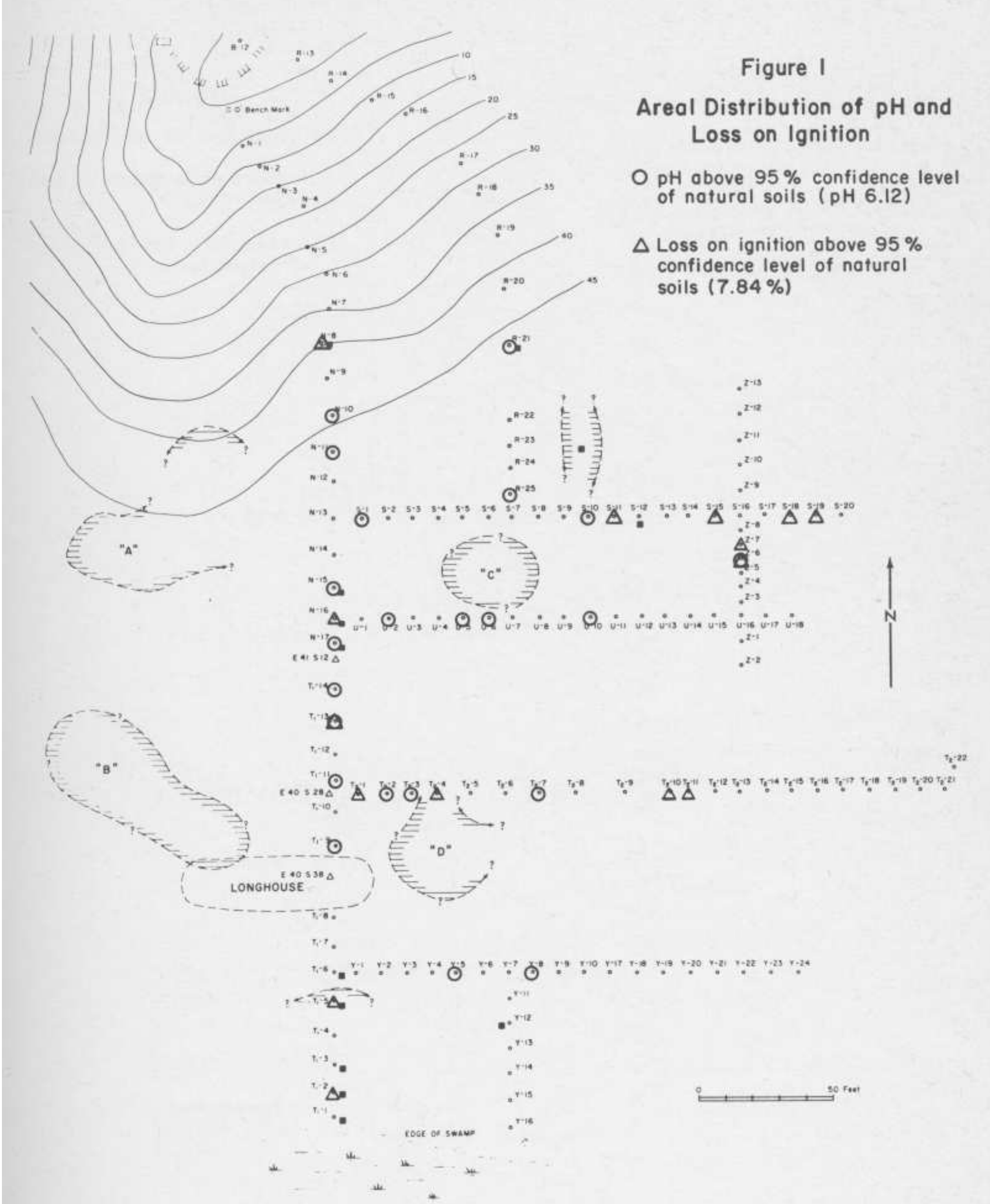


Figure I
Areal Distribution of pH and Loss on Ignition
O pH above 95 % confidence level of natural soils (pH 6.12)
Δ Loss on ignition above 95 % confidence level of natural soils (7.84 %)
"A"
"B"
"C"
"D"
LONGHOUSE
EDGE OF SWAMP
N
50 Feet

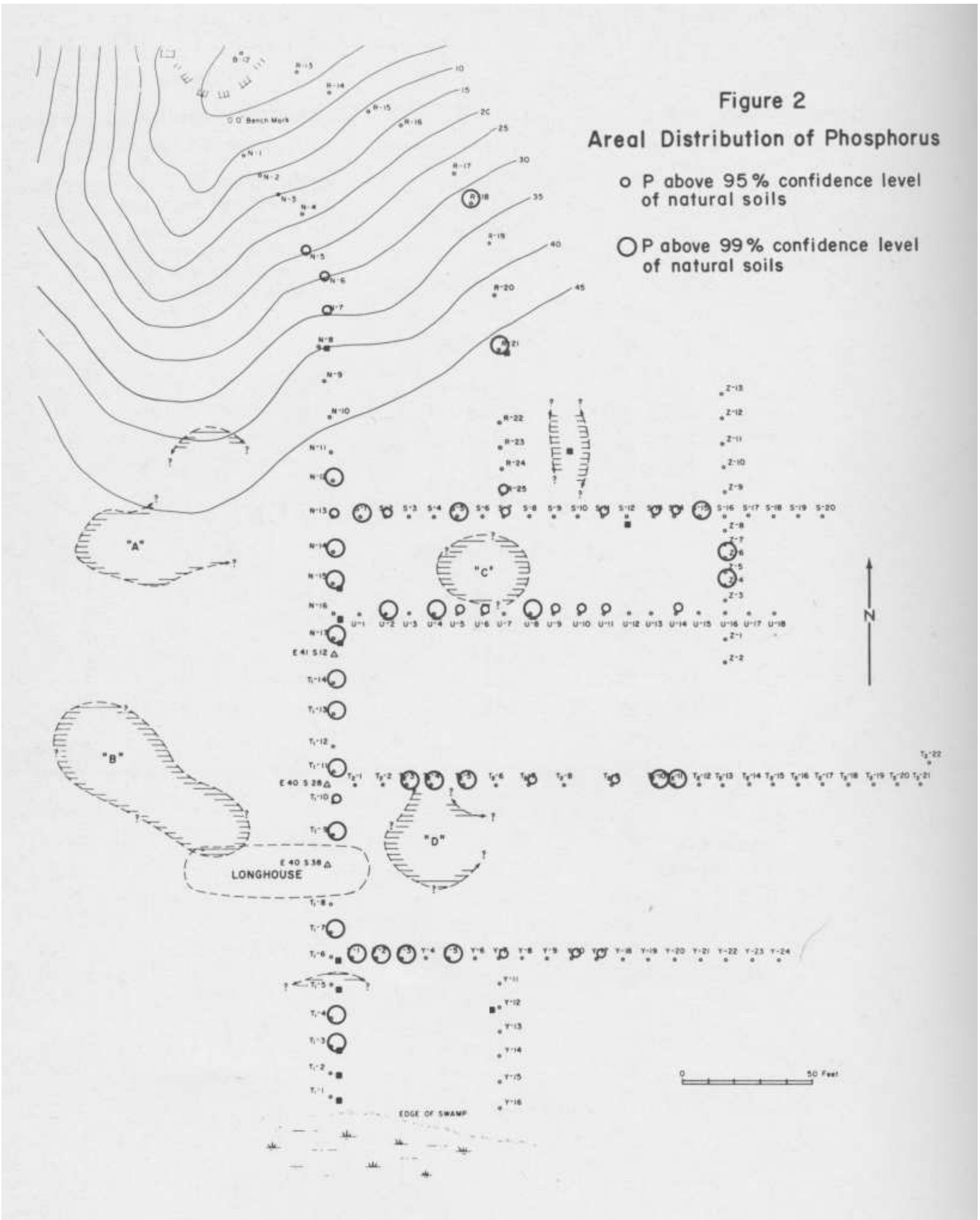


Figure 2
Areal Distribution of Phosphorus

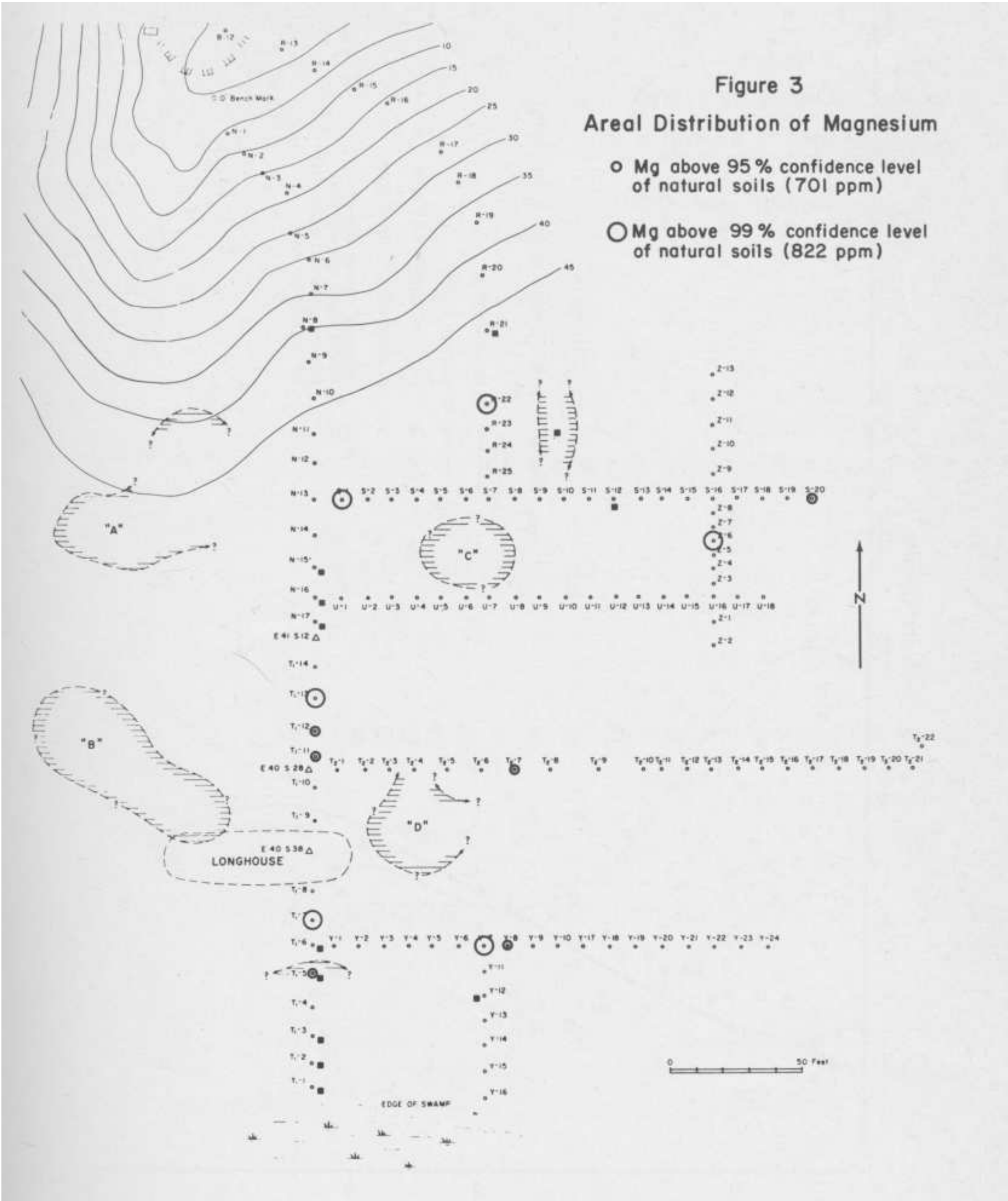


Figure 3
Areal Distribution of Magnesium
o Mg above 95 % confidence level of natural soils (701 ppm)
O Mg above 99 % confidence level of natural soils (822 ppm)
"A"
"B"
"C"
"D"
LONGHOUSE
EDGE OF SWAMP
N
50 Feet

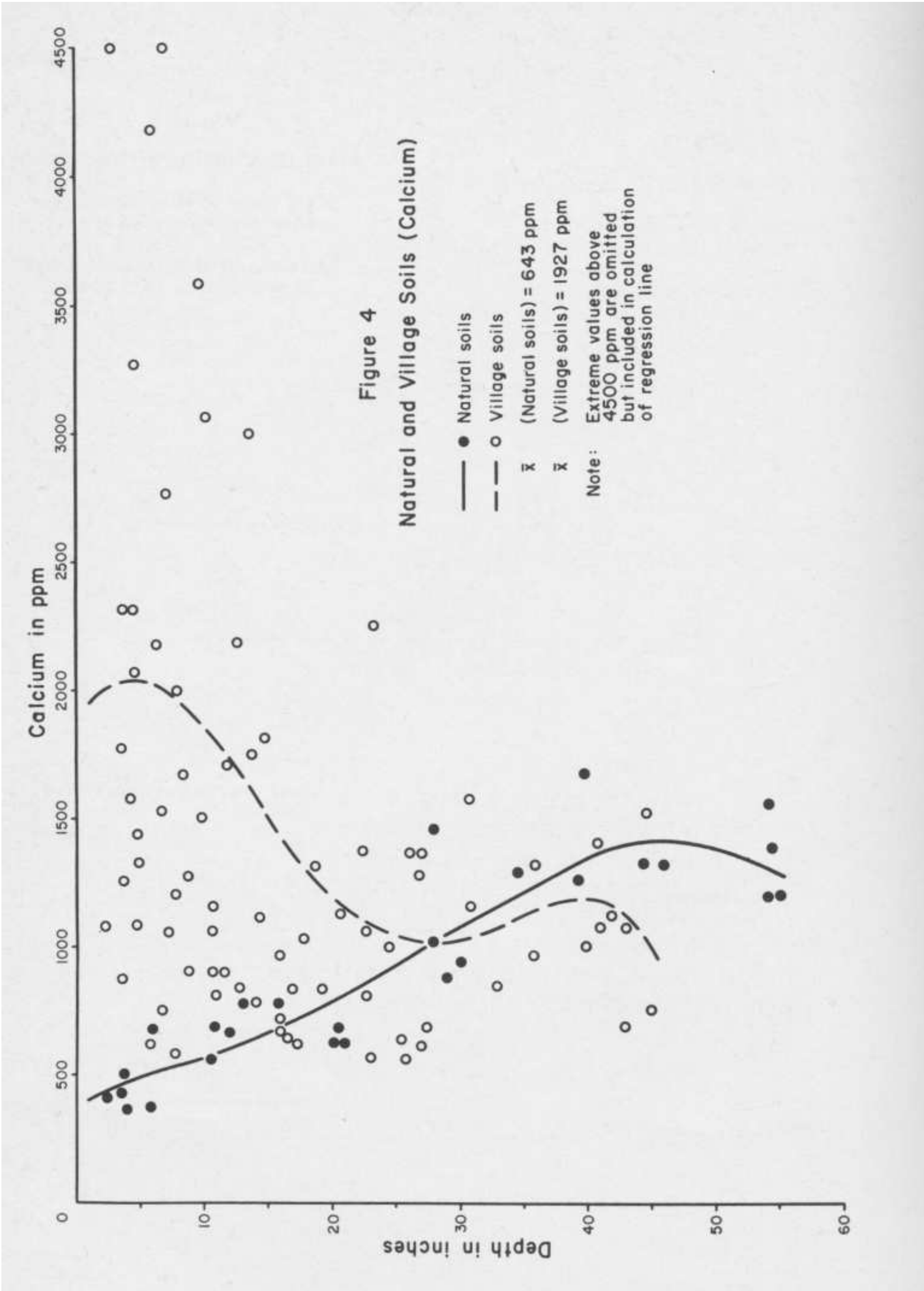


Figure 4
Natural and Village Soils (Calcium)

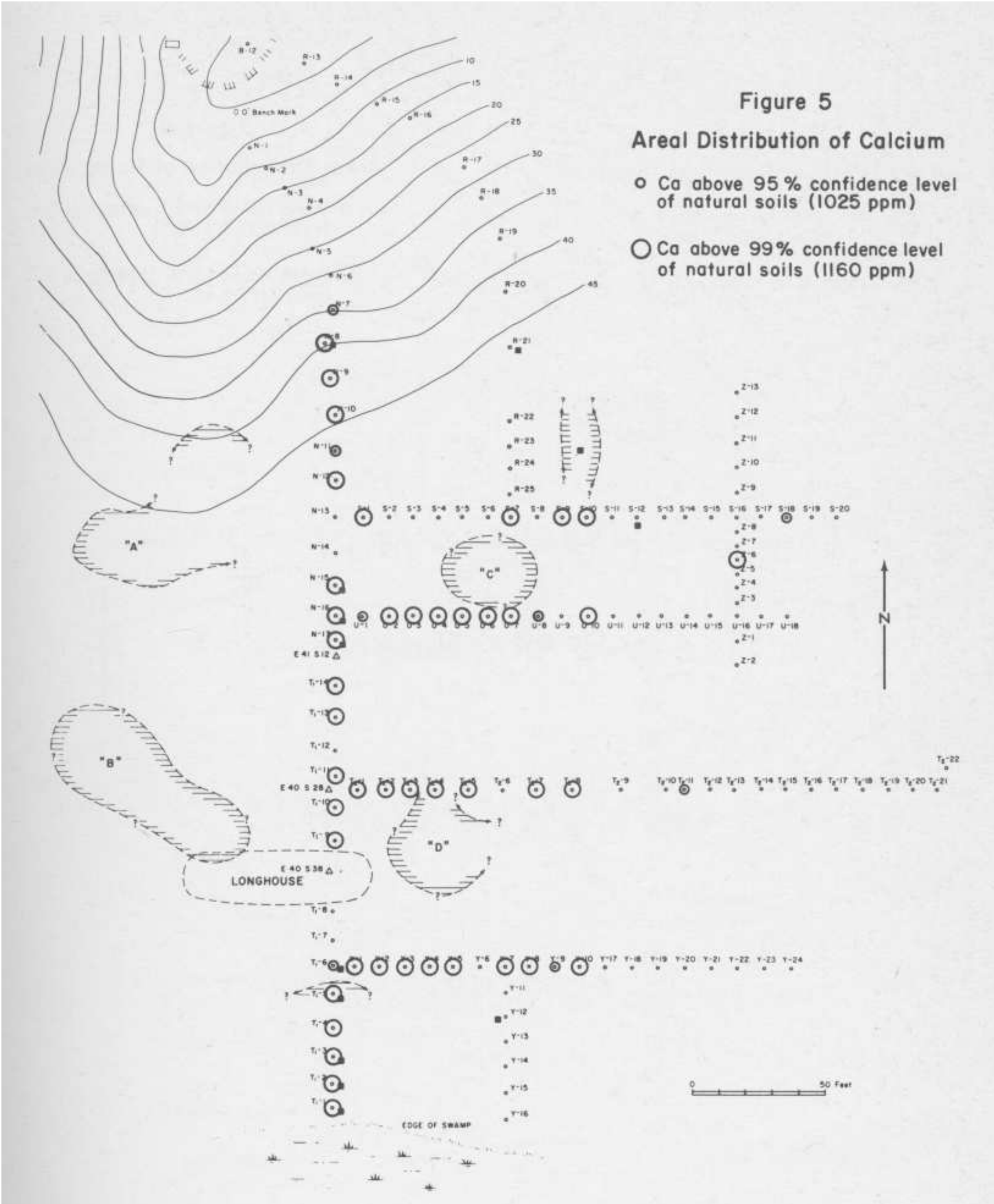


Figure 5
Areal Distribution of Calcium
Ca above 95 % confidence level of natural soils (1025 ppm)
Ca above 99 % confidence level of natural soils (1160 ppm)
0 O' Bench Mark
"A"
"B"
"C"
"D"
LONGHOUSE
EDGE OF SWAMP
E 41 S 12
E 40 S 28
E 40 S 38
N
0
50 Feet

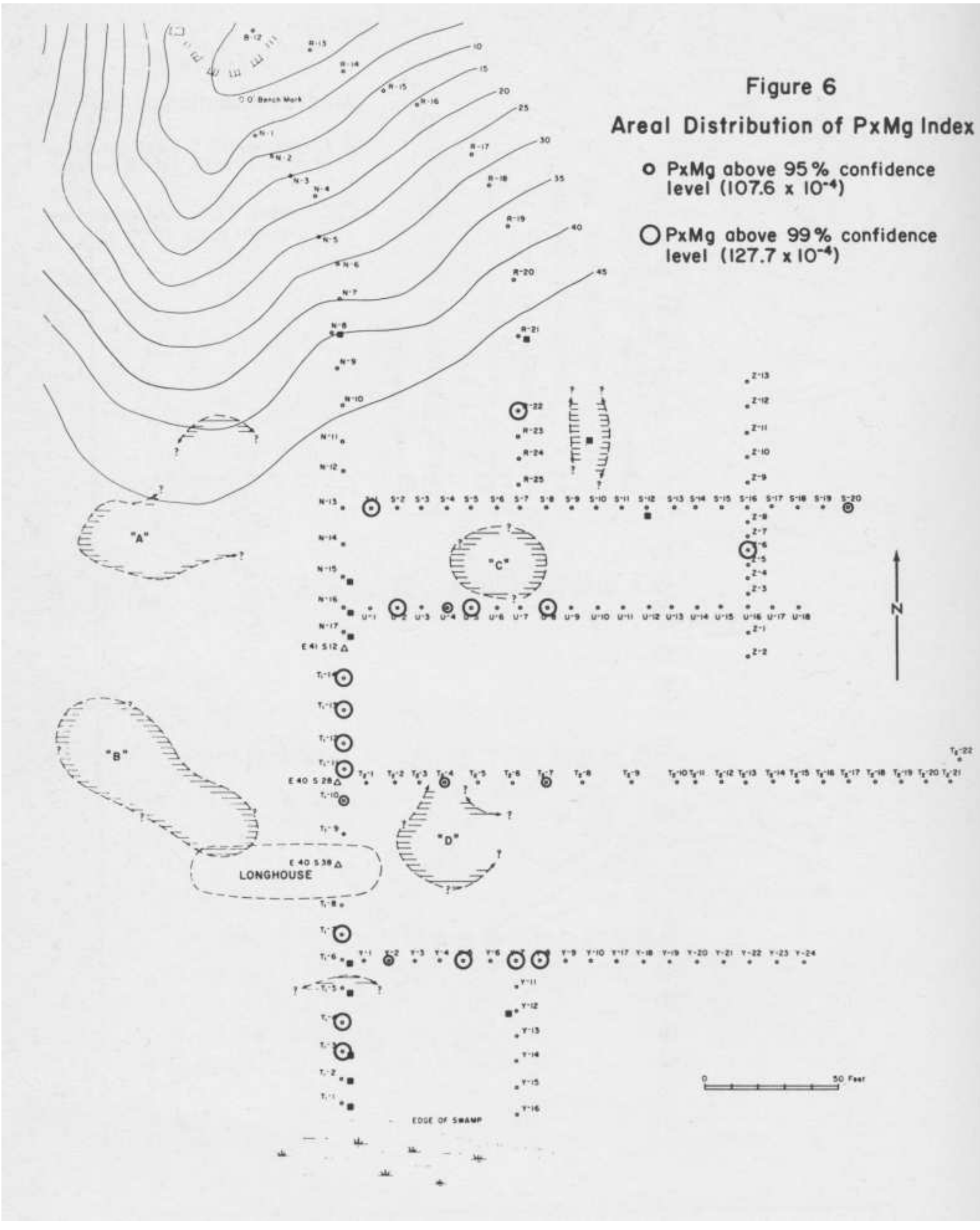


Figure 6
Areal Distribution of PxMg Index

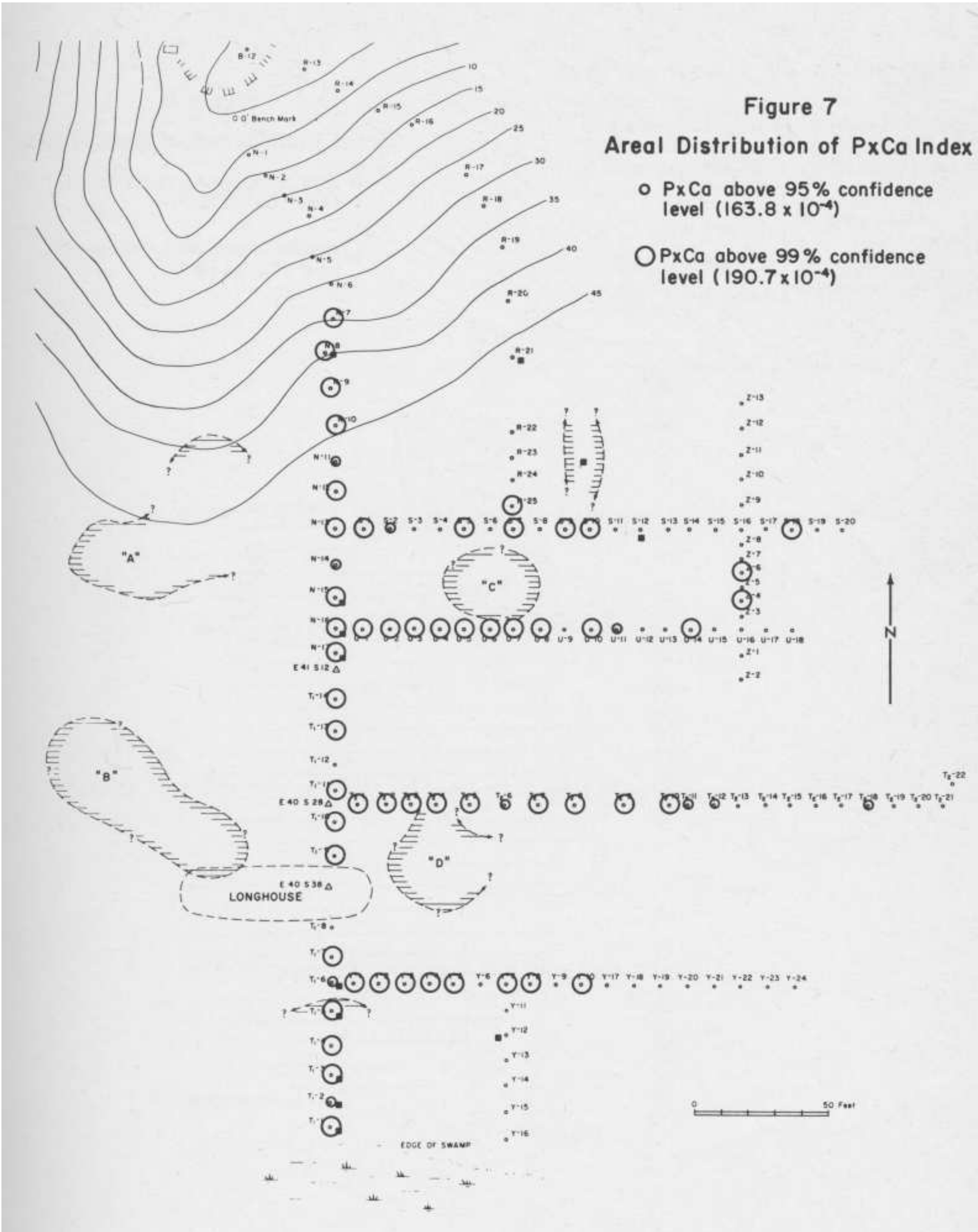


Figure 7
Areal Distribution of PxCa Index

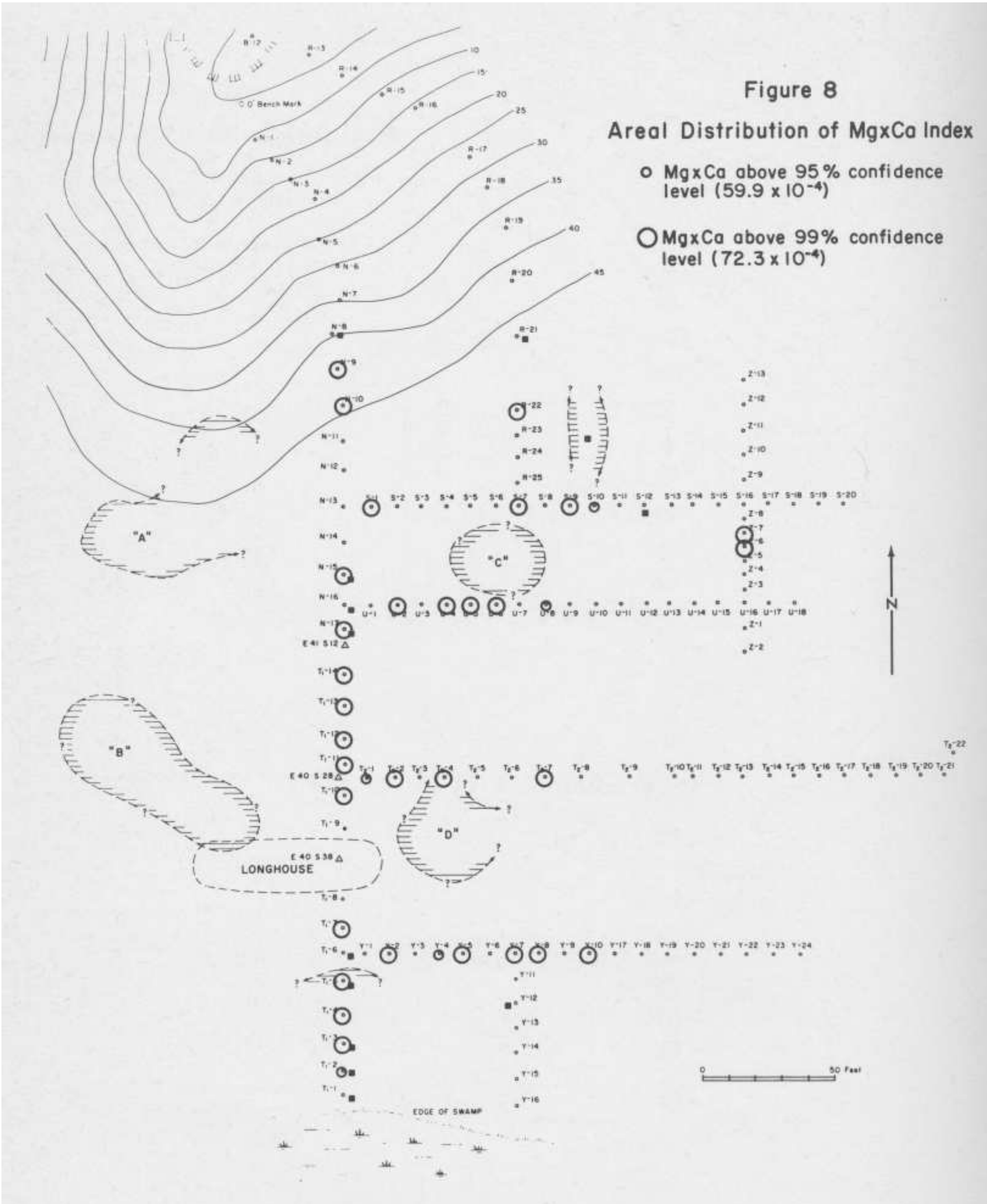


Figure 8

Areal Distribution of MgxCa Index

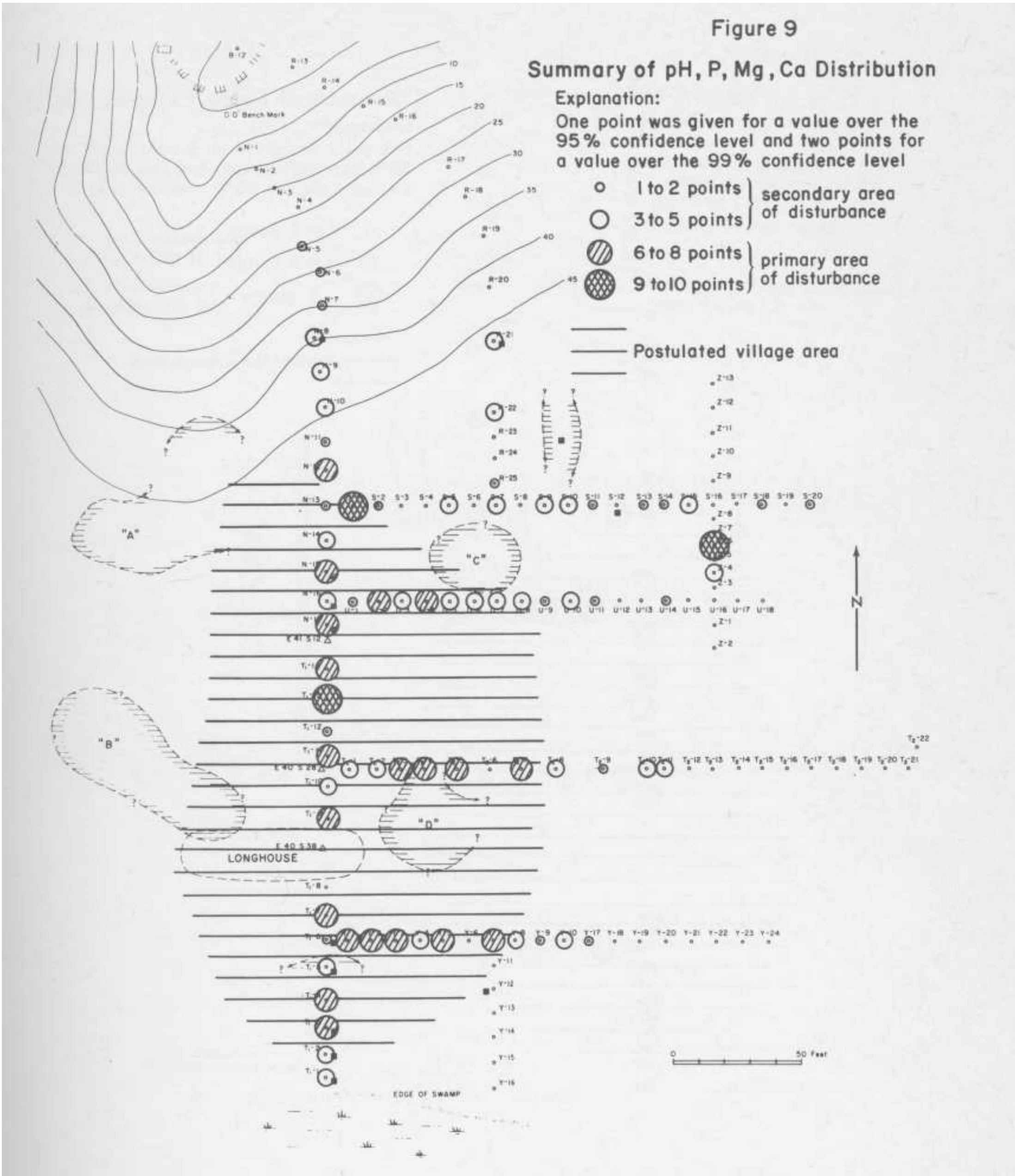


Figure 9
Summary of pH, P, Mg, Ca Distribution

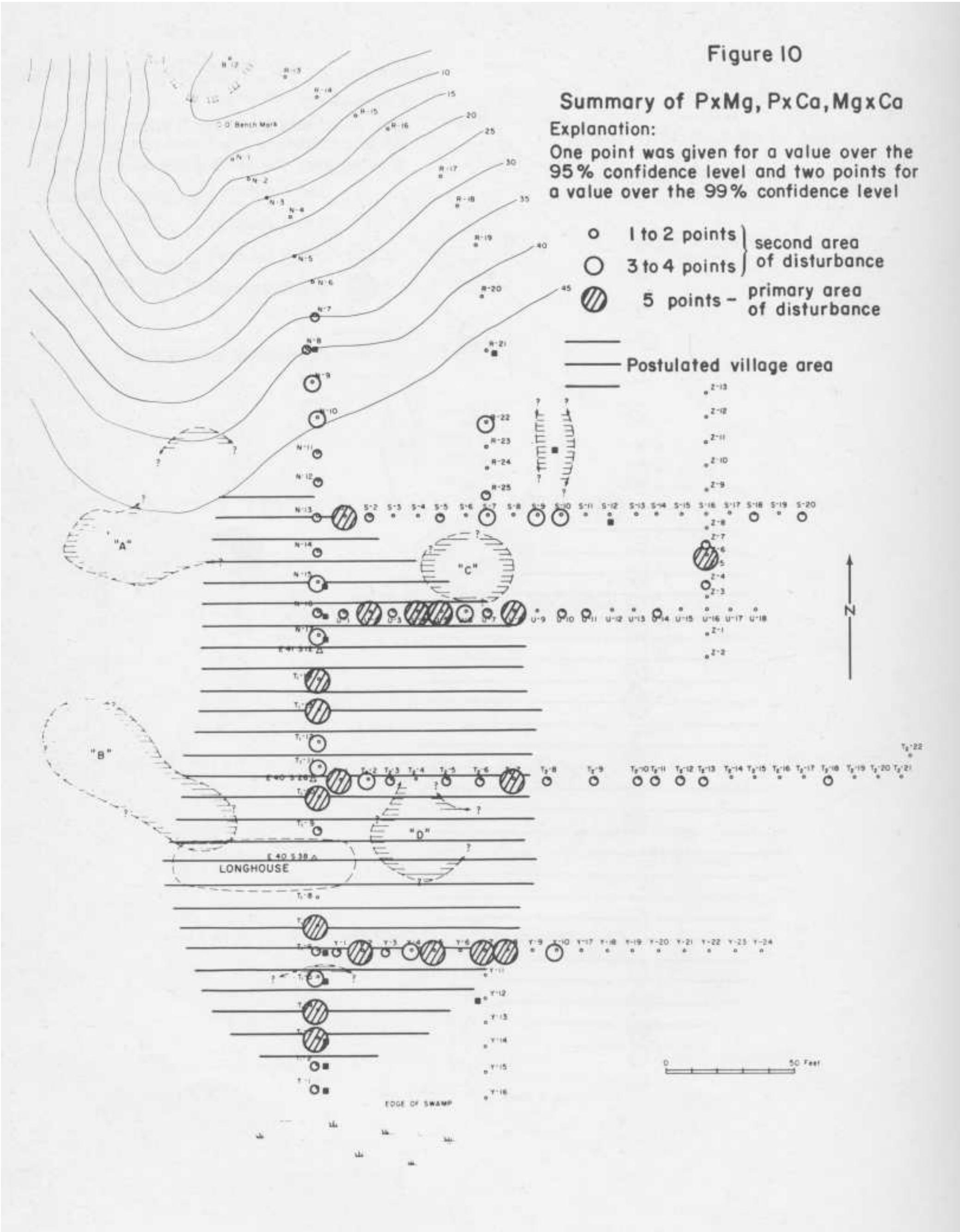


Figure 10

Summary of PxMg, PxCa, MgxCa

Explanation:
One point was given for a value over the 95% confidence level and two points for a value over the 99% confidence level

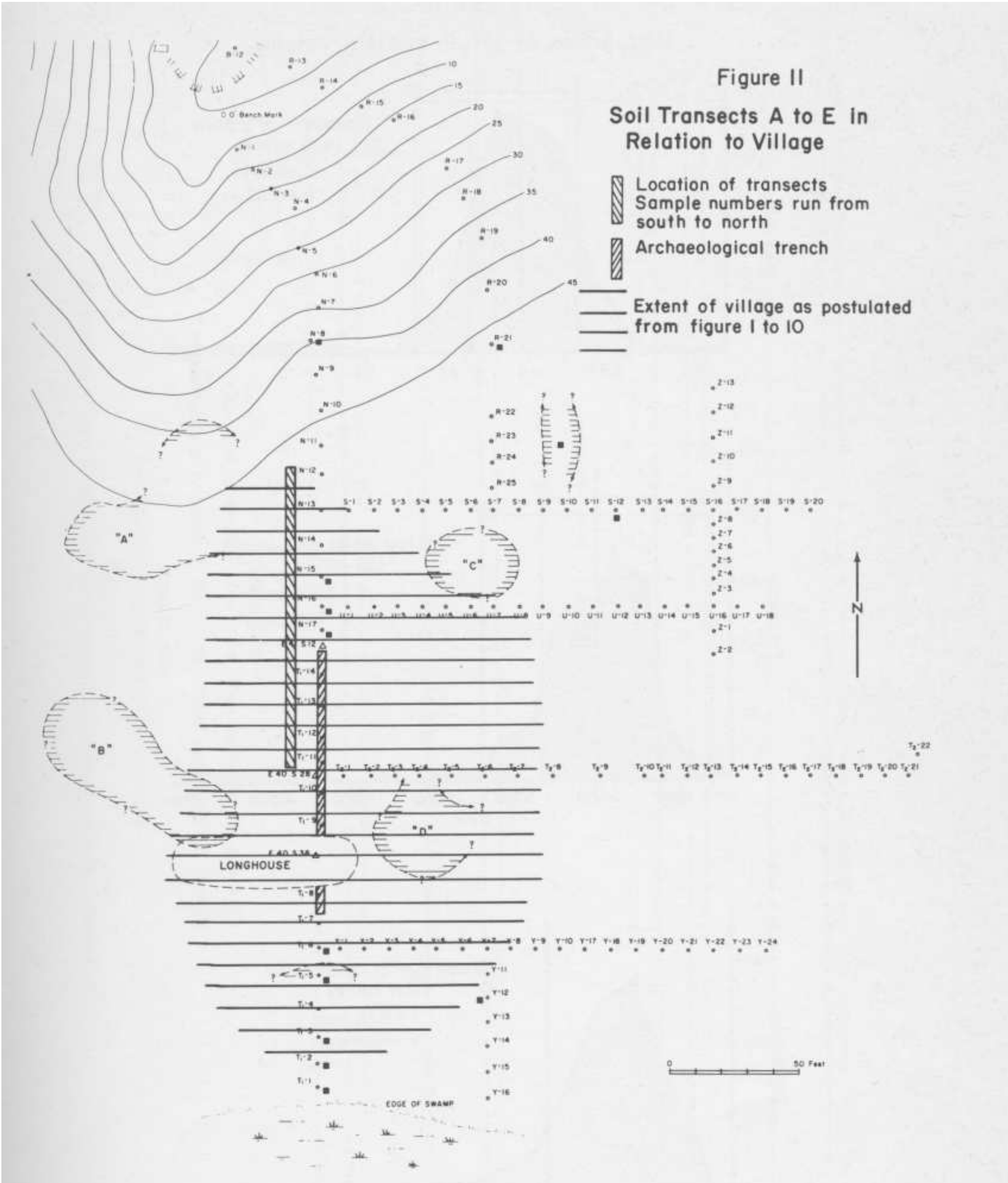
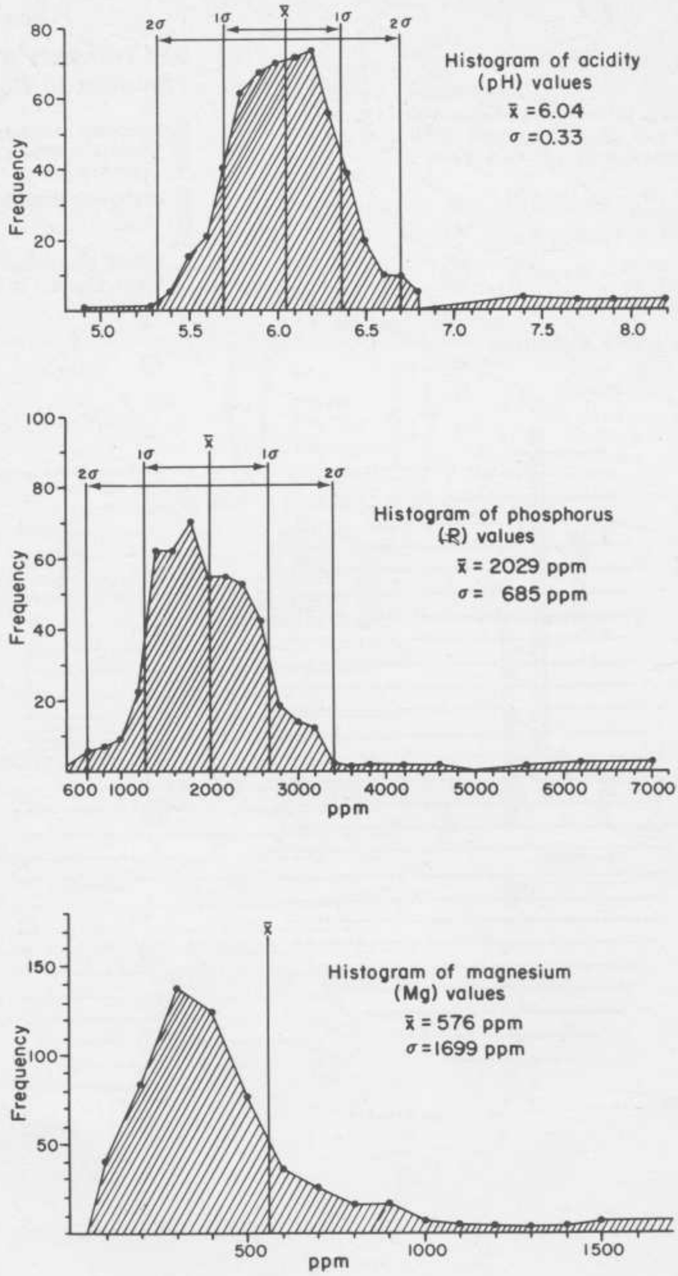


Figure II
Soil Transects A to E in Relation to Village

Figure 12

Histograms of pH, P and Mg Values



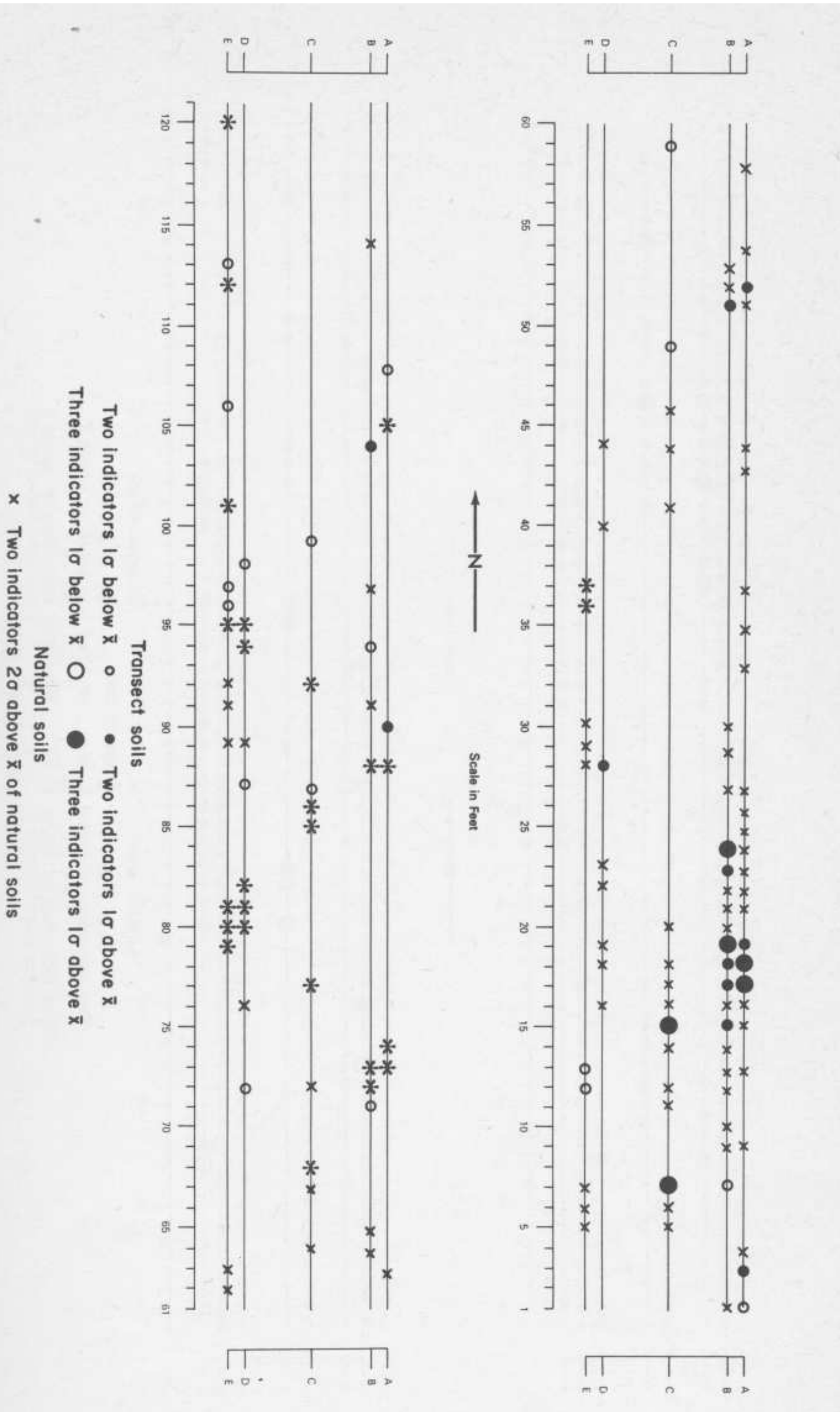


Figure 13
Summary of pH, P and Mg Distribution (x̄ based on all transects)

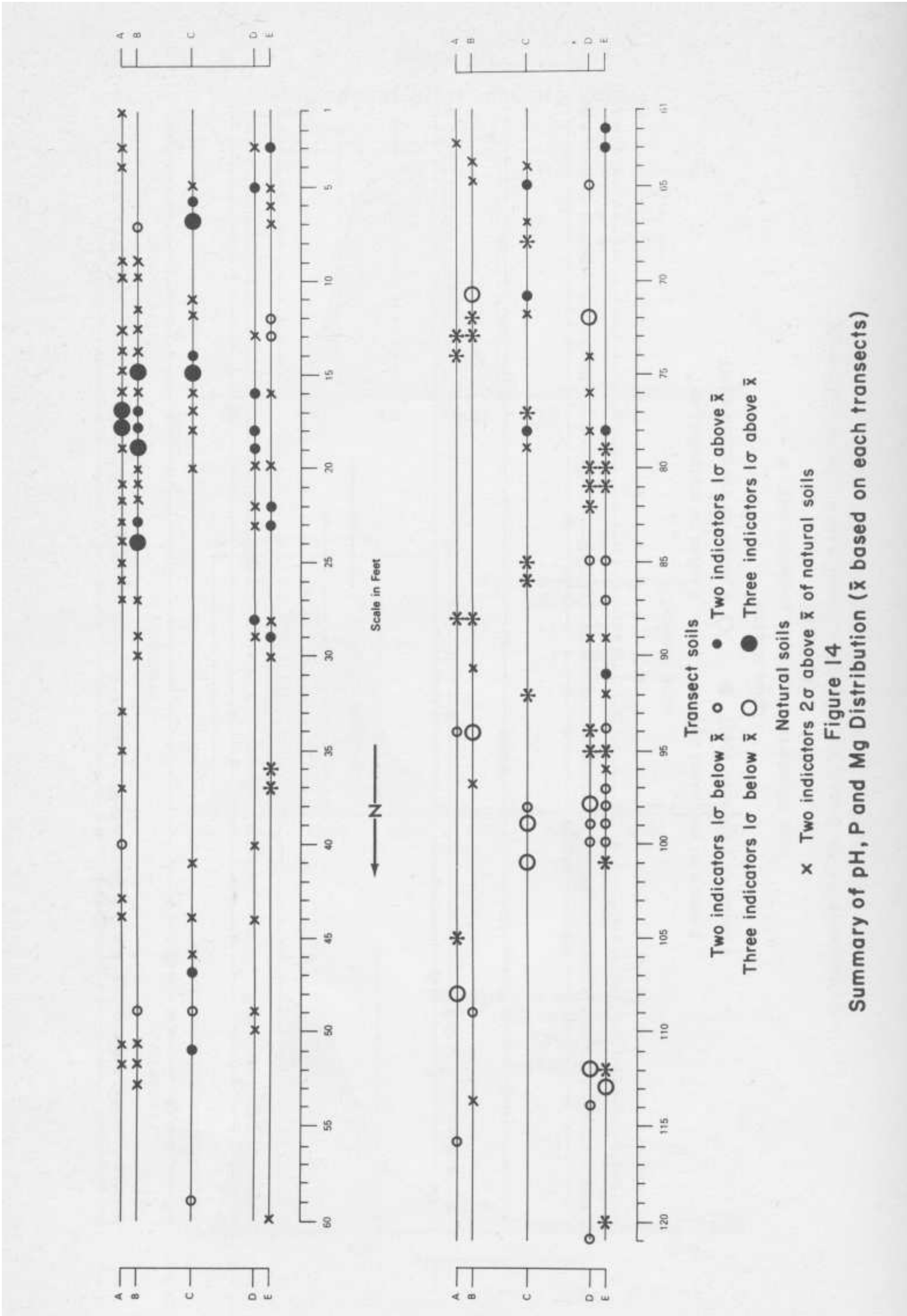


Figure 14
Summary of pH, P and Mg Distribution (x̄ based on each transects)

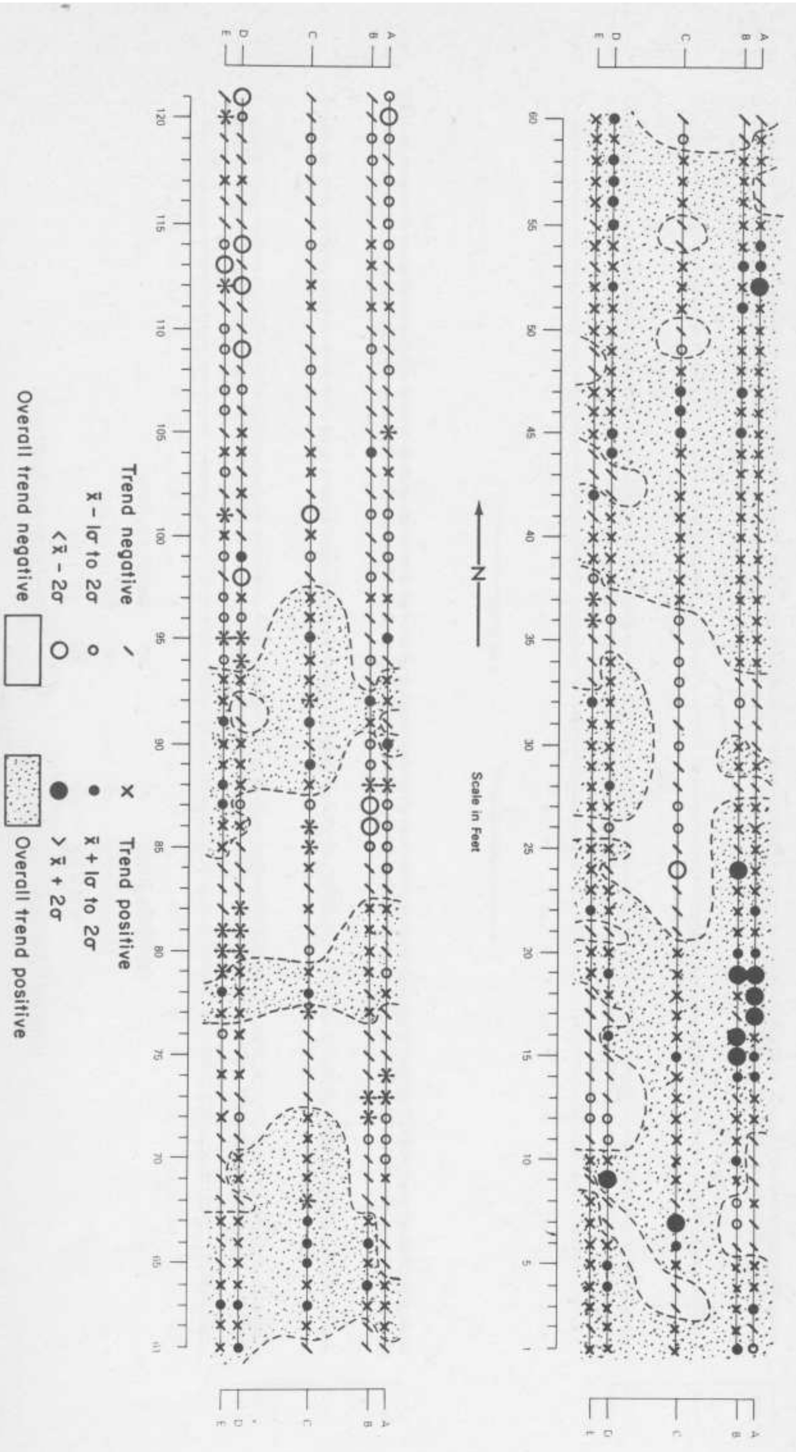


Figure 15
Distribution of pH in Standard Deviations (σ) Above and Below the Mean (x̄)
(data standardized and logarithmically transformed)

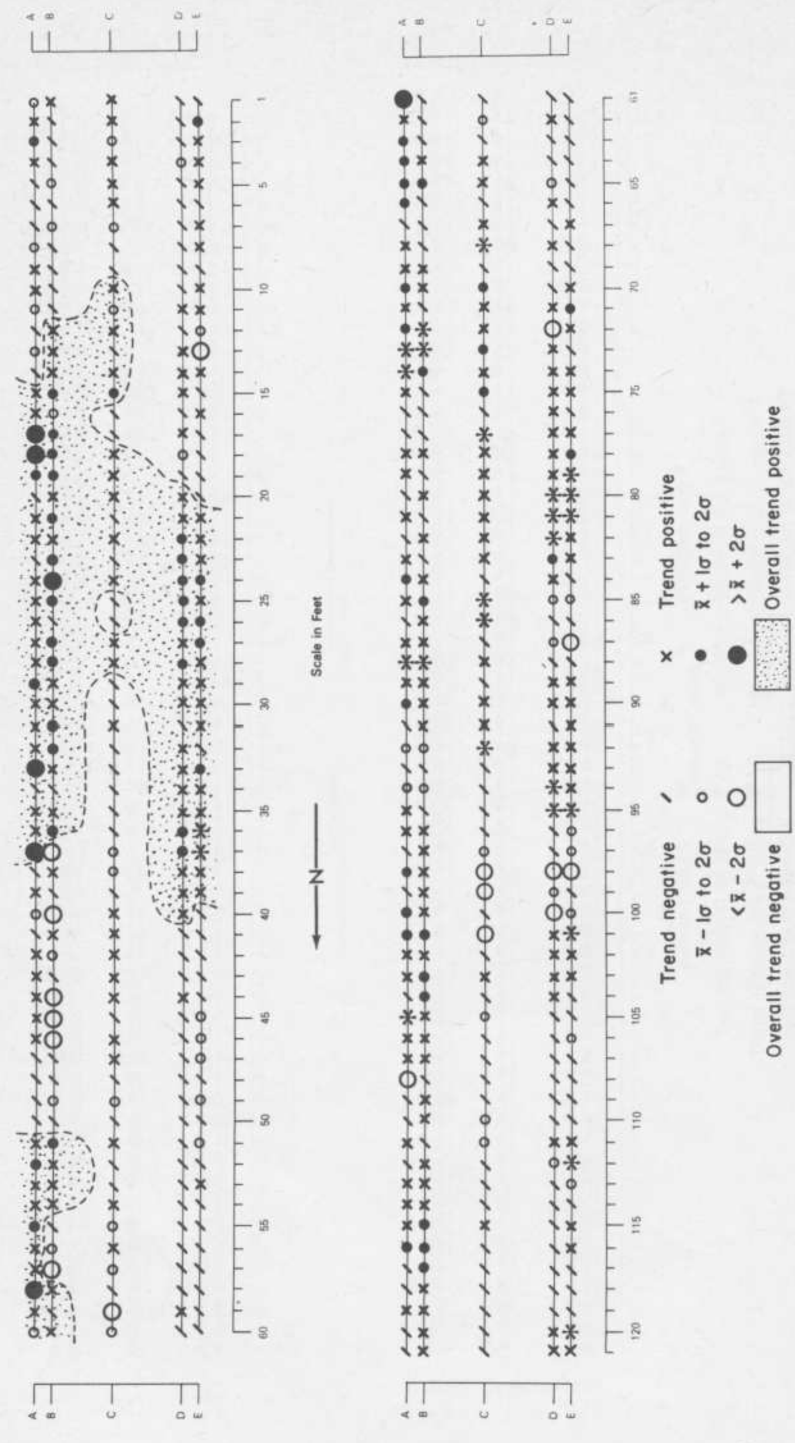


Figure 16
Distribution of Phosphorus in Standard Deviations (σ) Above and Below the Mean ($\bar{x}$)
(data standardized and logarithmically transformed)

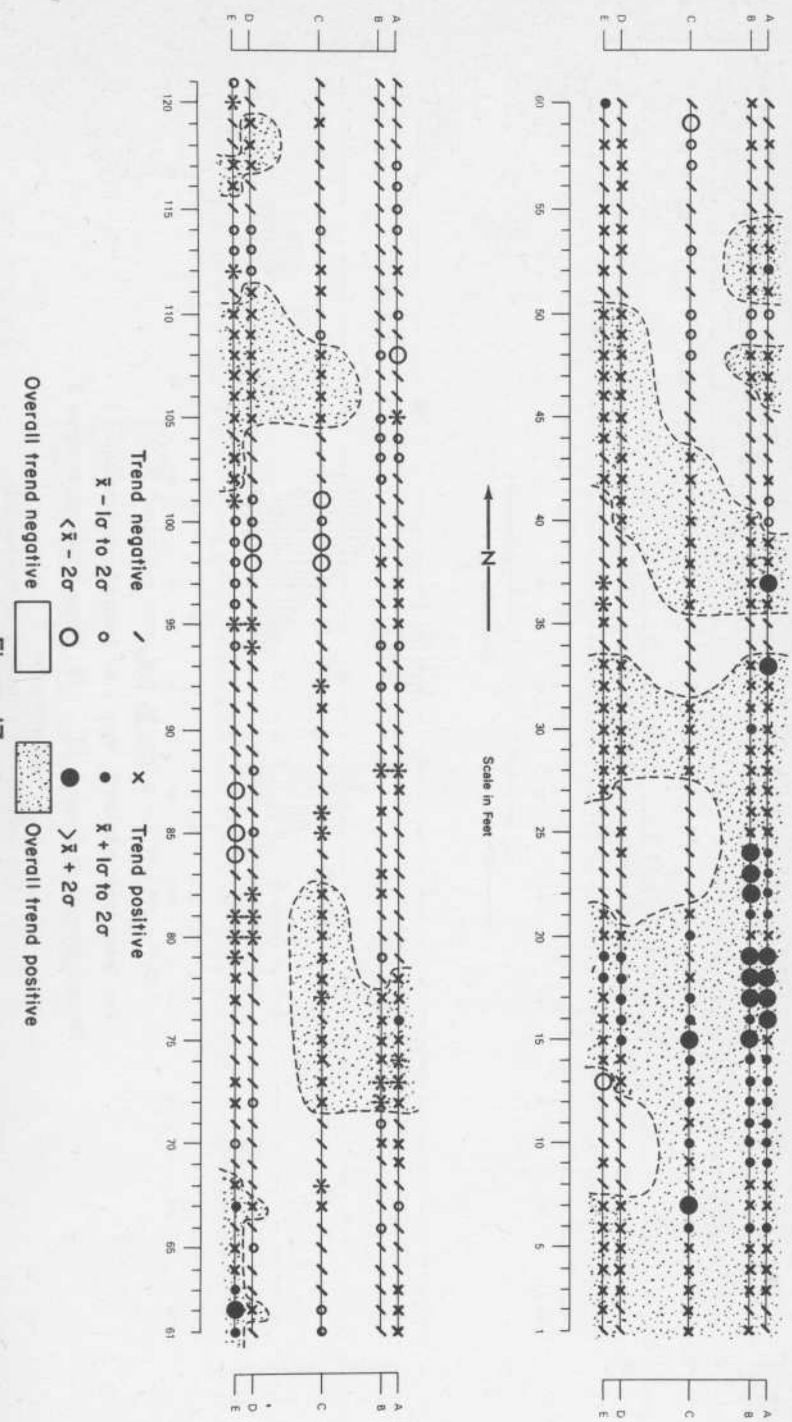


Figure 17

Distribution of Magnesium in Standard Deviations (σ) Above and Below the Mean (x̄)
(data standardized and logarithmically transformed)

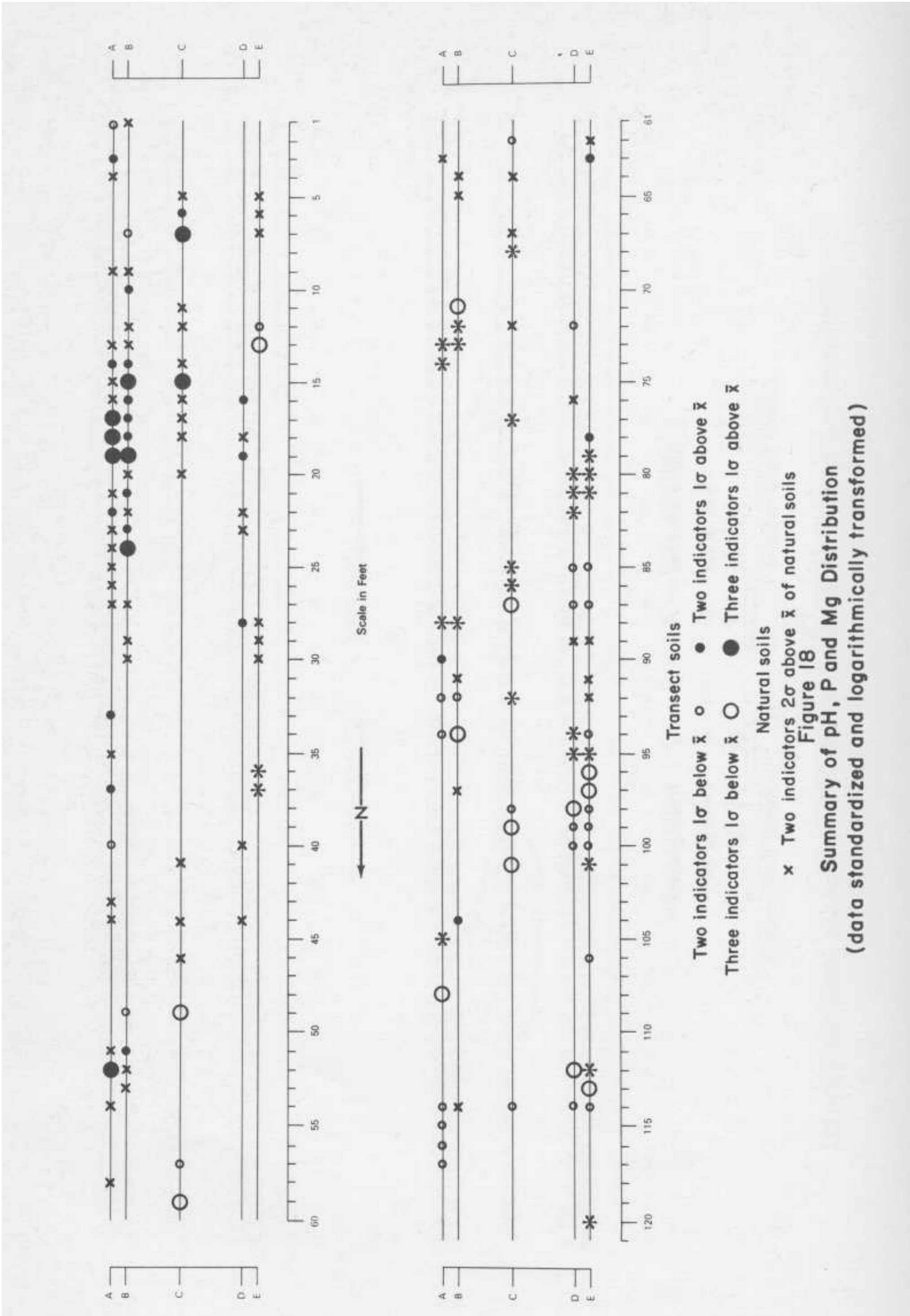


Figure 18
Summary of pH, P and Mg Distribution
(data standardized and logarithmically transformed)

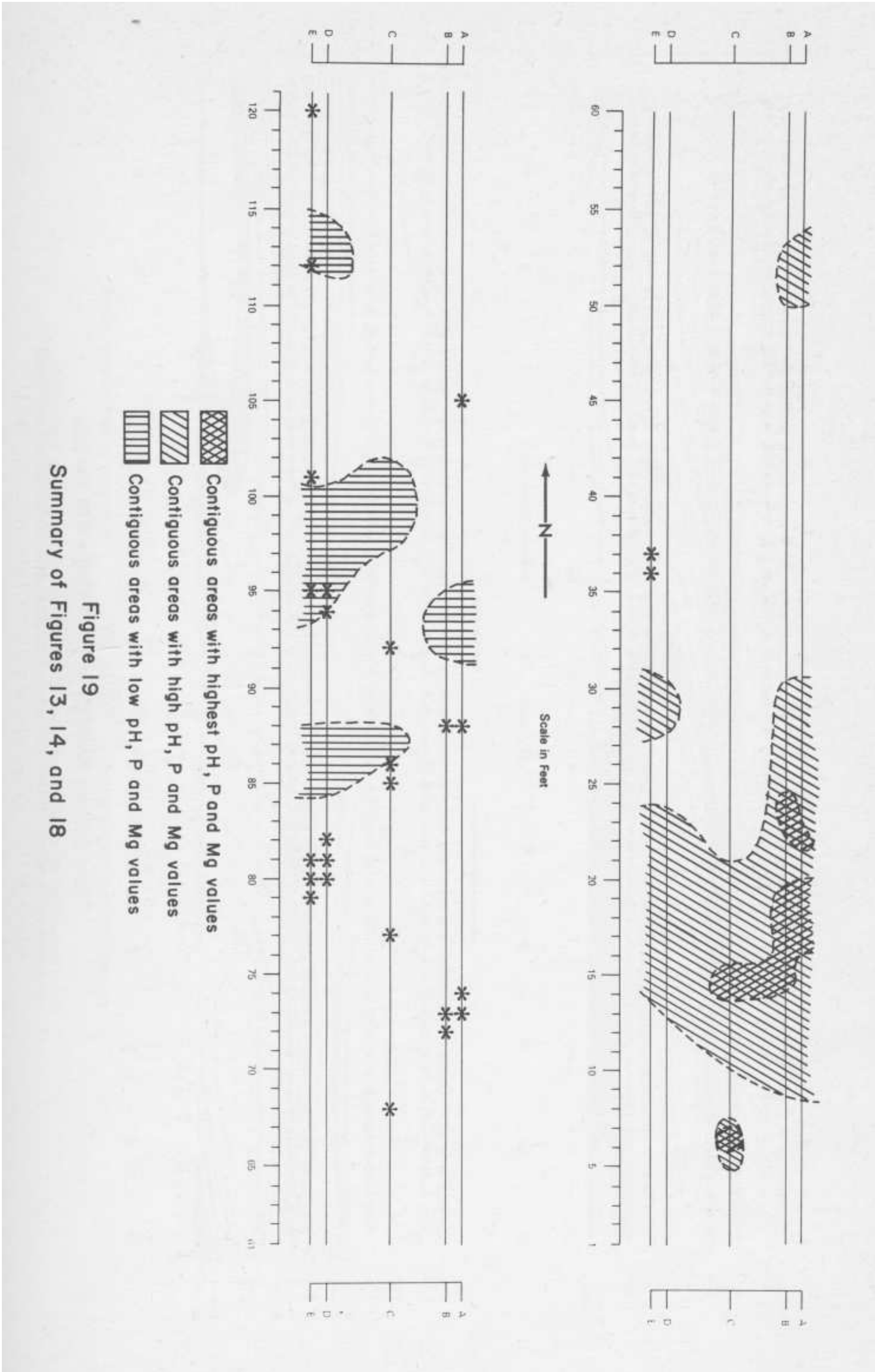


Figure 19
Summary of Figures 13, 14, and 18

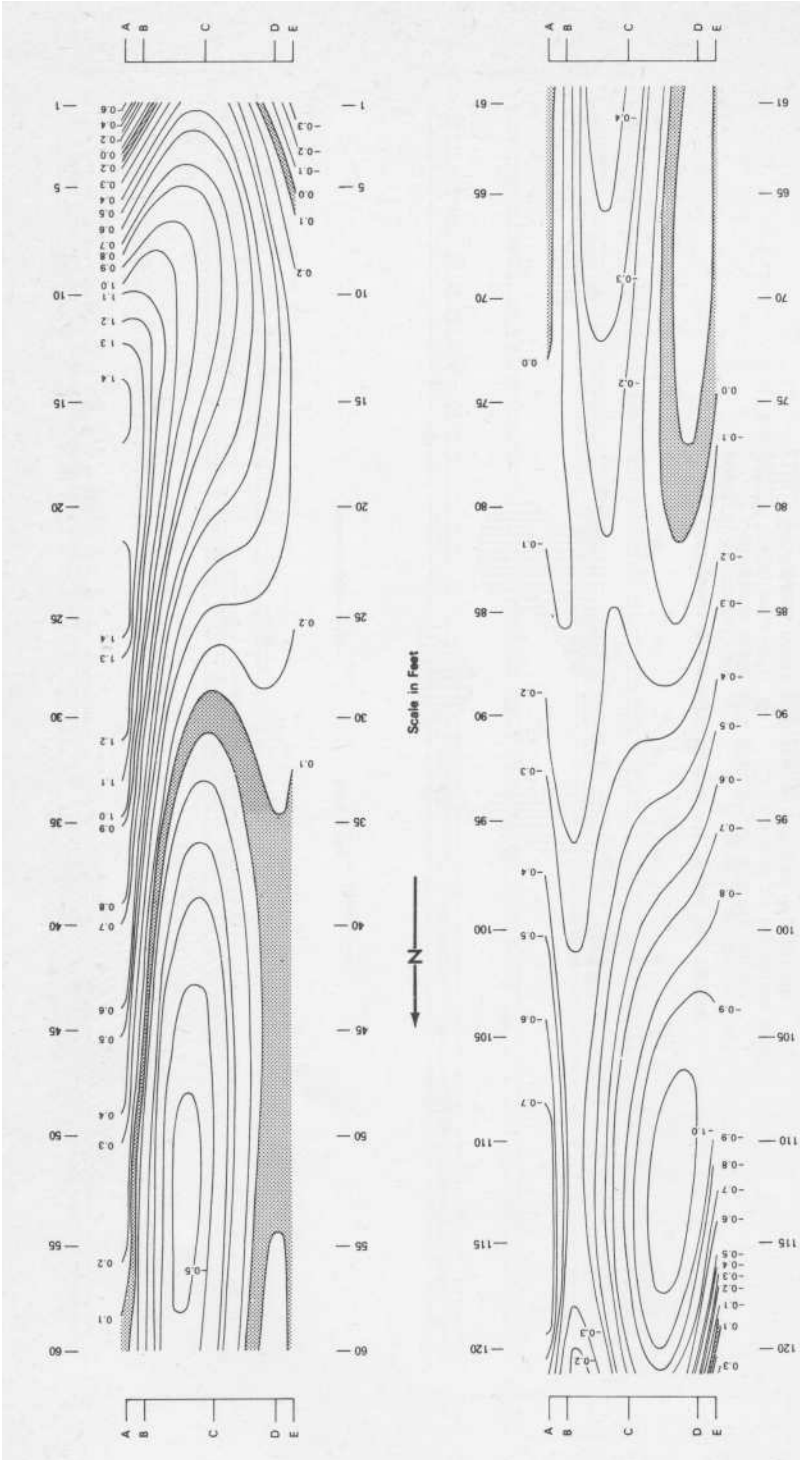


Figure 20
Trend Surface Analysis of pH+P+Mg — 5th Surface
(Index of pH+P+Mg was formed from data standardized and logarithmically transformed)
Contours are graduated in tenths of a standard deviation above and below the mean ($\bar{X}$=0.0)

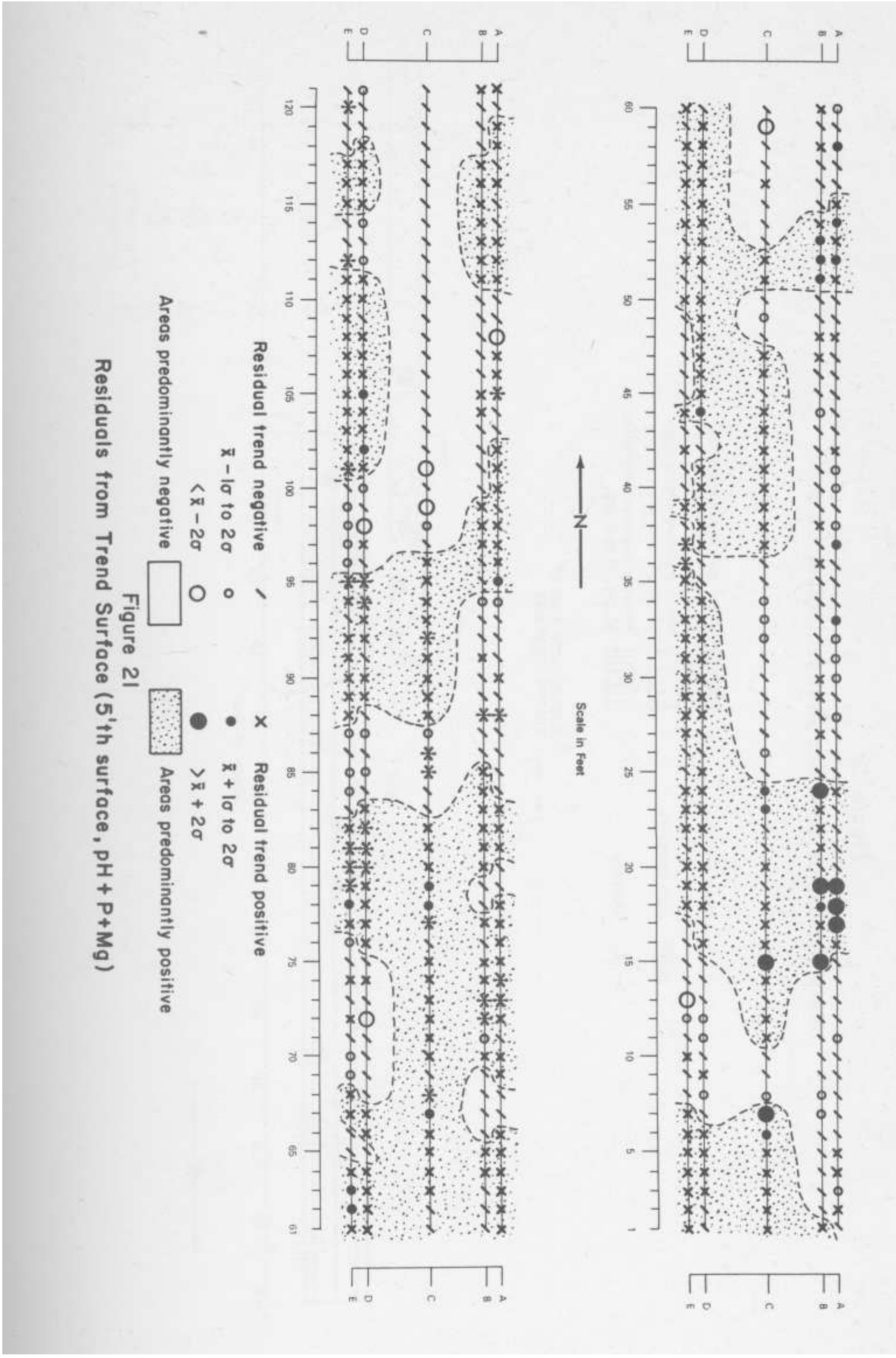


Figure 21
Residuals from Trend Surface (5'th surface, pH + P+Mg)

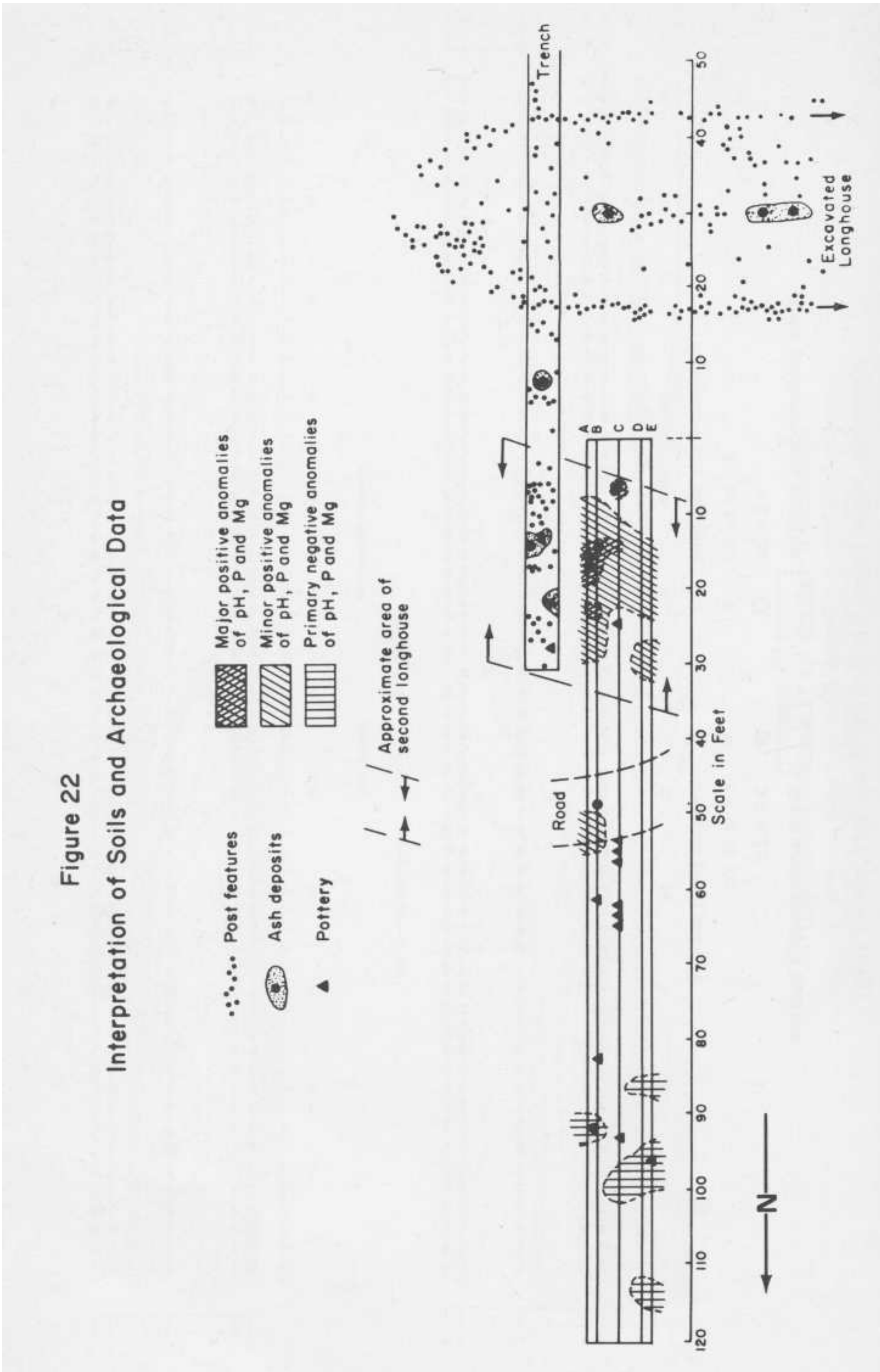


Figure 22

Interpretation of Soils and Archaeological Data