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EW-J1-04150
JSC-17424

Early Warning and Crop Condition Assessment

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

October 1981

AN EMPIRICAL, GRAPHICAL, AND ANALYTICAL STUDY OF THE RELATIONSHIP BETWEEN VEGETATION INDICES

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Lyndon B. Johnson Space Center
Houston, Texas 77058

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
JSC-17424; EW-J1-04150		

4. Title and Subtitle	5. Report Date
AN EMPIRICAL, GRAPHICAL, AND ANALYTICAL STUDY OF THE RELATIONSHIPS BETWEEN VEGETATION INDICES	October 1981
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Lyle F. Lautenschlager and Charles R. Perr , Jr.	
	10. Work Unit No.
9. Performing Organization Name and Address Statistical Reporting Service U.S. Department of Agriculture 1050 Bay Area Blvd. Houston, TX 77058	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address AgRISTARS -EW/CCA 1050 Bay Area Boulevard Houston, Texas 77058	14. Sponsoring Agency Code

15. Supplementary Notes

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is a joint program of the U.S. Department of Agriculture, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration (U.S. Department of Commerce), the Agency for International Development (U.S. Department of State), and the U.S. Department of the Interior.

16. Abstract

Since the launching of Landsat I in 1972, investigators have derived numerous formulae for the reduction of multispectral scanner (MSS) measurements to a single value (vegetation index) for predicting and assessing vegetative characteristics such as plant leaf area, total biomass and general plant stress and vigor. This report summarizes the origin, motivation, and derivation of some four dozen vegetation indices. Empirical, graphical, and analytical techniques are used to investigate the relationships among the various indices. It is concluded that many vegetative indices are very similar, some being simple algebraic transforms of others.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Vegetation index Landsat	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	133	

*For sale by the National Technical Information Service, Springfield, Virginia 22161

ACKNOWLEDGEMENTS

Research is both a scientific and social endeavor. Having someone to stimulate our brains and work on our biases, we get further than we do alone. We had each other and the other members of the Early Warning/Crop Condition Assessment Project; we were lucky, and we are grateful.

We thank Ms. Kay Jolly and Ms. Joani Connadan for their assistance with the graphics in Appendix D, and we thank Ms. Merrilyn Ferguson for her assistance with parts of the appendices. We extend special thanks to Ms. Sandy Sartorius for her expert editorial assistance and to Ms. Linda Scott for her expert typing. We are also grateful to Linda for her patience through the many updates and revisions of this report and the associated American Statistical Association paper. In addition, we thank Craig Wiegand for his editorial comments on the first draft of this report.

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> The aim of science is to seek the simplest explanation of complex facts. We are apt to fall into the error of thinking that the facts are simple because simplicity is the goal of our quest. The guiding motto in the life of every natural philosopher should be, "Seek simplicity and distrust it".
>
> Alfred North Whitehead

ABSTRACT

Since the launching of Landsat I in 1972, investigators have derived numerous formulae for the reduction of multispectral scanner (MSS) measurements to a single value (vegetation index) for predicting and assessing vegetative characteristics such as plant leaf area, total biomass and general plant stress and vigor. This report summarizes the origin, motivation, and derivation of some four dozen vegetation indices. Empirical, graphical, and analytical techniques are used to investigate the relationships among the various indices. It is concluded that many vegetative indices are very similar, some being simple algebraic transforms of others.

1. INTRODUCTION

Current and accurate information on a global basis regarding the extent and condition of the world's major food and fiber crops is important in today's complex world. Traditional sampling techniques for estimating crop conditions, based on field collection of data, are time consuming, costly, and not generally applicable to foreign regions. An alternate approach is remote sensing - the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [Lillesand and Kiefer (1979)].

A series of earth resources technology satellites (Landsats) have provided a way to monitor worldwide crop conditions since 1972. The sensor system onboard the Landsats, the multispectral scanner (MSS), measures the reflectance of the scene in four wavelength intervals (bands or channels) in the visible and near-infrared portions of the spectrum. The spectral measurements are influenced by the vegetation canopy, soil type, and atmospheric condition.

Investigators have developed techniques for qualitatively and quantitatively assessing the vegetative canopy from spectral measurements. The objective has been to reduce the four bands of Landsat spectral data to a single number for predicting or assessing such canopy characteristics as leaf area, biomass, percent ground cover, and plant population.

This report summarizes and references the origin, derivation, and motivation for some four dozen of these formulae which are referred to as vegetation indices (VIs). The VIs are categorized on the basis of statistical correlations and algebraic similarities. This analysis reveals the similarities of many vegetation indices.

2. LANDSAT DATA CHARACTERISTICS

Three Landsats have been launched since the summer of 1972, with Landsats 2 and 3 still operational. Each satellite is capable of providing 18-day repetitive coverage of the earth's surface. Each Landsat's onboard four-channel MSS system measures reflectance in four bands (fig. 1). The measurements are converted to digital counts and transmitted to receiving stations. Landsat MSS images cover an area of 185 by 185 kilometers and are composed of 7,581,600 picture elements (pixels). [Watkins and Freeden (1979)].

Typical reflectance patterns for herbaceous vegetation and soil are compared in figure 1. Dead or dormant vegetation has higher reflectance than living vegetation in the visible spectrum and lower reflectance in the near-infrared. Soil has higher reflectance than green vegetation and lower reflectance than dead vegetation in the visible, whereas in the near-infrared, soil has lower reflectance than green and dead vegetation [Tappan (1980)]. Jackson et al. (1980), Tucker and Miller (1977), and Deering et al. (1975) provide an extensive discussion of reflectance properties. Three papers of historical interest are Jordan (1969), Knipling (1970), and Pearson and Miller (1972).

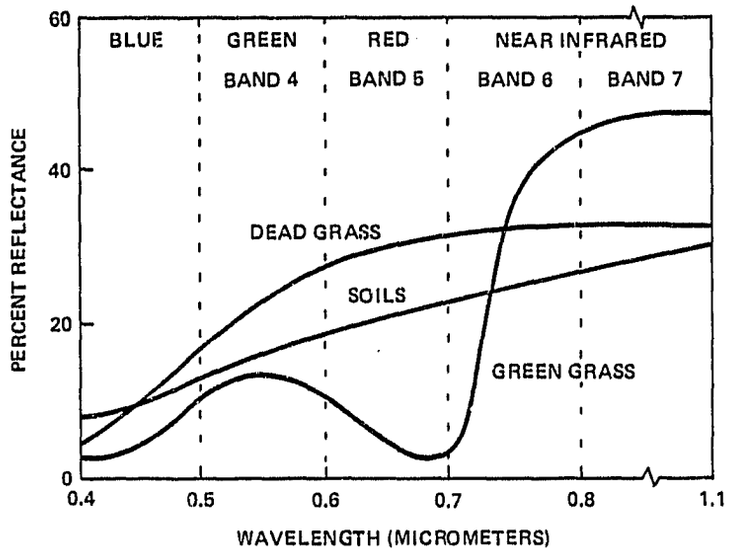


Figure 1. Typical Reflectance of herbaceous vegetation and soil from 0.4 to 1.1 micrometers.

3. DEVELOPMENT OF VEGETATION INDEX FORMULAE

Numerous vegetation indices have been used to make quantitative estimates of leaf area index, percent ground cover, plant height, biomass, plant population, and other parameters [Pearson and Miller (1972) and Wiegand et al. (1974)]. The formulae are based on ratios and linear combinations of the MSS bands.

The individual Landsat bands (CH4, CH5, CH6, CH7) have been used to estimate percent ground cover and vegetative biomass [Wiegand et al. (1974) and Seevers et al. (1973)]. The correlation coefficients reported ranged from 0.295 for CH7 with crop cover to 0.877 for CH6 with leaf area index. Similar correlations were reported by Tucker (1979).

Ratios of the Landsat bands have been used to estimate and monitor green biomass, etc. [Rouse et al. (1973, 1974), Carneggie et al. (1974), Johnson (1976), and Maxwell (1976)]. The obtained coefficients of determinations were slightly higher than those for the corresponding band differences. The twelve pairwise ratios (six of which are inverses of the other six) will be denoted by R45 = CH4/CH5, R46 = CH4/CH6, etc.

Rouse et al. (1973, 1974) proposed using the normalized difference of Landsat channels 7 and 5 for monitoring vegetation, which will be referred to as ND7. Deering et al. (1975) added 0.5 to ND7 to avoid negative values and took the square root of the result in hopes of stabilizing the variance. This index is referred to as the transformed vegetation index and will be denoted by TVI7. Similar formulae using channels 6 and 5 were proposed.

$$ND6 = (CH6 - CH5)/(CH6 + CH5)$$
$$ND7 = (CH7 - CH5)/(CH7 + CH5)$$
$$TVI6 = (ND6 + 0.5)^{1/2}$$
$$TVI7 = (ND7 + 0.5)^{1/2}$$

Our experience has been that the addition of 0.5 does not eliminate all negative values. We suggest the following computationally correct formulae:

$$TVI6 = (ND6 + .5)/ABS(ND6 + .5)[ABS(ND6 + .5)]^{1/2}$$
$$TVI7 = (ND7 + .5)/ABS(ND7 + .5)[ABS(ND7 + .5)]^{1/2}$$

where ABS denotes absolute value, and 0/0 is set equal 1. In section 6, it is shown that these formulae are equivalent for decision making to the basic ratios R65 and R75. Therefore, their use can only be justified if either they improve the regression fit or they normalize the regression errors [Draper and Smith (1966)].

Kauth and Thomas (1976) proposed an orthogonal transformation of the original Landsat data space to a new four-dimensional space. They christened this transformation the tassel cap transformation and named the four new axes soil brightness (SBI), green vegetation (GVI), yellow stuff (YVI), and non-such (NSI). The names attached to the new axes indicate the characteristics the indices were intended to measure.

$$SBI = .332\ CH4 + .603\ CH5 + .675\ CH6 + .262\ CH7$$
$$GVI = -.283\ CH4 - .660\ CH5 + .577\ CH6 + .388\ CH7$$
$$YVI = -.899\ CH4 + .428\ CH5 + .076\ CH6 - .041\ CH7$$
$$NSI = -.016\ CH4 + .131\ CH5 - .452\ CH6 + .882\ CH7$$

Wheeler et al. (1976) and Misra et al. (1977) applied principal component analysis to Landsat data. The structure of the resulting transformation and the interpretation of the principal components are similar to those for the Kauth-Thomas transformation.

$$MSBI = .406\ CH4 + .600\ CH5 + .645\ CH6 + .243\ CH7$$
$$MGVI = -.386\ CH4 - .530\ CH5 + .535\ CH6 + .532\ CH7$$
$$MYVI = .723\ CH4 - .597\ CH5 + .206\ CH6 - .278\ CH7$$
$$MNSI = .404\ CH4 - .039\ CH5 - .505\ CH6 + .762\ CH7$$

Misra et al. (1977) proposed another linear transform, based on the idea of spectral brightness and contrast. Generalizations of spectral brightness and contrast were defined in spectral density space, then transformed back to count space. The first two components of the resulting transformation are similar to the first two components of the two preceding transformations.

$$SSBI = .437\ CH4 + .564\ CH5 + .661\ CH6 + .233\ CH7$$
$$SGVI = -.437\ CH4 - .564\ CH5 + .661\ CH6 + .233\ CH7$$
$$SYVI = -.437\ CH4 + .564\ CH5 - .661\ CH6 + .233\ CH7$$
$$SNSI = -.437\ CH4 + .564\ CH5 + .661\ CH6 - .233\ CH7$$

Richardson and Wiegand (1977) used the perpendicular distance to the "soil line" as an indicator of plant development. The "soil line", a two-dimensional analogue of the Kauth-Thomas SBI, was estimated by linear regression. Two perpendicular vegetation indices were proposed.

$$PVI7 = [(.355\ CH7 - .149\ CH5)^2 + (.355\ CH5 - .852\ CH7)^2]^{1/2}$$
$$PVI6 = [(-.498 - .457\ CH5 + .498\ CH6)^2 + (2.734 + .498\ CH5 - .543\ CH6)^2]^{1/2}$$

Evidently a minor error was made in the derivation of PVI6. The formula for PVI6 should be:

$$PVI6 = [(-2.507 - .457\ CH5 + .498\ CH6)^2 + (2.734 + .498\ CH5 - .543\ CH6)^2]^{1/2}$$

These formulae are computationally inefficient and do not distinguish right from left of the "soil line" (water from green stuff). The standard formula from analytic geometry for the perpendicular distance from a point to a line solves this difficulty [Salas and Hille (1978)].

$$PVI6 = (1.091\ CH6 - CH5 - 5.49)/(1.091^2 + 1^2)^{1/2}$$
$$PVI7 = (2.4\ CH7 - CH5 - .01)/(2.4^2 + 1^2)^{1/2}$$

The difference vegetation index (DVI), suggested by Richardson and Wiegand (1977) as computationally easier than PVI7, is essentially a rescaling of PVI7.

$$DVI = 2.4\ CH7 - CH5$$

The Ashburn vegetation index [Ashburn (1979)] was suggested as a measure of green growing vegetation. The doubling of CH7 is to make the scale compatible; CH7 is 6-bit data and has one-half the range of the other three bands which are 8-bit data.

$$AVI = 2.0\ CH7 - CH5$$

Colwell et al. (1979) proposed a vegetation indicator called greenness above bare soil (GRABS). This was another attempt to develop an indicator for which a threshold value could be specified for detecting green vegetation. The calculations were made using the Kauth-Thomas tassel cap transformation applied to sun-angle and haze-corrected data. The resulting index is quite similar to the GVI, since the contribution of SBI is less than 10 percent of GVI.

$$GRABS = GVI - .09178\ SBI + 5.58959$$

Kanemasu et al. (1977) regressed winter wheat leaf area measurements on MSS band ratios and produced the following regression equation.

$$ELAI = 2.68 - 3.69\ R45 - 2.31\ R46 + 2.88\ R47 + 0.43\ R56 - 1.35\ R57 + 3.07[R45 - (.5\ R47)(R45)]$$

Pollack and Kanemasu (1979) later used a larger data set plus stepwise regression and obtained another regression equation.

$$CLAI = .366 - 2.265\ R46 - .431(R45 - R47)(R45) + 1.745\ R45 + .057\ PVI7$$

Separate regression equations were also obtained for CLAI values above and below 0.5.

LAI = 1.903 - 1.136 R56 - .071(R45 - R47)R45 - .016 PVI6,
if CLAI is less than 0.5

LAI = -5.33 + .036 PVI7 + 6.54 TVI6,
if CLAI is greater than 0.5

The Foreign Crop Condition Assessment Division (FCCAD) of the Foreign Agricultural Service (FAS), Houston, Texas uses another leaf area model. We have been unable to find any reference to the development of this model.

OLAI = 41.325 R45 - 42.45 R46

Badhwar (1981) proposed a ratio of GVI to SBI as an indicator of crop discrimination. It will be shown in section 6 that this index is a generalization of a normalized difference.

GVSB = GVI/SBI

Craig Wiegand (personal communication) suggested converting reflectance values to radiances. Linear transformations were used to change from reflectance to radiance values. Ratio and normalized difference formulae were also created using the radiance values.

RAD5 = 0.0157 CH5	for Landsat 1
= 0.0134 CH5 + 0.06	for Landsat 2
= 0.0139 CH5 + 0.03	for Landsat 3
RAD7 = 0.0730 CH7	for Landsat 1
= 0.0603 CH7 + 0.11	for Landsat 2
= 0.0603 CH7 + 0.03	for Landsat 3

RADR75 = RAD7/RAD5

NDRAD = (RAD7 - RAD5 /(RAD7 + RAD5)

Thompson and Wehmanen (1978) proposed a technique utilizing transformed Landsat digital data to indicate when agricultural vegetation is undergoing moisture stress. The screening number or green number (GIN) was proposed to estimate the percentage of land in an area with a "healthy" cover of vegetation. A "soil line" is determined by inspecting the channel data and discarding data not considered reasonable for agricultural data. The "soil line" is then evaluated as the minimum value remaining in CH5 and subtracted from GVI to obtain GIN.

GIN = GVI - soil line

The data sets included in this study did not permit the computation of GIN. However, GIN is a linear transformation of GVI.

4. EVALUATION OF VEGETATION INDICES

4.1 BACKGROUND

Richardson and Wiegand (1977) correlated eight VIs (GVI, DVI, SBI, PVI6, PVI7, TVI6, TVI7, and R57) with four plant component variables (crop cover, shadow cover, plant height, and leaf area index). The correlation coefficients obtained by plant component with the VIs (excluding SBI) were very similar. Later, Wiegand et al. (1979) correlated leaf area indices for winter wheat fields to five VIs (TVI7, TVI6, PVI7, PVI6, and GVI). The correlation coefficients by field and even between fields were similar.

Aaronson et al. (1979) studied the similarities and differences among seven VIs (AVI, DVI, GVI, OLAI PVI7, TVI7, and KVI). The obtained correlation coefficients ranged from 0.8 to 1.0 and were stable from spring greenup to harvest. Aaronson and Davis (1979) later used a large data set, which included vegetation measurements and several VIs, to study interrelationships. The VIs (AVI, DVI GVI, OLAI, KVI, PVI6, PVI7, TVI6, and TVI7) were correlated against each other and against vegetation measures such as plant height from tillering through harvest. The correlation coefficients between the VIs ranged from 0.81 to 1.00, and those between VIs and vegetation measures were similar.

4.2 CLUSTER ANALYSIS OF VI

The similarity between the VIs was first studied using the BMDP program P1M, cluster analysis of variables (Dixon and Brown, 1979) and the data set described in appendix A. The absolute value of the bivariate correlations was used as the measure of distance between VIs, and the average distance between elements was used as the between cluster distance. Similar results were obtained using other standard distance measures.

This procedure separated the VIs into two large clusters plus a number of small clusters. One large cluster contained VIs based on MSS bands 5 and 7, which included AVI, PVI7, R75, TVI7, and ND7. The other large cluster contained VIs, based on MSS bands 5 and 6, and a few VIs involving three or all four bands, which included GRABS, CLAI, OLAI, R65, TVI6, ND6, GVI, MGVI, PVI6, and SGVI. The VIs within these two clusters had absolute

simple linear correlations greater than 0.90, with most greater than 0.95. The elements of these two large clusters are correlated at 0.8 or higher. Three smaller clusters readily apparent were: (NSI, R76), (R64, R74), and (SBI, MSBI, SSBI, SNSI). This clustering is applicable to the period from spring greenup to harvest. There are some clusters, however, which have high correlations for the whole season, especially those involving bands 5 and 7. The cluster trees on which this discussion is based are attached as appendix B.

Some VIs were not used in the cluster analysis because of their known relationships to others. The inverse ratios R54, R46, R47, R56, R67, and R57 were not used. DVI was discarded because of its relationship to PVI7, as were RAD5, RAD7, RADR75, and NDRAD because of the linear relationships to CH5, CH7, R75, and ND7.

5. VEGETATION INDICES EQUIVALENCE

In this section, a definition of VI equivalence will be developed. This permits a natural categorization of the VIs. VIs are functions which associate a real value to the four-dimensional Landsat reflectance measurement vector, (MSS4, MSS5, MSS6, MSS7). Thus, it will be convenient to employ standard function notation: $f:S_1--S_2$ denotes a function from the set S_1 into the set S_2; $f(X)$, the value of f at the point (X) of S_1; Dom(f), the domain of f; Ran(f), the range of f; and $f^{-1}:S_2--S_1$, the inverse of f when it exists. The inverse exists if, and only if, f is one-to-one and onto. The composition of two functions has an inverse if, and only if, both functions have inverses; in which case $(f \circ g)^{-1} = g^{-1} \circ f^{-1}$.

It might seem that VI equivalence should correspond to function equality; i.e., $V_1 = V_1$ if, and only if, $V_1(X) = V_1(X)$ for each Landsat reflectance value X. However, this requirement is too restrictive because it involves only the VIs output and ignores the decisions made on the basis of this output. Since vegetation indices are formulae used in making decisions about crop characteristics and conditions, it seems appropriate to say that two VIs are equivalent if the same decision results regardless of the VI employed. This means that two VIs, V_1 and V_2, are equivalent for making the set of decisions D if, and only if for every decision rule---$d_1:Ran(V_1)--D$, there corresponds a decision rule $d_2:Ran(V_2)--D$ such that the decision, based on d_2 and V_2, is the same as the decision based on d_1 and V_1 for all Landsat reflectance measurements X; that is, $d_1(V_1(X)) = d_2(V_2(X))$ for each X. It is easy to see that the two vegetation indices, Vl and V_2, are equivalent if, and only if, there exists a one-to-one onto function $T:Ran(V_1)--Ran(V_2)$ such that $T \circ V_1 = V_2$. This implies that a decision d results from the same set of Landsat reflectance regardless of which VI is used; that is

$$V_1^{-1}[T^{-1}(d)]=(T \circ V_1)^{-1}(d) = V_2^{-1}(d) \qquad \text{(Equation 1)}$$

for each decision d in D, where the superscript -1 indicates the inverse image of d under the given function. The relationship defined is an equivalence relation on the set of vegetation indices; that is,

i. Each VI is equivalent to itself: Reflexive property.

ii. If V_1 is equivalent to V_2, then V_2 is equivalent to V_1: Symmetric property.

iii. If V_1 is equivalent to V_2, and V_2 is equivalent to V_3, the V_1 is equivalent to V_3: Transitive property.

These properties are important because they permit one to avoid many tedious computations.

A number of studies have investigated the transformed vegetation indices TVI6 and TVI7 and the corresponding ratios R65 and R75 as predictors of biomass, leaf area index, plant height, and percent ground cover. The predictive ability of TVI6 and R65 or TVI7 and R75 are similar as evidenced by the estimated correlation coefficient. We now show that the transformed vegetation index and its generalizations are equivalent to the corresponding ratios. This example makes clear not only the algebraic and geometric meaning of VI equivalence but also demonstrates the utility and appropriateness of this definition.

Let a and b be positive constants, and define the functions f, g, and T by

$$f(X_5,X_7) = (aX_7 - bX_5)/(aX_7 + bX_5)$$
$$g(X_5,X_7) = X_7/X_5$$
$$T(y) = (b/a)[(1 + y)/(1 - y)]$$

for X_5 and X_7 positive and ABS (y) less than one. Observe that T is invertible; in fact

$T^{-1}(z) = (az - b)/(az + b)$ for z positive

Thus, f and g are equivalent and the values of f can be computed from the values of g and vice versa.

$(T \circ f)(X_5,X_7) = g(X_5,X_7)$
$(T^{-1} \circ g)(X_5,X_7) = f(X_5,X_7)$

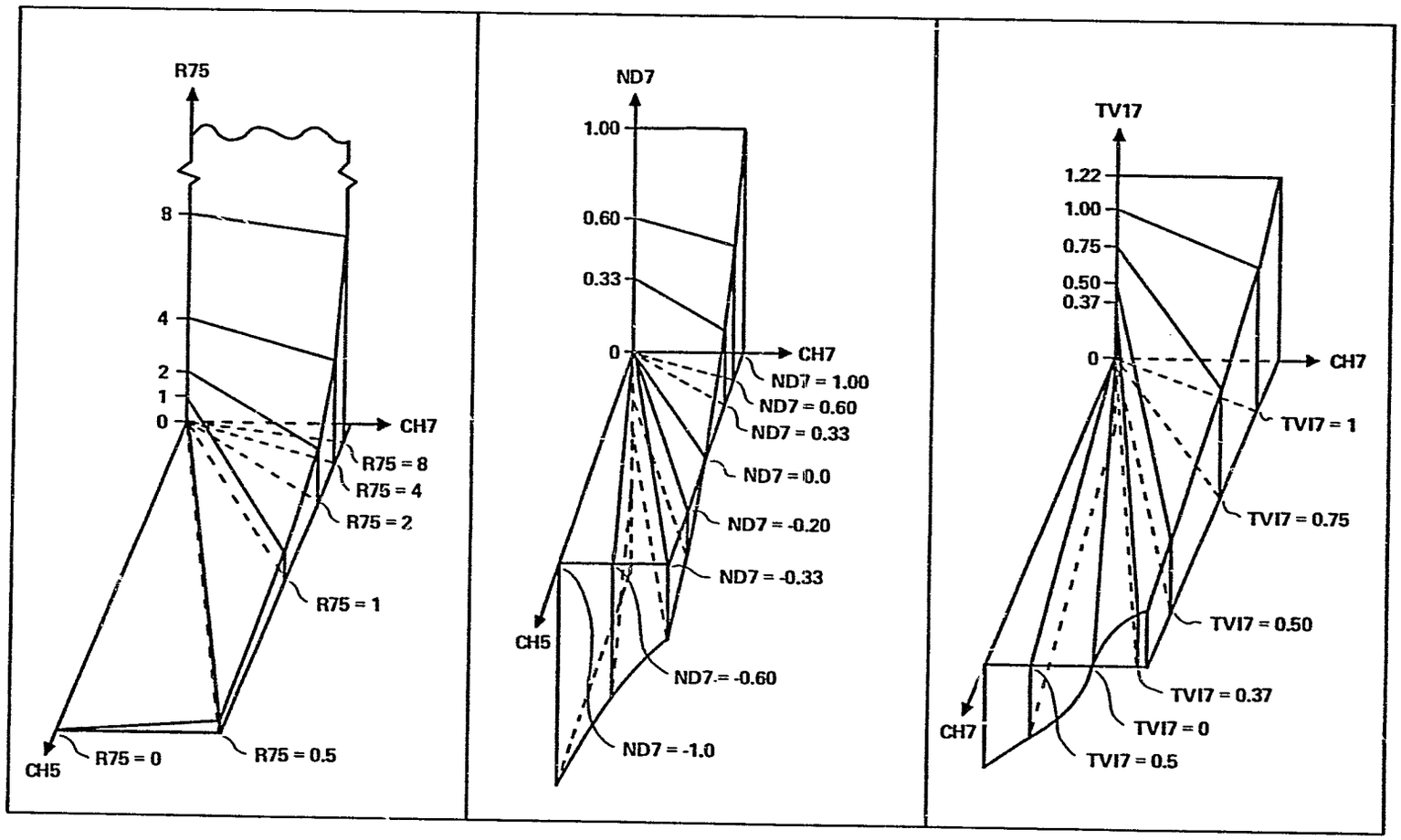
Let k and p be real, and define the functions G:(-1,1)--(k-1,k+1) and H:(k-1,k+1)--(L,U) by

$G(v) = v + k$
$H(w) = w[ABS(w)]^{p-1}$, for

w between k-1 and k+1, $L = (k-1)[ABS(k-1)]^{p-1}$, $U = (k+1)[ABS(k+1)]^{p-1}$, for ABS(v) less than one, and 0/0 defined as 1. It is easy to verify that G and H are one-to-one and onto and that
$(H \circ G \circ T^{-1} \circ g)(X_5,X_7) = (f(X_5,X_7) + k)[ABS(f(X_5,X_7) + k)]^{p-1}$.
Taking k = p = 1/2 and a = b = 1 shows that the transformed vegetation index, TVI7, is equivalent to the seven-five ratio, R75.

$(H \circ G \circ T^{-1})$ R75 = TVI7

Equivalence of VIs means their response surfaces determine precisely the same partition of the reflectance measurement space (equation 1). Elements of this partition are referred to as decision classes. Representive response surfaces and equivalence classes associated with R75, ND7, and TVI7 are illustrated in figures 2a, 2b, and 2c. Similar graphs for other popular indices are attached as appendix C. The nonlinear algebraic relationships exhibited among R75, ND7, and TVI7 are illustrated graphically in figure 3. Similar graphs for other indices are studied in appendix D.



(a) Associated with R75 (b) Associated with ND7 (c) Associated with TVI7

Figure 2. Response surface and equivalence classes.

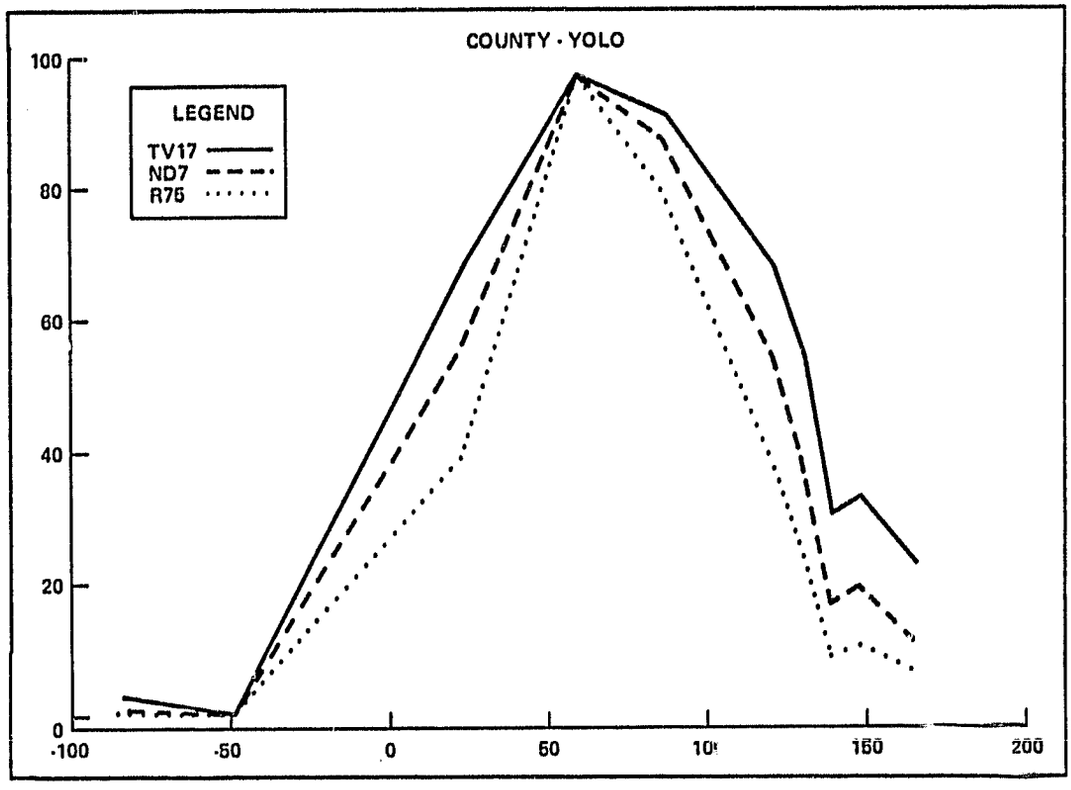


Figure 3. R75, ND7, and TVI7 versus time using data listed in Appendix A. All VI values have been rescaled 0 to 100.

As a further illustration of the utility of VI equivalence, GVSB is shown to be approximated by ND6. Thus, the more complicated GVSB can be expected to provide approximately the same information about crop condition as the simple ratio R65.

Using Landsat data described in appendix A, the following estimates were obtained.

GRANT AREA DATA / N = 6084

Variable	N	Mean	Std. Dev.
CH4	6084	23.2	7.2
CH5	6084	26.7	10.0
CH6	6084	41.4	15.9
CH7	6084	17.5	6.3

CORRELATION COEFFICIENTS

Variable	CH4	CH5	CH6	CH7
CH4	1.00			
CH5	0.86	1.00		
CH6	0.73	0.64	1.00	
CH7	0.67	0.50	0.96	1.00

From these estimates, one easily obtains the regression equations

CH7 = .4100 CH6 + .5100
CH4 = .6236 CH5 + 6.564

Naively substituting into the formulae for GVI and SBI gives the following formulae.

EGVI = .74 (CH6 - 1.14 CH5 + .03)
ESBI = .78 (CH6 + 1.03 CH5 + 2.96)

These approximations are illustrated in figures 4 and 5. Using the information in the above tables pertaining to the expected range of the data, it is easy to see that a rough approximation for GVSB is:

EGVSB = (CH6 - 1.14 CH5)/(CH6 + 1.03 CH5)

which is approximately ND6. In fact, let

h(v) = (b + vd)/(a - vc)
k(x,y) = (ax - by)/(cx + dy)
r(x,y) = x/y,
then h(k(x,y)) = x/y = r(x,y)

Thus, the estimate, EGVSB, is equivalent to R65 and ND6. These relationships are illustrated graphically in figure 6. Graphs similar to figures 4, 5 and 6 for other sites are contained in appendix E.

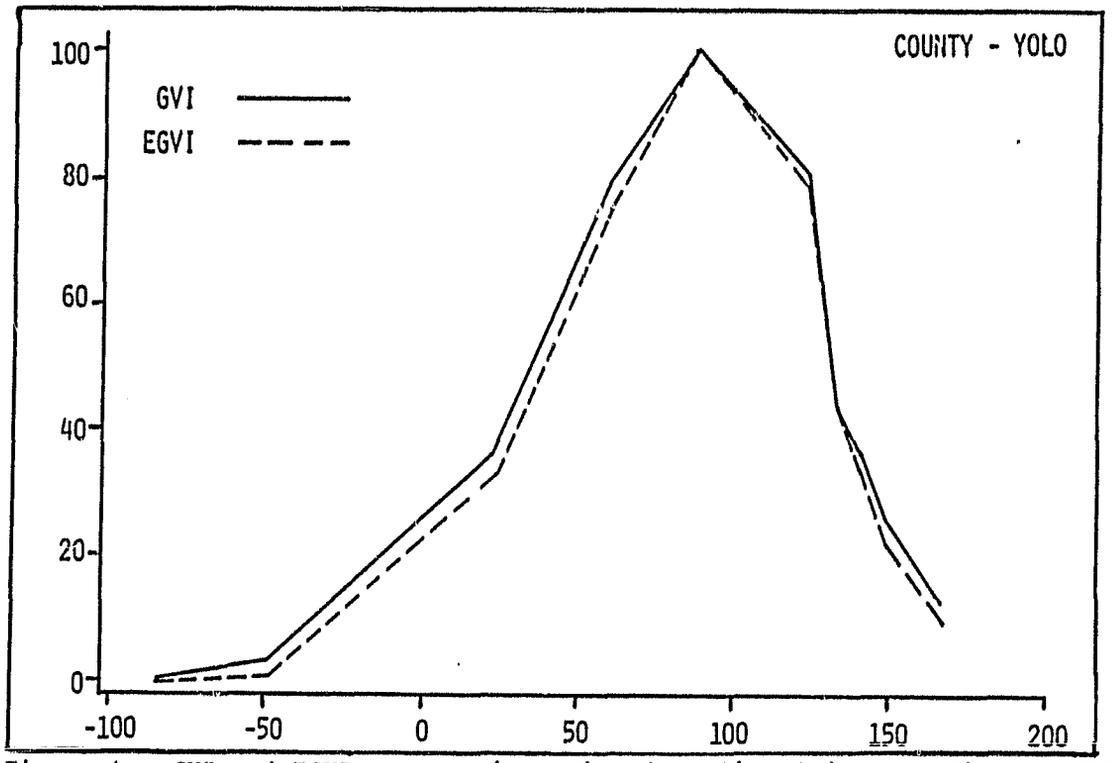


Figure 4. GVI and EGVI versus time using data listed in Appendix A. All VI values have been rescaled 0 to 100.

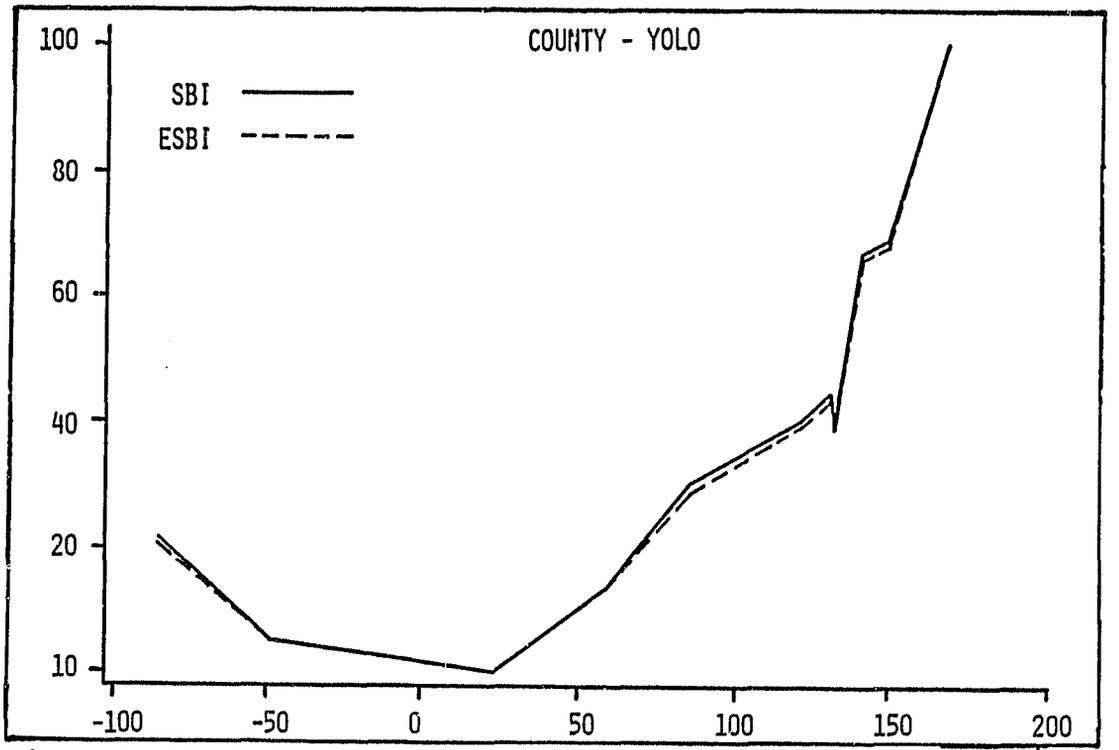


Figure 5. SBI and ESBI versus time using data listed in Appendix A. All VI values have been rescaled from 0 to 100.

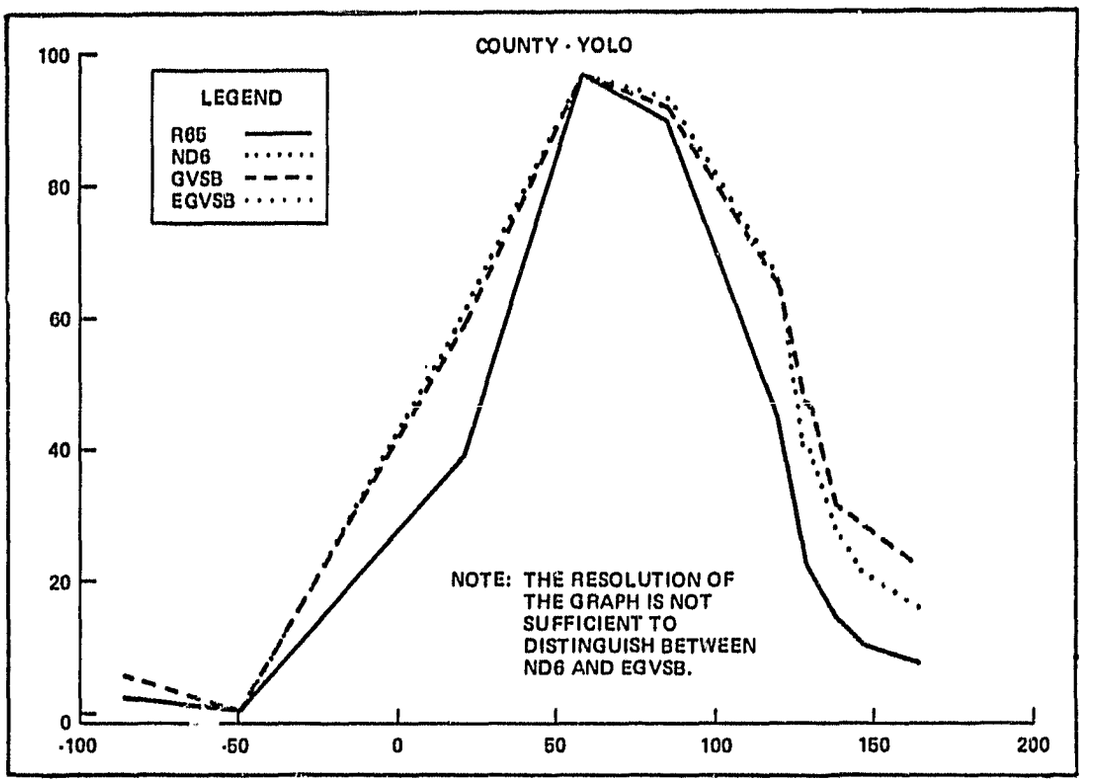


Figure 6. R65, GVSB, ND6, and EGVSB versus time using data listed in Appendix A. All VI values have been rescaled 0 to 100.

6. SUMMARY AND CONCLUSIONS

Other researchers have studied the relationships among a few of the VIs considered in this report. Past work has been based exclusively on correlation analysis. Aaronson and Davis (1979) showed conclusively that, during the spring greenup to harvest phase of the crop season, the VIs used operationally by The Foreign Agriculture Service (FAS)/Foreign Crop Condition Assessment Division (FCCAD) were highly correlated and had similar correlations with various plant components such as biomass, plant height, etc.

This study extends analysis to include all VIs found in the literature. Techniques used to investigate relationships between the VIs included variable clustering by correlation, graphical presentations, and functional equivalence for decision making. Variable clustering separated out two large clusters of VIs. One cluster contained those VIs which used channels 5 and 7 data. The other cluster contained VIs using channels 5 and 6 data plus some VIs using all four channels of data. The variable clustering technique also showed that these two clusters were highly correlated. The relationships were stable during the spring greenup to harvest period of the crop season. Graphical presentations reinforced the clustering results, illustrating the relationships over time and through response surfaces. Mathematical techniques were used to formalize the idea of VI equivalence. This equivalence was used to confirm relationships observed earlier and to investigate less apparent relationships.

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APPENDIX A

DATA SET DESCRIPTIONS

The data set consisted of Landsat acquisitons from six different sites for the 1977-78 crop year. The six sites were Finney County, Kansas; Grant County, Oklahoma; Greeley County, Kansas; Keith County, Nebraska; Washington County, Colorado; and Yolo County, California. The Finney County site consists of an area 40 pixels by 26 lines or 1040 pixels of data. The Yolo County site consists of an area 40 pixels by 40 lines or 1600 pixels of data. All other sites consist of an area 26 pixels by 26 lines or 676 pixels of data.

One field within each area was also selected, since it had already been defined for another project. The Finney, Grant, Greeley, Keith and Washington County fields were winter wheat and consisted of 85, 79, 67, 100 and 53 pixels of data respectively. The Yolo county field was a barley field and consisted of 500 pixels of data.

The data sets are identified by county, acquisition date and Landsat satellite as follows:

Finney	Keith	Yolo
9-22-77 (2)	10-12-77 (2)	10-07-77 (2)
9-23-77 (2)	11-17-77 (2)	11-12-77 (2)
10-11-77 (2)	12-04-77 (2)	1-23-78 (2)
11-16-77 (2)	3-22-78 (2)	2-28-78 (2)
1-08-78 (2)	3-31-78 (3)	3-27-78 (3)
3-04-78 (2)	4-28-78 (2)	5-02-78 (3)
3-31-78 (3)	5-15-78 (2)	5-11-78 (2)
5-15-78 (2)	5-16-78 (2)	5-12-78 (2)
5-23-78 (3)	5-25-78 (3)	5-20-78 (3)
6-01-78 (2)	6-11-78 (3)	5-29-78 (2)
6-11-78 (3)	6-21-78 (2)	6-16-78 (2)
6-11-78 (3)	6-29-78 (2)	
6-19-78 (2)	7-27-78 (2)	
6-29-78 (3)	8-13-78 (2)	
7-26-78 (2)	8-14-78 (2)	

Grant	Greeley	Washington
10-08-77 (2)	10-11-77 (2)	10-12-77 (2)
11-13-77 (2)	11-16-77 (2)	11-17-77 (2)
12-19-77 (2)	3-22-78 (2)	3-24-78 (2)
3-09-78 (3)	3-31-78 (3)	4-11-78 (2)
3-28-78 (3)	4-27-78 (2)	4-28-78 (2)
4-06-78 (2)	5-15-78 (2)	5-16-78 (2)
4-24-78 (2)	5-25-78 (3)	5-26-78 (3)
5-30-78 (2)	6-11-78 (3)	6-12-78 (3)
6-17-78 (2)	6-29-78 (3)	

The data were calibrated as follows to all look like Landsat II LACIE segment data. Data from Landsat 2 EROS full frame CCT's were calibrated using the calibration below (NASA (1976) and RICE (1977)).

$$CH4 = CH4 * 1.275 - 1.445$$
$$CH5 = CH5 * 1.141 - 2.712$$
$$CH6 = CH6 * 1.098 - 2.950$$
$$CH7 = CH7 * 0.948 + 0.446$$

Data from Landsat 3 were calibrated using the following calibrations which were developed by Wehmanen (1978).

$$CH4 = CH4 * 1.161$$
$$CH5 = CH5 * 1.230$$
$$CH6 = CH6 * 1.246$$
$$CH7 = CH7 * 1.062$$

The field data were adjusted using the X-STAR haze correction procedure developed by Lambeck (1979). Pixel data screened as shadow, water, haze, cloud or garbled through this procedure were deleted from further use. Sun angle correction was also applied which is part of the X-STAR haze correction algorithm.

A partial listing containing descriptive statistics of MSS data by band, date, field or area, and county are attached.

The dates are Julian dates where positive dates are for 1978 and negative dates are for 1977 and indicate the number of days from end of year. The Julian date for 1977 may be obtained by adding 365 to each negative date.

Keith County Field Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=81						
CH4	65	35.33	3.38	26.00	43.00	0.42
CH5	85	42.07	4.69	28.00	55.00	0.52
CH6	85	48.19	5.34	29.00	57.00	0.58
CH7	85	20.19	2.13	11.00	24.00	0.23
DATE=90						
CH4	95	30.47	2.30	22.22	37.15	0.24
CH5	95	34.57	3.73	24.60	44.28	0.38
CH6	95	51.13	5.45	32.40	63.55	0.56
CH7	95	20.37	2.54	10.62	23.36	0.26
DATE=118						
CH4	99	18.61	1.62	16.00	23.00	0.16
CH5	99	15.49	2.49	11.00	23.00	0.25
CH6	99	46.53	3.70	36.00	53.00	0.37
CH7	99	23.67	2.29	18.00	28.00	0.23
DATE=135						
CH4	95	30.71	2.93	25.00	42.00	0.30
CH5	95	28.76	4.39	21.00	48.00	0.50
CH6	95	61.62	2.61	56.00	68.00	0.27
CH7	95	29.51	2.16	24.00	34.00	0.22
DATE=136						
CH4	100	25.16	3.22	20.00	35.00	0.32
CH5	100	22.53	4.41	15.00	38.00	0.44
CH6	100	56.42	3.19	47.00	65.00	0.32
CH7	100	27.42	2.21	22.00	33.00	0.22
DATE=145						
CH4	100	29.33	3.66	22.86	44.12	0.37
CH5	100	27.06	5.67	18.45	49.20	0.57
CH6	100	62.66	3.86	53.58	69.78	0.39
CH7	100	27.99	2.40	23.36	33.98	0.24
DATE=162						
CH4	100	24.90	2.78	19.74	34.83	0.28
CH5	100	35.79	4.82	15.99	43.05	0.48
CH6	100	60.33	4.79	52.33	74.76	0.48
CH7	100	30.81	3.12	25.49	38.23	0.31

Keith County Field Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
			DATE=178			
CH4	100	28.59	2.64	24.05	35.53	0.26
CH5	100	30.63	3.55	23.53	41.79	0.35
CH6	100	51.87	5.00	45.36	66.22	0.50
CH7	100	23.25	2.47	17.51	28.89	0.25
			DATE=180			
CH4	100	33.03	1.69	29.02	35.99	0.17
CH5	100	49.73	3.44	39.36	57.81	0.34
CH6	100	63.23	3.12	57.32	72.27	0.31
CH7	100	26.67	1.63	23.36	33.98	0.16
			DATE=182			
CH4	100	31.54	2.15	26.00	38.00	0.32
CH5	100	40.23	5.10	20.00	48.00	0.51
CH6	100	46.02	3.98	37.00	58.00	0.40
CH7	100	19.02	1.68	15.00	27.00	0.19
			DATE=-80			
CH4	100	22.26	2.17	16.40	26.60	0.22
CH5	100	26.82	3.40	18.97	32.66	0.34
CH6	100	37.27	4.08	24.50	48.66	0.41
CH7	100	17.47	1.76	10.87	20.35	0.18
			DATE=-44			
CH4	100	11.92	1.17	10.03	15.13	0.12
CH5	100	11.45	2.21	7.56	20.11	0.22
CH6	100	27.52	2.27	16.31	33.28	0.23
CH7	100	14.32	1.32	8.03	16.56	0.13
			DATE=-27			
CH4	95	9.60	1.22	7.00	14.00	0.12
CH5	95	9.68	1.69	7.00	14.00	0.17
CH6	95	13.11	2.29	9.00	19.00	0.24
CH7	95	7.04	1.02	5.00	9.00	0.10

Keith County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERR. OF MEAN
DATE=81						
CH4	676	36.80	4.36	22.00	52.00	0.17
CH5	676	44.92	6.32	28.00	63.00	0.24
CH6	676	49.46	5.49	29.00	64.00	0.21
CH7	676	20.49	2.05	11.00	25.00	0.08
DATE=90						
CH4	676	34.06	4.01	23.22	47.60	0.15
CH5	676	40.93	7.30	24.60	63.96	0.28
CH6	676	51.00	7.66	32.40	72.27	0.29
CH7	676	19.23	2.97	10.62	25.49	0.11
DATE=118						
CH4	676	22.74	4.08	16.00	34.00	0.16
CH5	676	34.83	7.44	11.00	48.00	0.29
CH6	676	37.69	8.31	10.00	54.00	0.32
CH7	676	17.47	4.99	9.00	28.00	0.19
DATE=135						
CH4	676	38.51	6.05	25.00	52.00	0.23
CH5	676	42.42	10.54	21.00	65.00	0.41
CH6	676	57.94	4.72	44.00	73.00	0.18
CH7	676	25.04	3.31	19.00	34.00	0.13
DATE=136						
CH4	676	32.91	5.67	20.00	46.00	0.23
CH5	676	35.89	10.28	15.00	56.00	0.40
CH6	676	50.51	5.10	36.00	65.00	0.20
CH7	676	21.96	3.84	16.00	33.00	0.15
DATE=145						
CH4	676	38.66	7.46	22.06	52.64	0.29
CH5	676	44.74	14.03	18.45	71.34	0.54
CH6	676	64.60	5.53	49.64	78.50	0.21
CH7	676	25.23	2.12	20.18	33.98	0.08
DATE=162						
CH4	676	34.54	8.39	19.74	51.08	0.32
CH5	676	46.15	16.52	15.99	76.26	0.64
CH6	676	66.45	11.53	42.36	90.96	0.44
CH7	676	30.25	4.38	22.30	38.23	0.16

Keith County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
			DATE=172			
CH4	676	30.78	3.90	21.50	41.90	0.15
CH5	676	32.77	6.55	15.54	47.49	0.25
CH6	676	58.12	5.73	39.87	78.62	0.22
CH7	676	20.75	2.81	15.67	30.64	0.11
			DATE=180			
CH4	676	31.49	4.14	26.90	42.96	0.16
CH5	676	41.62	12.31	19.68	61.50	0.47
CH6	676	65.67	6.30	47.35	80.99	0.24
CH7	676	29.31	5.03	19.12	40.36	0.19
			DATE=208			
CH4	676	29.26	7.69	17.00	52.00	0.30
CH5	676	32.77	14.61	12.00	67.00	0.56
CH6	676	55.45	8.78	32.00	74.00	0.34
CH7	676	25.66	6.66	13.00	39.00	0.26
			DATE=225			
CH4	676	39.96	5.96	17.00	42.00	0.23
CH5	676	32.18	11.39	14.00	54.00	0.44
CH6	676	51.92	8.25	33.00	71.00	0.32
CH7	676	23.96	6.40	13.00	37.00	0.25
			DATE=226			
CH4	676	27.46	5.60	16.00	38.00	0.22
CH5	676	29.81	10.73	13.00	49.00	0.41
CH6	676	48.61	8.14	31.00	68.00	0.31
CH7	676	22.13	6.33	13.00	34.00	0.24
			DATE=-80			
CH4	676	22.59	4.62	13.65	32.99	0.18
CH5	676	29.37	7.90	16.68	48.63	0.30
CH6	676	37.91	7.40	17.91	56.34	0.28
CH7	676	16.64	2.99	9.03	23.25	0.12
			DATE=-44			
CH4	676	14.88	3.21	8.75	22.78	0.12
CH5	676	16.36	6.64	7.56	32.66	0.26
CH6	676	26.94	4.79	12.42	39.87	0.18
CH7	676	11.86	2.33	4.29	17.57	0.09

Keith County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=-27						
CH4	676	10.75	1.67	6.00	15.00	0.06
CH5	676	11.97	2.56	5.00	20.00	0.10
CH6	676	12.59	3.32	6.00	23.00	0.13
CH7	676	6.21	1.63	3.00	11.00	0.06

Yolo County Field Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=23						
CH4	465	12.81	1.13	8.75	15.13	0.05
CH5	465	11.34	1.91	7.56	15.54	0.09
CH6	465	22.37	3.87	12.42	33.28	0.18
CH7	465	10.81	1.96	6.13	16.56	0.09
DATE=59						
CH4	465	16.51	1.48	13.00	22.00	0.07
CH5	465	11.95	2.11	8.00	23.00	0.10
CH6	465	45.78	5.86	28.00	62.00	0.27
CH7	465	21.71	3.28	12.00	33.00	0.15
DATE=86						
CH4	485	24.04	1.71	18.58	33.67	0.08
CH5	485	17.91	3.15	12.30	34.44	0.14
CH6	485	64.80	7.68	39.87	88.47	0.35
CH7	485	27.87	4.14	15.93	40.36	0.19
DATE=122						
CH4	495	32.90	2.39	26.79	41.80	0.11
CH5	495	31.04	3.39	22.14	55.35	0.15
CH6	495	70.32	5.21	54.82	85.97	0.23
CH7	495	28.72	2.02	19.12	35.05	0.09

Yolo County Field Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERR OF MEAN
			DATE=131			
CH4	500	34.34	[illegible]	26.00	43.00	0.15
CH5	500	41.36	6.67	26.00	61.00	0.30
CH6	500	65.86	5.25	54.00	81.00	0.23
CH7	500	29.36	1.91	25.00	36.00	0.09
			DATE=136			
CH4	500	31.31	3.50	24.00	41.00	0.16
CH5	500	38.98	6.78	23.00	55.00	0.30
CH6	500	60.50	4.86	51.00	77.00	0.22
CH7	500	27.24	1.90	22.00	33.00	0.08
			DATE=140			
CH4	500	47.19	3.06	40.63	56.69	0.14
CH5	500	61.81	6.78	43.05	78.72	0.30
CH6	500	83.31	3.93	74.76	97.19	0.18
CH7	500	31.02	1.29	27.61	36.11	0.06
			DATE=149			
CH4	500	47.48	6.34	32.98	71.23	0.28
CH5	500	66.66	11.46	39.58	104.54	0.51
CH6	500	81.69	8.94	67.32	114.54	0.40
CH7	500	34.62	2.98	29.83	45.00	0.13
			DATE=167			
CH4	500	62.38	7.06	39.35	75.05	0.32
CH5	500	94.10	12.13	52.06	115.95	0.54
CH6	500	106.90	10.01	73.91	128.81	0.45
CH7	500	42.69	2.93	31.73	48.79	0.13
			DATE=-85			
CH4	285	28.22	4.62	20.23	40.63	0.27
CH5	285	34.54	6.54	20.11	55.48	0.39
CH6	285	34.37	7.64	16.81	57.44	0.45
CH7	285	12.93	2.85	7.08	21.30	0.17
			DATE=-49			
CH4	320	19.10	2.71	12.58	27.89	0.15
CH5	320	22.56	4.63	12.12	34.94	0.26
CH6	320	21.04	5.81	9.13	35.48	0.32
CH7	320	8.27	1.74	4.24	12.77	0.10

Yolo County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
			DATE=23			
CH4	1640	12.78	1.51	7.48	17.68	0.04
CH5	1640	11.15	2.45	4.13	21.25	0.06
CH6	1640	23.22	5.74	4.74	46.46	0.14
CH7	1640	9.65	2.87	2.49	21.36	0.07
			DATE=59			
CH4	1640	16.66	1.78	6.00	27.00	0.04
CH5	1640	12.54	2.28	6.00	28.00	0.06
CH6	1640	48.31	7.95	16.00	68.00	0.20
CH7	1640	19.86	4.33	7.00	34.00	0.11
			DATE=86			
CH4	1640	25.90	3.90	18.58	41.80	0.10
CH5	1640	21.57	7.24	12.30	54.12	0.18
CH6	1640	68.24	10.62	33.64	88.47	0.26
CH7	1640	25.01	5.68	10.62	40.36	0.15
			DATE=122			
CH4	1640	34.41	3.99	25.54	49.92	0.10
CH5	1640	34.14	7.14	20.91	63.96	0.18
CH6	1640	68.45	6.60	41.12	85.97	0.16
CH7	1640	27.17	3.79	13.81	36.11	0.09
			DATE=131			
CH4	1640	35.03	4.24	24.00	50.00	0.10
CH5	1640	41.35	7.53	20.00	63.00	0.19
CH6	1640	61.97	8.23	36.60	82.00	0.20
CH7	1640	27.53	4.88	13.00	39.00	0.12
			DATE=132			
CH4	1640	31.86	4.32	19.00	47.00	0.11
CH5	1640	38.69	7.64	15.00	58.00	0.19
CH6	1640	57.21	8.42	31.00	77.00	0.21
CH7	1640	25.10	4.91	12.00	38.00	0.12
			DATE=140			
CH4	1640	47.83	3.56	37.15	56.89	0.09
CH5	1640	61.80	8.10	36.90	78.72	0.20
CH6	1640	90.63	7.99	51.09	98.43	0.20
CH7	1640	29.42	4.09	18.05	37.17	0.10

Yolo County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=149						
CH4	1640	46.60	5.60	31.70	71.83	0.14
CH5	1640	62.32	12.05	32.65	104.54	0.30
CH6	1640	75.21	12.55	38.77	114.54	0.31
CH7	1640	30.56	6.19	13.77	45.86	0.15
DATE=167						
CH4	1640	53.96	8.98	34.25	75.05	0.22
CH5	1640	77.99	17.79	37.22	115.95	0.44
CH6	1640	88.49	20.02	42.07	128.81	0.49
CH7	1640	34.52	8.40	14.72	47.99	0.21
DATE=-85						
CH4	1640	30.94	6.13	18.95	61.03	0.15
CH5	1640	37.66	8.94	18.97	65.75	0.22
CH6	1640	36.61	10.65	5.83	67.32	0.26
CH7	1640	13.32	4.27	5.24	28.94	0.11
DATE=-49						
CH4	1640	21.01	4.39	12.58	36.60	0.11
CH5	1640	24.88	6.80	10.98	52.06	0.17
CH6	1640	23.75	7.79	8.03	50.85	0.19
CH7	1640	8.09	2.82	1.45	18.51	0.07

Finney County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=8						
CH4	1040	13.00	1.27	9.00	18.00	0.04
CH5	1040	15.79	2.26	11.00	22.00	0.07
CH6	1040	17.33	2.45	12.00	23.00	0.08
CH7	1040	8.36	1.11	6.00	12.00	0.03
DATE=63						
CH4	1040	35.29	12.73	17.68	98.00	0.39
CH5	1040	41.43	14.50	23.53	119.37	0.45
CH6	1040	43.22	12.36	28.69	115.63	0.38
CH7	1040	16.35	3.37	9.98	34.63	0.10

Finney County Area Data by Julian Date

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR MEAN
			DATE=90			
CH4	1040	35.96	3.16	26.70	45.68	0.10
CH5	1040	42.64	5.62	28.29	57.81	0.18
CH6	1040	54.31	4.69	41.12	72.27	0.15
CH7	1040	19.94	2.27	14.67	25.49	0.07
			DATE=135			
CH4	1007	36.24	7.94	18.95	55.93	0.25
CH5	1007	41.90	12.89	15.54	72.59	0.41
CH6	1007	56.88	5.90	39.87	76.11	0.19
CH7	1007	23.22	3.40	15.67	65.91	0.11
			DATE=143			
CH4	1040	40.73	6.84	24.38	61.53	0.21
CH5	1040	46.35	12.27	18.45	78.72	0.38
CH6	1040	64.06	6.03	48.59	85.97	0.19
CH7	1040	22.83	1.86	16.99	28.67	0.06
			DATE=152			
CH4	1040	36.63	6.47	24.00	55.00	0.20
CH5	1040	40.45	10.97	19.00	78.00	0.34
CH6	1040	52.75	6.19	38.00	77.00	0.19
CH7	1040	21.96	1.95	17.00	28.00	0.06
			DATE=162			
CH4	1040	35.90	6.15	24.38	55.73	0.19
CH5	1040	49.12	12.17	23.37	83.64	0.38
CH6	1040	64.91	8.57	47.35	93.45	0.27
CH7	1040	27.38	2.90	19.12	36.11	0.09
			DATE=170			
CH4	1040	48.94	18.96	22.00	127.00	0.59
CH5	1040	57.02	21.84	19.00	127.00	0.68
CH6	1040	60.24	20.84	18.00	127.00	0.65
CH7	1040	22.54	7.40	5.00	48.00	0.23
			DATE=186			
CH4	1040	40.14	4.08	33.67	58.05	0.13
CH5	1040	60.69	6.48	45.51	97.33	0.20
CH6	1040	66.75	6.61	51.09	93.45	0.20
CH7	1040	25.93	2.38	21.24	35.05	0.07

Finney County Area Data by Julian Date

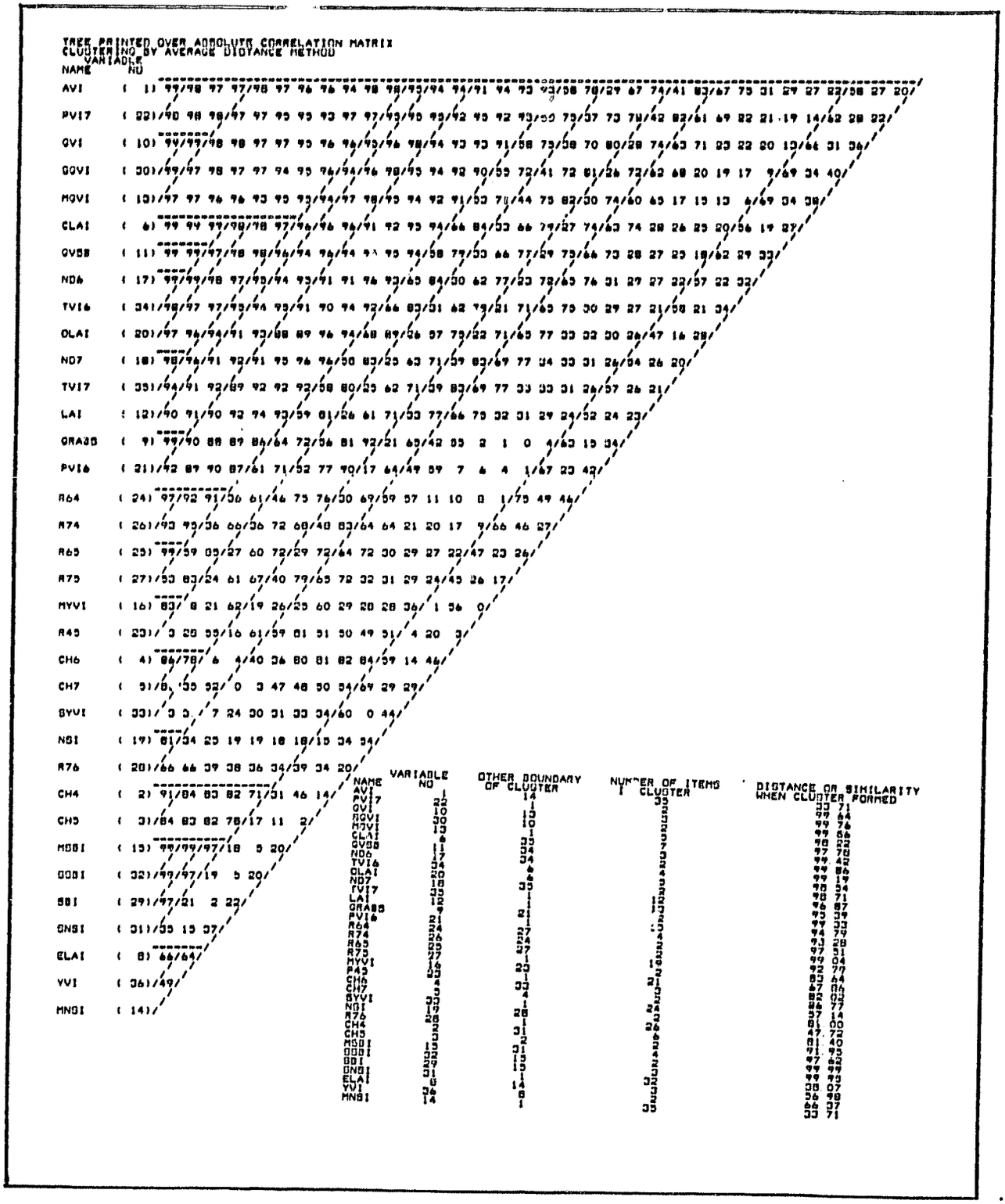
VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
DATE=207						
CH4	1040	40.18	4.50	30.00	61.00	0.15
CH5	1040	50.23	7.44	36.00	81.00	0.23
CH6	1040	53.74	6.37	38.00	82.00	0.20
CH7	1040	21.35	2.10	15.00	30.00	0.07
DATE=234						
CH4	1040	40.27	5.45	30.00	60.00	0.17
CH5	1040	49.35	8.72	29.00	80.00	0.27
CH6	1040	52.84	6.86	36.00	78.00	0.21
CH7	1040	20.69	2.03	14.00	29.00	0.07
DATE=225						
CH4	1040	37.55	5.70	28.00	62.00	0.18
CH5	1040	46.76	8.67	26.00	82.00	0.27
CH6	1040	50.39	7.19	32.00	78.00	0.22
CH7	1040	19.99	2.56	13.00	29.00	0.08
DATE=-108						
CH4	1040	27.64	2.99	19.00	37.00	0.09
CH5	1040	33.78	4.61	20.00	46.00	0.14
CH6	1040	38.57	4.82	23.00	50.00	0.15
CH7	1040	15.79	2.17	9.00	22.00	0.07
DATE=-99						
CH4	1040	25.58	3.02	18.00	34.00	0.09
CH5	1040	31.95	4.54	18.00	43.00	0.14
CH6	1040	36.80	5.23	19.00	49.00	0.16
CH7	1040	15.13	2.33	9.00	21.00	0.07
DATE=-81						
CH4	1040	24.48	3.92	14.00	38.00	0.12
CH5	1040	30.41	5.36	16.00	49.00	0.17
CH6	1040	35.20	5.91	19.00	53.00	0.18
CH7	1040	15.51	2.36	9.00	22.00	0.07
DATE=-45						
CH4	1040	15.54	1.96	10.03	21.50	0.06
CH5	1040	17.97	3.22	9.84	28.09	0.10
CH6	1040	23.97	4.69	12.42	34.38	0.15
CH7	1040	9.97	2.56	5.24	16.62	0.08

APPENDIX B

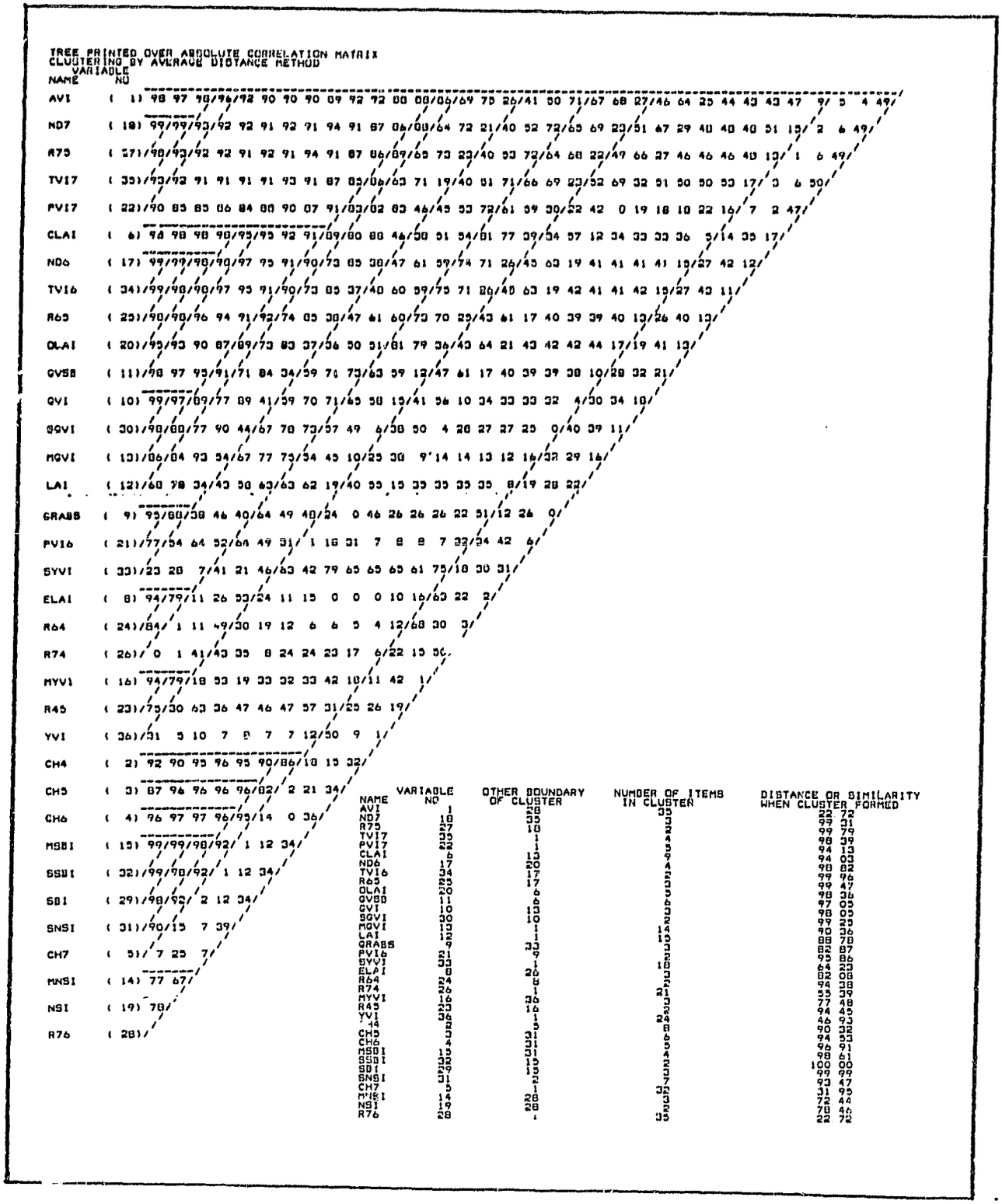
CLUSTER TREES

The cluster trees included in this appendix are for the Yolo County and Keith County locations as described in appendix A. Separate trees were produced by date for the area pixels and the field pixels. Data were also combined by area or by field for the period spring greenup to harvest which indicate the correlation coefficients remain high over this time period. Although cluster trees are not attached for other data sets described in appendix A, the results were very similar.

Keith County - March 27 thru August 14, 1978 - Area

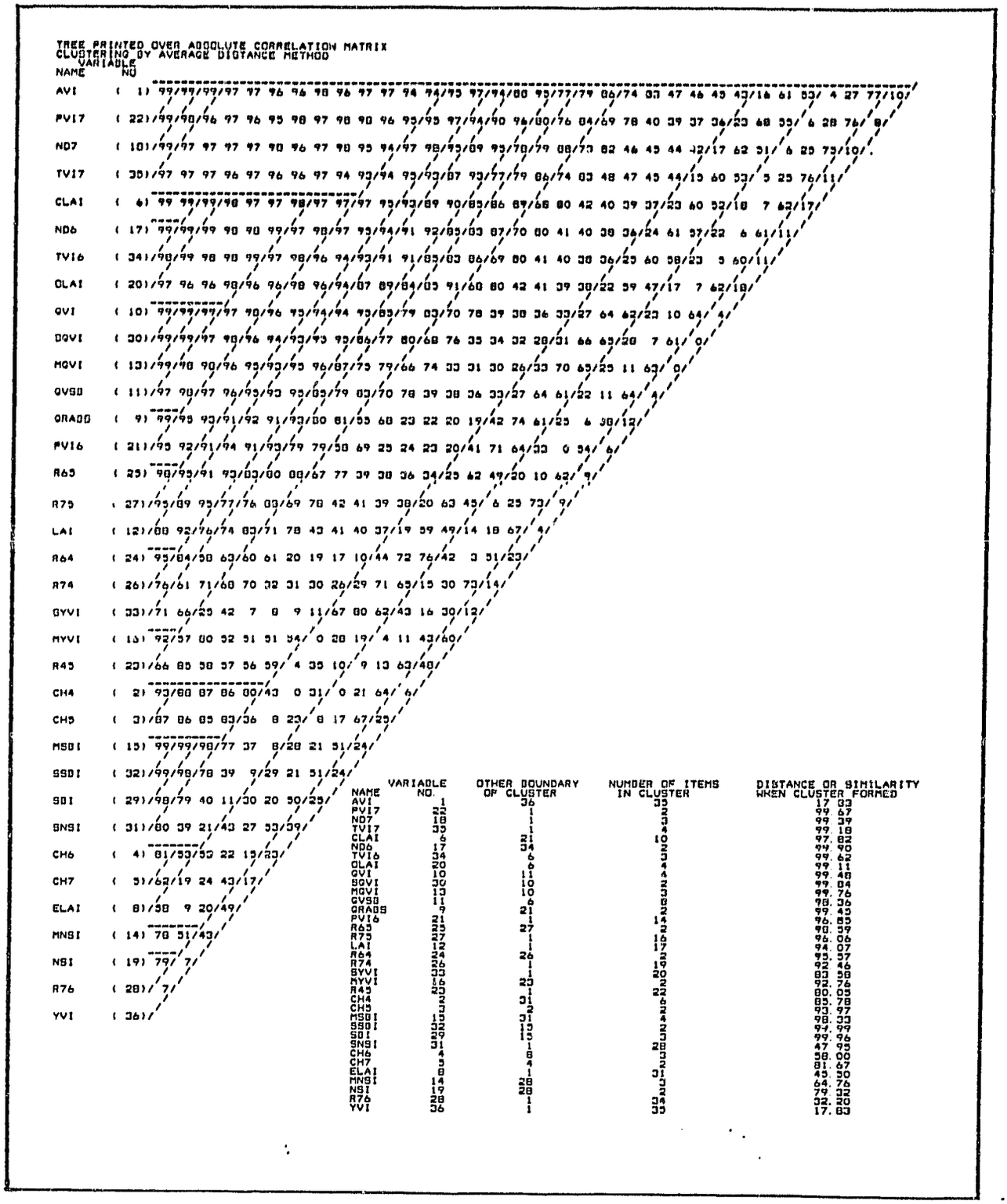


Keith County - October 12, 1977 - Area

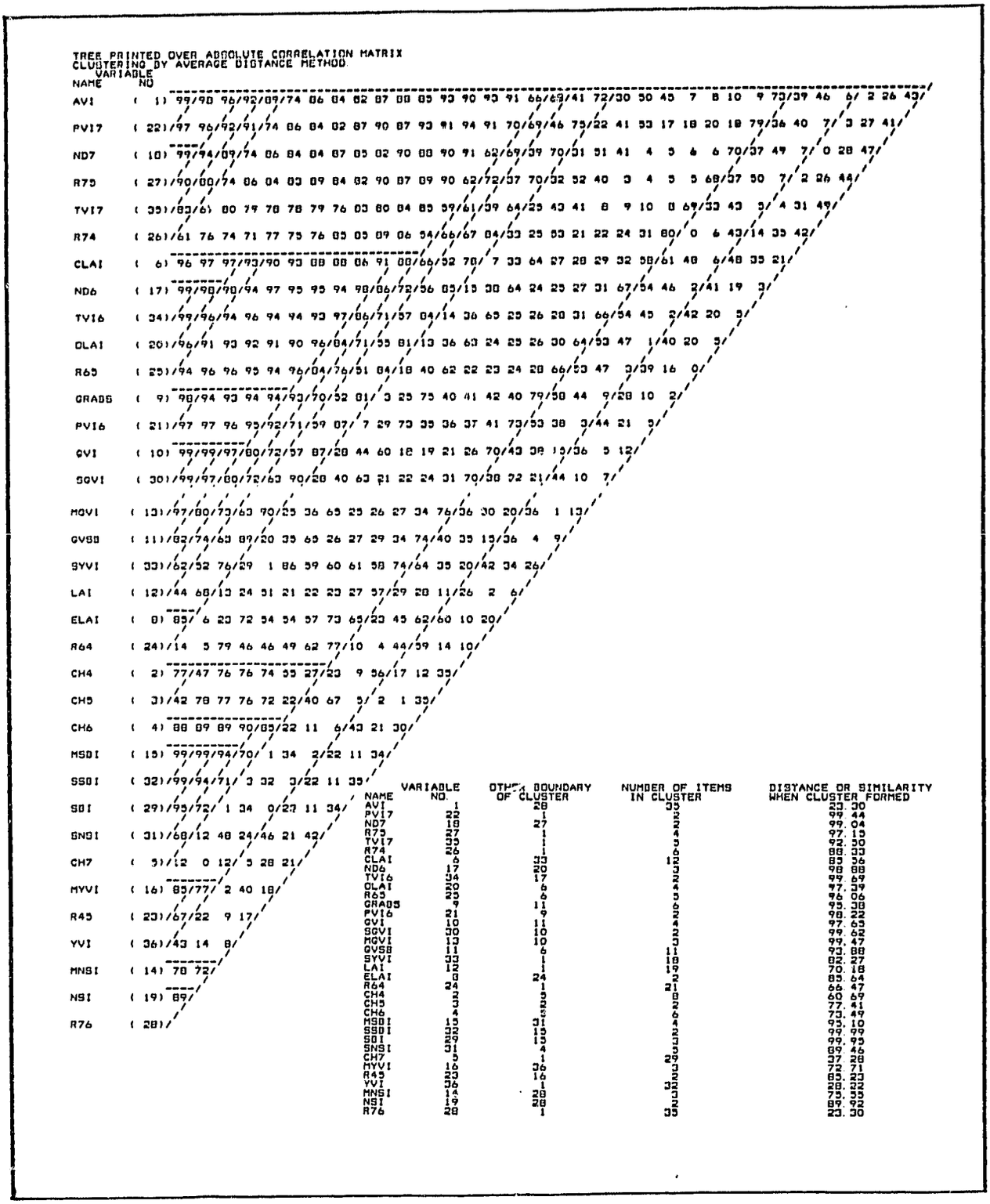


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	28	35	22 72
ND7	18	35	2	99 91
R75	27	10	3	99 79
TVI7	35	1	4	98 39
PVI7	22	1	5	94 13
CLAI	6	10	2	94 03
ND6	17	20	3	98 82
TVI6	34	17	4	99 76
R65	25	17	5	99 47
OLAI	20	6	2	98 36
GVSB	11	6	3	97 05
QVI	10	10	2	98 05
SQVI	30	10	3	99 23
MQVI	13	1	4	90 56
LAI	12	1	5	88 70
GRASS	9	33	2	82 87
PVI6	21	9	3	95 86
SYVI	33	1	6	64 20
ELAI	8	24	2	82 08
R64	24	5	3	94 28
R74	26	1	4	55 39
MYVI	16	36	2	77 48
R45	23	16	3	94 45
YVI	36	1	4	46 93
CH4	2	5	2	90 32
CH5	3	31	3	94 53
CH6	4	31	4	96 91
MSBI	15	31	5	98 61
SSBI	32	15	6	100 00
SBI	29	15	7	99 99
SNSI	31	2	8	93 47
CH7	5	1	2	31 99
MNSI	14	28	3	72 44
NSI	19	28	4	78 46
R76	28	1	35	22 72

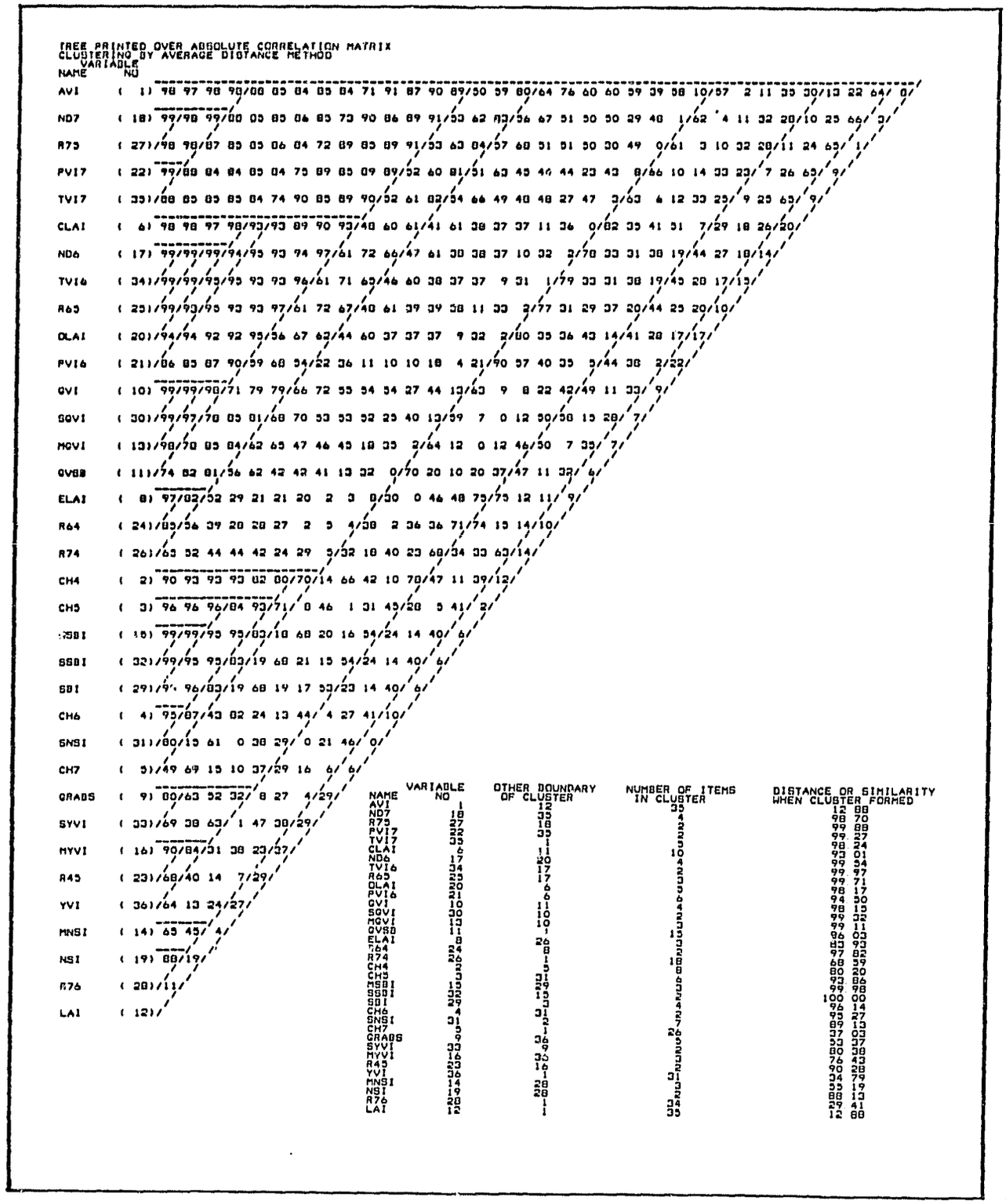
Keith County - November 17, 1977 - Area



NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	33	17.83
PVI7	22	1	2	99.67
ND7	18	1	3	99.39
TVI7	33	1	4	99.18
CLAI	6	21	10	97.82
ND6	17	34	2	99.90
TVI6	34	6	3	99.62
OLAI	20	6	4	99.11
GVI	10	11	4	99.48
DGVI	30	10	5	99.84
MGVI	13	10	6	99.76
GVSB	11	6	7	98.36
GRADB	9	21	2	99.43
PVI6	21	1	14	96.85
R65	25	27	2	98.39
R75	27	1	15	96.06
LAI	12	1	17	94.07
R64	24	26	2	95.37
R74	26	1	16	92.46
SYVI	35	1	20	83.58
MYVI	36	25	2	92.76
R45	23	1	21	80.05
CH4	2	31	2	85.78
CH5	3	2	23	93.97
MSBI	15	31	2	98.33
SSBI	32	15	2	94.99
SBI	29	15	2	99.96
SNSI	31	1	24	47.95
CH6	4	8	2	98.00
CH7	5	4	2	81.67
ELAI	8	1	31	45.30
MNSI	14	28	2	64.76
NSI	19	28	2	79.32
R76	28	1	34	32.20
YVI	36	1	35	17.83

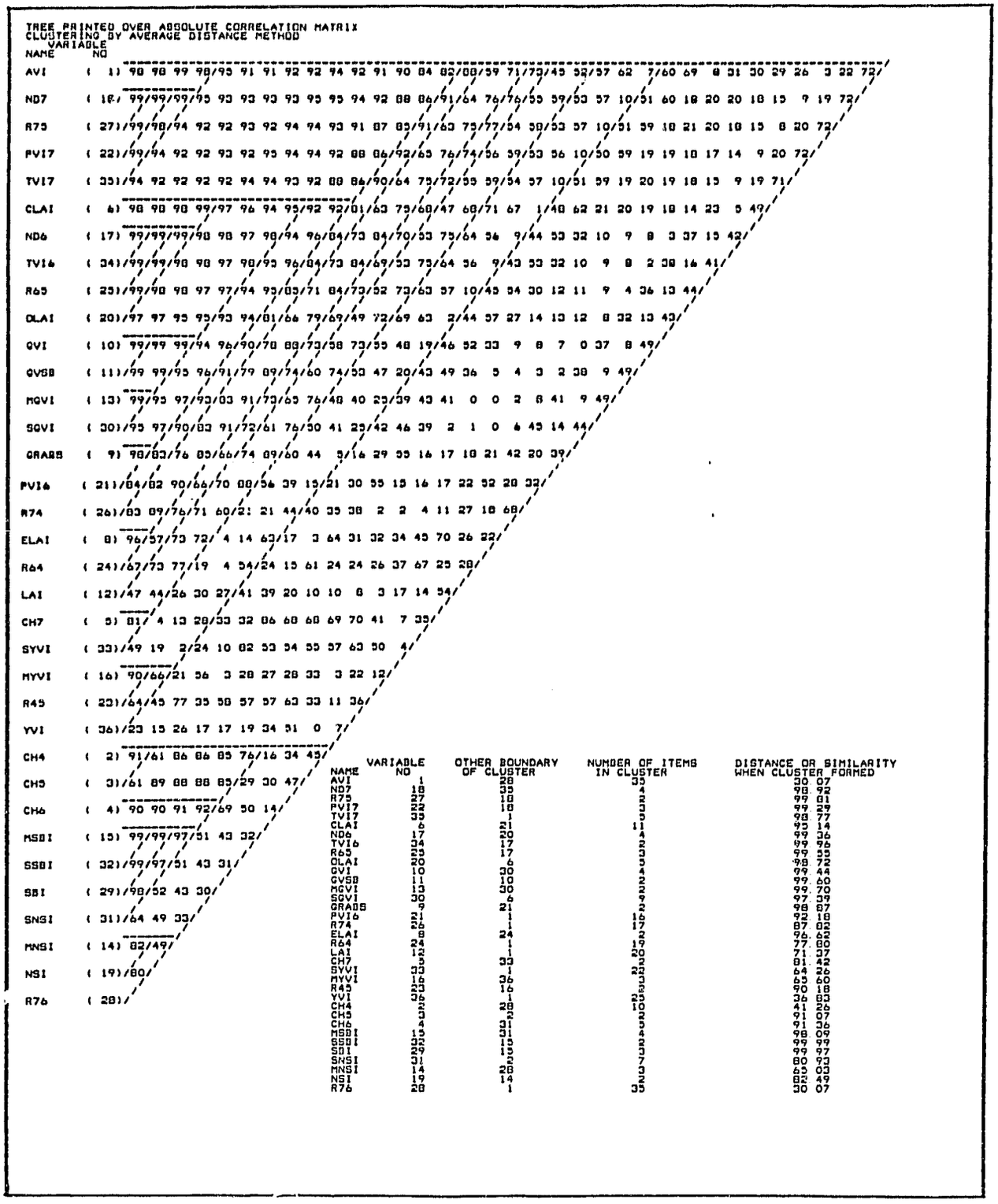


Keith County - March 22, 1978 - Area



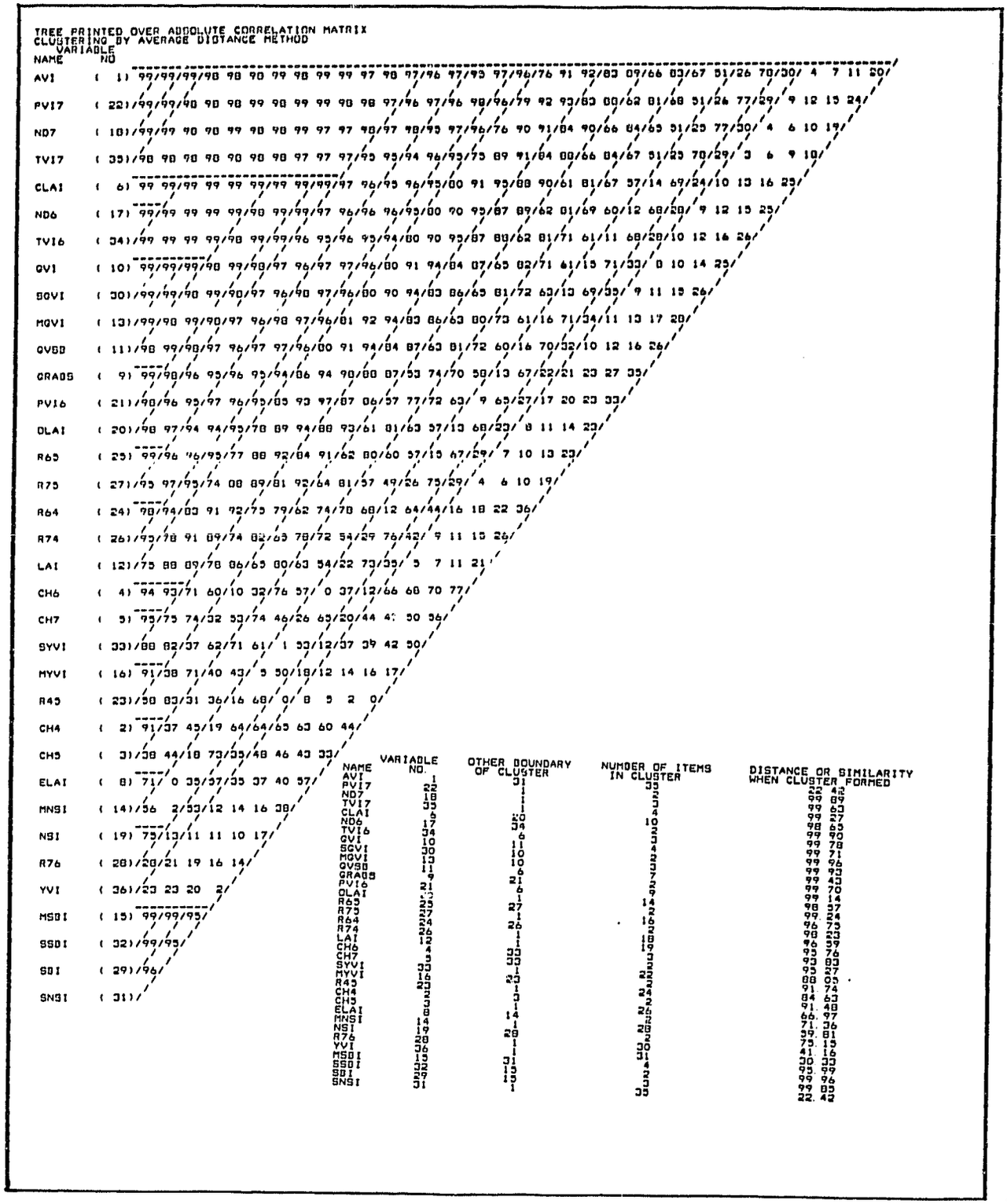
NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	12	35	12 88
ND7	18	35	4	98 70
R75	27	18	2	99 88
PVI7	22	35	2	99 27
TVI7	35	1	3	98 24
CLAI	6	11	10	93 01
ND6	17	20	4	99 54
TVI6	34	17	3	99 97
R65	25	17	3	99 71
DLAI	20	6	3	98 17
PVI6	21	6	6	94 50
QVI	10	11	4	98 15
SQVI	30	10	4	99 32
MQVI	13	10	2	99 11
QVBB	11	1	15	96 03
ELAI	8	26	3	83 93
R64	24	8	2	97 82
R74	26	1	18	68 59
CH4	2	5	8	80 20
CH5	3	31	6	93 86
MSBI	15	29	2	99 98
SSBI	32	15	2	100 00
SBI	29	3	4	96 14
CH6	4	31	4	93 27
SNSI	31	2	7	89 13
CH7	5	1	26	37 03
GRABS	9	36	5	53 37
SYVI	33	9	2	80 38
MYVI	16	35	2	76 48
R45	23	16	2	90 28
YVI	36	1	31	34 79
MNSI	14	28	3	55 19
NSI	19	28	2	88 13
R76	28	1	34	29 41
LAI	12	1	35	12 88

Keith County - March 31, 1978 - Area

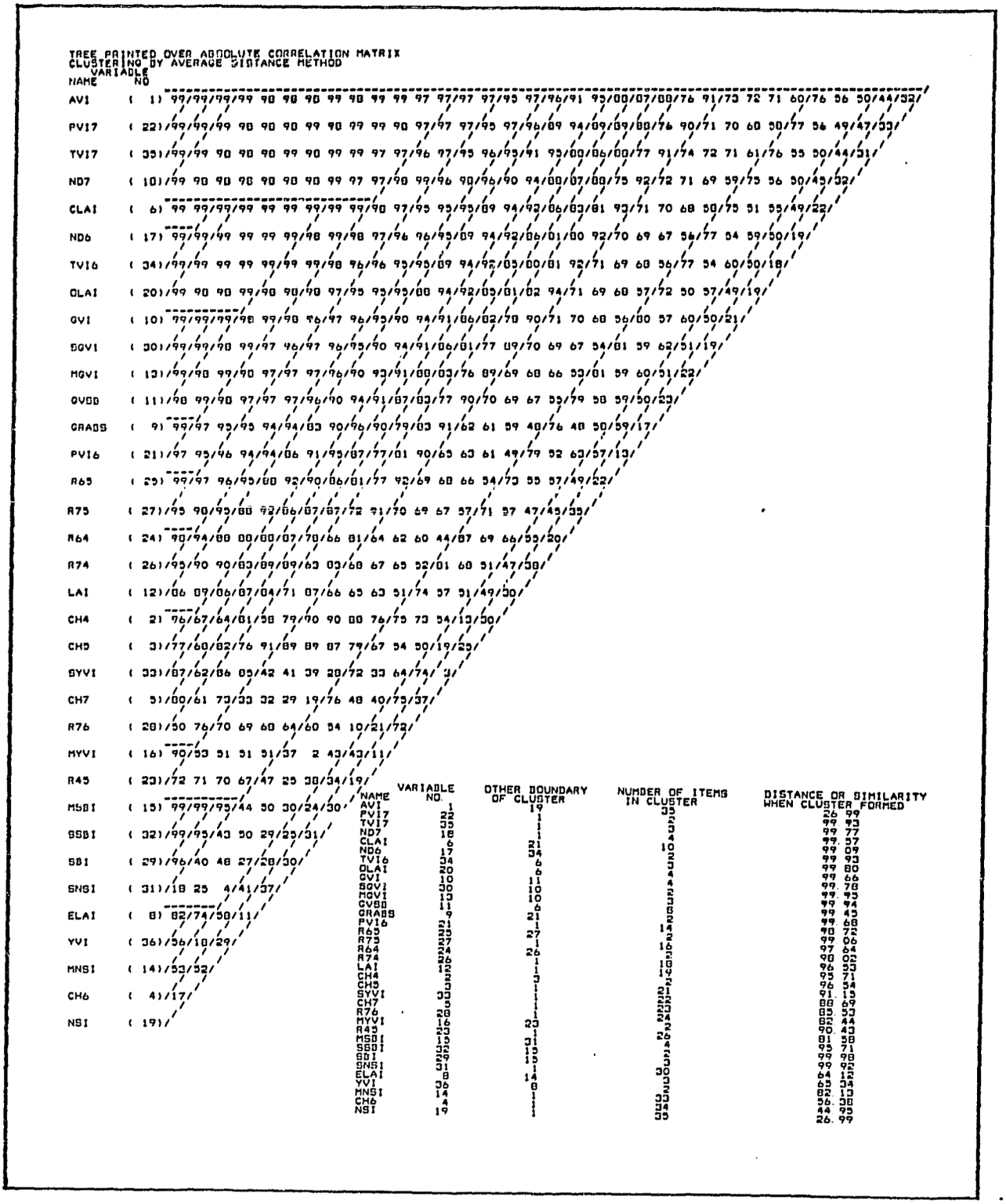


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	28	35	30 07
ND7	18	35	4	98 92
R75	27	18	2	99 81
PVI7	22	18	3	99 29
TVI7	33	1	5	98 77
CLAI	6	21	11	95 14
ND6	17	20	4	99 36
TVI6	34	17	2	99 96
R65	25	17	3	99 55
CLAI	20	6	5	98 72
GVI	10	30	4	99 44
GVSB	11	10	2	99 60
MGVI	13	30	2	99 70
SGVI	30	6	9	97 39
GRASS	9	21	2	98 87
PVI6	21	1	16	92 18
R74	26	1	17	87 82
ELAI	8	24	2	96 62
R64	24	1	19	77 80
LAI	12	1	20	71 37
CH7	5	33	2	81 42
SYVI	33	1	21	64 26
MYVI	16	36	3	65 60
R45	23	14	5	90 18
YVI	36	1	22	36 83
CH4	2	28	2	41 26
CH5	31	28	3	91 07
CH6	4	31	5	91 36
MSBI	15	31	4	98 09
SSBI	32	15	2	99 99
SBI	29	15	3	99 97
SNSI	31	9	7	80 93
MNSI	14	28	7	65 03
NSI	19	14	2	82 49
R76	28	1	35	30 07

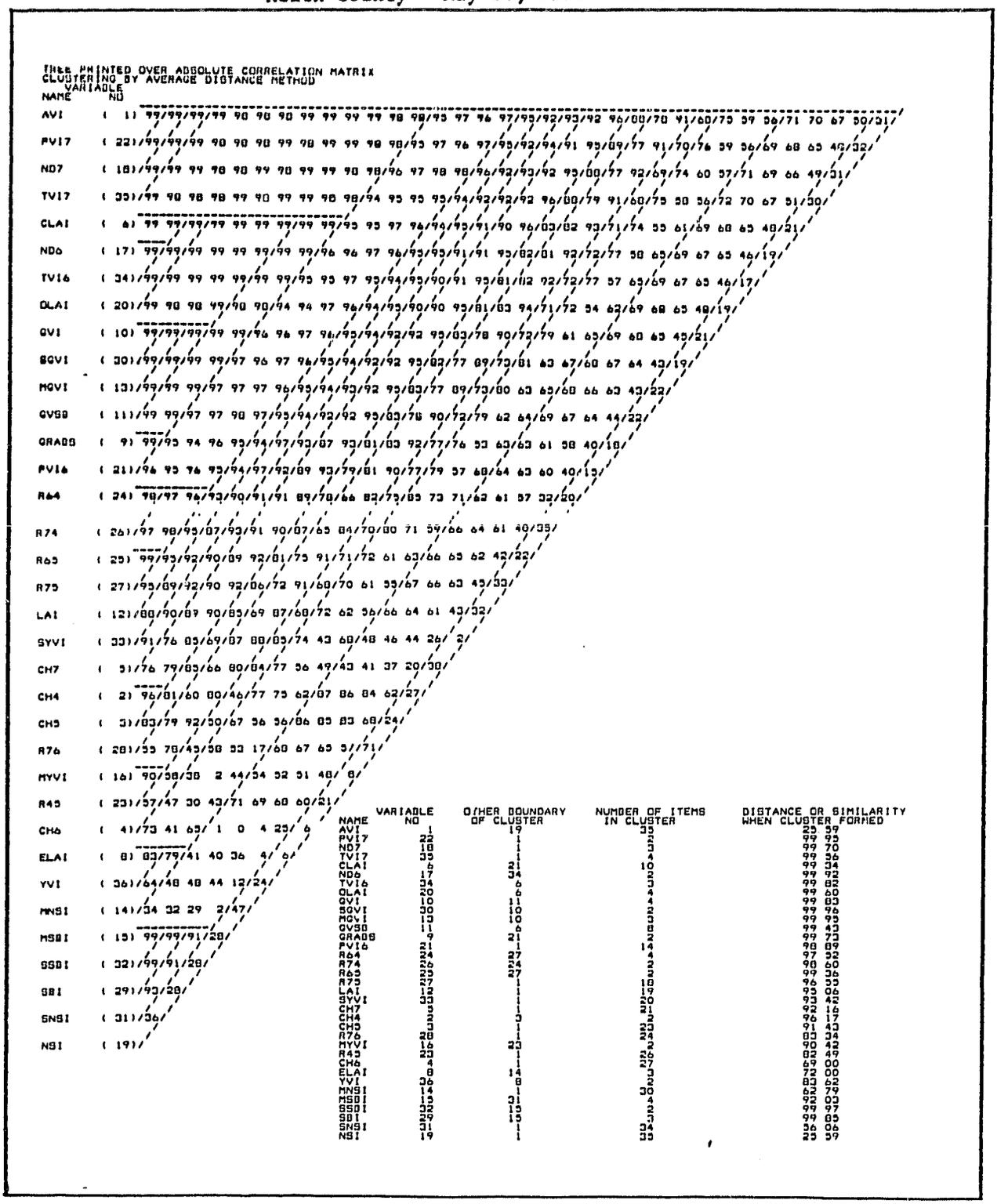
Keith County - April 28, 1978 - Area



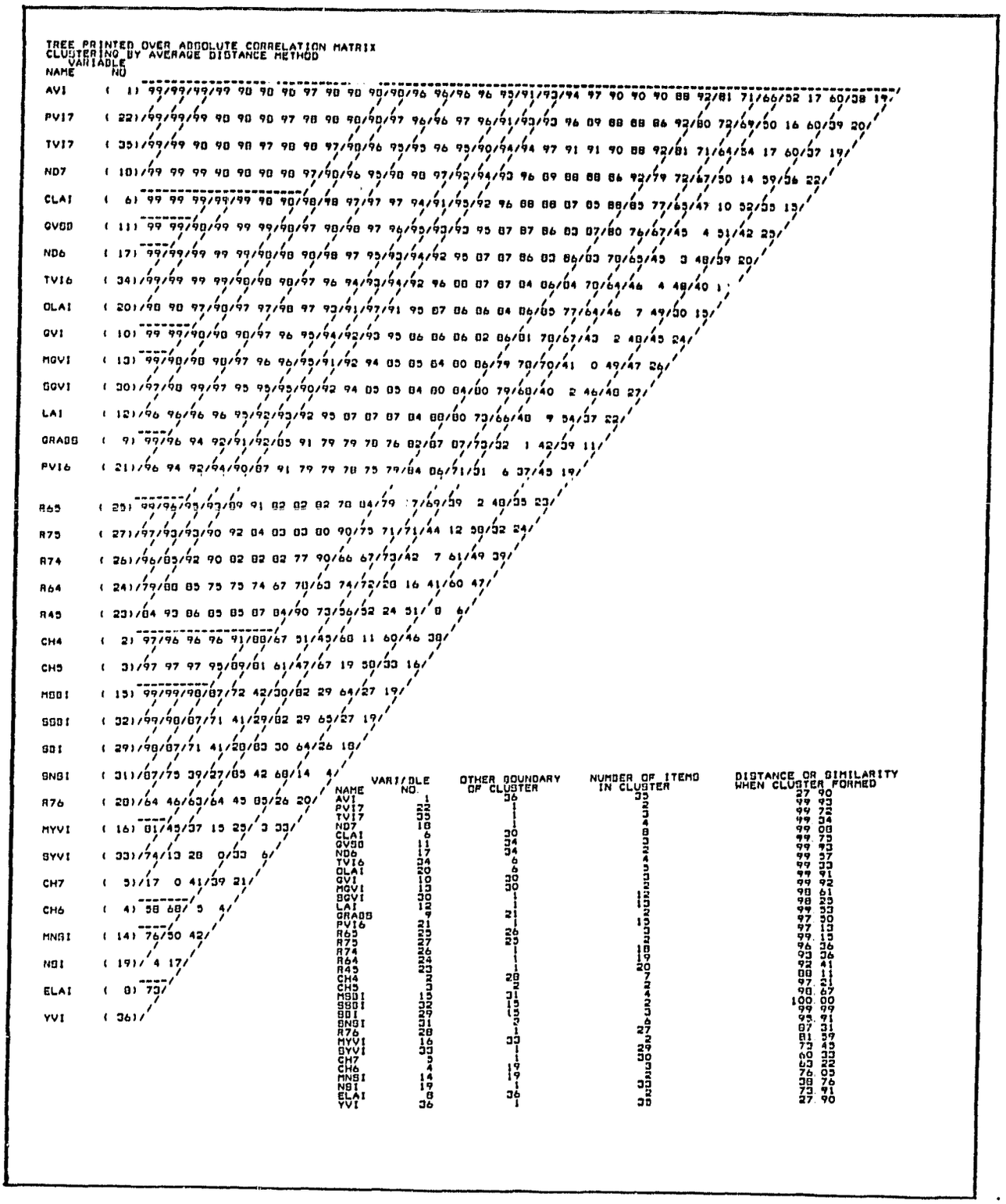
Keith County - May 15, 1978 - Area



Keith County - May 16, 1978 - Area



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	19	35	25 39
PVI7	22	1	2	99 95
ND7	18	1	3	99 70
TVI7	35	1	4	99 56
CLAI	6	21	10	99 34
ND6	17	34	2	99 92
TVI6	34	6	3	99 82
OLAI	20	6	4	99 60
QVI	10	11	4	99 83
SQVI	30	10	2	99 96
MQVI	13	10	3	99 95
QVS8	11	6	8	99 43
GRAD8	9	21	2	99 73
PVI6	21	1	14	98 89
R64	24	27	4	97 32
R74	26	24	2	98 60
R63	25	27	3	99 36
R75	27	1	18	96 55
LAI	12	1	19	95 06
SYVI	33	1	20	93 42
CH7	3	1	21	92 16
CH4	2	0	2	96 17
CH5	0	1	23	91 40
R76	28	1	24	80 34
MYVI	16	23	2	90 42
R43	23	1	26	82 49
CH6	4	1	27	69 00
ELAI	8	14	3	72 00
YVI	36	8	2	80 62
MNSI	14	1	30	62 79
MSBI	15	31	4	92 03
SSBI	32	15	2	99 97
SBI	29	15	3	99 85
SNSI	31	1	34	56 06
NSI	19	1	35	25 59



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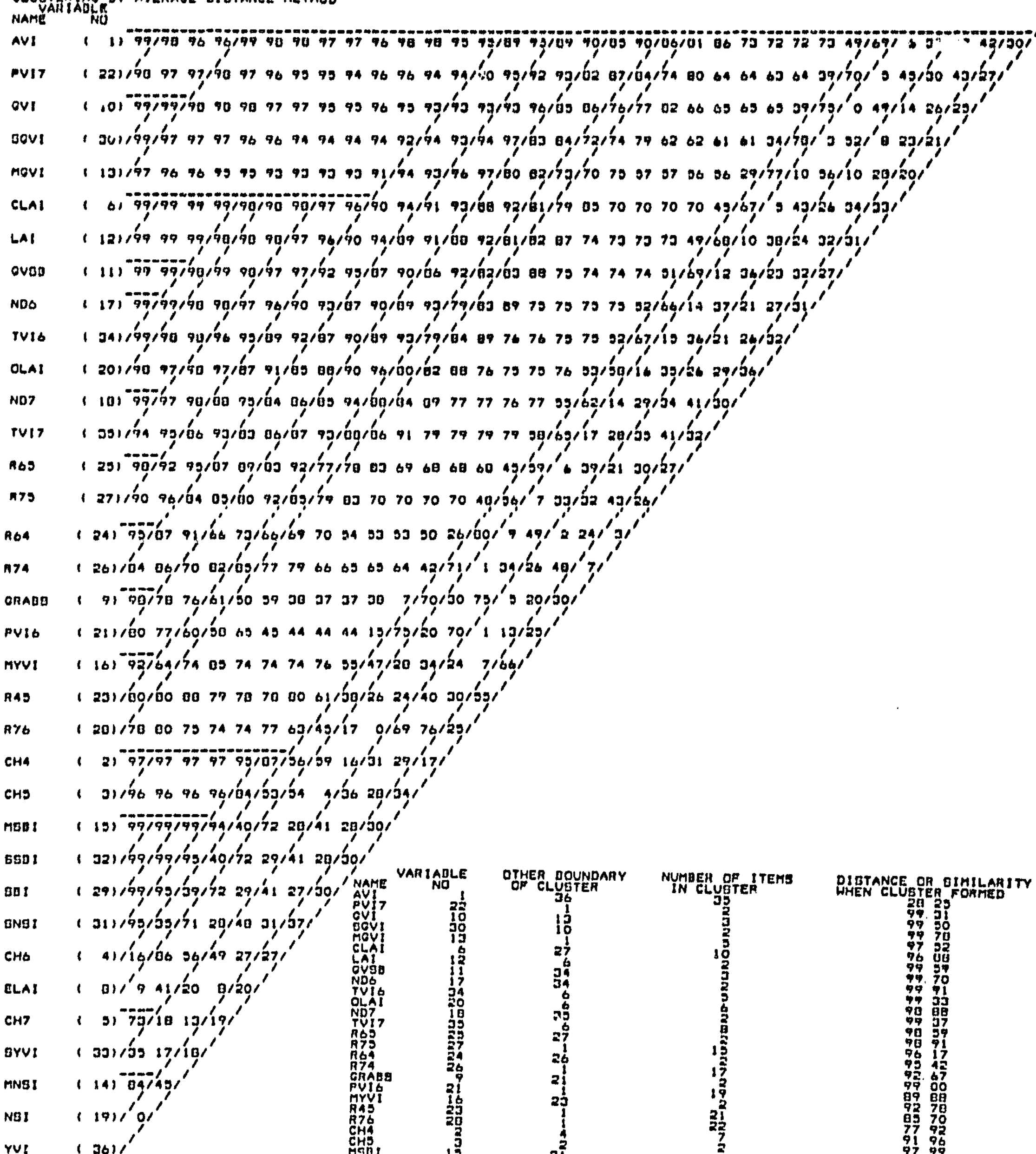
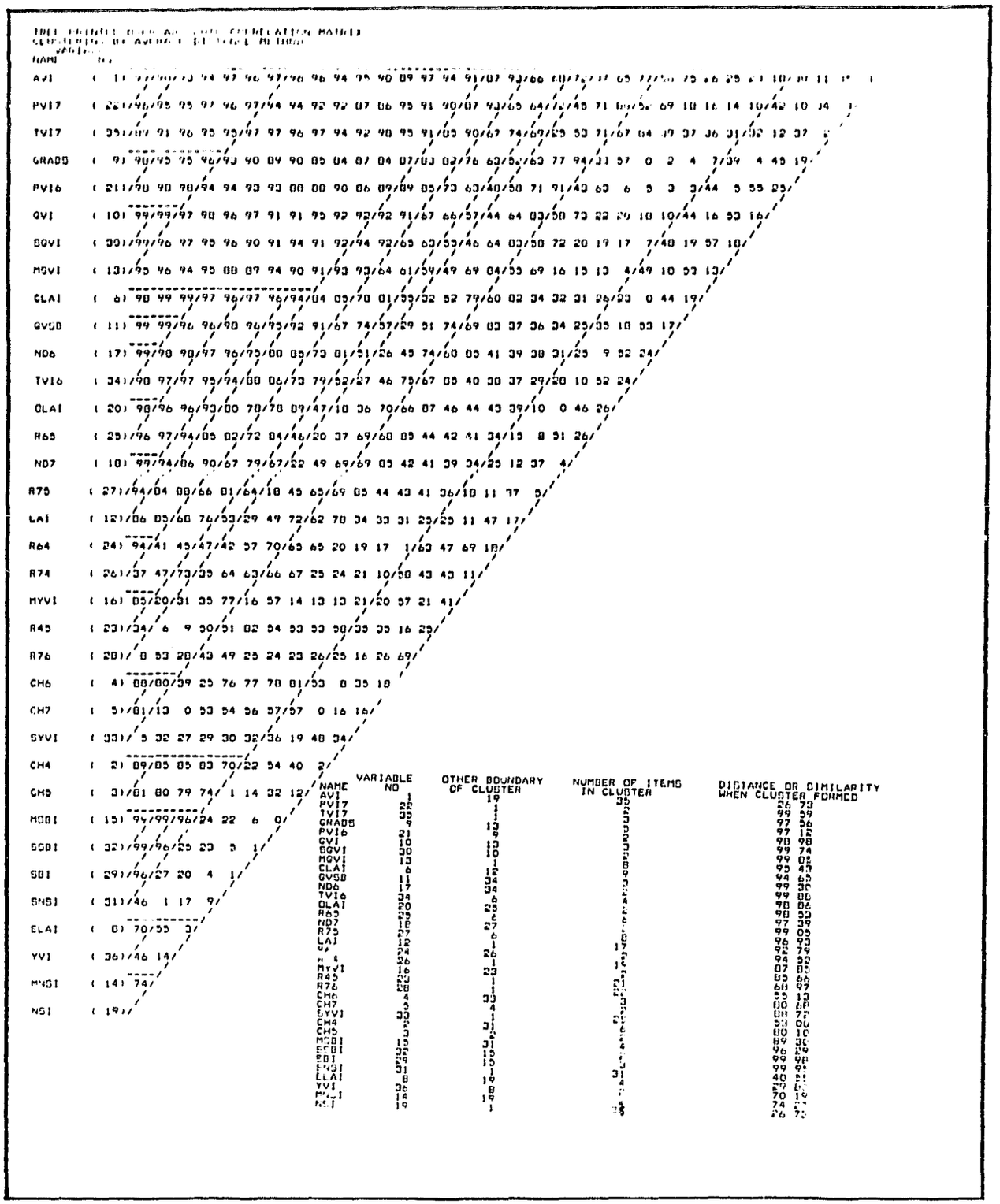
Keith County - June 11, 1978 - Area

TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	28 25
PVI7	22	1	2	99 31
GVI	10	13	3	99 50
BGVI	30	10	2	99 70
MGVI	13	1	5	97 32
CLAI	6	27	10	96 08
LAI	12	6	2	99 59
GVSB	11	34	3	99 70
ND6	17	34	2	99 91
TVI6	34	6	5	99 33
OLAI	20	6	6	98 88
ND7	18	35	2	99 37
TVI7	35	6	8	98 59
R65	25	27	2	98 91
R75	27	1	15	96 17
R64	24	26	2	95 42
R74	26	1	17	92 67
GRABB	9	21	2	99 00
PVI6	21	1	19	89 88
MYVI	16	23	2	92 78
R45	23	1	21	85 70
R76	28	1	22	77 92
CH4	2	4	7	91 96
CH5	3	2	2	97 99
MSBI	15	31	4	99 56
SSBI	32	15	2	100 00
SBI	29	15	3	99 99
BNSI	31	2	6	96 89
CH6	4	1	29	67 97
ELAI	8	1	30	59 47
CH7	5	33	2	73 03
BYVI	33	1	32	31 75
MNSI	14	19	2	04 18
NSI	19	1	34	29 16
YVI	36	1	35	28 25

Keith County - June 21, 1978 - Area



Keith County - June 29, 1978 - Area

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TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD
        VARIABLE
NAME       NO
AVI     (  1) 99/99/99 99 99 98 99 99 98 99 99 99/98/97 96 97/97/97/94 97/96/94 94/91/86/82/75/67 62 64 69/64/ 7 34/
PVI7    ( 22)/99/99 99 99 98 98 99 98 99 99 99/98/97 96 97/97/96/94 97/96/94 93/91/85/83/73/66 61 62 68/64/ 7 34/
TVI7    ( 35)/99 99 99 99 99 98 98 99 99 98/98/98 96 97/96/98/94 97/94/94 94/90/87/80/73/70 65 67 71/65/ 6 32/
CLAI    (  6) 99/99 99 99/99 99 99 99 99/98/99 97 98/98/97/95 97/95/95 95/88/85/82/72/67 62 64 69/66/ 3 28/
ND7     ( 18)/99 99 99/98 98 99 99 98/99/99 98 98/96/98/95 97/94/94 96/90/87/80/71/70 65 67 71/64/ 5 31/
GVSB    ( 11) 99 99/99 99 99 99 99/98/98 98 98/97/97/96 97/94/94 94/87/88/82/75/60 63 65 68/61/ 2 25/
ND6     ( 17) 99/99 99 99 99 99/98/99 98 98/97/98/96 97/93/95 95/85/87/82/73/60 63 65 69/64/ 2 22/
TVI6    ( 34)/99 99 99 99 99/98/99 97 97/98/98/95 96/93/95 95/85/87/82/75/60 63 65 68/64/ 2 22/
GRADS   (  9) 99/99 99 99/98/98 96 96/99/96/94 96/96/96 94/86/82/86/75/62 57 58 64/66/ 0 24/
FVI6    ( 21)/99 99 99/98/98 96 96/99/96/96 96/95/95 93/84/84/87/77/62 57 58 63/63/ 5 20/
GVI     ( 10) 99/99/98/98 97 97/98/97/96 97/95/94 93/86/87/85/77/65 60 62 65/61/ 3 25/
MGVI    ( 13)/99/98/97 96 97/98/96/97 98/96/93 92/87/87/86/70/64 58 60 63/60/ 3 26/
SGVI    ( 30)/98/98 97 96/98/96/97 97/95/93 92/85/87/86/70/64 59 61 63/59/ 5 23/
LAI     ( 12)/98 97 97/96/96/94 96/94/94 95/88/85/82/71/66 61 63 60/64/ 3 29/
OLAI    ( 20) 99 98/96/97/94 95/91/95 97/85/85/80/65/69 65 66 71/67/ 0 22/
R65     ( 25) 99/95/96/95 96/90/92 96/83/86/79/64/68 64 65 68/61/ 3 22/
R75     ( 27)/94/96/95 97/92/92 96/87/86/78/63/69 64 66 70/62/ 3 30/
SYVI    ( 33)/93/93 93/94/96 93/80/77/90/74/55 49 51 58/68/ 6 15/
CH5     (  3)/92 94/87/95 95/87/90/70/70/80 77 78 81/66/ 5 27/
R64     ( 24) 98/91/84 86/80/91/84/79/62 56 59 55/42/19 19/
R74     ( 26)/94/87 89/89/91/81/77/66 61 63 63/49/ 1 35/
CH7     (  5)/87 86/89/75/90/75/46 40 42 51/57/ 8 40/
MYVI    ( 16) 96/80/73/77/63/66 62 62 73/83/ 8 16/
R45     ( 23)/83/77/72/52/70 66 67 76/78/12 23/
R76     ( 28)/78/62/63/67 63 65 74/59/40 68/
CH4     (  2)/57/73/83 79 81 71/30/13 25/
CH6     (  4)/73/16 10 12 18/44/24  5/
ELAI    (  8)/41 36 38 33/22/24 14/
MSBI    ( 15) 99 99/94/47/18 28/
SBI     ( 29) 99/94/46/20 27/
SSBI    ( 32)/94/45/18 27/
SNSI    ( 31)/69/42 40/
YVI     ( 36)/43 17/
MNSI    ( 14) 79/
NSI     ( 19)/
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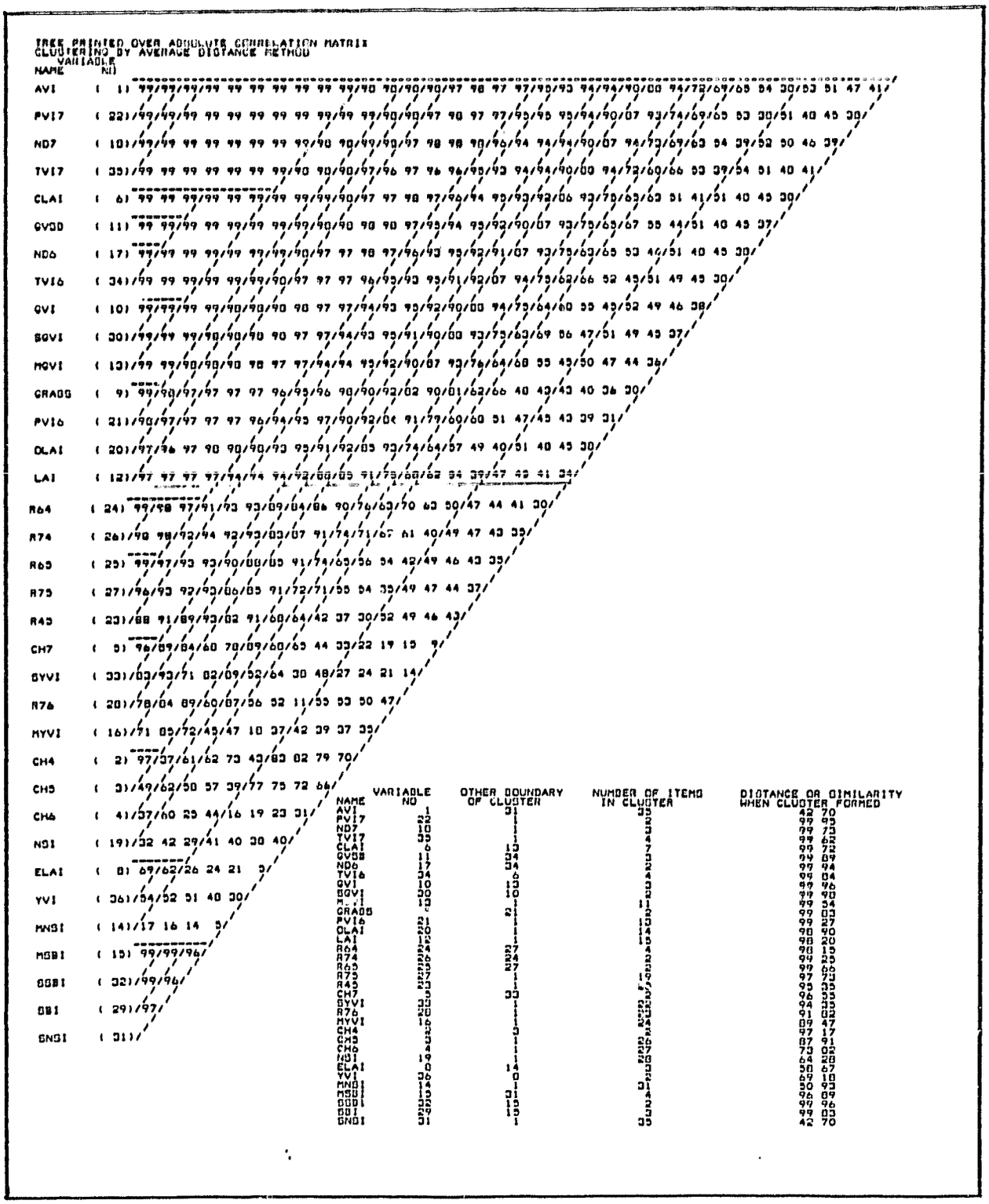
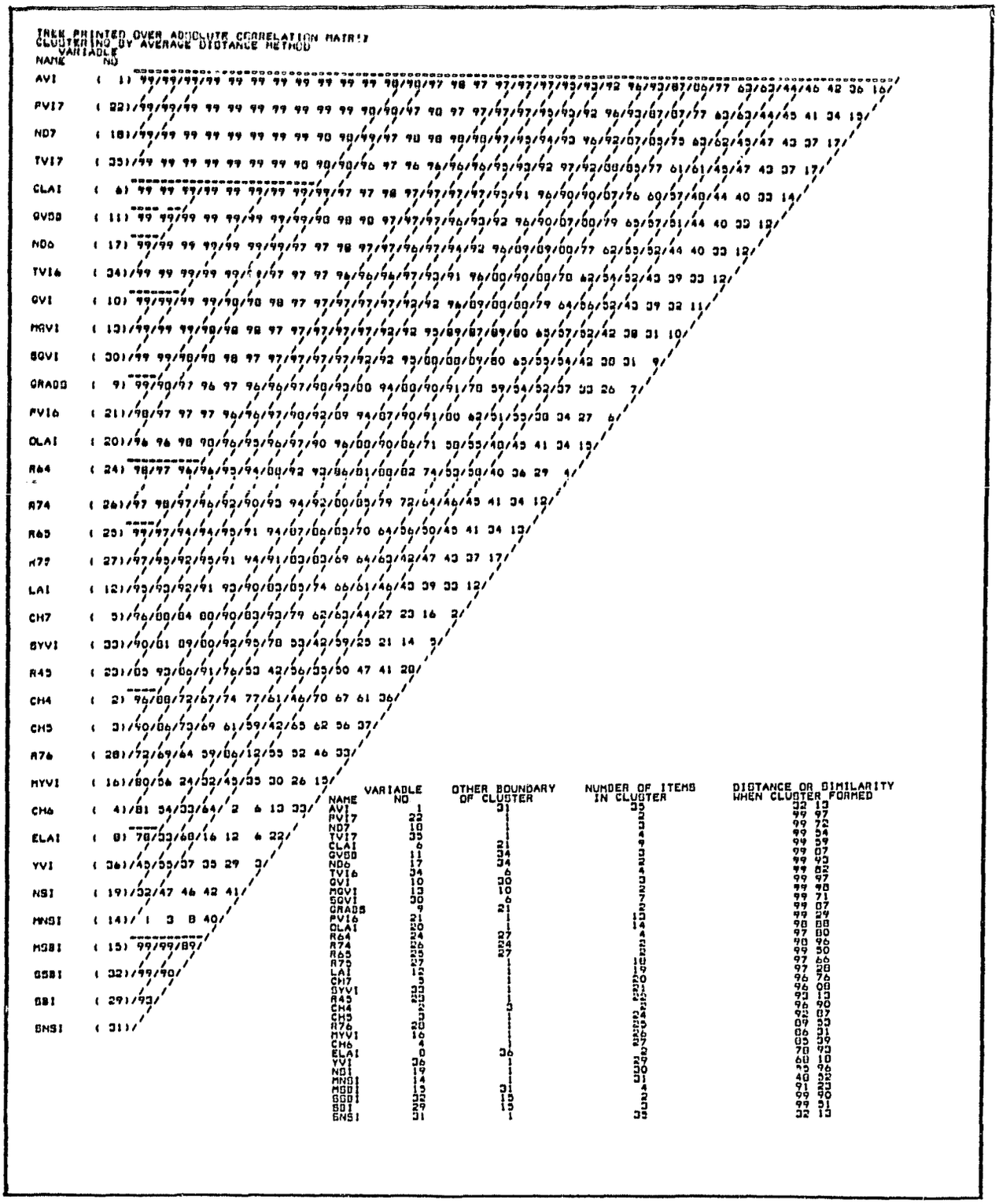
NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
		19	35	19 14
AVI	1	1	2	99 97
PVI7	22	1	3	99 65
TVI7	35	30	10	99 36
CLAI	6	6	2	99 72
ND7	18	34	3	99 86
GVSB	11	34	2	99 94
ND6	17	6	5	99 58
TVI6	34	30	2	99 66
GRADS	9	9	3	99 81
FVI6	21	30	2	99 95
GVI	10	10	2	99 96
MGVI	13	1	13	9? 22
SGVI	30	1	14	98 62
LAI	12	27	3	99 00
OLAI	20	27	2	99 60
R65	25	1	17	97 70
R75	27	1	10	97 37
SYVI	33	1	19	96 97
CH5	3	26	2	98 33
R64	24	1	21	96 09
R74	26	23	22	94 09
CH7	5	1	2	96 89
MYVI	16	1	24	93 70
R45	23	1	25	86 56
R76	28	1	26	85 04
CH4	2	1	27	80 64
CH6	4	31	28	72 25
ELAI	8	32	4	94 59
MSBI	15	15	3	99 93
SBI	29	1	3	99 83
SSBI	32	1	33	62 33
SNSI	31	19	3	59 23
YVI	36	1	35	79 70
MNSI	14			19 14
NSI	19			

Keith County - July 27, 1978 - Area



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	31	35	42 70
PVI7	22		2	99 99
ND7	10	1	3	99 73
TVI7	35	1	4	99 62
CLAI	6	10	7	99 72
GVSB	11	34	2	99 89
ND6	17	34	3	99 94
TVI6	34	6	4	99 84
GVI	10	13	3	99 96
SGVI	30	10	3	99 90
MGVI	13	1	11	99 54
GRASS	9	21	2	99 03
PVI6	21	1	12	99 27
OLAI	20	1	14	98 90
LAI	12	1	15	98 20
R64	24	27	4	98 15
R74	26	24	2	94 25
R65	25	27	3	99 66
R75	27	1	19	97 70
R45	23	1	20	95 25
CH7	9	33	2	96 35
SYVI	33	1	22	94 35
R76	28	1	23	91 02
MYVI	16	1	24	89 47
CH4	2	3	2	97 17
CH5	3	1	26	87 91
CH6	4	1	27	79 02
NSI	19	1	28	64 28
ELAI	8	14	2	58 67
YVI	36	0	29	69 10
MNSI	14	1	31	50 93
MSBI	15	31	4	96 89
SSBI	32	15	2	99 96
SBI	29	15	32	99 03
SNSI	31	1	35	42 70

Keith County - August 13, 1978 - Area



TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD

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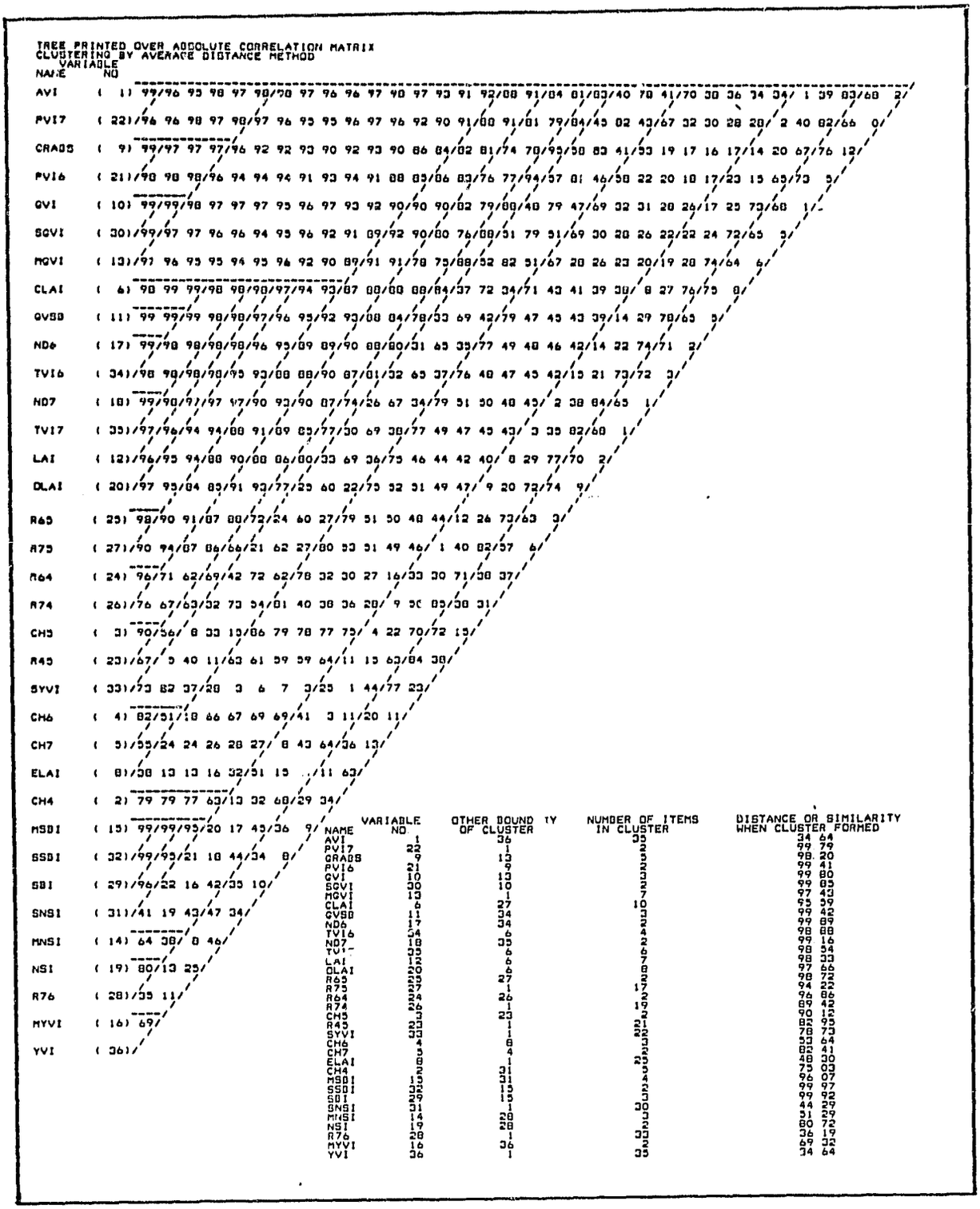
VARIABLE
NAME      NO
AVI       ( 1) 99/99/99/99 99 99 99 99 99 99 99 98/98/97 98 97 97/97/97/96/94/92 96/93/88/87/77 60/63/43/40 36 28  9/
PVI7      ( 22)/99/99/99 99 99 99 99 99 99 99 99/98/97 98 97 97/97/98/96/93/91 96/93/89/87/77 60/63/43/38 34 27  7/
ND7       ( 18)/99/99 99 99 99 99 99 99 99 98/99/97 98 98 98/97/97/96/94/92 96/93/88/87/76 61/64/43/41 36 29  9/
TVI7      ( 35)/99 99 99 99 99 99 99 98 98/98/96 97 96 96/96/96/95/93/91 96/93/87/87/78 59/64/43/41 37 30 10/
CLAI      (  6) 99 99 99/99 99 99/99 99/99/97 98 98 98/97/97/97/95/91 96/91/89/90/76 58/60/47/39 34 27  7/
GVSB      ( 11) 99 99/99 99 99/99 99/99/98 98 98 97/97/97/97/93/92 96/91/89/87/80 63/59/50/39 34 27  5/
ND6       ( 17) 99/99 99 99/99 99/99/98 98 98 97/97/96/97/94/91 96/90/89/89/78 60/57/50/39 34 27  6/
TVI6      ( 34)/99 99 99/99 99/99/97 97 97 97/96/96/97/94/91 96/89/89/89/79 60/57/50/39 34 27  6/
GVI       ( 10) 99/99/99 99/98/98 98 97 97/97/97/97/93/92 96/90/90/88/80 62/58/51/38 33 26  4/
MGVI      ( 13)/99/99 99/98/98 98 97 97/97/97/97/93/91 95/90/90/87/80 63/59/51/37 32 25  2/
SGVI      ( 30)/99 99/98/98 98 97 97/97/97/97/92/92 95/89/90/87/81 63/57/53/37 33 25  2/
GRASS     (  9) 99/98/97 97 97 97/96/97/98/94/88 94/89/92/89/78 57/57/49/32 27 20  0/
PVI6      ( 21)/98/98 97 97 96/96/97/98/93/89 94/88/92/89/80 60/54/53/33 29 21  0/
DLAI      ( 20)/96 97 98 98/96/95/96/96/90 96/89/88/90/73 56/58/47/39 35 28  8/
R64       ( 24) 99/98 97/96/95/95/89/92 93/86/90/81/83 71/53/57/34 30 22  3/
R74       ( 26)/98 98/97/97/94/91/92 94/92/88/89/79 68/66/46/38 34 26  4/
R65       ( 25) 99/97/95/95/95/90 94/87/88/86/71 60/57/49/37 33 26  4/
R75       ( 27)/97/95/94/96/90 94/91/86/84/69 60/64/42/39 35 28  8/
LAI       ( 12)/95/94/93/89 93/90/88/83/74 62/62/45/36 32 24  4/
CH7       (  5)/96/89/83 98/92/94/83/78 59/66/41/21 16  8  9/
SYVI      ( 33)/91/82 90/83/95/92/77 51/47/55/21 16  9 10/
R45       ( 23)/83 93/86/80/92/54 39/58/33/43 39 33 20/
CH4       (  2) 96/86/69/71/77 76/59/49/66 62 38 28/
CH5       (  3)/89/76/86/71 58/59/43/61 57 50 30/
R76       ( 28)/74/73/67 56/86/13/45 42 33 23/
CH6       (  4)/80/79 53/41/59/  4  8 16 26/
MYVI      ( 16)/54 20/37/39/31 27 21 12/
ELAI      (  8) 80/37/67/17 14  7 23/
YVI       ( 36)/39/60/33 31 24 11/
NSI       ( 19)/31/38 36 31 31/
MNSI      ( 14)/ 3  0  4 39/
MSBI      ( 15) 99/99/87/
SSBI      ( 32)/99/89/
SBI       ( 29)/91/
SNSI      ( 31)/
```

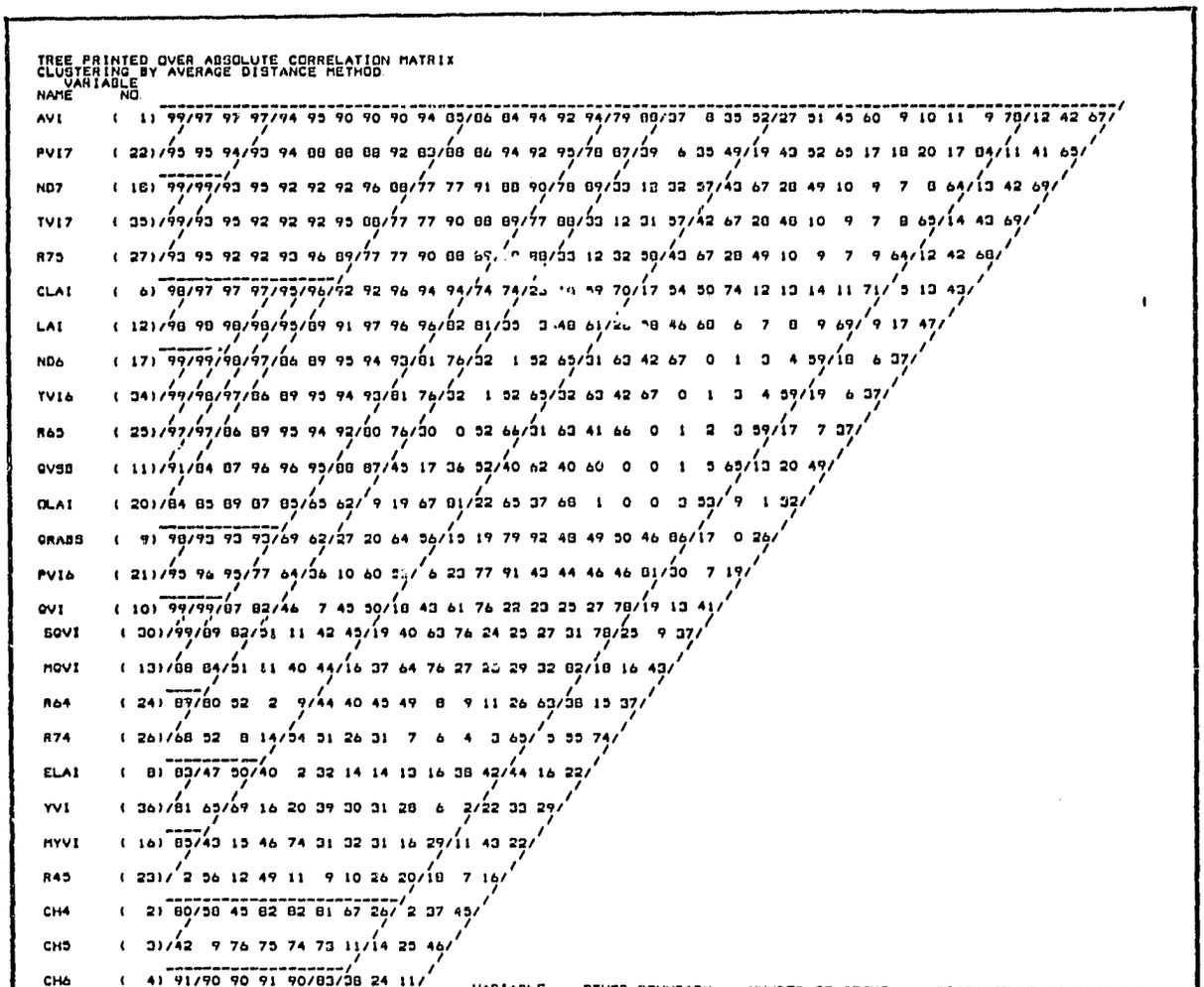
NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	31	35	26.38
PVI7	22	1	2	99.97
ND7	18	1	3	99.77
TVI7	35	1	4	99.46
CLAI	6	21	9	99.39
GVSB	11	34	3	99.87
ND6	17	34	4	99.93
TVI6	34	6	4	99.80
GVI	10	30	3	99.97
MGVI	13	10	2	99.98
SGVI	30	6	7	99.71
GRASS	9	21	2	99.85
PVI6	21	1	13	99.30
DLAI	20	1	14	99.02
R64	24	27	4	97.96
R74	26	24	2	99.00
R65	25	27	2	99.32
R75	27	1	16	97.84
LAI	12	1	19	97.20
CH7	5	1	20	96.85
SYVI	33	1	21	96.62
R45	23	1	22	93.54
CH4	2	3	2	96.42
CH5	3	1	24	92.59
R76	28	1	23	90.14
CH6	4	1	26	87.62
MYVI	16	1	27	86.05
ELAI	8	36	2	80.32
YVI	36	1	29	67.23
NSI	19	1	30	58.03
MNSI	14	1	31	47.16
MSBI	15	31	4	89.51
SSBI	32	15	2	99.88
SBI	29	15	3	99.42
SNSI	31	1	33	26.98

Keith County - March 22 thru July 27, 1978 - Field



Keith County - October 12, 1977 - Field

TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	28	35	27.77
PVI7	22	1	2	99.57
ND7	16	27	3	99.59
TVI7	35	18	2	99.89
R75	27	1	5	96.44
CLAI	6	20	7	95.86
LAI	12	6	2	98.95
ND6	17	25	3	99.38
TVI6	34	17	2	99.98
R65	25	6	5	98.24
GVSB	11	6	6	97.69
OLAI	20	1	12	92.28
GRASS	9	10	5	94.77
PVI6	21	9	2	98.65
GVI	10	13	3	99.59
SGVI	30	10	4	99.71
MGVI	13	1	17	90.00
R64	24	26	2	89.97
R74	26	1	19	79.89
ELAI	8	23	4	61.06
YVI	36	8	2	83.40
MYVI	16	23	5	85.84
R45	23	1	23	37.34
CH4	2	5	9	37.76
CH5	3	2	2	80.42
CH6	4	5	7	70.59
SYVI	33	4	2	91.10
MSBI	15	31	4	96.03
SSBI	32	15	2	99.09
SBI	29	15	3	99.95
SNSI	31	4	6	80.53
CH7	5	1	32	34.46
MNSI	14	28	3	74.62
NSI	19	28	2	94.94
R76	28	1	35	27.77

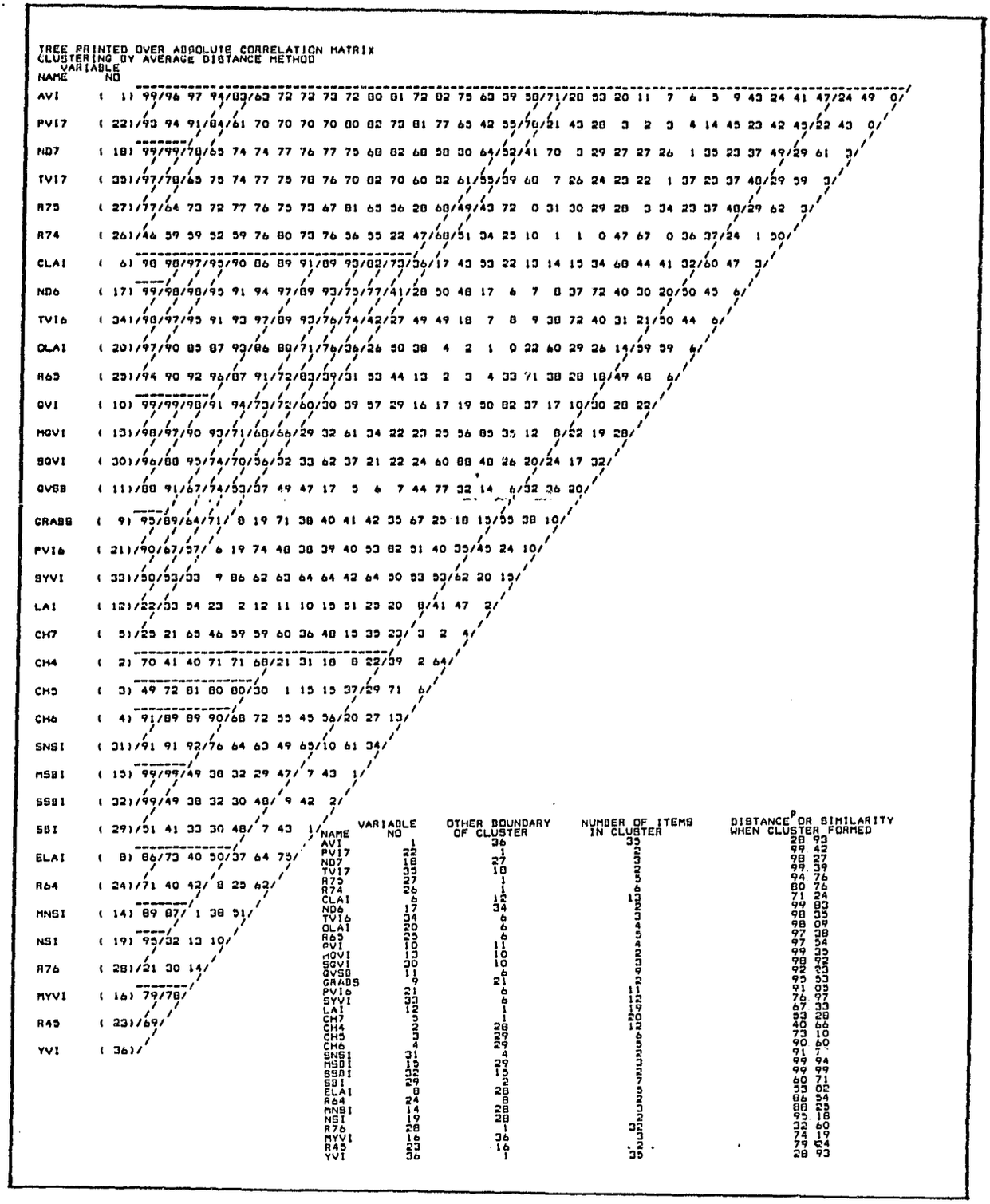
Keith County - November 17, 1977 - Field

TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD

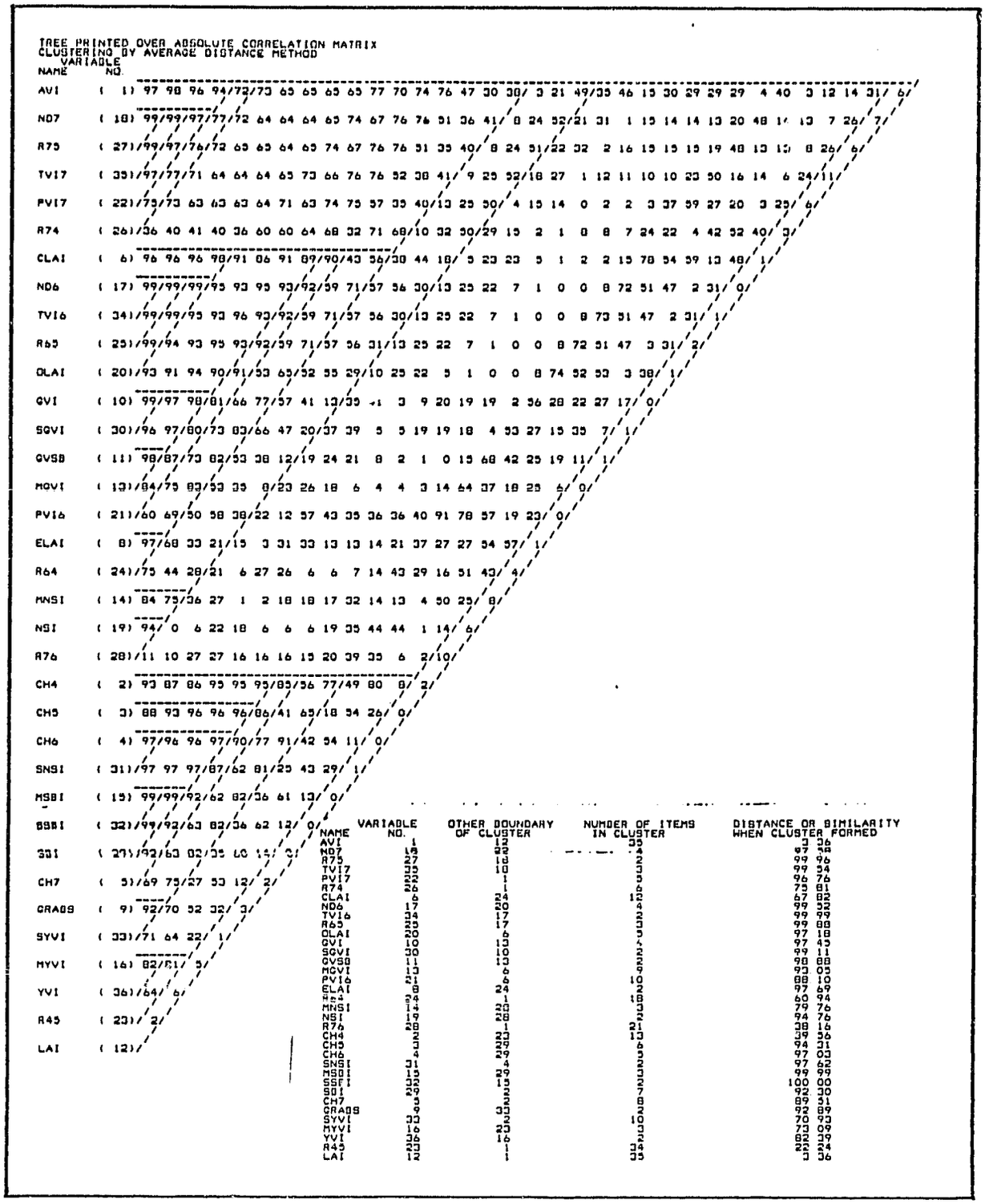
NAME	VARIABLE NO	
AVI	1	99/97 97 94/92 85 88 94 89 94 92 94 94 93 91 91/81/80/57 77 87/69 86/ 5 1 56 66/14 9 38/ 1 1 4 5/
PVI7	22	/93 96 92/90 83 86 93 88 93 91 94 92 92 89 89/80/76/55 76 87/71 89/ 7 3 53 63/12 12 40/ 3 6 9 9/
ND7	18	99/98/96 92 94 93 91 94 92 93 97 97 96 96/82/90/64 77 84/62 73/ 4 4 65 76/21 3 29/18 13 12 6/
TVI7	35	/96/96 91 92 94 91 93 92 94 97 97 96 96/83/90/63 77 83/63 74/ 1 4 65 74/22 3 29/17 13 10 5/
R75	27	/94 93 96 90 87 91 89 90 94 93 93 92/79/88/63 75 82/58 70/11 4 62 78/20 2 29/20 17 14 8/
CLAI	6	98/96/96 94 94 92 92 96 98 98 98/91/91/54 73 71/67 65/14 17 79 84/33 22 9/14 10 8 3/
OLAI	20	/93/91 88 87 85 84 90 93 94 94/87/91/46 63 61/58 55/30 29 85 92/28 24 6/21 17 16 14/
R65	25	/92 93 94 93 92 95 95 96 93/88/89/63 80 75/67 60/ 9 3 71 79/43 28 2/16 13 10 2/
GRASS	9	98/98 96 97/95 96 95 96/96/80/50 79 75/82 77/ 1 6 72 72/38 21 7/ 8 12 14 19/
PVI6	21	/98 98 97/96 96 96 96/96/80/57 85 76/85 70/10 3 69 66/52 33 5/ 7 10 13 25/
GVI	10	99/99/98 97 97 97/92/82/65 88 85/81 76/15 10 61 64/45 21 7/ 2 5 8 21/
SGVI	30	/99/97 96 96 96/92/80/67 91 85/83 74/20 15 59 60/51 26 2/ 4 7 10 26/
MGVI	13	/97 96 93 93/90/79/65 90 87/83 79/20 15 56 59/44 17 10/ 6 9 13 25/
GVSB	11	99 98 98/87/89/71 88 86/71 70/11 9 62 67/42 19 1/12 9 5 9/
LAI	12	99 99/90/90/64 82 80/71 68/ 2 2 71 74/39 22 9/13 9 6 4/
ND6	17	99/91/92/65 82 77/69 63/ 0 3 73 76/44 28 3/16 13 10 2/
TVI6	34	/91/92/65 82 77/69 63/ 0 3 73 75/44 28 3/16 12 9 3/
SYVI	33	/73/38 72 59/86 63/ 2 13 79 71/53 44 17/17 21 22 28/
CH5	3	/68 66 63/37 39/18 17 74 81/30 24 9/51 48 46 33/
CH4	2	84 82/30 31/46 38 7 18/49 14 6/44 43 38 1/
R64	24	/91/73 63/30 31 27 29/64 26 4/ 1 3 8 39/
R74	26	/62 79/43 47 16 31/27 14 36/ 5 3 1 21/
CH6	4	75/34 21 41 31/56 30 16/57 59 62 70/
CH7	5	/24 17 23 34/ 2 35 51/40 42 45 36/
ELAI	8	90/55 64/43 0 8/32 31 36 67/
YVI	36	/66 61/40 5 2/17 15 21 57/
MYVI	16	91/24 46 19/18 14 15 24/
R45	23	/4 20 9/31 28 29 40/
MNSI	14	86 78/ 9 11 13 53/
NSI	19	93/3 1 1 25/
R76	28	/12 12 12 36/
MSBI	15	99/99/84/
SSBI	32	/99/84/
SBI	29	/86/
SNSI	31	/

NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	31	35	18 81
PVI7	22	1	2	99 83
ND7	18	27	2	97 06
TVI7	35	18	2	99 63
R75	27	1	3	95 69
CLAI	6	34	12	93 53
OLAI	20	6	2	98 06
R65	25	6	3	96 04
GRASS	9	34	3	96 70
PVI6	21	9	2	98 60
GVI	10	13	3	99 64
SGVI	30	10	2	99 73
MGVI	13	9	5	97 99
GVSB	11	34	4	98 92
LAI	12	34	3	99 70
ND6	17	34	2	99 90
TVI6	34	1	17	92 82
SYVI	33	1	18	88 44
CH5	3	1	19	85 58
CH4	2	26	3	83 40
R64	24	26	2	91 19
R74	26	1	22	72 87
CH6	4	5	2	75 64
CH7	5	1	24	68 40
ELAI	8	23	4	61 96
YVI	36	8	2	90 55
MYVI	16	23	2	91 53
R45	23	1	28	38 51
MNSI	14	28	3	82 15
NSI	19	28	2	93 69
R76	28	1	31	24 02
MSBI	15	31	4	85 38
SSBI	32	15	2	99 92
SBI	29	15	3	99 77
SNSI	31	1	35	18 81

Keith County - December 4, 1977 - Field

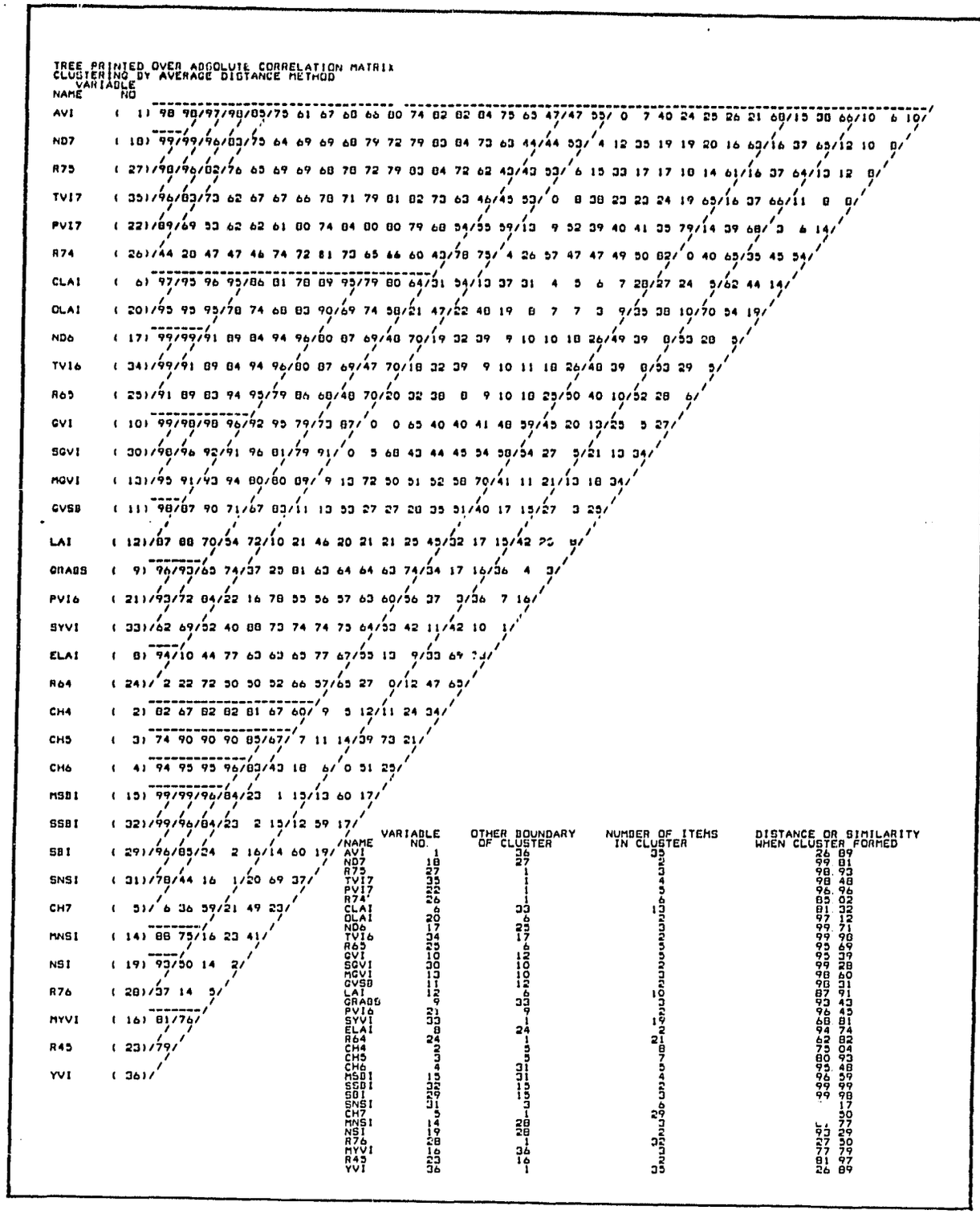


Keith County - March 22, 1978 - Field



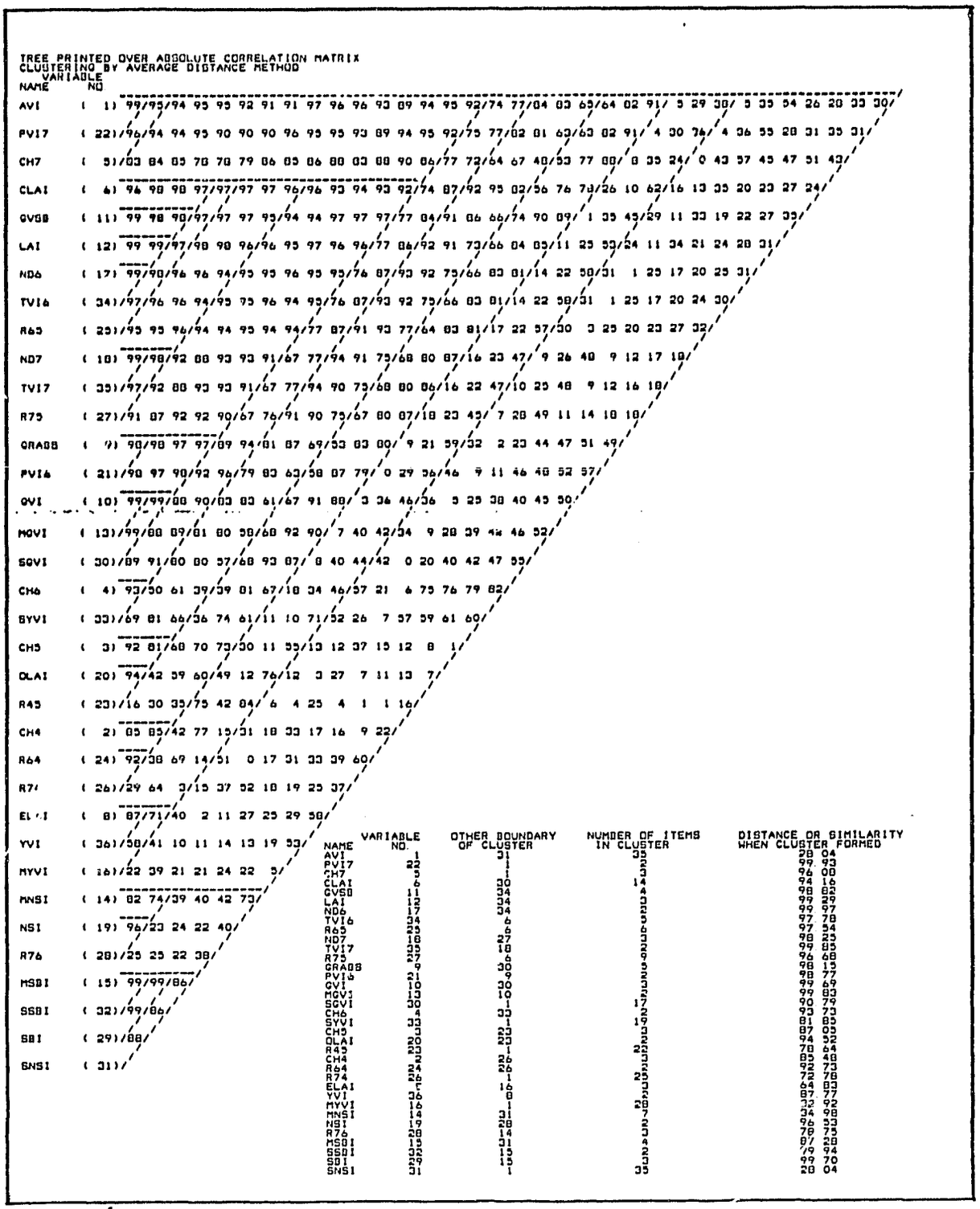
NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	12	35	3 36
ND7	18	22	4	97 38
R75	27	18	2	99 96
TVI7	35	10	3	99 54
PVI7	22	1	5	96 76
R74	26	1	6	75 81
CLAI	6	24	12	67 82
ND6	17	20	4	99 32
TVI6	34	17	2	99 99
R65	25	17	3	99 88
OLAI	20	6	5	97 18
GVI	10	13	4	97 45
SGVI	30	10	2	99 11
GVSB	11	13	3	98 88
MGVI	13	6	9	93 03
PVI6	21	6	10	88 10
ELAI	8	24	2	97 69
R64	24	1	18	60 94
MNSI	14	20	3	79 76
NSI	19	28	2	94 76
R76	28	1	21	38 16
CH4	2	23	13	39 36
CH5	3	29	6	94 31
CH6	4	29	5	97 03
SNSI	31	4	2	97 62
MSBI	15	29	3	99 99
SSBI	32	15	2	100 00
SBI	29	2	7	92 30
CH7	5	2	8	89 51
GRASS	9	33	2	92 89
SYVI	33	2	10	70 93
MYVI	16	23	3	73 09
YVI	36	16	12	82 39
R45	23	1	34	22 24
LAI	12	1	35	3 36

Keith County - March 31, 1978 - Field



NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	26 89
ND7	18	27	2	99 81
R75	27	1	3	98 93
TVI7	35	1	4	98 48
PVI7	22	1	5	96 96
R74	26	1	6	85 02
CLAI	6	33	13	81 32
OLAI	20	6	2	97 12
ND6	17	23	2	99 71
TVI6	34	17	2	99 98
R65	25	6	5	95 69
GVI	10	12	2	95 39
SGVI	30	10	3	99 28
NGVI	13	10	3	98 80
GVSB	11	12	4	90 31
LAI	12	6	10	87 91
GRASS	9	33	2	93 43
PVI6	21	9	3	96 45
SYVI	33	1	19	68 81
ELAI	8	24	2	94 74
R64	24	1	21	62 82
CH4	2	3	8	75 04
CH5	3	5	7	80 93
CH6	4	31	6	95 48
MSBI	15	31	4	96 59
SSBI	32	15	3	99 99
SBI	29	15	5	99 98
SNSI	31	3	6	17
CH7	5	1	29	30
MNSI	14	28	2	61 77
NSI	19	28	3	93 29
R76	28	1	32	87 90
MYVI	16	36	2	77 79
R45	23	16	2	81 97
YVI	36	1	35	26 89

Keith County - April 21, 1978 - Field



Keith County - May 15, 1978 - Field

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TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD
      VARIABLE
NAME     NO
AVI     (  1) 99/99 99/97/90 97 98 96 95 96 96 95 94 94 91/94 95/87 87 95/93/44 81/41 72/73 72 69 57/10 53 79/ 7 40/
PVI7    ( 22)/99 98/97/97 97 97 95 95 96 96 94 94 94 90/93 92/87 86 95/94/42 80/42 71/71 70 68 56/11 54 80/ 8 40/
ND7     ( 18) 99/99/98 98 98 97 97 96 96 94 96 94 91/96 95/88 87 94/90/47 84/38 72/76 75 73 60/ 8 50 77/ 3 37/
TVI7    ( 35)/97/98 98 99 97 97 96 96 95 95 94 92/97 95/89 86 93/88/48 83/37 73/78 77 75 61/ 6 40 76/ 5 38/
R75     ( 27)/97 96 96 95 94 94 94 92 96 92 89/93 94/85 85 94/91/44 84/39 70/72 71 68 58/12 52 70/ 0 36/
CLAI    (  6) 98 99 99 98/97 97 96/98/98 95/96 98/84 86 98/87/59 88/47 81/71 70 68 55/ 0 38 68/ 1 30/
GVSB    ( 11) 99/99 99/99 99 98/98/96 96/96 95/91 92 93/86/49 88/49 79/73 71 69 50/ 8 36 66/13 44/
LAI     ( 12)/99 99/99 98 98/97/97 96/97 97/88 89 92/87/54 84/48 80/73 71 69 53/ 4 37 67/ 7 38/
ND6     ( 17) 99/98 98 98/98/98 97/96 97/87 90 89/83/50 85/51 84/71 70 67 53/12 29 61/ 5 36/
TVI6    ( 34)/98 98 98/98/97 97/97 97/87 89 89/82/58 84/50 84/72 71 68 50/12 28 61/ 6 36/
GVI     ( 10) 99/99/97/98 98/94 94/88 93 92/87/51 78/57 84/66 65 62 42/15 30 61/16 44/
MGVI    ( 13)/99/96/97 97/93 93/89 94 93/80/48 76/57 82/65 64 61 41/13 33 63/19 47/
SGVI    ( 30)/96/97 98/93 92/88 95 91/85/50 75/60 85/64 62 59 37/20 26 57/20 47/
R65     ( 25)/97 96/93 97/83 90 89/84/57 85/54 83/66 64 62 46/10 30 60/ 2 35/
GRASS   (  9) 98/91 96/79 88 86/86/63 84/63 90/58 56 54 39/13 25 57/ 3 30/
PVI6    ( 21)/90 93/81 91 84/81/61 78/68 92/56 55 52 31/27 14 48/13 37/
CH5     (  3) 95/90 83 87/77/54 84/30 72/85 84 83 67/ 0 38 68/ 1 34/
DLAI    ( 20)/78 79 82/80/69 94/45 83/70 69 67 57/ 1 30 61/15 17/
CH4     (  2) 91 92/74/17 56/26 53/83 83 80 52/10 41 67/40 70/
R64     ( 24) 92/80/26 55/61 74/57 56 52 21/31 23 51/44 69/
R74     ( 26)/92/19 63/39 59/70 69 65 46/ 5 57 7?/30 63/
CH7     (  5)/27 66/48 63/50 49 46 39/21 63 82/13 42/
MYVI    ( 16) 80/44 79/25 22 24 29/18 25  2/56 47/
R45     ( 23)/30 75/63 61 62 65/15 29 56/47 14/
CH6     (  4) 82/20 22 26 45/60 32 10/26 24/
SYVI    ( 33)/28 26 24  9/42 14 18/ 3 10/
MSBI    ( 15) 99/99/87/21 50 71/ 0 33/
SSBI    ( 32)/99/87/22 51 71/ 0 33/
SBI     ( 29)/89/24 50 69/ 3 29/
SNSI    ( 31)/58 64 74/39  7/
MNSI    ( 14) 82 63/47 30/
NSI     ( 19) 93/ 3 24/
R76     ( 28)/ 1 32/
ELAI    (  8) 89/
YVI     ( 36)/
```
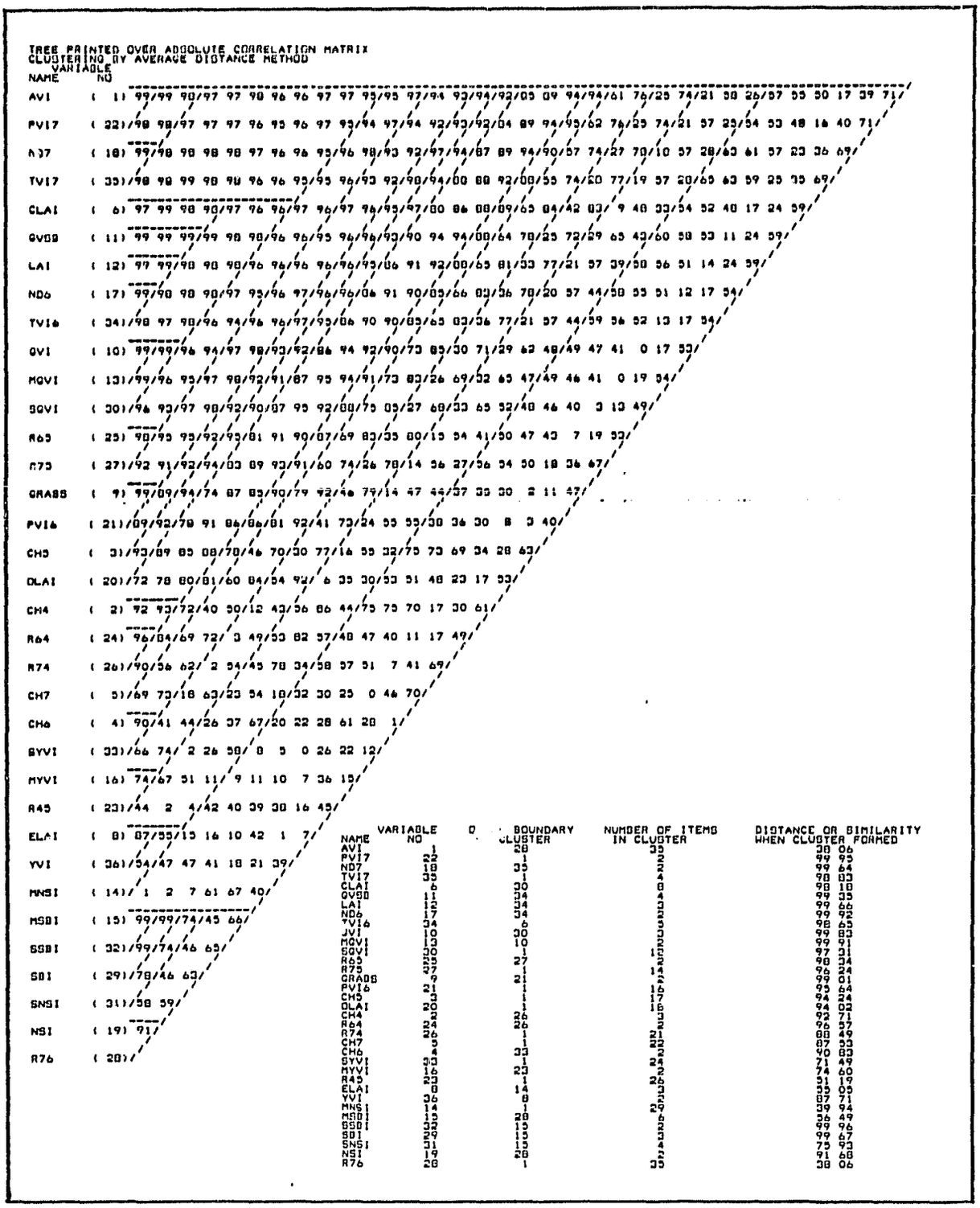
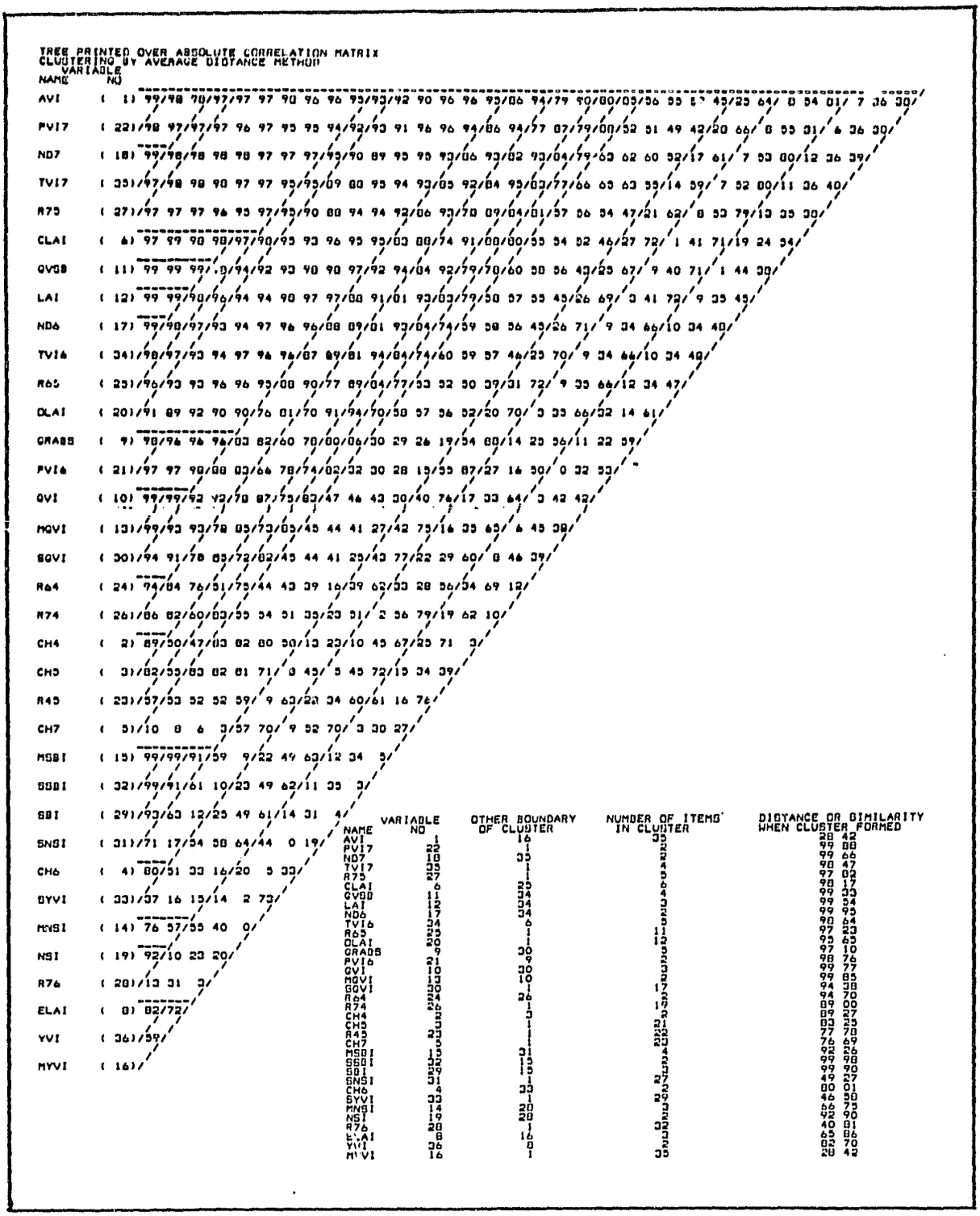

NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	26 04
PVI7	22	1	2	99 95
ND7	18	35	2	99 52
TVI7	35	1	4	99 19
R75	27	1	5	97 99
CLAI	6	21	11	97 49
GVSB	11	34	4	99 40
LAI	12	11	2	99 65
ND6	17	34	2	99 93
TVI6	34	6	5	99 03
GVI	10	30	3	99 77
MGVI	13	10	2	99 88
SGVI	30	6	8	98 45
R65	25	6	9	97 73
GRASS	9	21	2	98 94
PVI6	21	1	16	95 86
CH5	3	20	2	95 45
DLAI	20	1	18	95 16
CH4	2	26	3	91 99
64	24	26	2	92 85
4	26	1	21	88 76
17	5	1	22	85 91
MYVI	16	23	2	80 77
R45	23	1	24	63 44
CH6	4	33	2	82 43
SYVI	33	1	26	62 19
MSBI	15	31	4	88 49
SSBI	32	15	2	99 97
SBI	29	15	3	99 84
SNSI	31	1	30	50 85
MNSI	14	28	3	73 02
NSI	19	28	2	93 23
R76	28	1	33	39 31
ELAI	8	36	2	89 50
YVI	36	1	35	26 04

Keith County - May 16, 1978 - Field



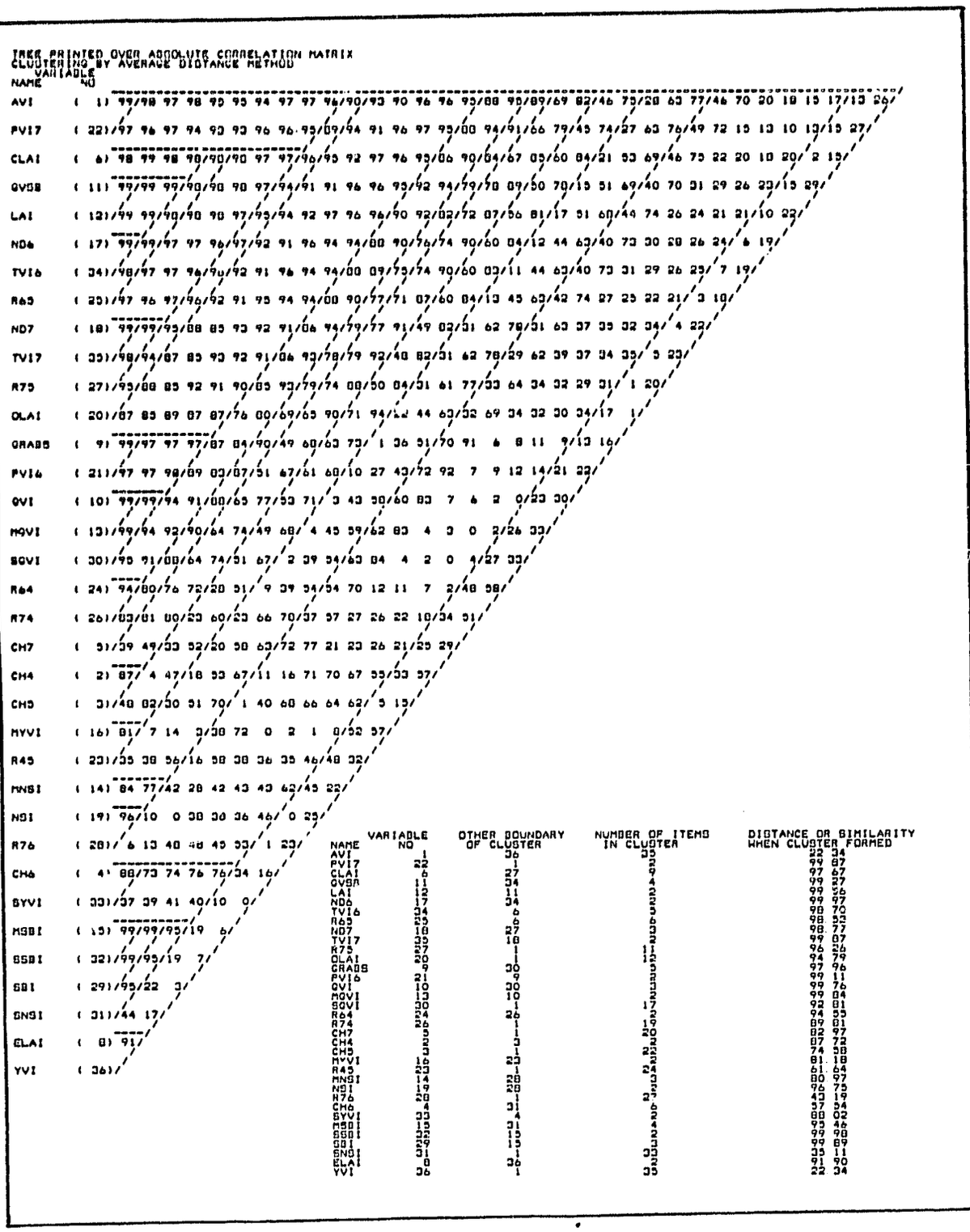
NAME	VARIABLE NO	D	BOUNDARY CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1		28	35	38 06
PVI7	32		1	2	99 93
ND7	18		35	2	99 64
TVI7	33		1	4	98 03
CLAI	6		30	8	98 18
GVGG	11		34	4	99 05
LAI	12		34	3	99 66
ND6	17		34	2	99 92
TVI6	34		6	5	98 65
JVI	10		30	9	99 83
MGVI	13		10	2	99 91
SGVI	30		1	12	97 31
R65	25		27	2	98 34
R75	27		1	14	96 24
GRASS	9		21	2	99 01
PVI6	21		1	16	95 64
CH5	3		1	17	94 24
DLAI	20		1	18	94 02
CH4	2		26	3	92 71
R64	24		26	2	96 57
R74	26		1	21	88 49
CH7	5		1	22	87 33
CH6	4		33	2	90 83
SYVI	30		1	24	71 49
MYVI	16		23	2	74 60
R45	23		1	26	91 19
ELAI	8		14	3	85 05
YVI	36		8	2	87 71
MNSI	14		1	29	39 94
MSBI	15		28	6	56 49
SSBI	22		19	2	99 96
SBI	29		19	3	99 67
SNSI	31		15	4	75 93
NSI	19		28	2	91 68
R76	28		1	35	38 06

Keith County - May 25, 1978 - Field



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	16	36	28 42
PVI7	22	1	2	99 88
ND7	18	35	2	99 66
TVI7	35	1	4	98 47
R75	27	1	5	97 02
CLAI	6	25	6	98 17
GVGB	11	34	4	99 33
LAI	12	34	5	99 54
ND6	17	34	7	99 95
TVI6	34	6	8	90 64
R65	25	1	11	97 23
OLAI	20	1	12	95 65
GRASS	9	30	2	97 10
PVI6	21	9	3	98 76
GVI	10	30	2	99 77
MGVI	13	10	3	99 85
SGVI	30	1	17	94 38
R64	24	26	4	94 70
R74	26	1	13	89 00
CH4	2	3	2	89 27
CH5	3	1	3	83 35
R45	23	1	14	77 78
CH7	5	1	15	76 69
MSBI	15	31	4	92 26
SSBI	32	15	2	99 98
SBI	29	15	19	99 90
SNBI	31	1	21	49 27
CH6	4	33	2	80 01
BYVI	33	1	22	46 58
MNBI	14	20	2	66 73
NBI	19	28	23	42 90
R76	28	1	24	40 81
ELAI	8	16	2	65 86
YVI	36	0	25	82 70
MYVI	16	1	36	28 42

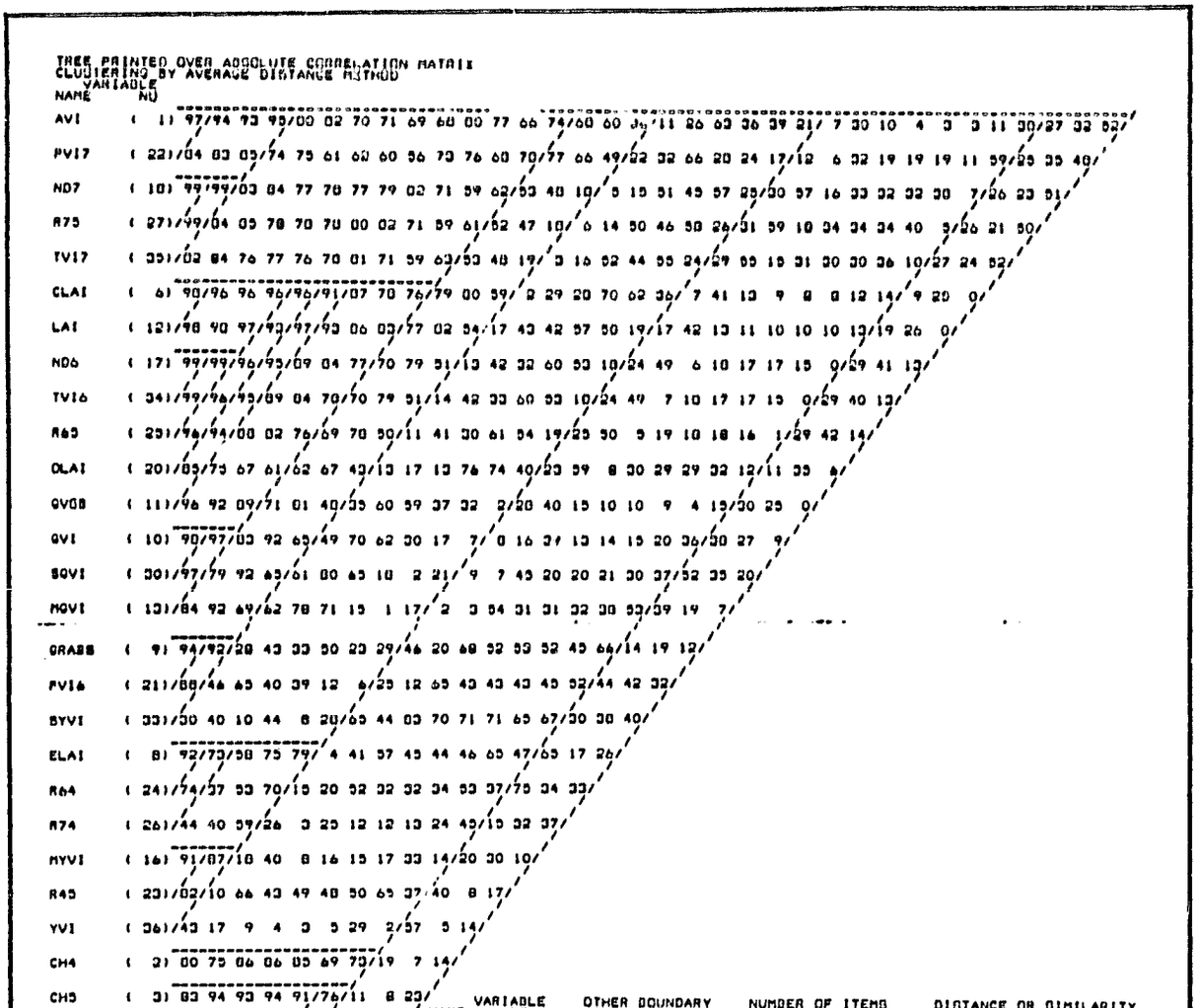
Keith County - June 11, 1978 - Field



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	22 34
PVI7	22	1	2	99 67
CLAI	6	27	3	97 67
GVSB	11	34	4	99 97
LAI	12	11	5	99 56
ND6	17	34	6	99 97
TVI6	24	6	7	98 70
R65	25	6	8	98 93
ND7	18	27	9	98 77
TVI7	23	18	10	99 07
R75	27	1	11	96 56
OLAI	20	1	12	94 79
GRASS	9	30	13	97 96
PVI6	21	9	14	99 11
GVI	10	20	15	99 76
MGVI	13	10	16	99 84
SGVI	30	1	17	92 81
R64	24	26	18	94 55
R74	26	1	19	89 81
CH7	5	1	20	82 97
CH4	2	3	21	87 72
CH5	3	1	22	74 58
MYVI	16	23	23	81 18
R45	23	1	24	61 64
MNSI	14	28	25	80 97
NSI	19	28	26	76 75
R76	28	1	27	43 19
CH6	4	31	28	37 54
SYVI	33	4	29	88 02
MSBI	15	31	30	93 46
SSBI	32	15	31	99 98
SBI	29	15	32	99 89
SNSI	31	1	33	35 11
ELAI	8	36	34	91 90
YVI	36	1	35	22 34

Keith County - June 21, 1978 - Field

TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	20	35	26 00
PVI7	22	1	2	97 11
ND7	10	35	2	99 56
R75	27	10	4	99 86
TVI7	35	1	5	99 97
CLAI	6	10	10	82 04
LAI	12	6	11	98 21
ND6	17	22	13	99 66
TVI6	34	17	14	99 90
R65	25	6	9	97 30
OLAI	20	6	6	95 00
QVDB	11	6	7	93 40
QVI	10	10	17	97 79
BQVI	30	10	20	98 48
MQVI	13	1	19	98 97
GRASS	9	35	22	90 78
PVI6	21	9	23	94 30
BYVI	33	1	24	60 41
ELAI	8	36	6	57 72
R64	24	8	8	92 04
R74	26	8	9	73 92
MYVI	16	36	10	84 82
R45	23	16	12	91 06
YVI	36	1	24	86 11
CH4	2	3	8	79 50
CH5	3	5	7	85 21
CH6	4	31	8	95 95
MSBI	15	39	13	99 98
SSBI	32	15	14	99 99
SBI	29	4	4	96 29
BNSI	31	3	6	91 41
CH7	5	1	32	28 32
MNSI	14	20	33	85 83
NSI	19	28	34	92 86
R76	28	1	35	26 00

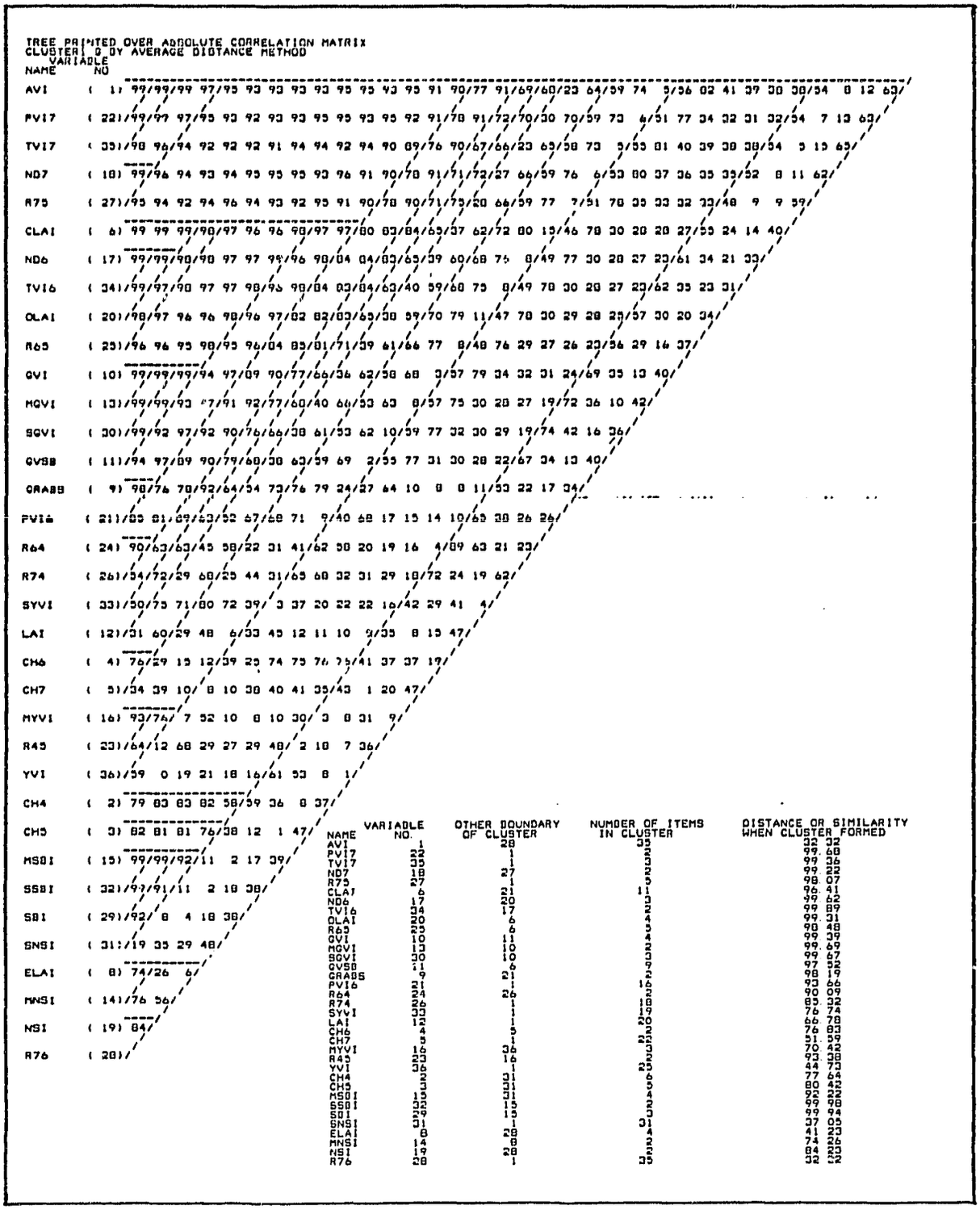
INDX PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD

VARIABLE NAME / NO

AVI (1) 99/99/99/99/97 93 91 90 91 90 89 94 94 94 91 93/79/85/85 64 83/87/80/87 87 39/29 13 9 8 27 14 16 59/
ND7 (18)/99/99/99/97 93 91 91 92 91 90 94 94 94 91 94/80/86/85 64 82/85/59/80 68 39/30 14 10 10 20 13 14 50/
PVI7 (22)/99/99/96 93 90 89 90 89 88 93 92 94 91 93/79/82/84 64 84/89/81/85 65 36/20 8 5 4 23 15 18 61/
TVI7 (33)/99/97 92 90 90 90 90 89 94 94 94 91 93/79/86/86 64 82/85/80/87 66 39/30 15 12 11 29 15 16 59/
R75 (27)/97 93 91 91 92 92 90 94 94 94 91 94/81/85/83 64 81/85/80/80 69 39/28 13 9 9 27 13 13 57/
CLAI (6) 98/97 97 97 97 96/97 97 97 95/96/90/87/86 66 74/80/69/78 74 45/22 7 3 3 21 0 5 41/
GRADS (9)/98 98 98 98 98/97 96 95 98/95/96/82/84 64 67/78/77/82 77 50/12 3 8 7 11 7 16 29/
ND6 (17) 99/99/99/99/98 98 96 97/96/94/87/89 72 60/70/73/79 71 41/26 6 2 2 13 20 25 21/
TVI6 (34)/99/99/99/98 98 96 97/96/94/87/89 72 60/70/73/79 71 41/26 6 2 2 12 20 26 21/
R65 (23)/99/98/98 98 96 97/96/94/87/87 71 60/71/73/79 72 42/25 6 2 2 13 18 24 22/
CLAI (20)/98/96 96 94 95/95/95/88/83 64 63/68/71/80 78 50/18 7 7 3 18 14 25 22/
PVI6 (21)/98 98 97 9 96/81/89 74 60/73/80/77 60 39/22 4 8 8 2 24 20 18/
GVI (10) 99/99/99/97/9 /84/93 79 79/78/75/70 62 30/35 4 0 0 7 17 14 31/
GVSS (11)/99/99/97/89/86/93 79 79/77/73/70 62 30/37 8 4 3 10 17 14 32/
MGVI (13)/99/96/87/81/94 82 83/81/76/64 57 24/37 1 2 3 3 17 9 33/
SGVI (30)/96/89/81/95 84 80/76/77/65 56 23/39 1 1 3 1 25 18 26/
LAI (12)/88/83/87 72 76/78/71/71 66 35/29 5 1 1 13 10 10 33/
GYVI (33)/72/76 57 48/65/83/87 78 55/ 3 17 22 21 0 23 39 4/
CH5 (31)/74 93 60/48/81/76 75 47/40 82 49 49 96 2 8 34/
ELAI (8) 90/86/72/78/48 36 3/54 6 3 0 4 31 13 28/
R64 (24)/84/58/67/18 4 31/70 1 3 7 30 34 20 11/
R74 (26)/83/51/17 15 18/65 10 8 5 0 1 31 62/
CH7 (5)/70/40 43 19/11 27 30 31 7 22 35 67/
CH6 (4)/50 38 15/ 4 60 63 64 53 42 36 4/
MYVI (16) 96/86/24 7 3 7 38 3 35 4/
R45 (23)/92/32 11 7 11 50 26 15 20/
YVI (36)/59 6 2 8 53 40 12 10/
CH4 (2) 55 55 50 8/33 8 20/
MSSI (15) 99/99/83/21 16 22/
SSSI (32)/99/81/21 17 22/
SSI (29)/84/23 16 21/
SNSI (31)/61 32 43/
MNSI (14) 82 75/
NSI (19) 80/
R76 (28)/

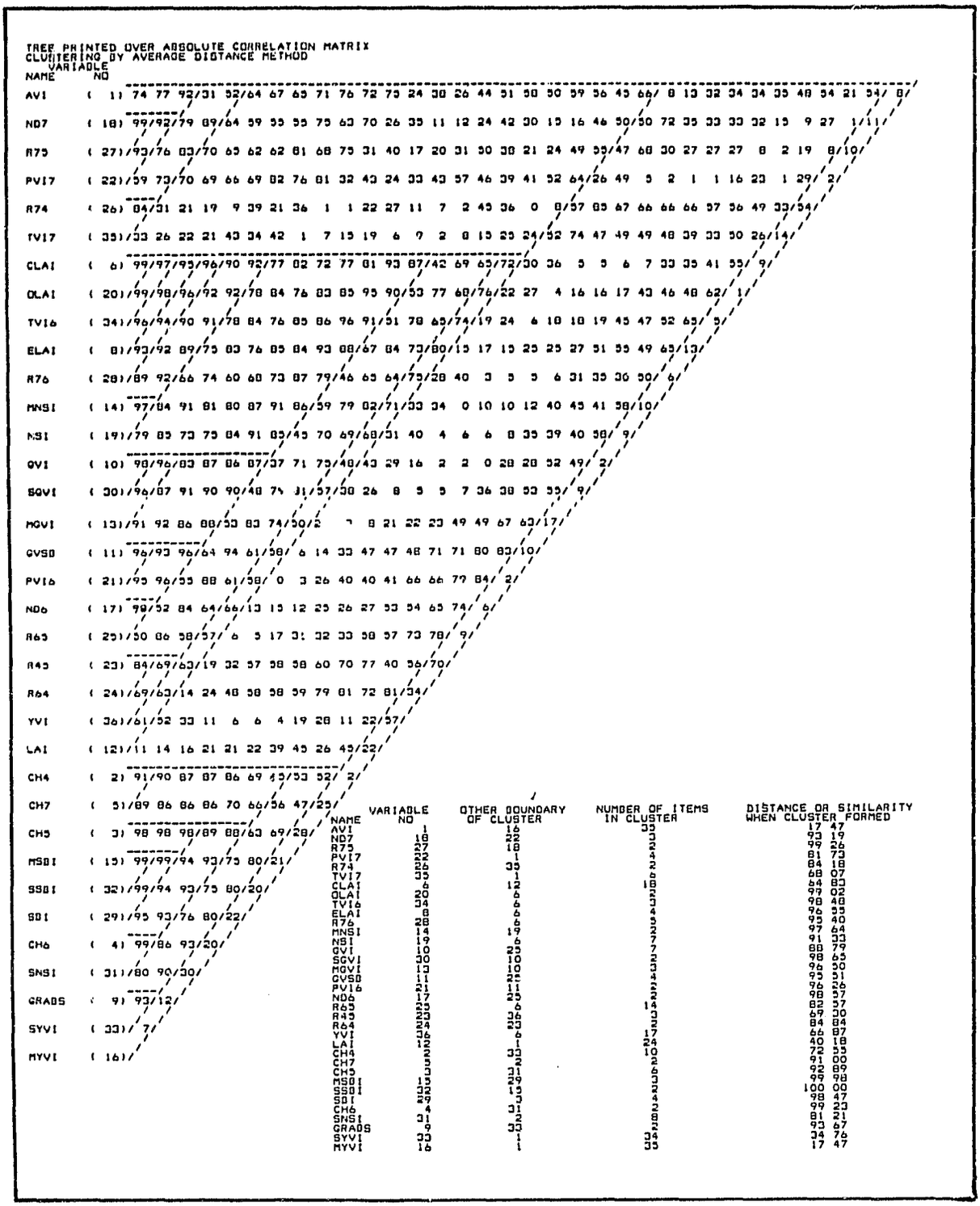
VARIABLE NAME	NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	20	35	19 76
ND7	18	1	2	99 90
PVI7	22	1	3	99 75
TVI7	33	1	4	99 61
R75	27	1	5	99 29
CLAI	6	12	1	96 16
GRADS	9	6	2	98 78
ND6	17	21	3	98 97
TVI6	34	17	4	99 96
R65	23	17	5	99 49
CLAI	20	17	6	99 27
PVI6	21	8	4	97 05
GVI	10	30	4	99 52
GVSS	11	10	5	99 91
MGVI	13	10	6	99 55
SGVI	30	6	7	97 33
LAI	12	1	7	92 00
GYVI	33	1	8	88 63
CH5	31	1	9	84 36
ELAI	8	26	2	85 46
R64	24	8	8	90 76
R74	26	1	9	76 70
CH7	5	1	10	75 00
CH6	4	1	11	60 22
MYVI	16	36	3	89 53
R45	23	16	12	96 90
YVI	36	1	13	90 76
CH4	2	20	14	85 47
MSSI	15	31	4	93 16
SSSI	32	15	5	99 90
SSI	29	15	6	99 02
SNSI	31	22	7	42 73
MNSI	14	20	8	79 42
NSI	19	20	9	88 95
R76	28	1	35	19 76

Keith County - July 27, 1978 - Field



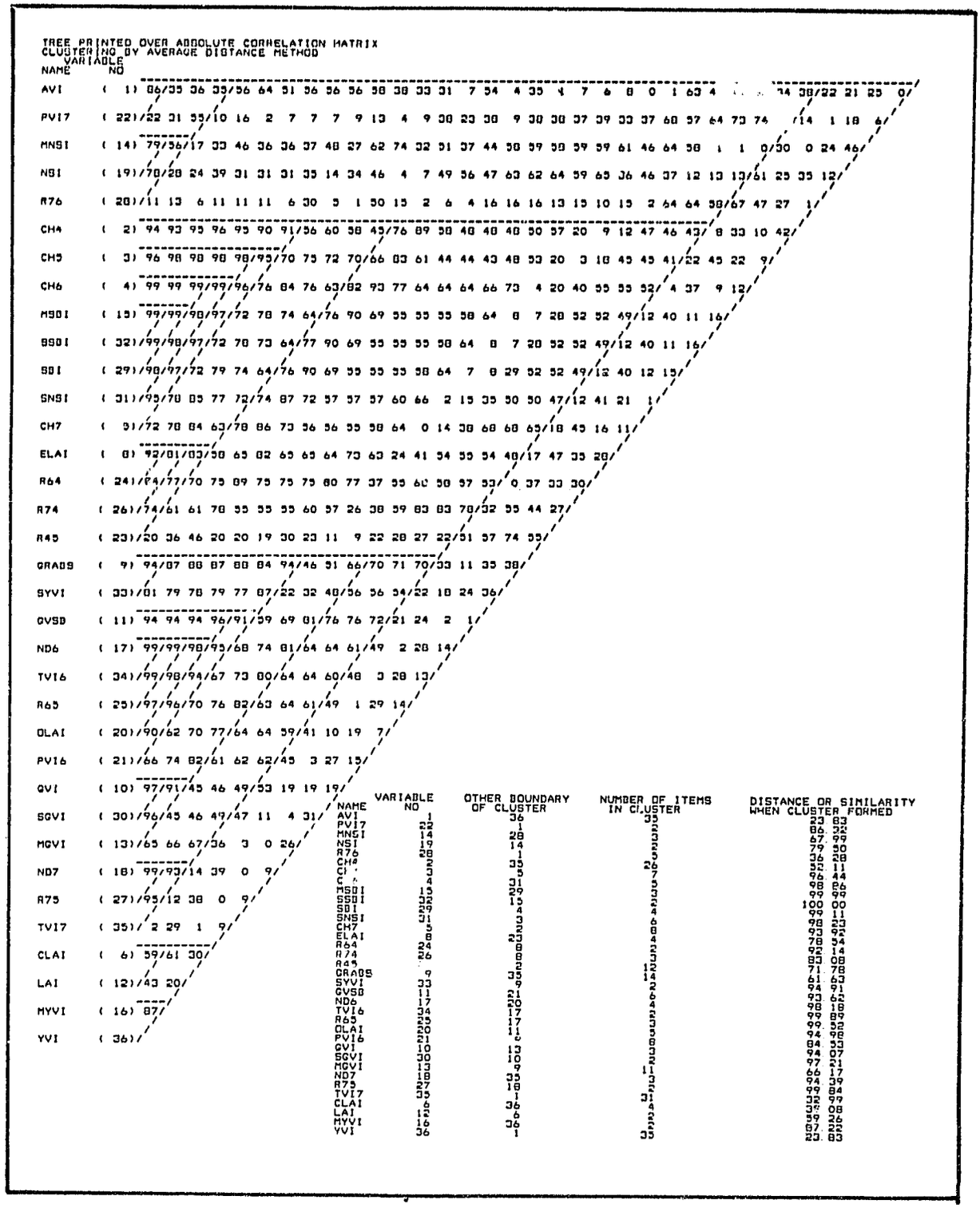
NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	28	35	32.32
PVI7	22	1	2	99.68
TVI7	35	1	3	99.36
ND7	18	27	2	99.22
R75	27	1	5	98.07
CLAI	6	21	11	96.41
ND6	17	20	2	99.62
TVI6	34	17	2	99.89
OLAI	20	6	4	99.31
R65	25	6	5	98.48
QVI	10	11	4	99.39
MQVI	13	10	2	99.69
SQVI	30	10	3	99.67
QVSB	11	6	9	97.52
GRABB	9	21	2	98.19
PVI6	21	1	16	93.66
R64	24	26	2	98.09
R74	26	1	18	83.32
SYVI	33	1	19	76.74
LAI	12	1	20	66.78
CH6	4	5	2	76.83
CH7	5	1	22	91.59
MYVI	16	36	3	70.42
R45	23	16	3	93.38
YVI	36	1	25	44.73
CH4	2	31	6	77.64
CH5	3	31	5	80.42
MSBI	15	31	4	95.22
SSBI	32	19	2	99.98
SBI	29	19	3	99.94
SNSI	31	1	31	37.05
ELAI	8	28	4	41.23
MNSI	14	8	2	74.26
NSI	19	28	2	84.23
R76	28	1	35	32.32

Yolo County - October 7, 1977 - Area

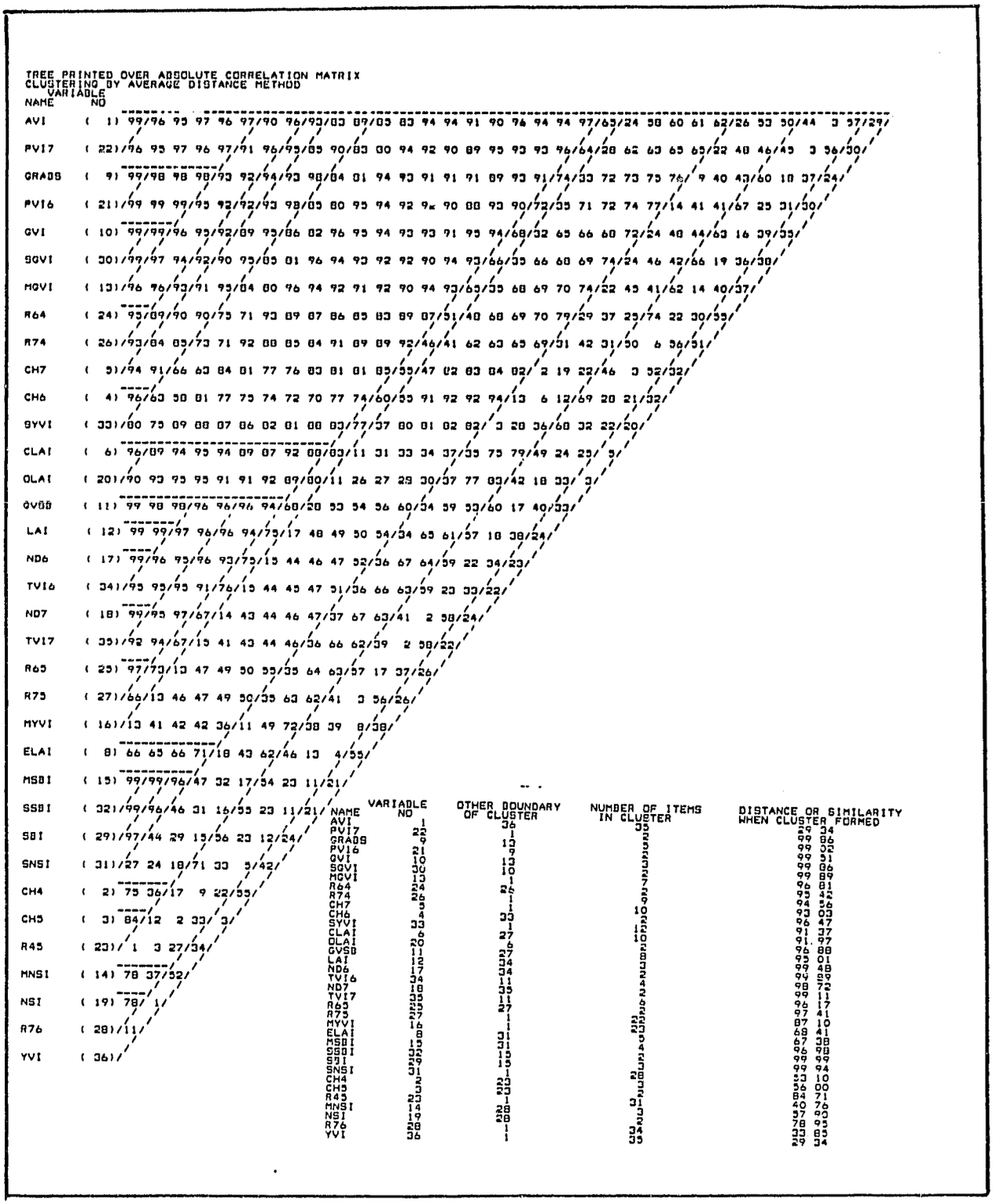


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	16	33	17 47
ND7	18	22	3	93 19
R75	27	18	2	99 26
PVI7	22	1	4	81 73
R74	26	35	2	84 18
TVI7	35	1	6	68 07
CLAI	6	12	18	64 83
OLAI	20	6	2	97 02
TVI6	34	6	3	98 48
ELAI	8	6	4	96 33
R76	28	6	5	95 40
MNSI	14	19	2	97 64
NSI	19	6	7	91 33
GVI	10	25	7	88 79
SGVI	30	10	2	98 65
MGVI	13	10	3	96 50
GVSB	11	25	4	95 31
PVI6	21	11	2	98 26
ND6	17	25	2	98 57
R65	25	6	14	82 37
R45	23	36	3	69 30
R64	24	23	2	84 84
YVI	36	6	17	66 87
LAI	12	1	24	40 18
CH4	2	33	10	72 55
CH7	5	2	2	91 00
CH5	3	31	6	92 89
MSBI	15	29	3	99 98
SSBI	32	15	2	100 00
SBI	29	3	4	98 47
CH6	4	31	2	99 23
SNSI	31	2	8	81 21
GRASS	9	33	2	93 97
SYVI	33	1	34	34 76
MYVI	16	1	35	17 47

Yolo County - November 12, 1977 - Area

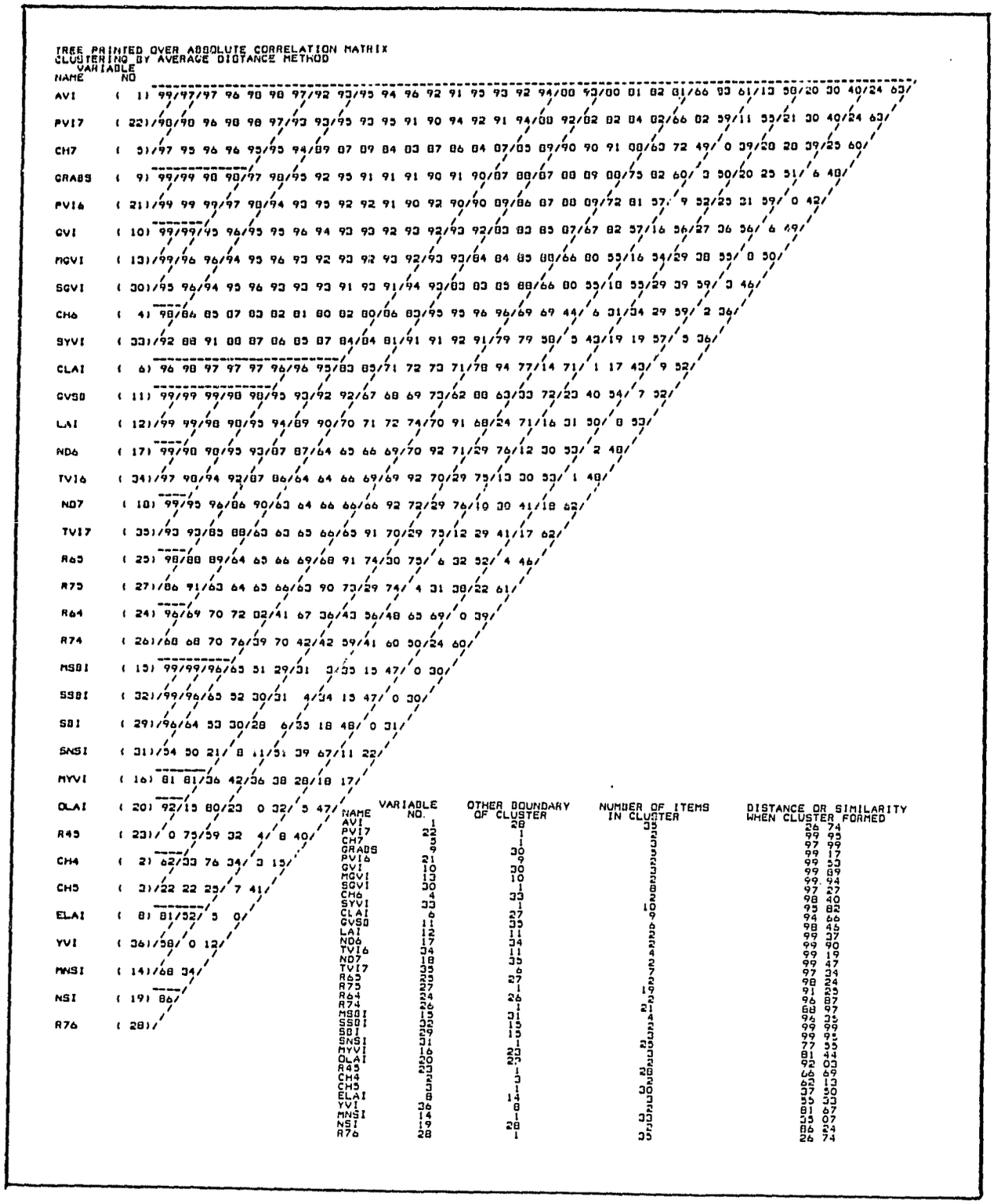


Yolo County - January 28, 1978 - Area

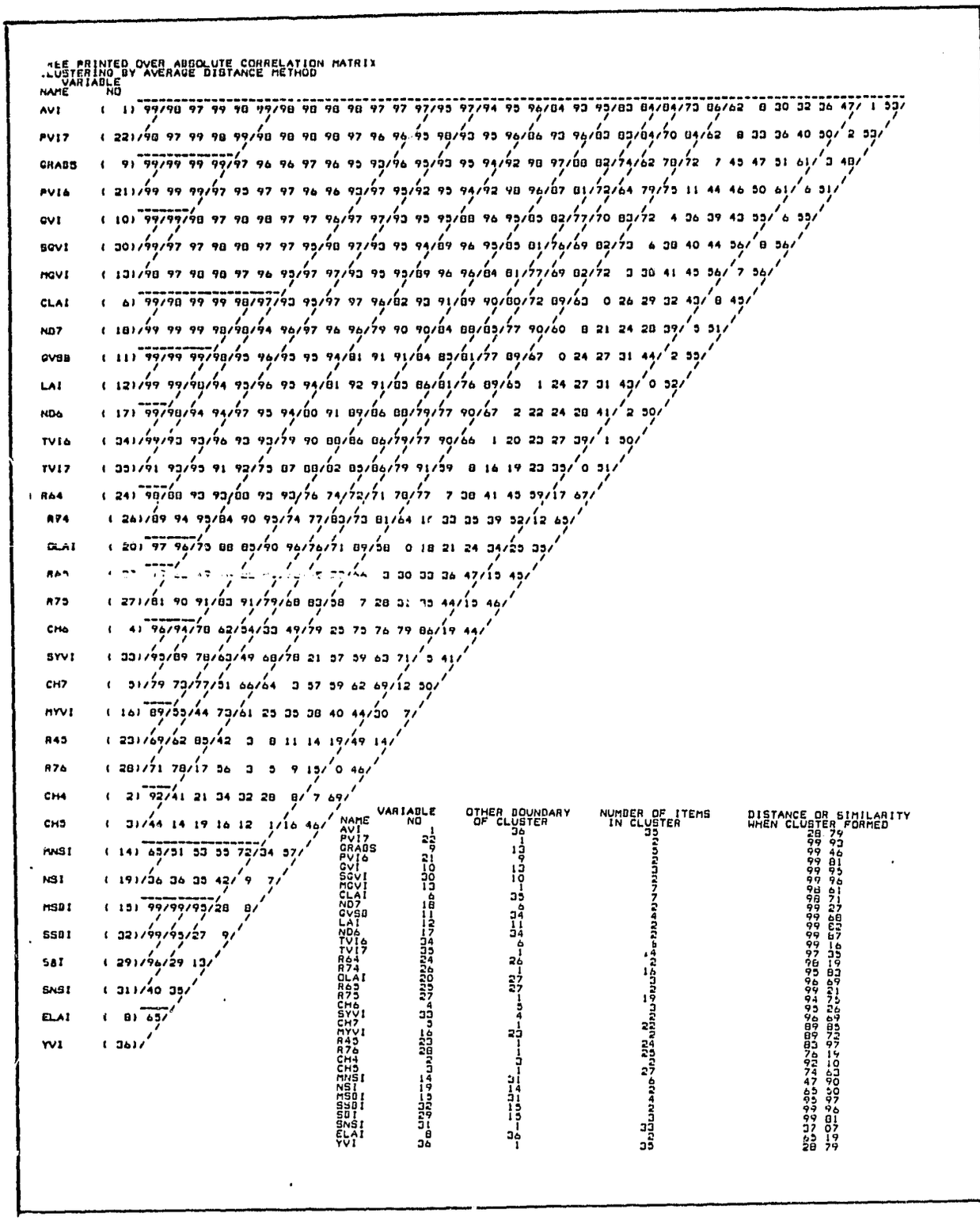


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	99 34
PVI7	22	1	2	99 96
GRAOS	9	13	3	99 92
PVI6	21	9	4	99 91
GVI	10	13	5	99 86
SGVI	30	10	6	99 89
MGVI	13	1	7	96 81
R64	24	26	8	95 42
R74	26	1	9	94 56
CH7	5	1	10	93 03
CH6	4	33	11	96 47
SYVI	33	1	12	91 37
CLAI	6	27	13	91 97
OLAI	20	6	14	96 88
GVSB	11	27	15	95 01
LAI	12	34	16	99 48
ND6	17	34	17	94 89
TVI6	34	11	18	98 72
ND7	18	35	19	99 11
TVI7	35	11	20	96 17
R65	25	27	21	97 41
R75	27	1	22	87 10
MYVI	16	1	23	68 41
ELAI	8	31	24	67 38
MSBI	15	31	25	96 98
SSBI	32	15	26	98 99
SBI	29	15	27	99 94
SNSI	31	1	28	53 10
CH4	2	23	29	56 00
CH5	3	23	30	68 71
R45	23	1	31	40 76
MNSI	14	28	32	37 90
NSI	19	28	33	78 95
R76	28	1	34	33 85
YVI	36	1	35	29 34

Yolo County - February 28, 1978 - Area

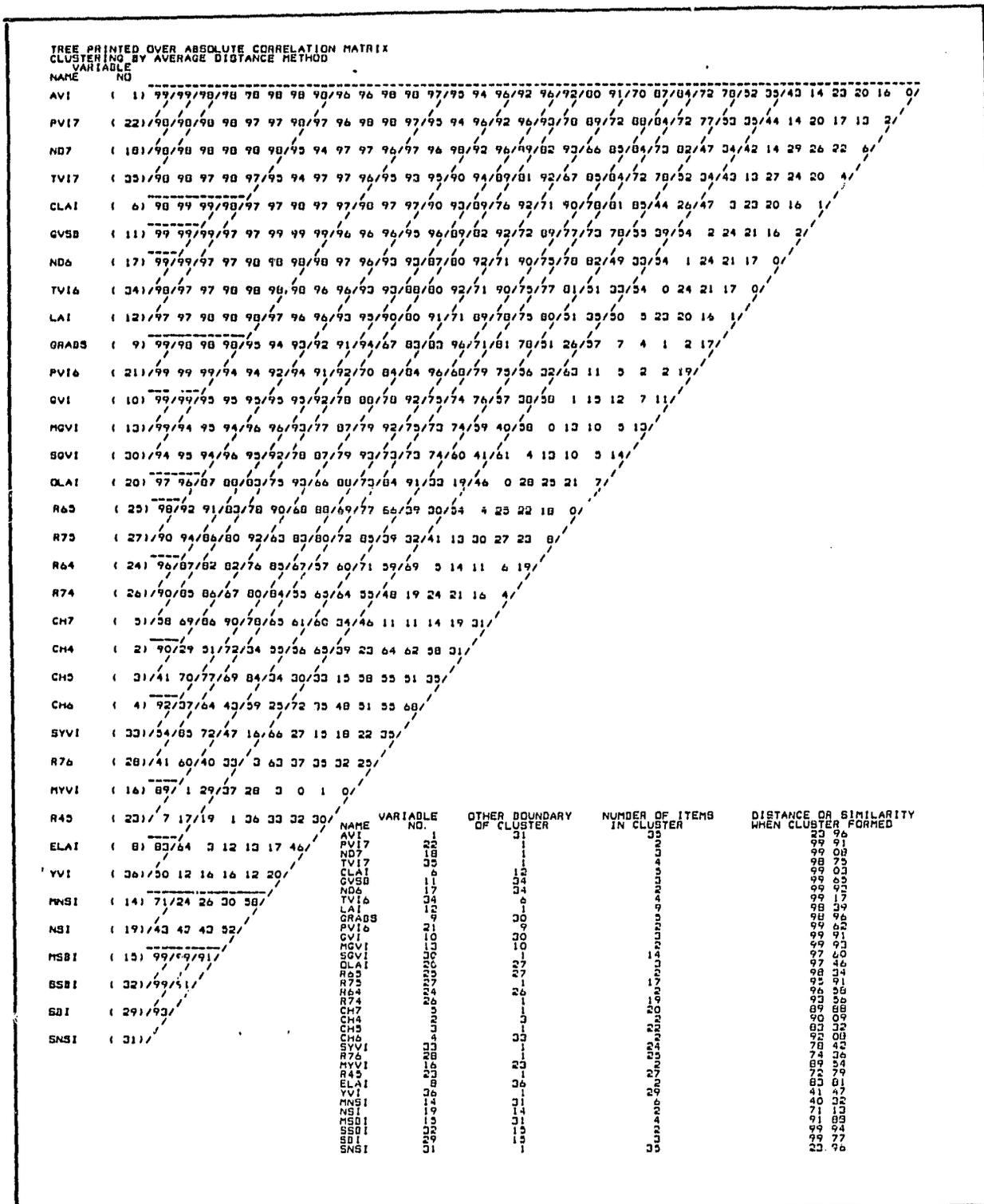


Yolo County - March 27, 1978 - Area



NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	28 79
PVI7	22	1	2	99 93
GRASS	9	13	2	99 46
PVI6	21	9	3	99 81
GVI	10	13	3	99 95
SGVI	30	10	4	99 96
MGVI	13	1	5	98 61
CLAI	6	35	7	98 71
ND7	18	6	4	99 27
GVSB	11	34	4	99 68
LAI	12	11	8	99 65
ND6	17	34	12	99 87
TVI6	34	6	6	99 16
TVI7	33	1	14	97 35
R64	24	26	10	98 19
R74	26	1	12	95 83
CLAI	20	27	3	96 69
R43	23	27	2	99 21
R75	27	1	19	94 72
CH6	4	8	3	93 26
SYVI	33	4	3	96 69
CH7	5	1	2	89 85
MYVI	16	23	3	89 73
R45	25	1	24	83 97
R76	28	1	25	76 15
CH4	3	3	2	92 10
CH5	5	1	27	74 63
MNSI	14	21	6	47 90
NSI	19	14	26	65 50
MSBI	15	31	4	95 97
SSBI	32	15	32	99 96
SBI	29	15	32	99 81
SNSI	31	1	33	97 07
ELAI	8	36	34	65 19
YVI	36	1	35	28 79

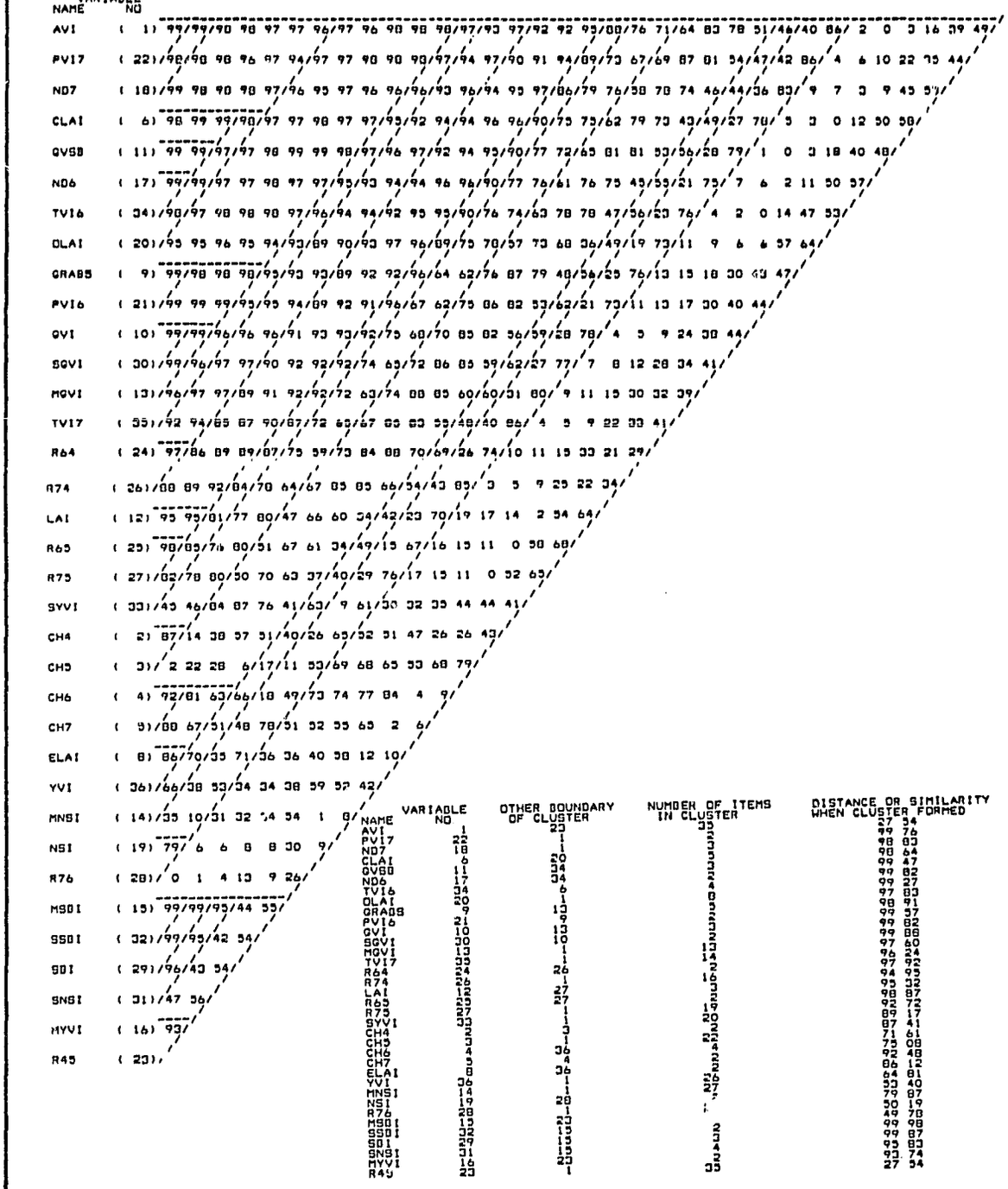
Yolo County - May 2, 1978 - Area



NAME	VARIABLE NO.	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	31	35	23 96
PVI7	22	1	2	99 91
ND7	18	1	3	99 08
TVI7	35	1	4	98 75
CLAI	6	12	5	99 03
GVSB	11	34	3	99 65
ND6	17	34	4	99 92
TVI6	34	6	4	99 17
LAI	12	1	9	98 39
GRABS	9	30	5	98 96
PVI6	21	9	2	99 62
GVI	10	30	3	99 91
MGVI	13	10	4	99 93
SGVI	30	1	14	97 60
OLAI	20	27	3	97 46
R65	25	27	2	98 34
R75	27	1	17	92 91
R64	24	26	2	96 58
R74	26	1	19	92 56
CH7	5	1	20	89 88
CH4	2	3	2	90 09
CH5	3	1	22	83 32
CH6	4	33	2	92 08
SYVI	33	1	24	78 42
R76	28	1	22	74 36
MYVI	16	23	2	89 54
R45	23	1	27	72 79
ELAI	8	36	2	83 81
YVI	36	1	29	41 47
MNSI	14	31	6	40 32
NSI	19	14	2	71 13
MSBI	15	31	4	91 88
SSBI	32	15	2	99 94
SBI	29	15	3	99 77
SNSI	31	1	35	23 96

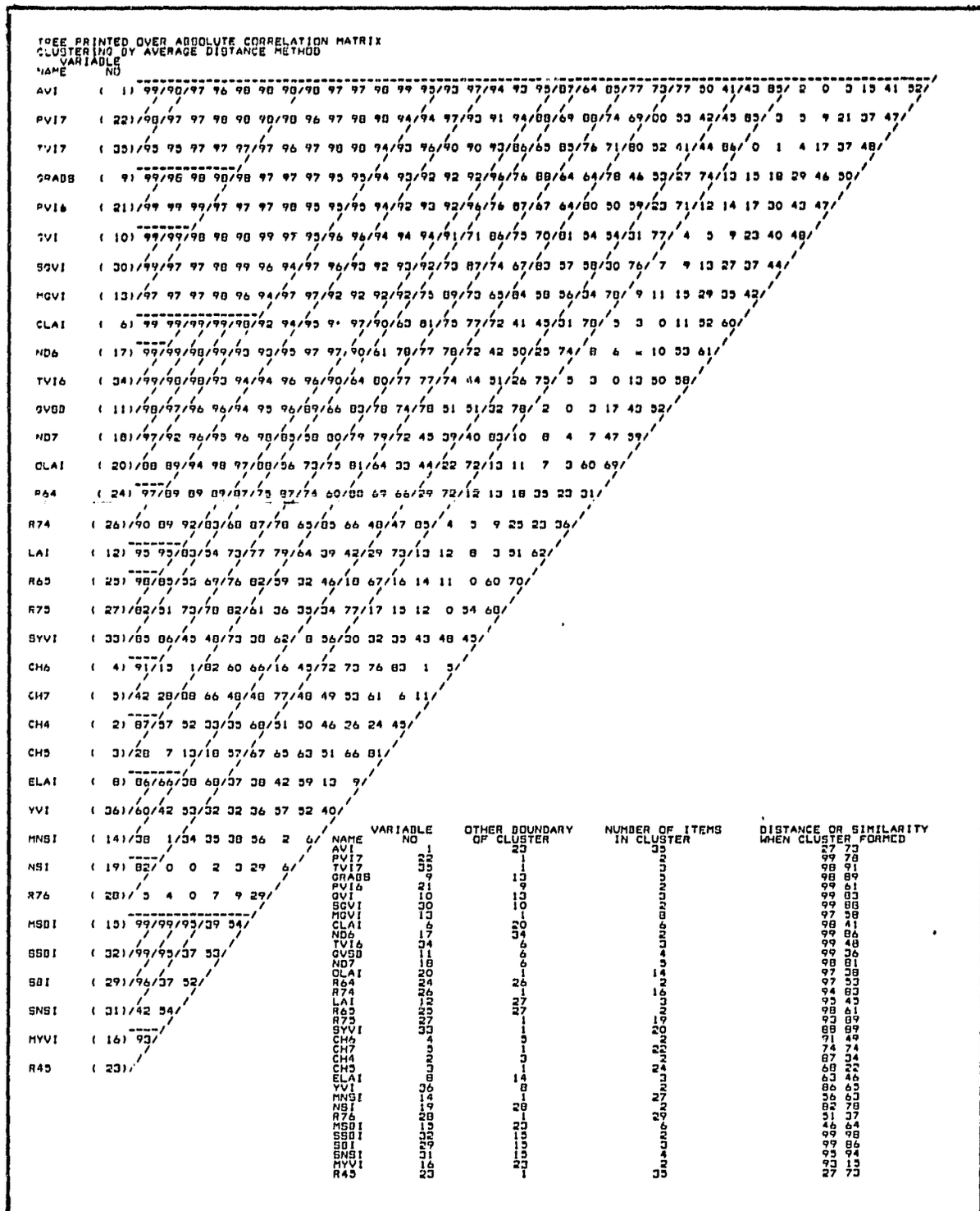
Yolo County - May 11, 1978 - Area

TREE PRINTED OVER ABSOLUTE CORRELATION MATRIX
CLUSTERING BY AVERAGE DISTANCE METHOD

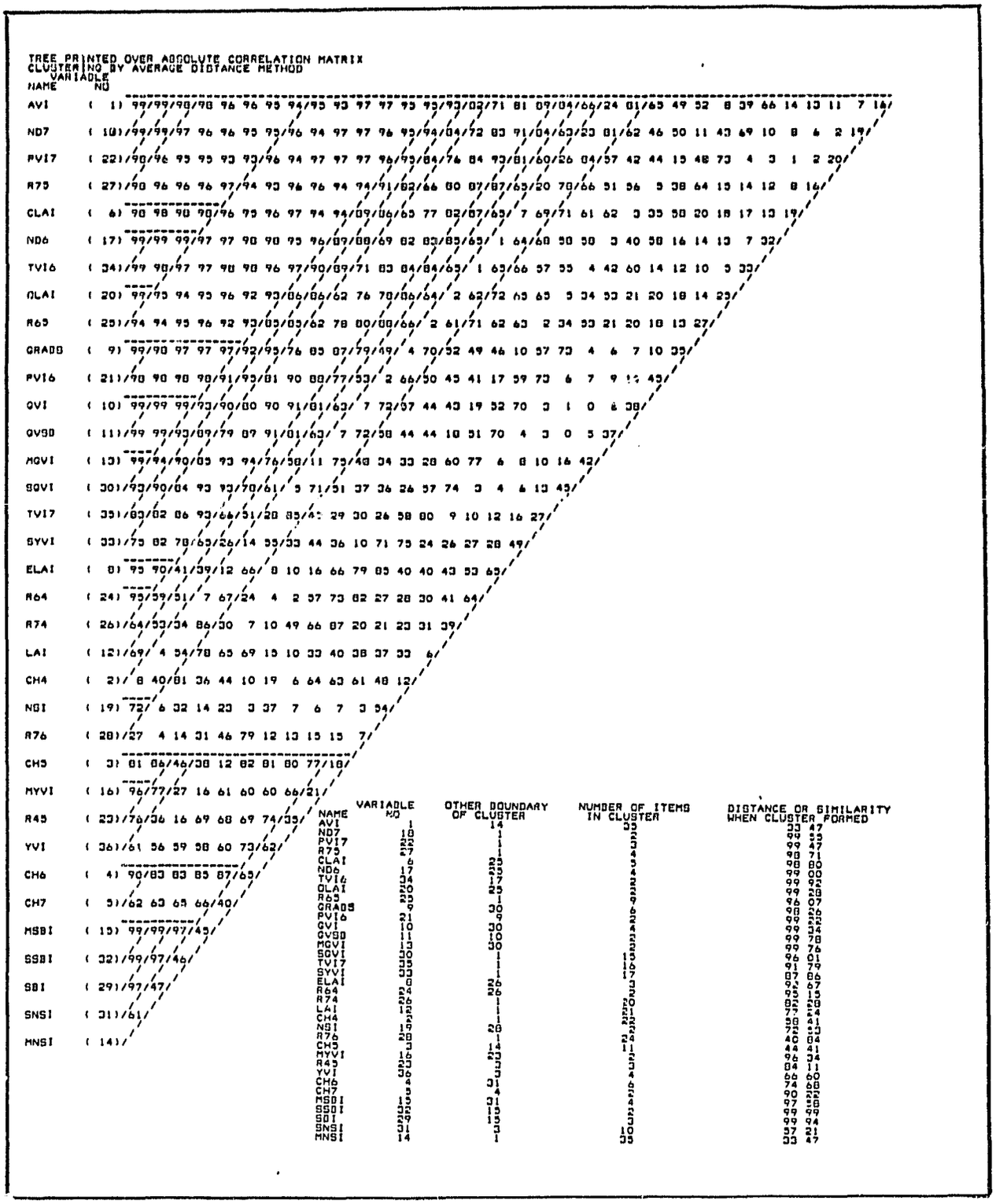


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	23	35	27 34
PVI7	22	1	3	99 76
ND7	18	1	3	98 83
CLAI	6	20	3	98 64
GVSB	11	34	3	99 47
ND6	17	34	4	99 82
TVI6	34	6	8	99 27
OLAI	20	1	5	97 83
GRASS	9	13	5	98 91
PVI6	21	9	5	99 57
GVI	10	13	5	99 82
SGVI	30	10	7	99 88
MGVI	13	1	12	97 60
TVI7	35	1	14	96 24
R64	24	26	2	97 92
R74	26	1	16	94 95
LAI	12	27	3	95 32
R65	29	27	19	98 87
R75	27	1	17	92 72
SYVI	33	1	20	89 17
CH4	2	3	2	87 41
CH5	3	1	2	71 61
CH6	4	36	2	75 08
CH7	5	4	2	92 48
ELAI	8	36	2	86 12
YVI	36	1	25	64 81
MNSI	14	1	27	55 40
NSI	19	28	4	79 87
R76	28	1	5	50 19
MSDI	15	23		49 78
SSDI	32	15		99 98
SDI	29	15		99 87
SNSI	31	15	32	95 83
MYVI	16	23	2	93 74
R45	23	1	33	27 34

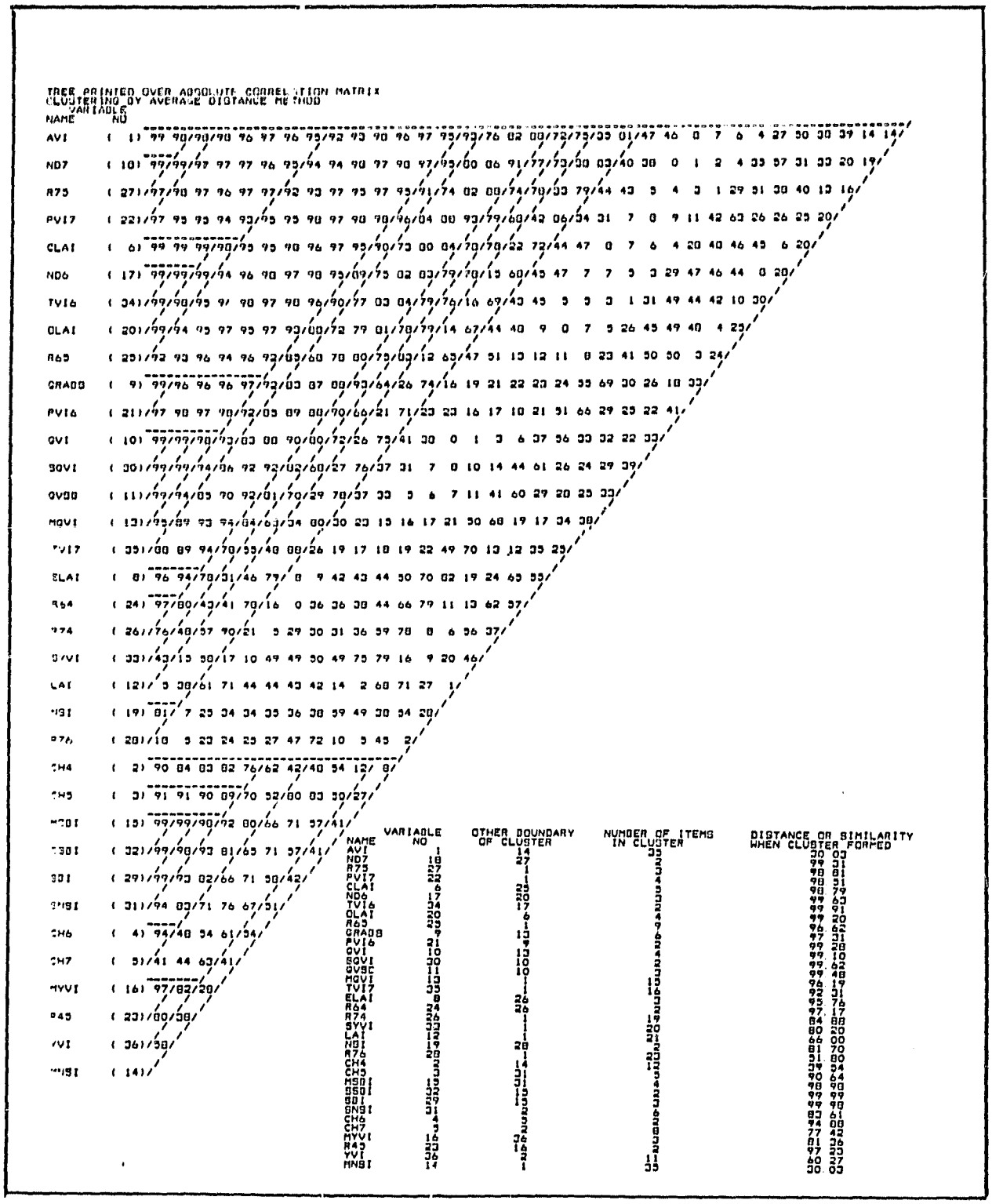
Yolo County - May 12, 1978 - Area



Yolo County - May 20, 1978 - Area

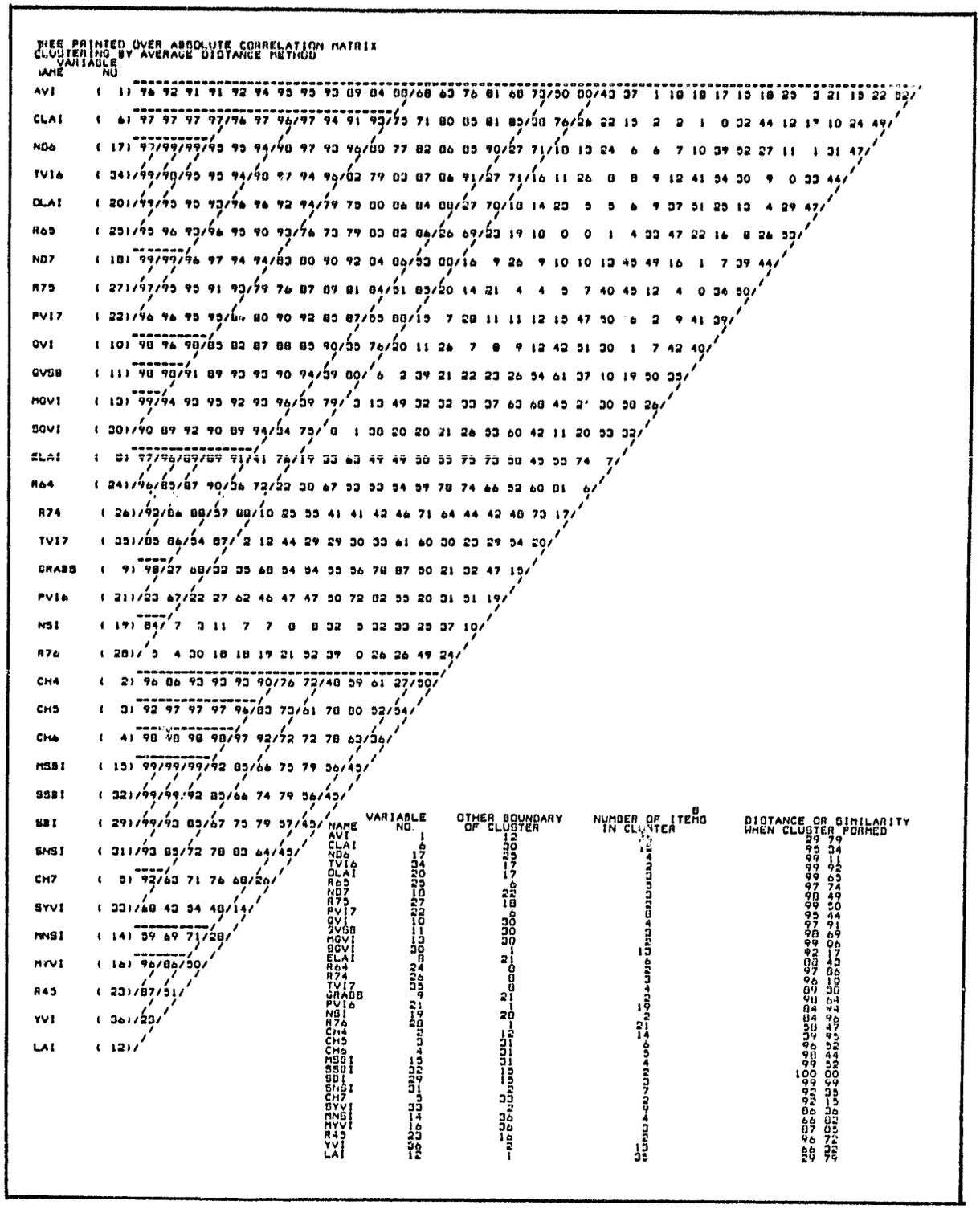


Yolo County - May 29, 1978 - Area

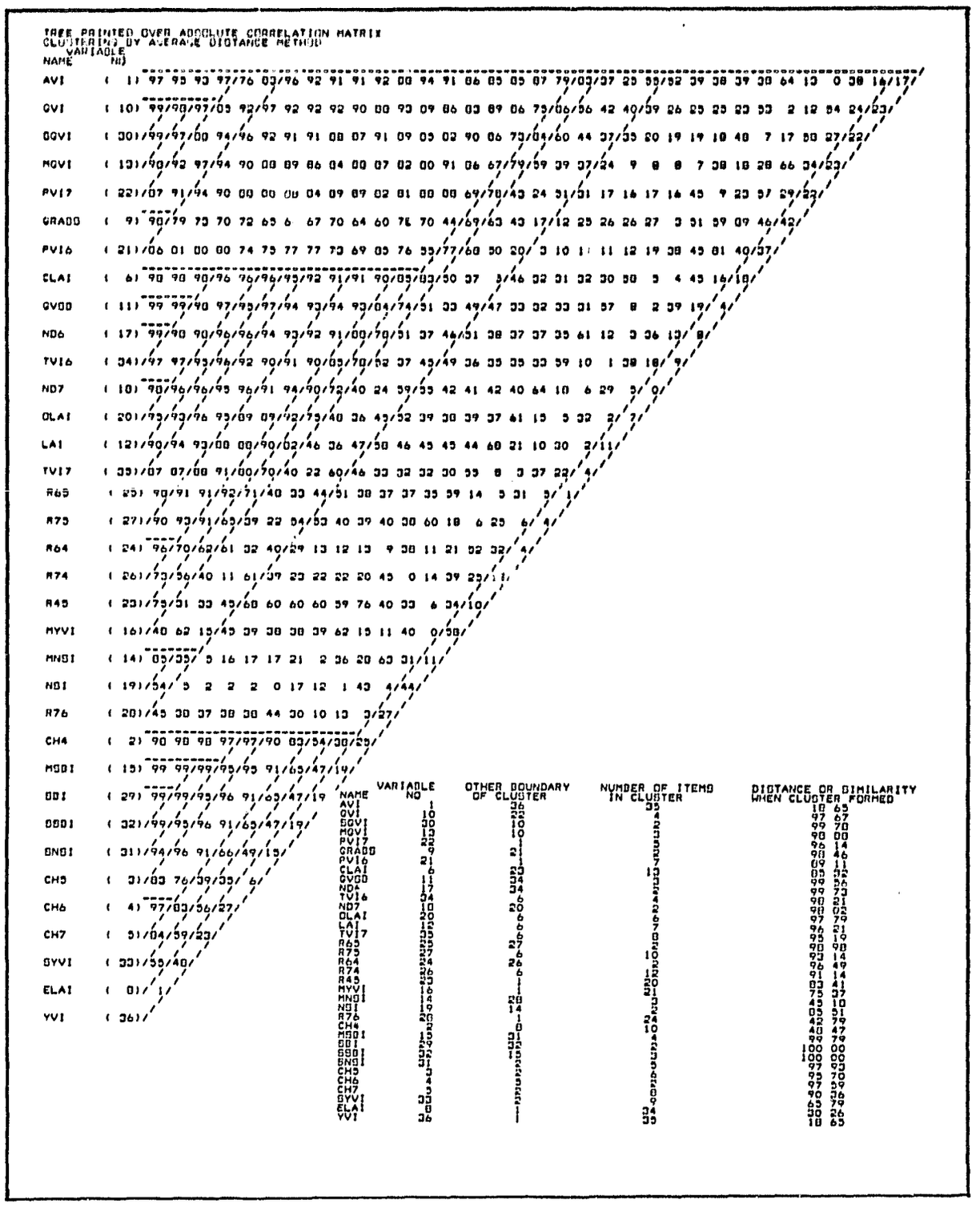


NAME	VARIABLE NO	OTHER BOUNDARY OR CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	14	35	100 00
ND7	18	27	2	99 31
R75	27	1	3	98 81
PVI7	22	1	4	98 31
CLAI	6	25	5	98 79
ND6	17	20	3	97 60
TVI6	34	17	2	97 91
OLAI	20	6	4	97 20
R65	25	1	9	96 62
GRA08	9	13	6	97 31
PVI6	21	9	2	97 28
GVI	10	13	4	97 10
SGVI	30	10	3	97 62
GVSC	11	10	3	97 48
MGVI	13	1	15	96 19
TVI7	33	1	16	92 31
ELAI	8	26	3	95 76
R64	24	26	3	97 17
R74	26	1	19	84 88
SYVI	32	1	20	80 29
LAI	12	1	21	66 00
NBI	19	28	2	81 70
R76	28	1	23	51 80
CH4	2	14	33	39 54
CH5	31	31	4	90 64
MSBI	15	31	5	98 90
SSBI	32	15	2	99 99
BBI	29	15	3	99 98
BNSI	31	2	8	83 61
CH6	4	32	6	94 08
CH7	5	32	8	77 42
MYVI	16	24	2	81 36
R45	23	16	2	97 33
YVI	36	24	11	60 27
MNSI	14	1	35	30 03

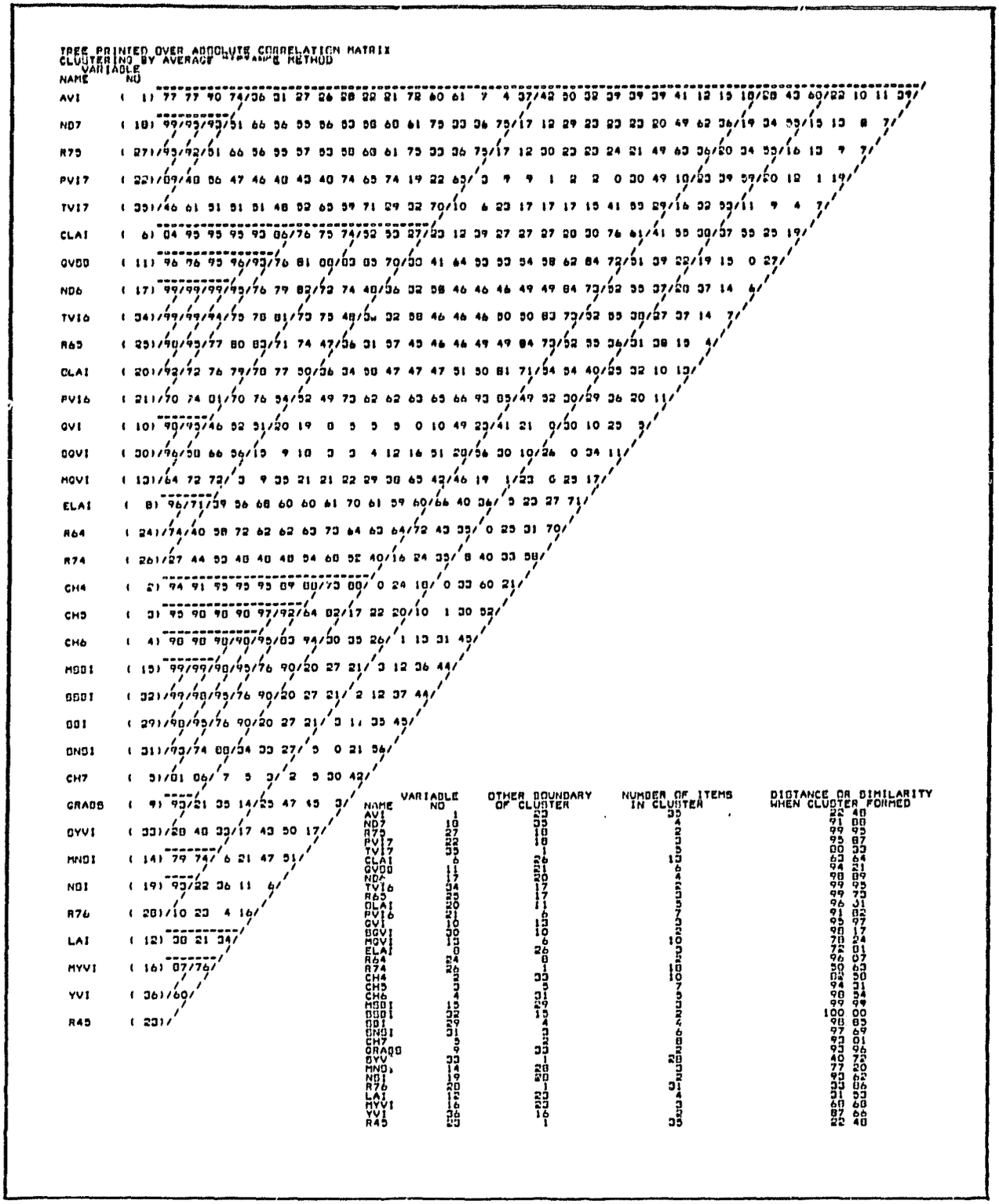
Yolo County - June 16, 1978 - Area



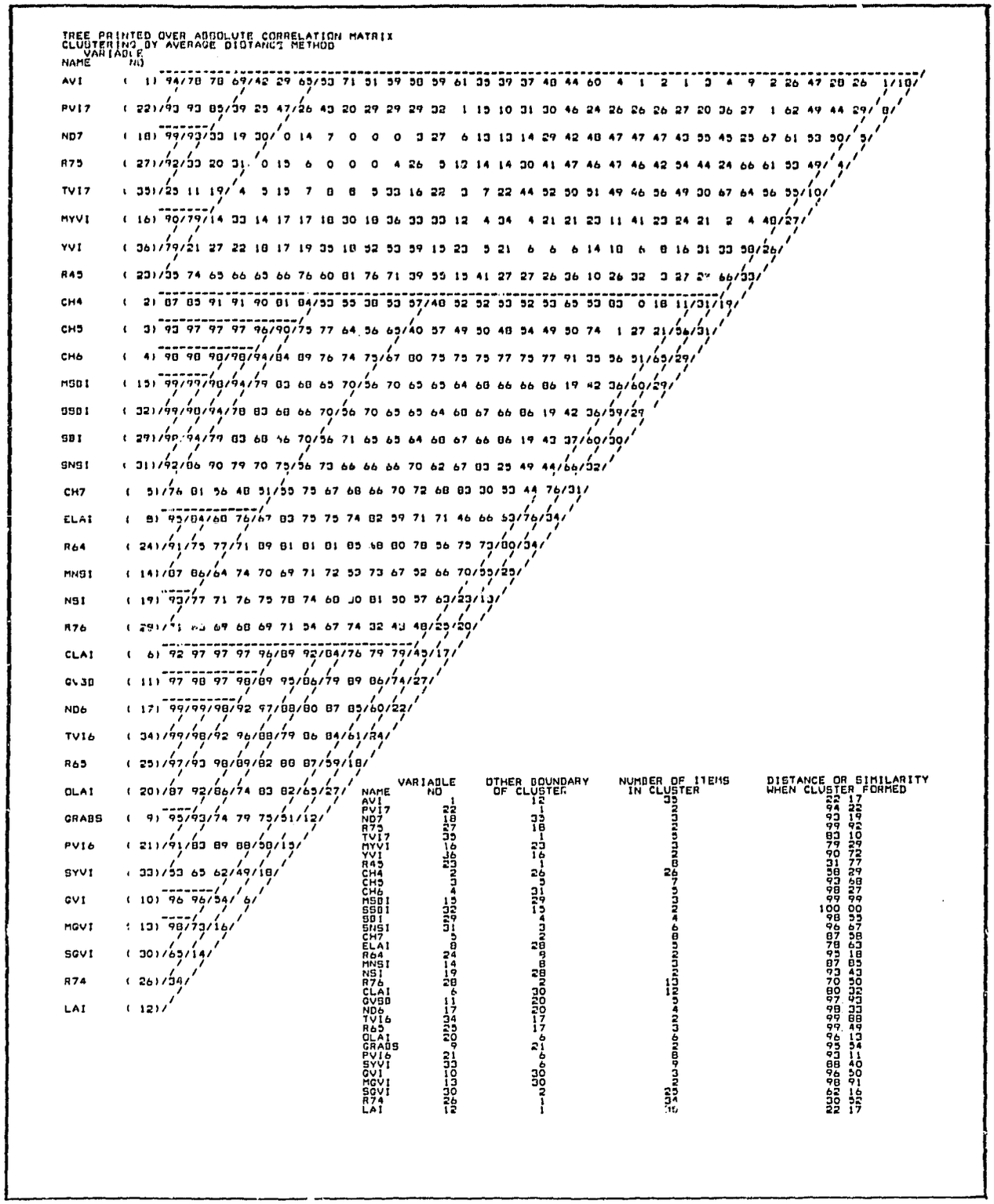
Yolo County - All Dates Combined - Field



Yolo County - October 7, 1977 - Field

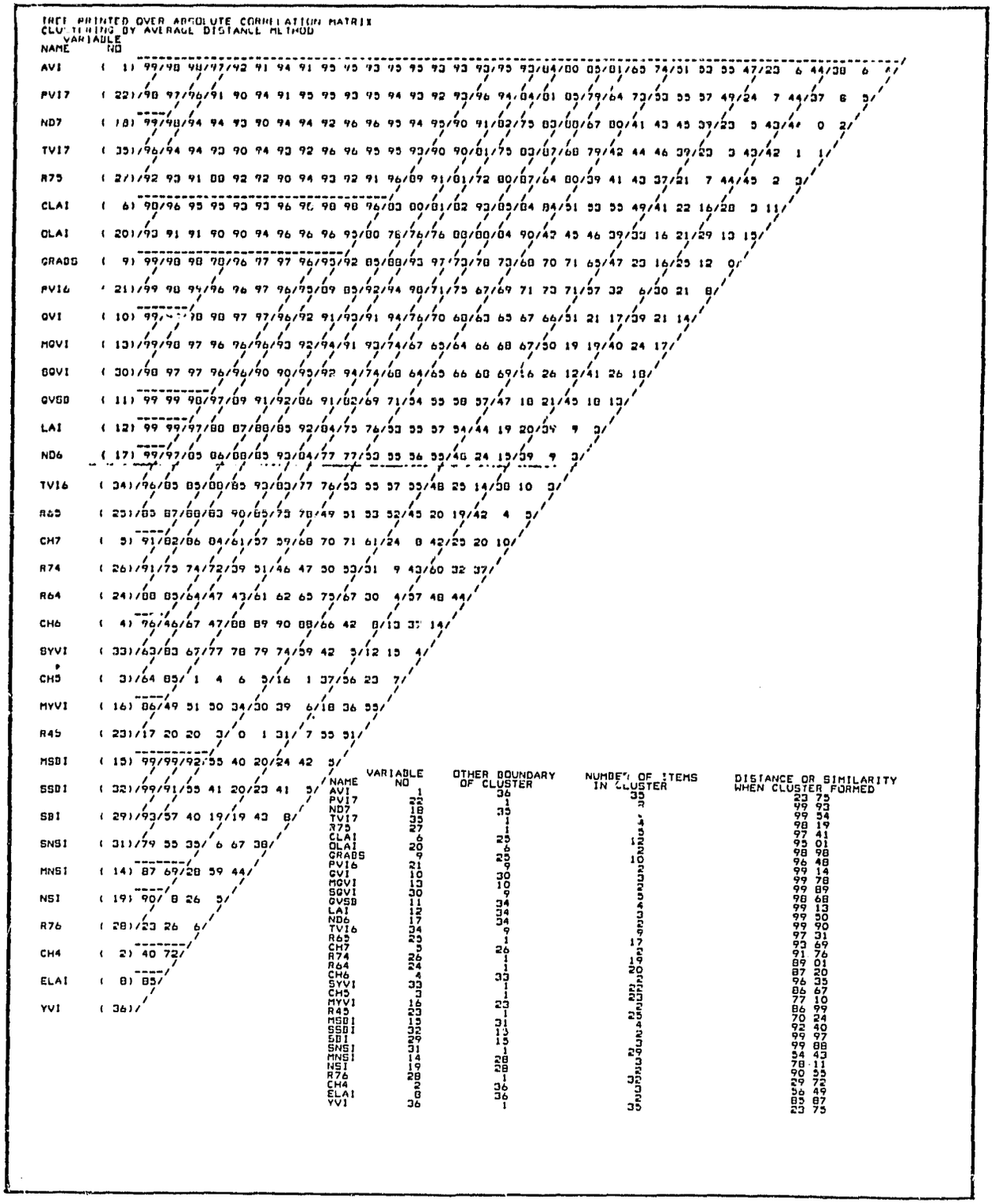


Yolo County - November 12, 1977 - Field

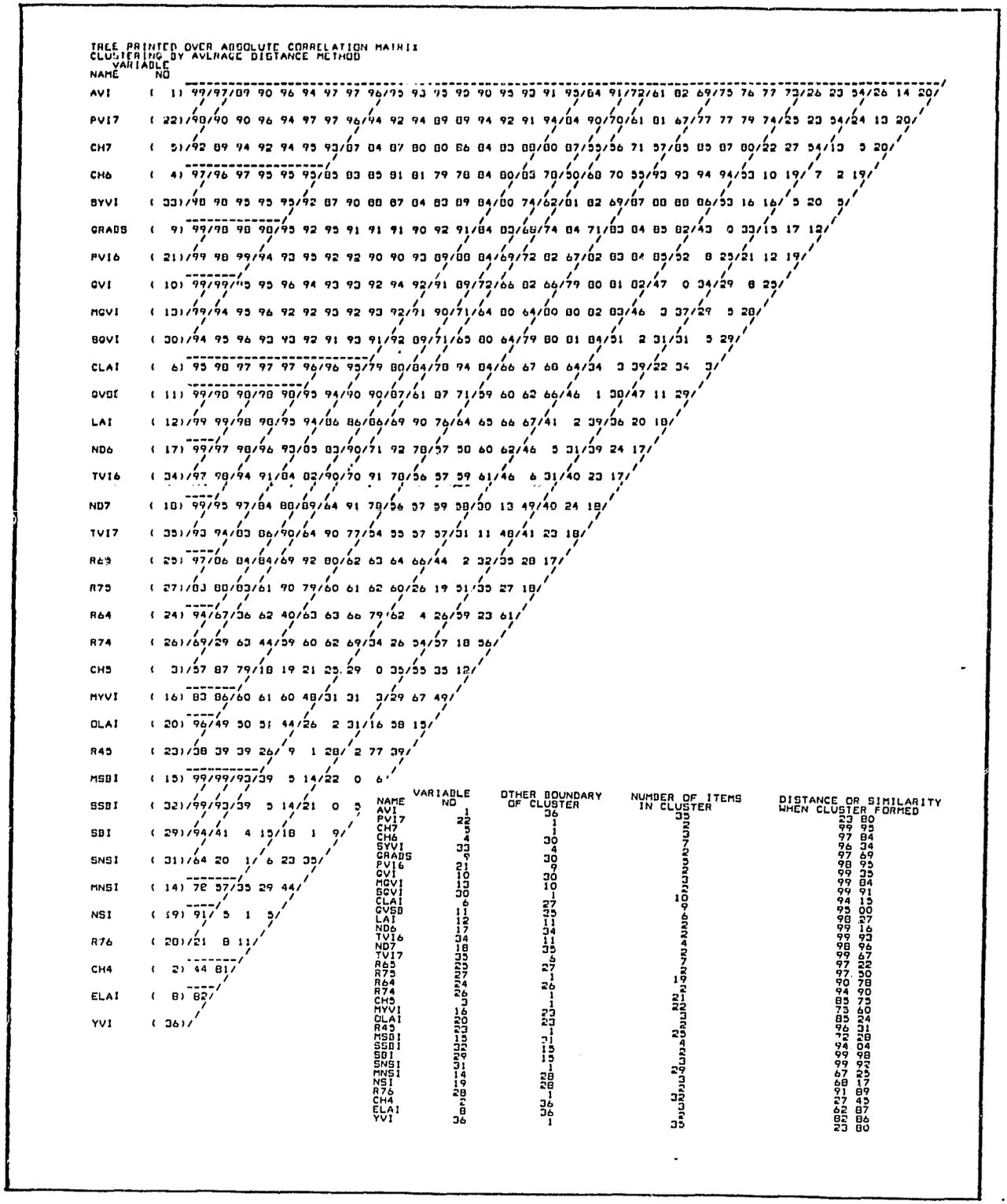


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	12	35	22 17
PVI7	22	1	2	94 22
ND7	18	35	3	93 19
R75	27	18	2	99 92
TVI7	35	1	3	93 10
MYVI	16	23	3	79 29
YVI	36	16	2	90 72
R45	23	1	8	31 77
CH4	2	26	26	58 29
CH5	3	3	7	93 68
CH6	4	31	5	98 27
MSDI	15	29	3	99 99
SSDI	32	15	2	100 00
SDI	29	4	4	98 55
SNSI	31	3	6	96 67
CH7	5	2	8	87 58
ELAI	8	29	5	78 63
R64	24	8	2	95 18
MNSI	14	8	3	87 85
NSI	19	28	2	93 43
R76	28	2	10	70 50
CLAI	6	30	12	80 32
GV3B	11	20	5	97 93
ND6	17	20	4	98 33
TVI6	34	17	2	99 88
R65	25	17	3	99 49
OLAI	20	6	6	96 13
GRABS	9	21	2	95 54
PVI6	21	6	8	93 11
SYVI	33	6	9	88 40
GVI	10	30	3	96 50
MGVI	13	30	2	98 91
SGVI	30	2	25	62 16
R74	26	1	34	30 52
LAI	12	1	36	22 17

Yolo County - January 23, 1978 - Field

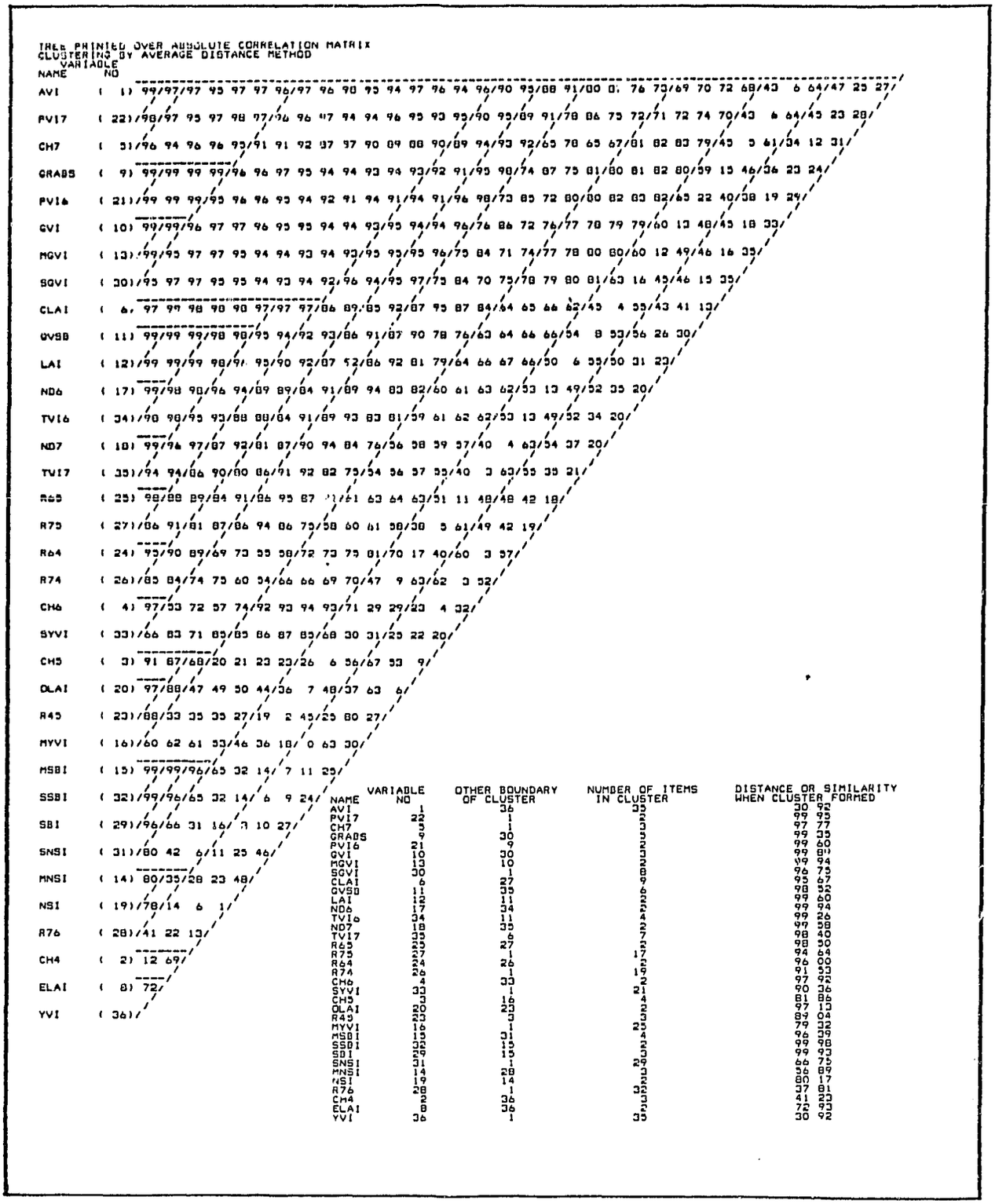


Yolo County - February 28, 1978 - Field



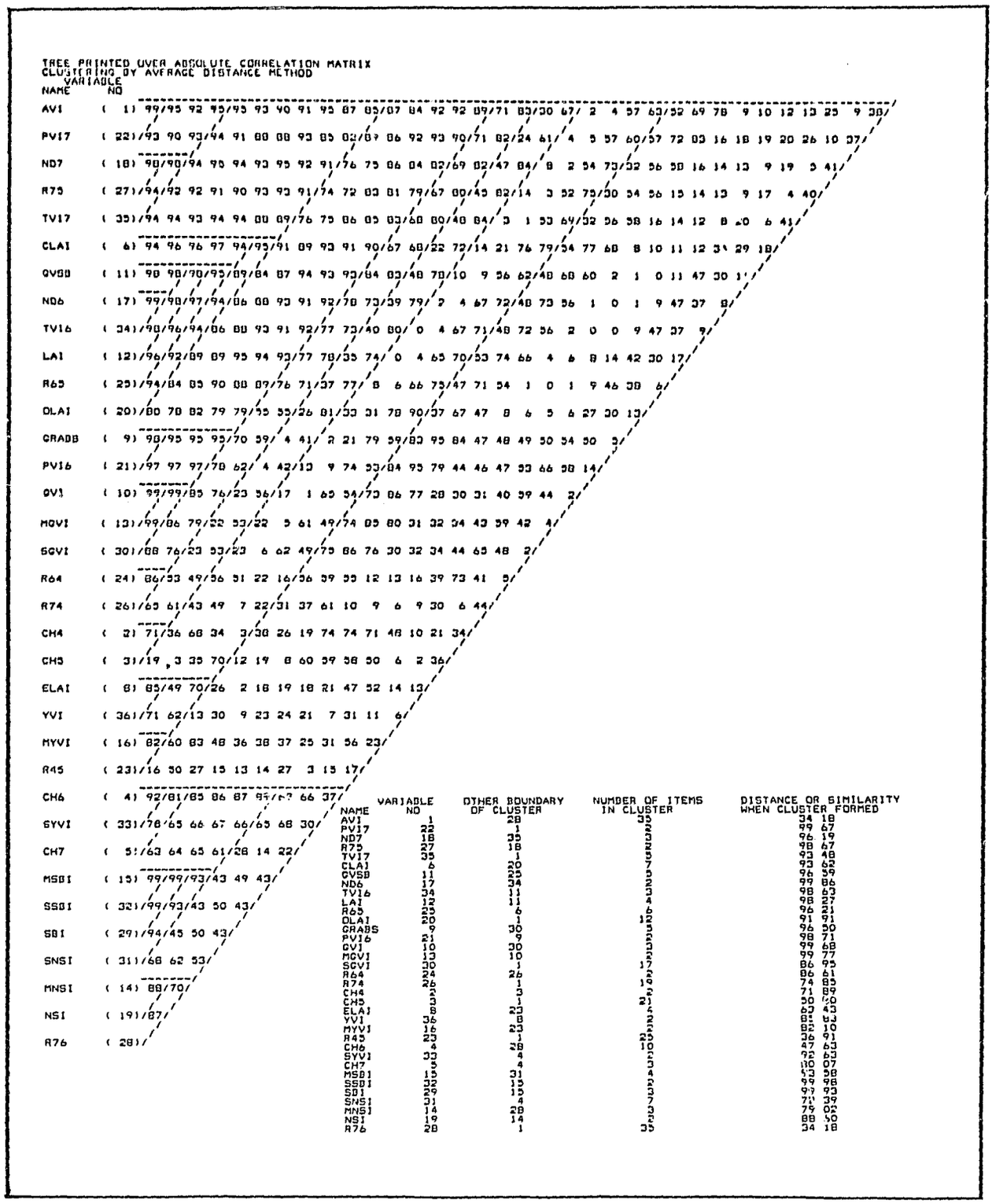
NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	35	23 80
PVI7	22	1	2	99 95
CH7	5	1	3	97 84
CH6	4	30	7	96 34
SYVI	33	4	2	97 69
GRADS	9	30	3	98 95
PVI6	21	9	5	99 35
GVI	10	30	2	99 84
MGVI	13	10	2	99 91
SGVI	30	1	10	94 15
CLAI	6	27	9	95 00
GVSB	11	35	6	98 27
LAI	12	11	2	99 16
ND6	17	34	2	99 93
TVI6	34	11	4	98 96
ND7	18	35	2	99 67
TVI7	35	6	7	97 22
R65	25	27	8	97 30
R75	27	1	19	90 78
R64	24	26	2	94 90
R74	26	1	21	85 75
CH5	3	1	22	73 60
MYVI	16	23	3	85 24
OLAI	20	23	6	96 31
R45	23	1	25	72 28
MSBI	15	31	4	94 04
SSBI	32	15	2	99 98
SBI	29	15	3	99 92
SNSI	31	1	29	67 25
MNSI	14	28	2	68 17
NSI	19	28	30	91 89
R76	28	1	32	82 45
CH4	2	36	33	62 87
ELAI	8	36	34	82 86
YVI	36	1	35	23 80

Yolo County - March 27, 1978 - Field

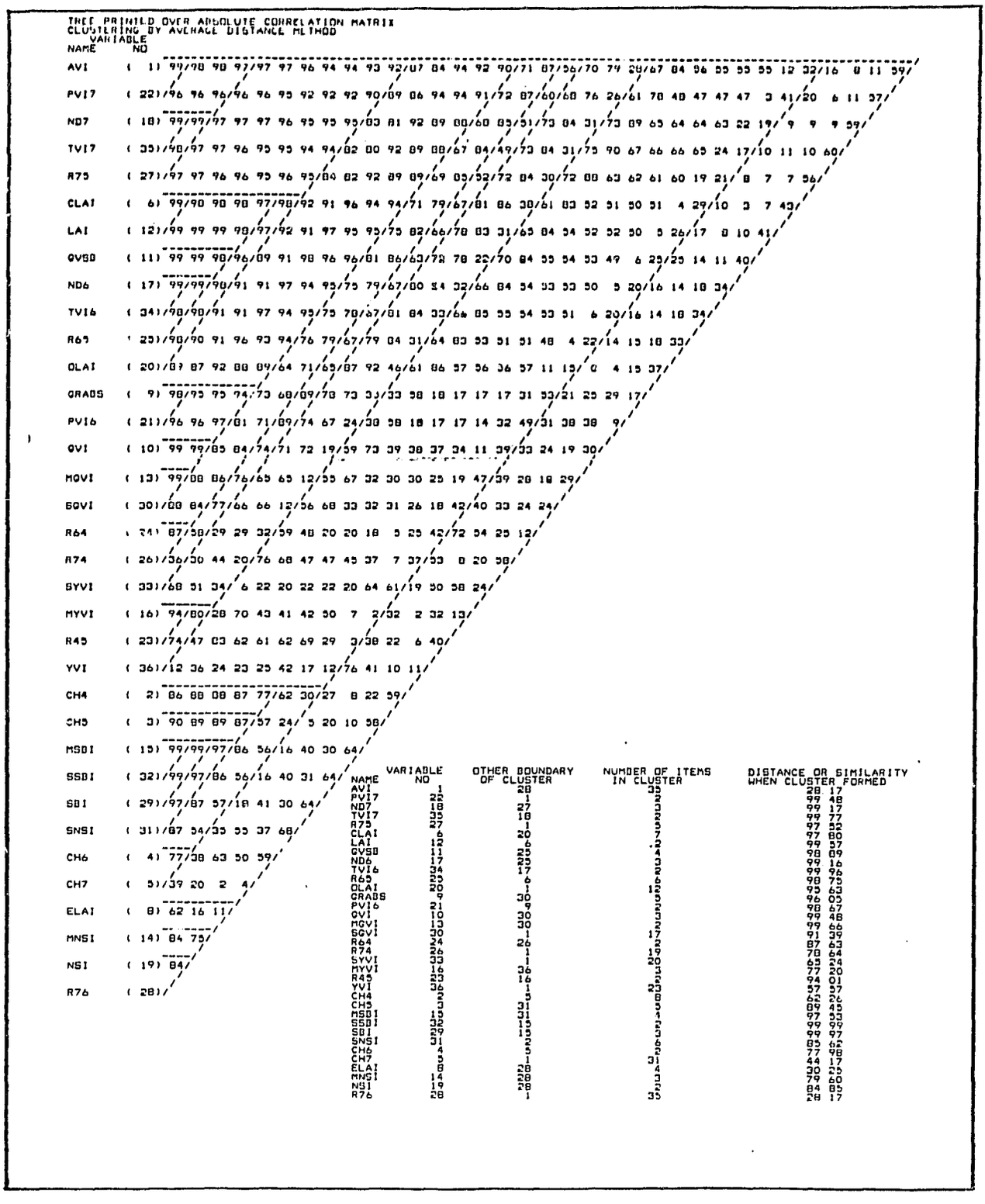


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	36	33	30 92
PVI7	22	1	2	99 95
CH7	3	1	3	97 77
GRABS	9	30	3	99 35
PVI6	21	9	5	99 60
GVI	10	30	5	99 89
MGVI	13	10	2	99 94
SGVI	30	1	8	96 73
CLAI	6	27	9	95 67
GVSB	11	35	6	98 52
LAI	12	11	2	99 60
ND6	17	34	2	99 94
TVI6	34	11	4	99 26
ND7	18	35	2	99 58
TVI7	35	6	7	98 40
R65	25	27	2	98 50
R75	27	1	17	94 64
R64	24	26	2	96 00
R74	26	1	19	91 53
CH6	4	33	2	97 92
SYVI	33	1	21	90 36
CH5	3	16	4	81 86
GLAI	20	23	3	97 13
R45	23	3	5	89 04
MYVI	16	1	25	79 32
MSBI	15	31	4	96 39
SSBI	32	15	6	99 98
SBI	29	15	8	99 93
SNSI	31	1	29	66 75
MNSI	14	28	3	56 89
NSI	19	14	2	80 17
R76	28	1	32	37 81
CH4	2	36	3	41 23
ELAI	8	36	4	72 93
YVI	36	1	35	30 92

Yolo County - May 2, 1978 - Field

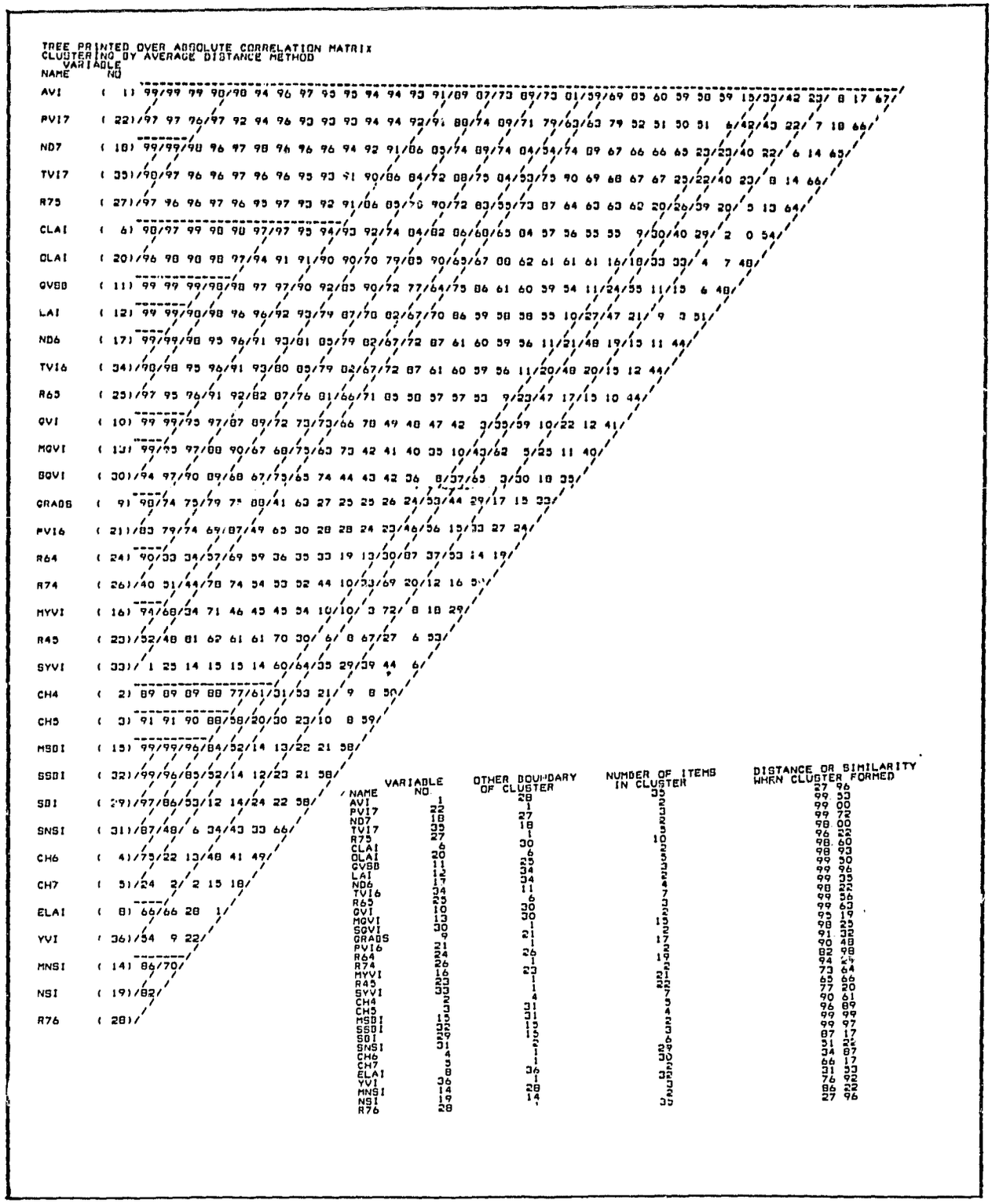


Yolo County - May 11, 1978 - Field

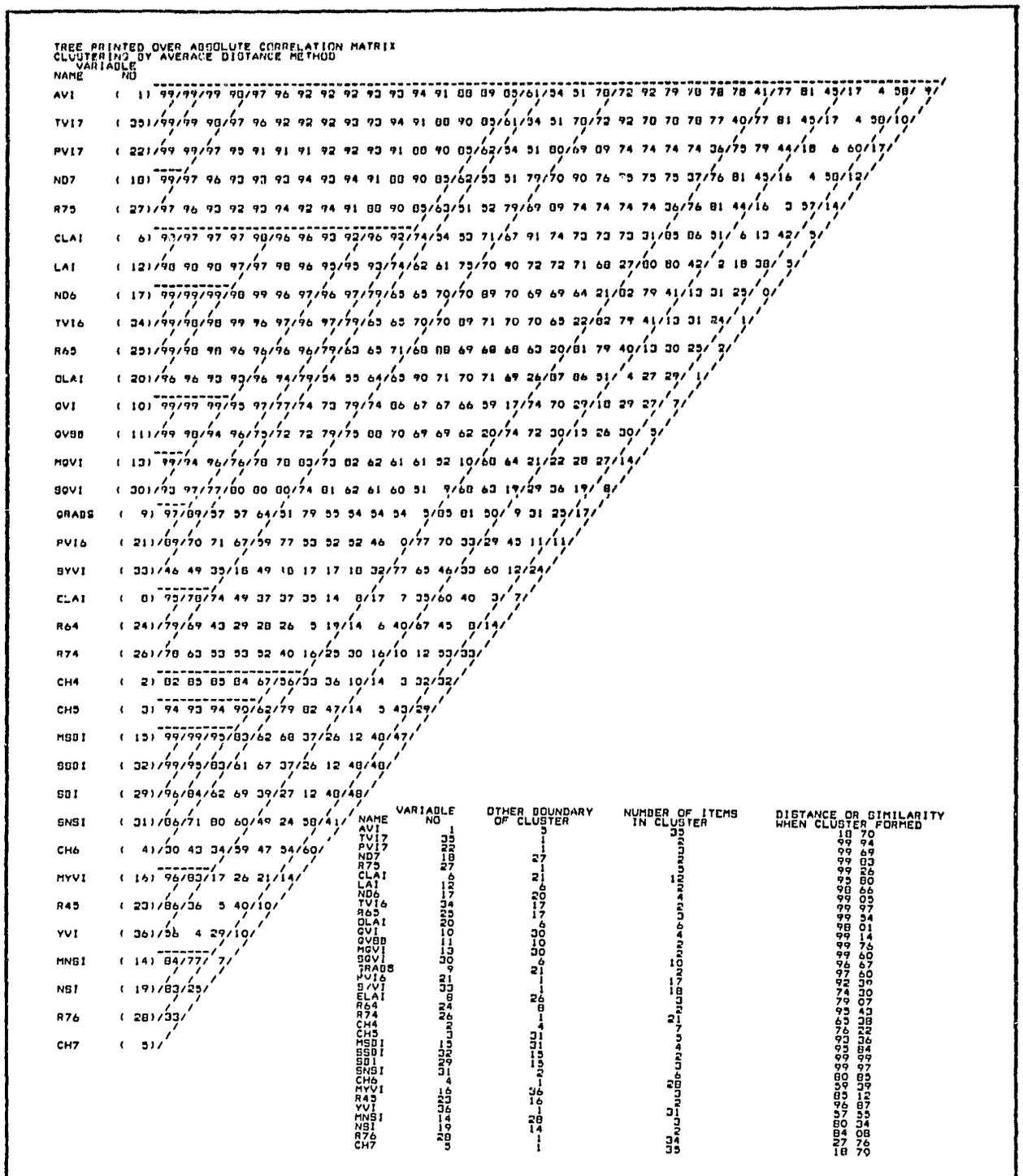


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	28	35	28 17
PVI7	22	1	2	99 48
ND7	18	27	3	99 17
TVI7	35	18	5	99 77
R75	27	1	8	97 52
CLAI	6	20	7	97 80
LAI	12	6	12	99 57
QVSD	11	25	4	98 89
ND6	17	25	3	99 16
TVI6	34	17	8	99 96
R65	25	6	6	98 75
QLAI	20	1	12	95 63
QRADS	9	30	5	96 05
PVI6	21	9	2	98 67
QVI	10	30	3	99 48
MQVI	13	30	2	99 66
SQVI	30	1	17	91 39
R64	24	26	2	87 63
R74	26	1	19	78 64
SYVI	33	1	20	65 24
MYVI	16	36	3	77 20
R45	23	16	2	94 01
YVI	36	1	23	57 57
CH4	2	5	8	62 26
CH5	3	31	5	89 45
MSDI	15	31	4	97 53
SSDI	32	15	2	99 99
SDI	29	15	3	99 97
SNSI	31	2	6	85 62
CH6	4	5	2	77 98
CH7	5	1	31	44 17
ELAI	8	28	4	30 25
MNSI	14	28	3	79 60
NSI	19	28	2	84 85
R76	28	1	35	28 17

Yolo County - May 12, 1978 - Field

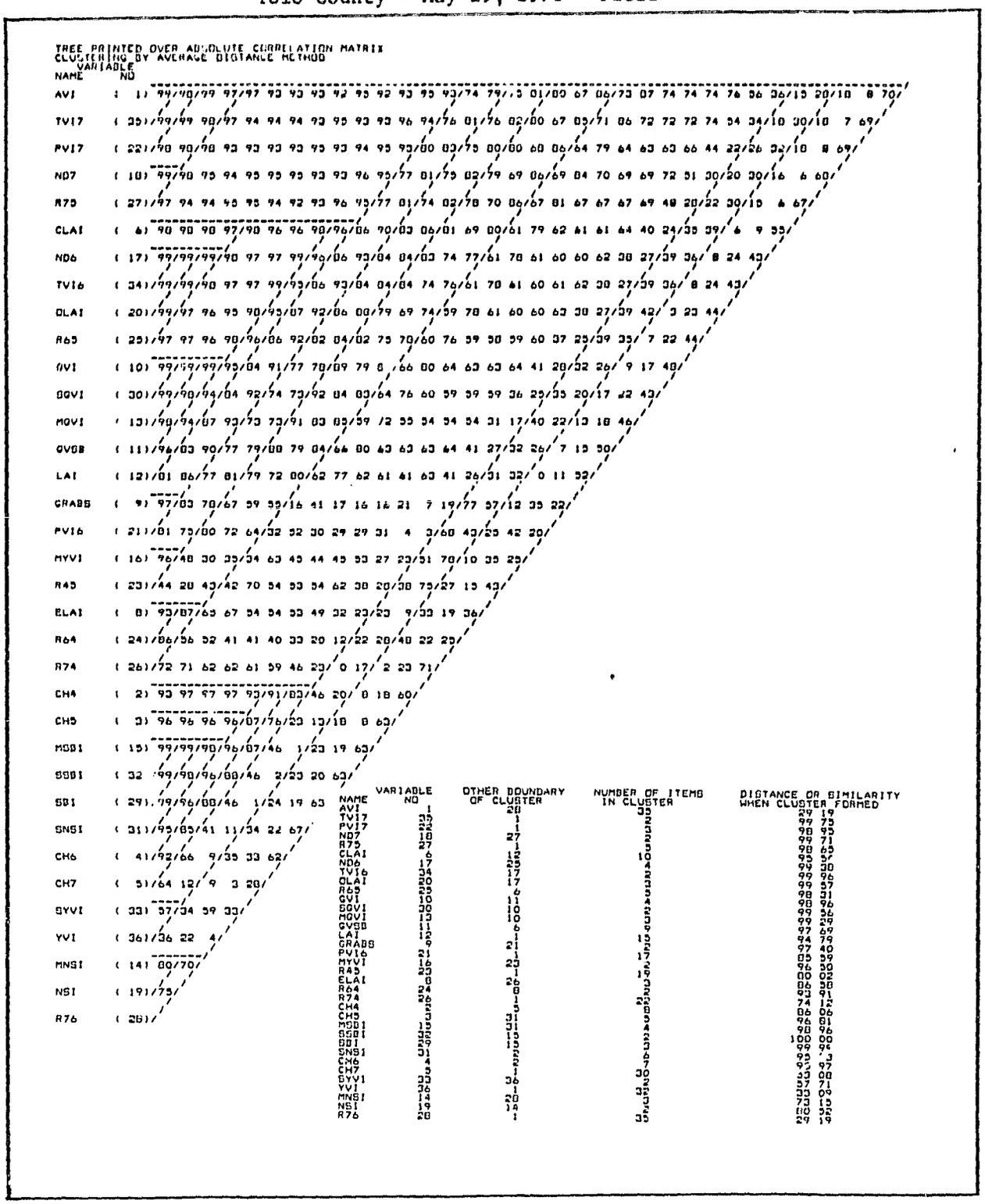


Yolo County - May 20, 1978 - Field

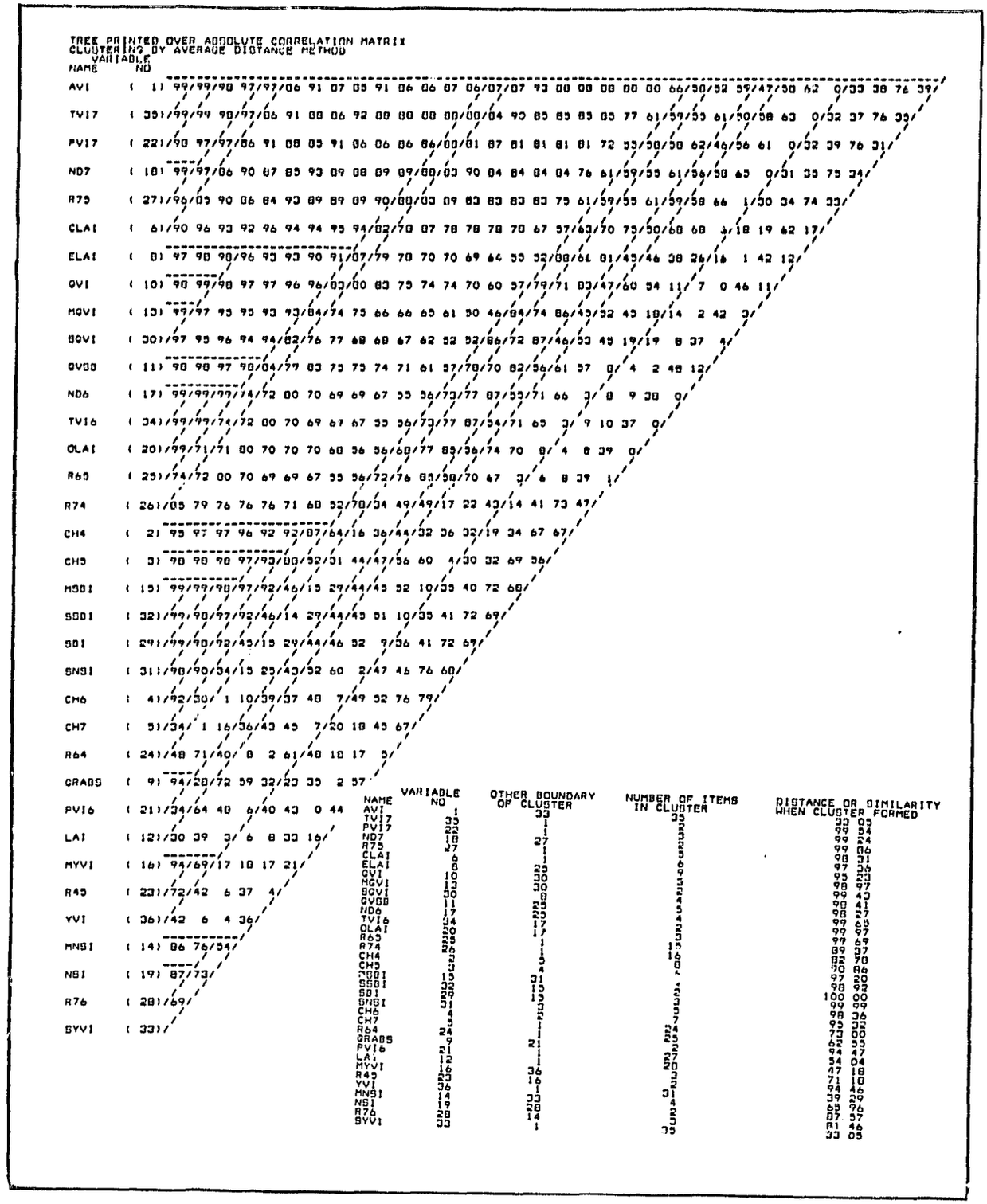


NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	5	35	18 70
TVI7	35	1	2	99 94
PVI7	22	1	3	99 69
ND7	18	27	2	99 83
R75	27	1	5	99 26
CLAI	6	21	1	95 80
LAI	12	6	2	98 66
ND6	17	20	4	99 05
TVI6	34	17	5	99 97
R65	25	17	6	99 34
OLAI	20	6	5	98 01
GVI	10	30	4	99 14
GVBB	11	10	2	99 76
MGVI	13	30	3	99 60
SGVI	30	6	10	96 67
GRASS	9	21	2	97 60
PVI6	21	1	17	92 30
BYVI	33	1	18	74 30
ELAI	8	26	2	79 07
R64	24	8	20	93 43
R74	26	1	21	65 38
CH4	2	4	2	76 22
CH5	3	31	5	90 36
MSBI	15	31	4	95 84
SSBI	32	15	2	99 99
SBI	29	15	6	99 97
SNSI	31	2	8	80 85
CH6	4	1	2	59 29
MYVI	16	36	2	85 12
R45	23	16	2	96 87
YVI	36	1	31	57 55
MNSI	14	28	2	80 34
NSI	19	14	2	84 08
R76	28	1	34	27 76
CH7	5	1	35	18 70

Yolo County - May 29, 1978 - Field



Yolo County - June 16, 1978 - Field



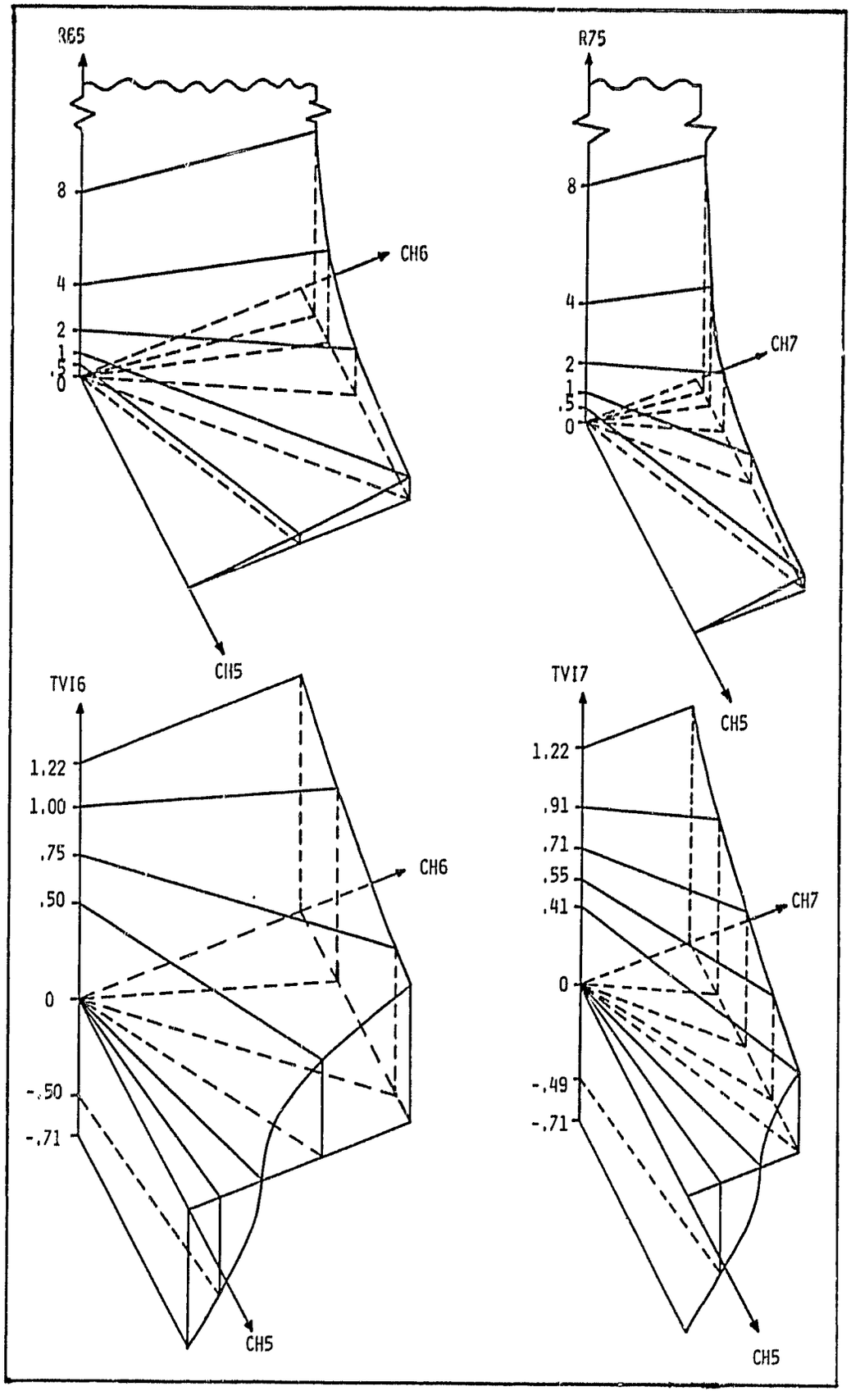
NAME	VARIABLE NO	OTHER BOUNDARY OF CLUSTER	NUMBER OF ITEMS IN CLUSTER	DISTANCE OR SIMILARITY WHEN CLUSTER FORMED
AVI	1	33	35	33 05
TVI7	35	1	2	99 54
PVI7	22	1	2	99 54
ND7	10	27	2	99 06
R75	27	1	2	98 31
CLAI	6	1	2	97 34
ELAI	8	23	2	95 25
QVI	10	30	2	98 97
MQVI	13	30	3	99 43
BQVI	30	0	5	98 41
QV00	11	23	2	98 27
ND6	17	25	4	99 65
TVI6	34	17	5	99 97
OLAI	20	17	3	99 69
R65	25	1	2	89 37
R74	26	1	15	82 78
CH4	2	1	2	90 86
CH5	3	4	4	97 20
MSSI	15	31	7	98 92
SSSI	32	15	12	100 00
SSI	29	15	13	99 99
SNSI	31	3	5	98 36
CH6	4	5	7	95 00
CH7	5	2	9	73 00
R64	24	1	22	62 55
GRASS	9	21	3	94 47
PVI6	21	1	23	54 04
LAI	12	1	27	47 18
MYVI	16	36	20	71 10
R45	23	16	2	94 46
YVI	36	1	2	39 29
MNSI	14	33	31	65 96
NSI	19	28	4	87 37
R76	28	14	2	81 46
SYVI	33	1	35	33 05

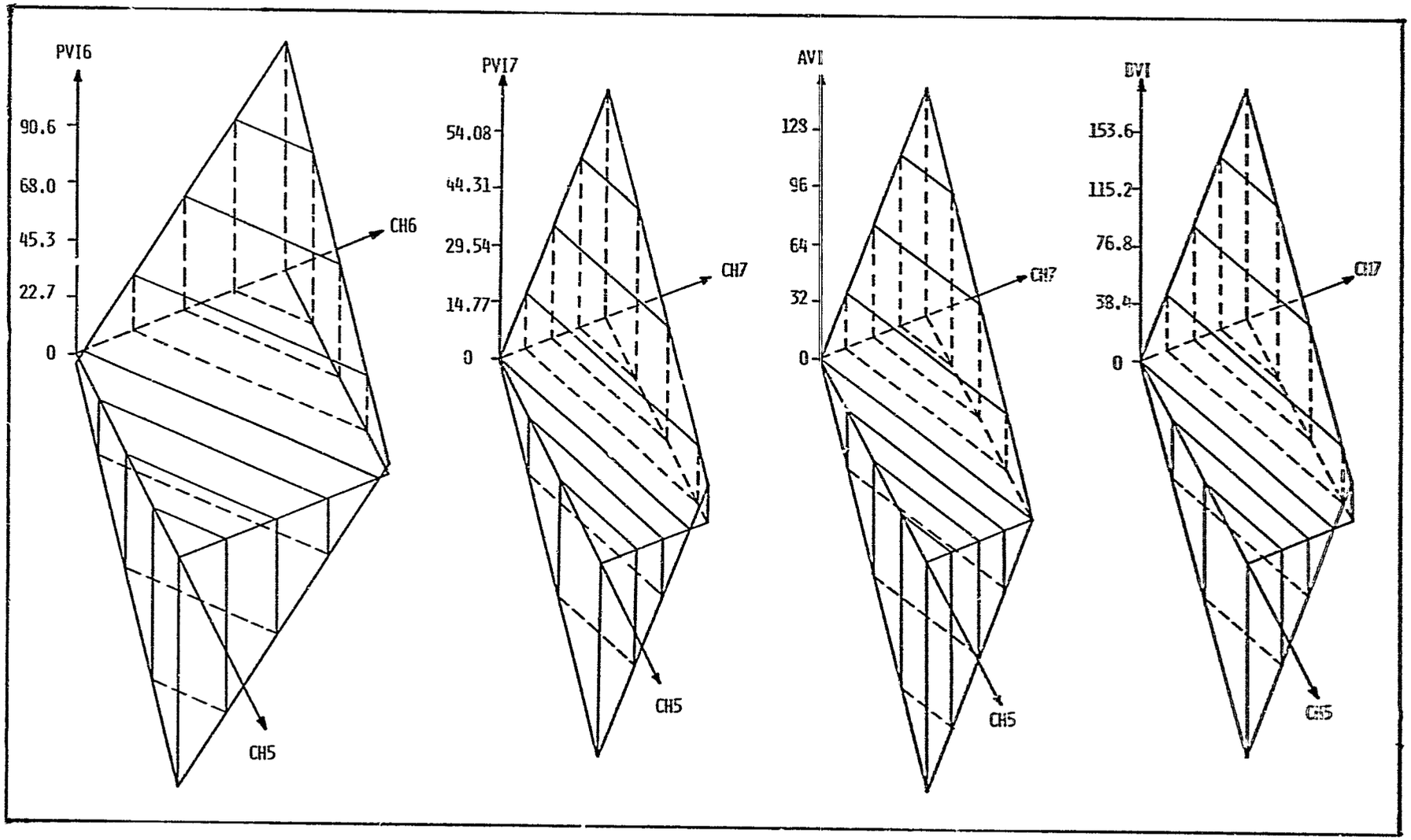
APPENDIX C

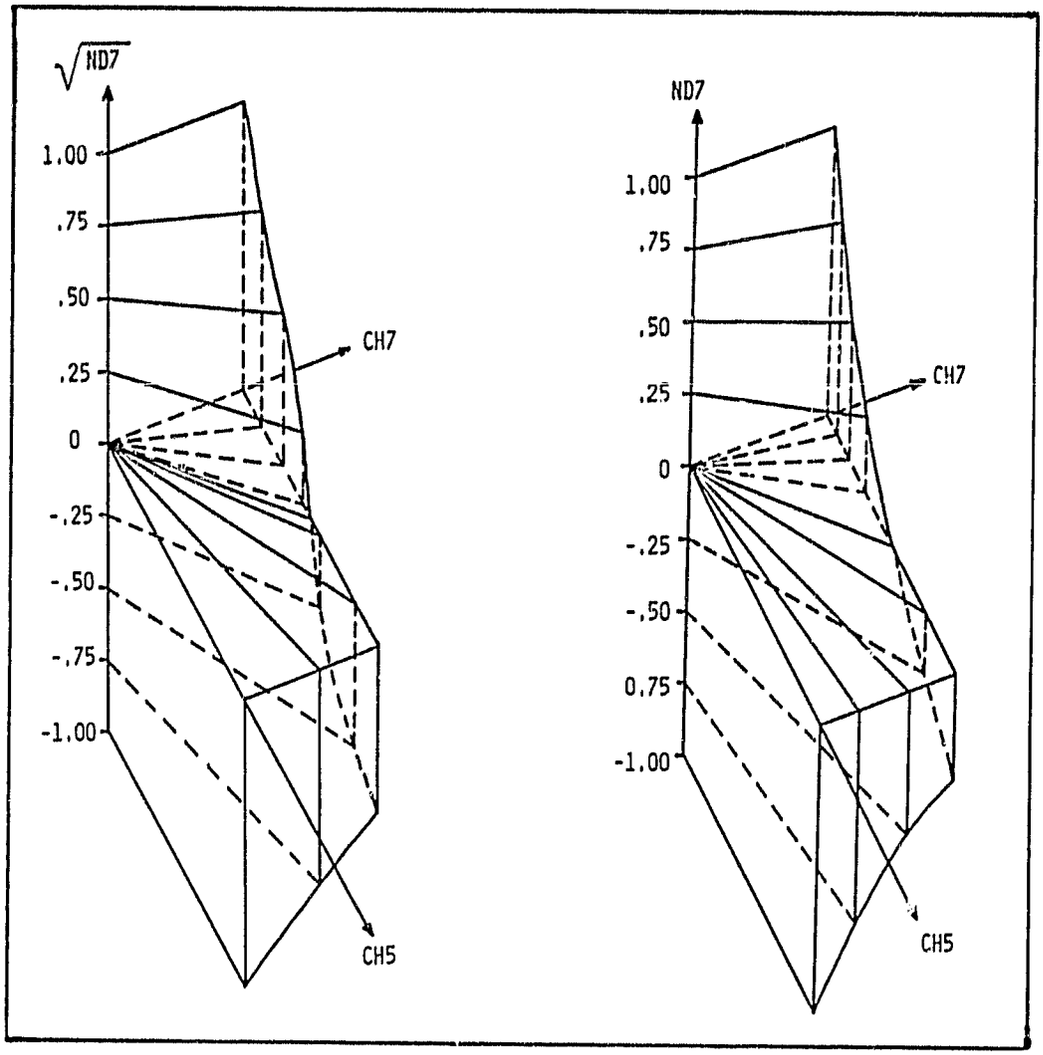
GRAPHICAL REPRESENTATION OF VEGETATION INDICES

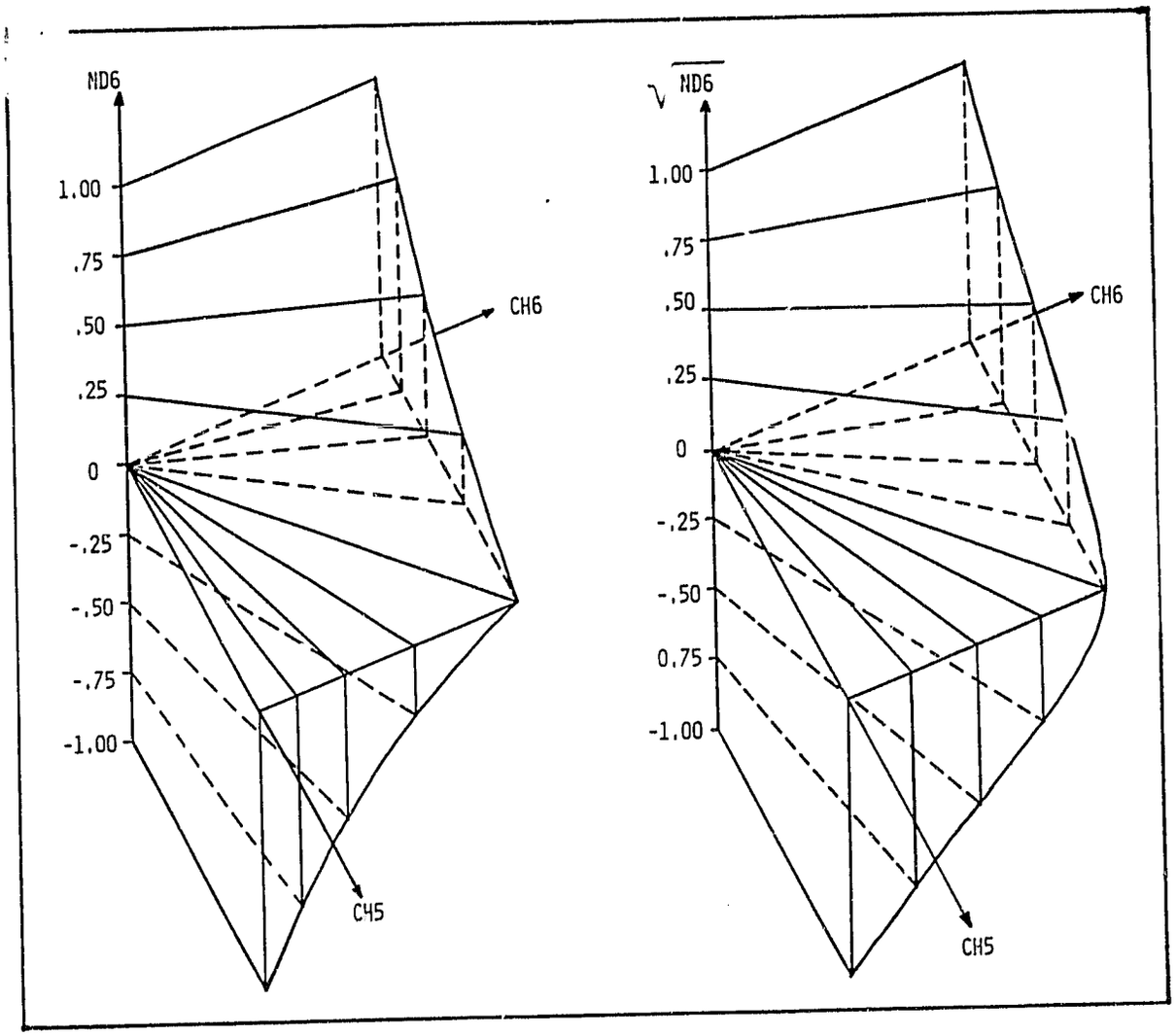
Part 1. Graphical representation of response surfaces and equivalent classes associated with VIs involving two MSS channels.

Graphs for the square root of ND6 and ND7 are included in this appendix. They probably have been studied by other investigators; however, we found no specific reference to them.


R65
8
4
2
1
.5
0
CH6
CH5
R75
8
4
2
1
.5
0
CH7
CH5
TVI6
1.22
1.00
.75
.50
0
-.50
-.71
CH6
CH5
TVI7
1.22
.91
.71
.55
.41
0
-.49
-.71
CH7
CH5


PVI6
90.6
68.0
45.3
22.7
0
CH6
CH5
PVI7
54.08
44.31
29.54
14.77
0
CH7
CH5
AVI
128
96
64
32
0
CH7
CH5
EVI
153.6
115.2
76.8
38.4
0
CH7
CH5


√ND7
1.00
.75
.50
.25
0
-.25
-.50
-.75
-1.00
CH7
CH5
ND7
1.00
.75
.50
.25
0
-.25
-.50
0.75
-1.00
CH7
CH5


ND6
1.00
.75
.50
.25
0
-.25
-.50
-.75
-1.00
CH6
CH5
√ ND6
1.00
.75
.50
.25
0
-.25
-.50
0.75
-1.00
CH6
CH5

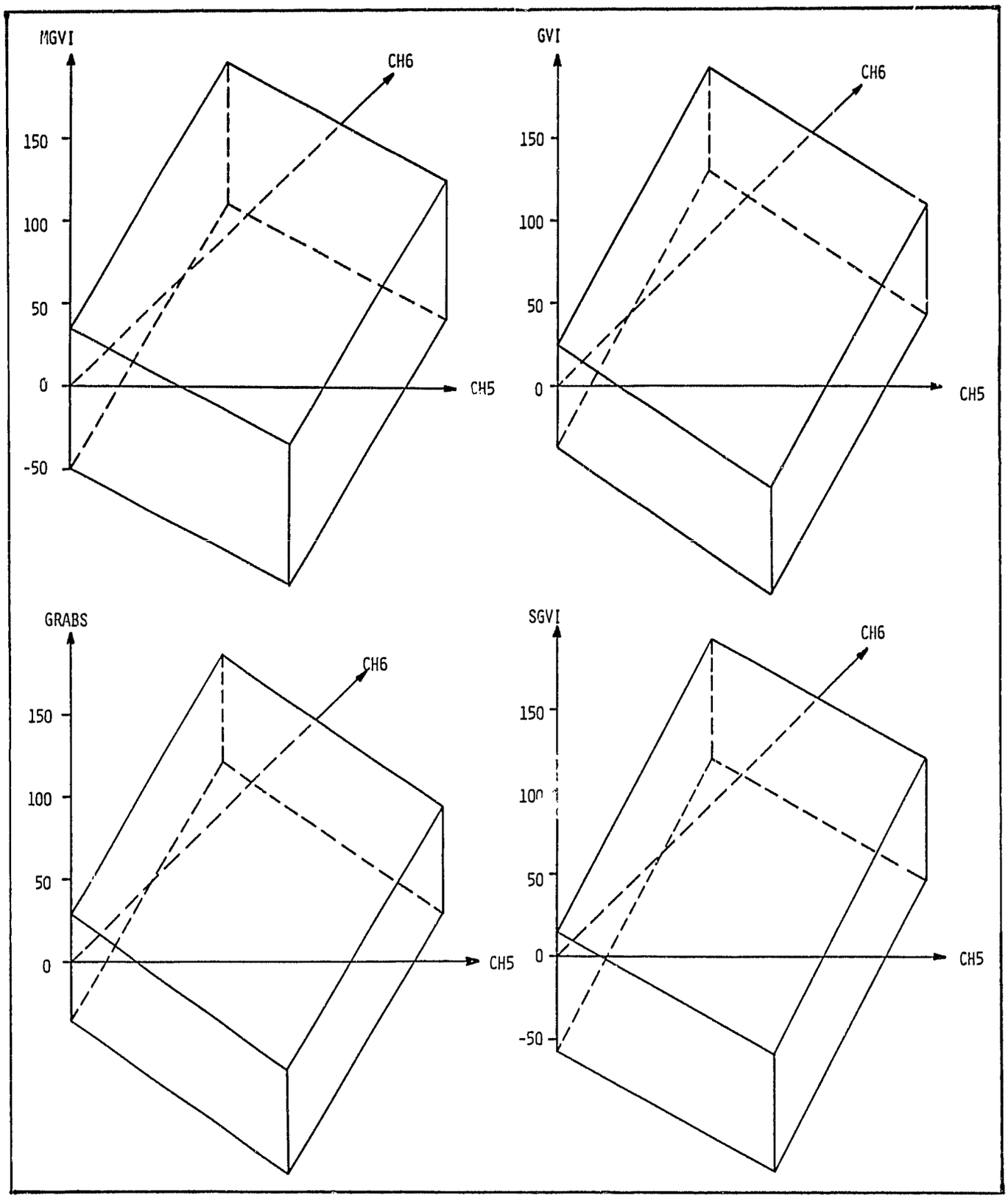
C-2

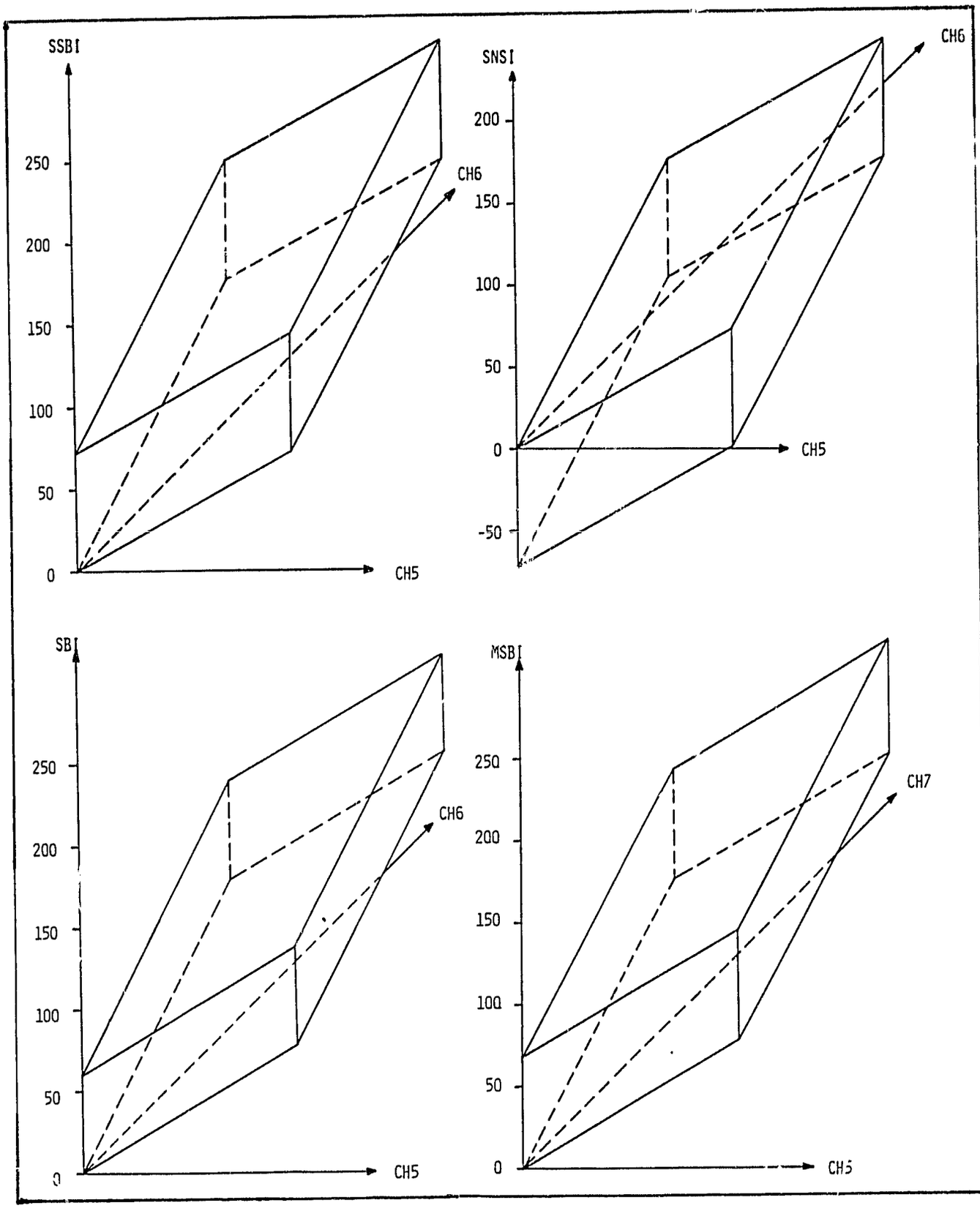
APPENDIX C

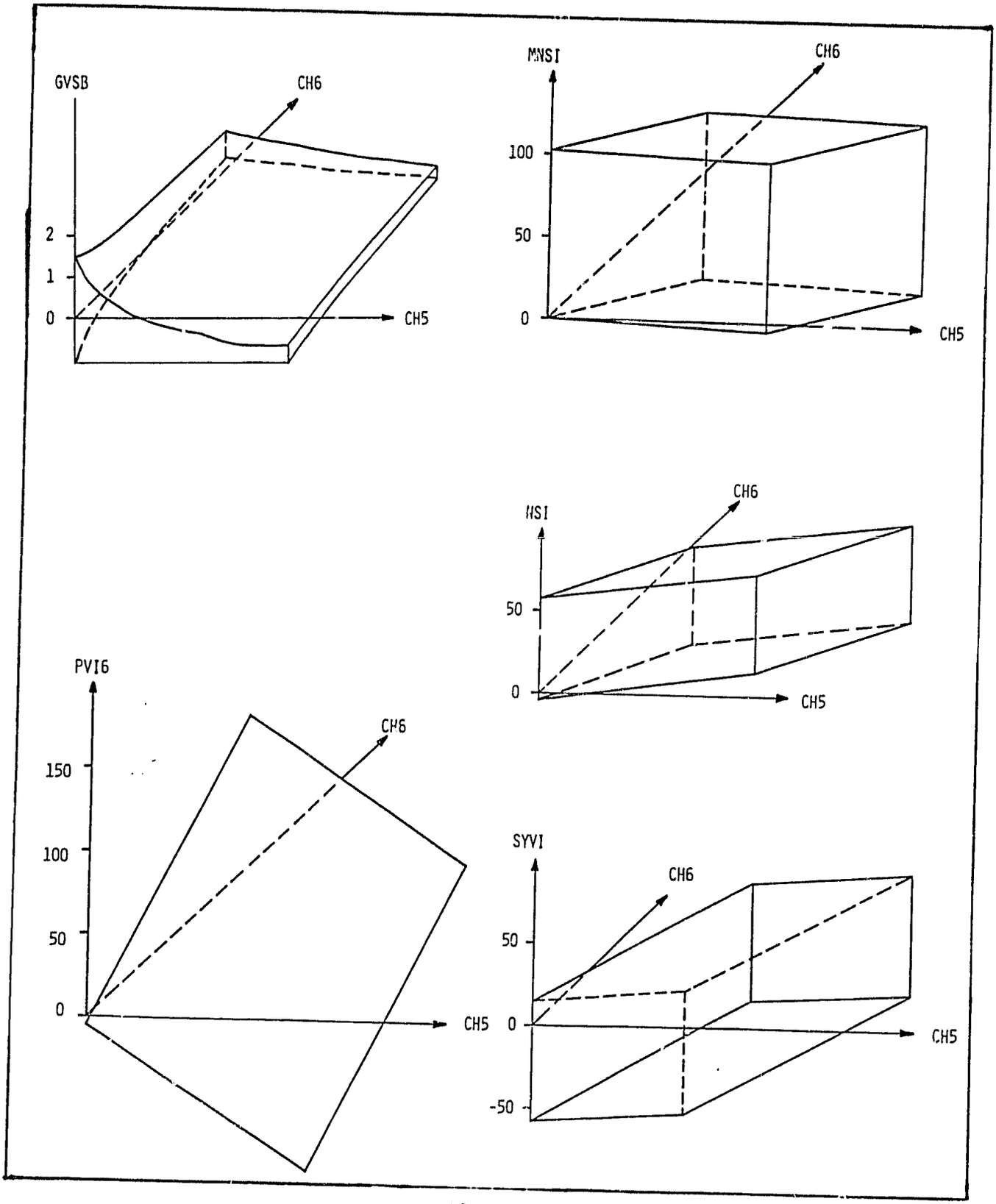
GRAPHICAL REPRESENTATION OF VEGETATION INDICES

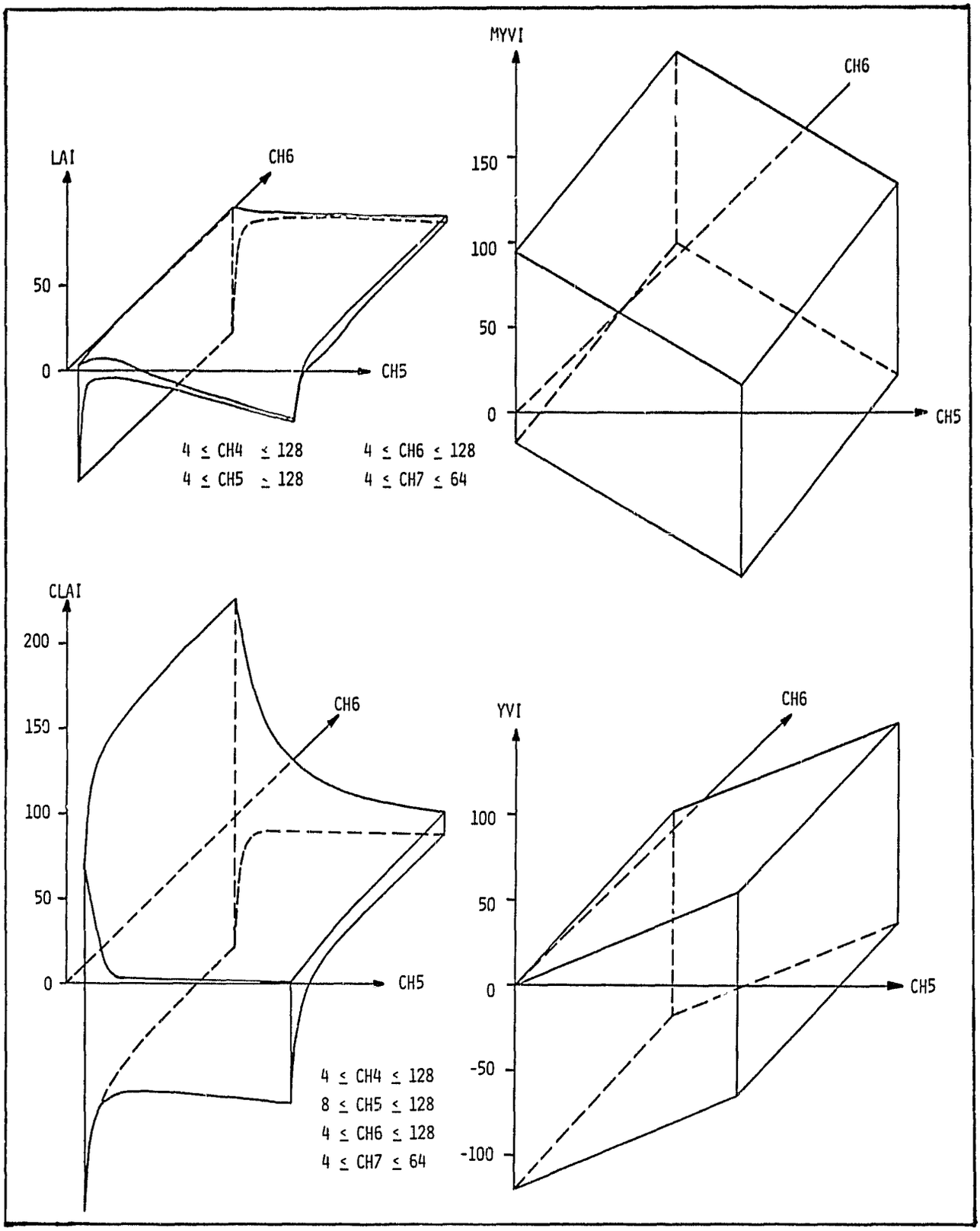
Part 2. Generalized representation of VIs involving more than two MSS channels.

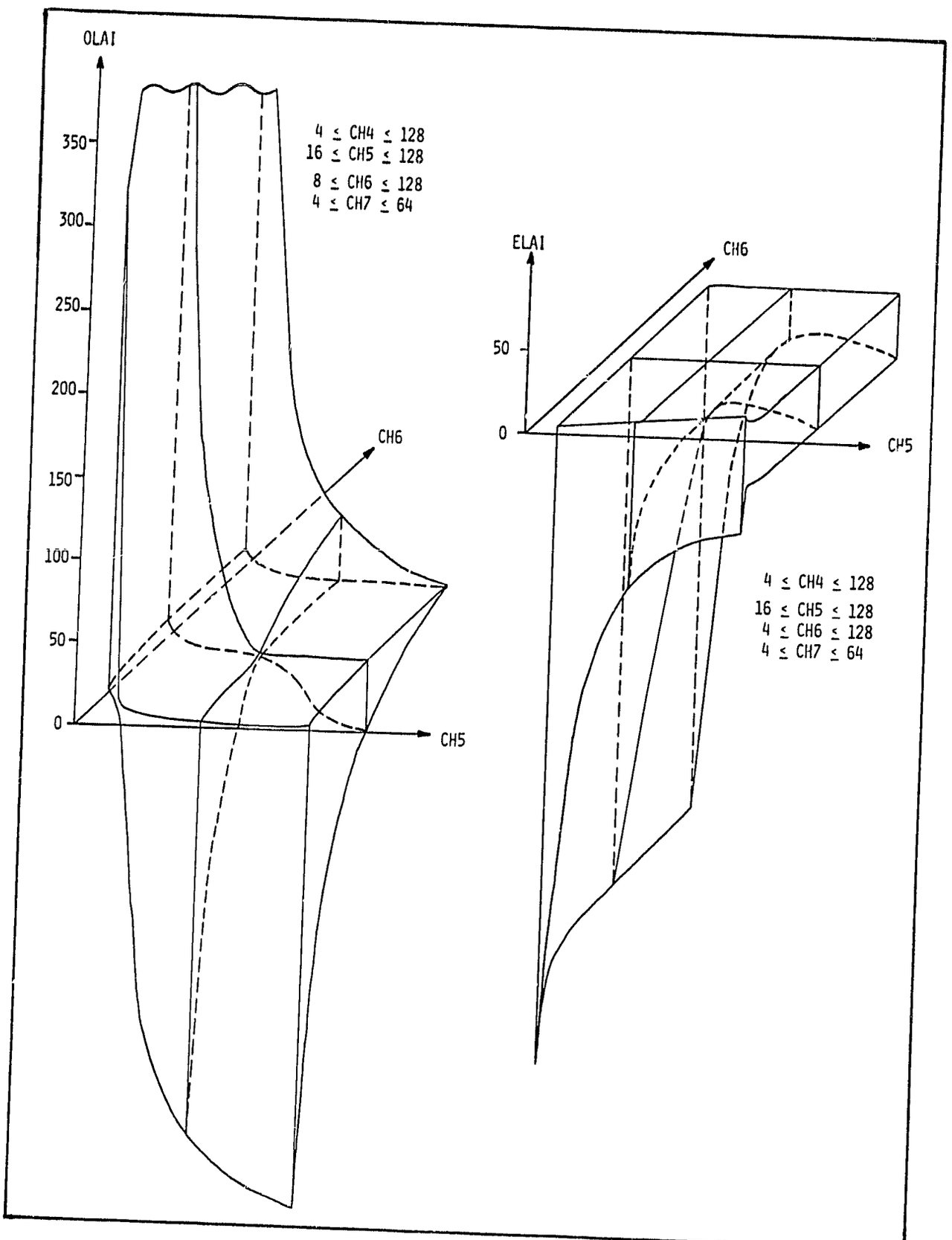
Representation in 3 dimension of vegetative indices involving more than two MSS channels is not possible. However, insight into this behavior is obtained by studying their range as a function of two MSS channels. In these graphs, the VI's range is represented on the vertical axis for fixed two-dimensional subsets of the MSS data. Care should be used in interpretating these graphs, and consideration should be given to the high correlations that are known to exist between (CH4 and CH5) and (CH6 and CH7). Even with these limitations, these graphs show the close relationship between the soil brightness components and greenness components of the Kauth-Thomas and the two Misra-Wheeler transformations.

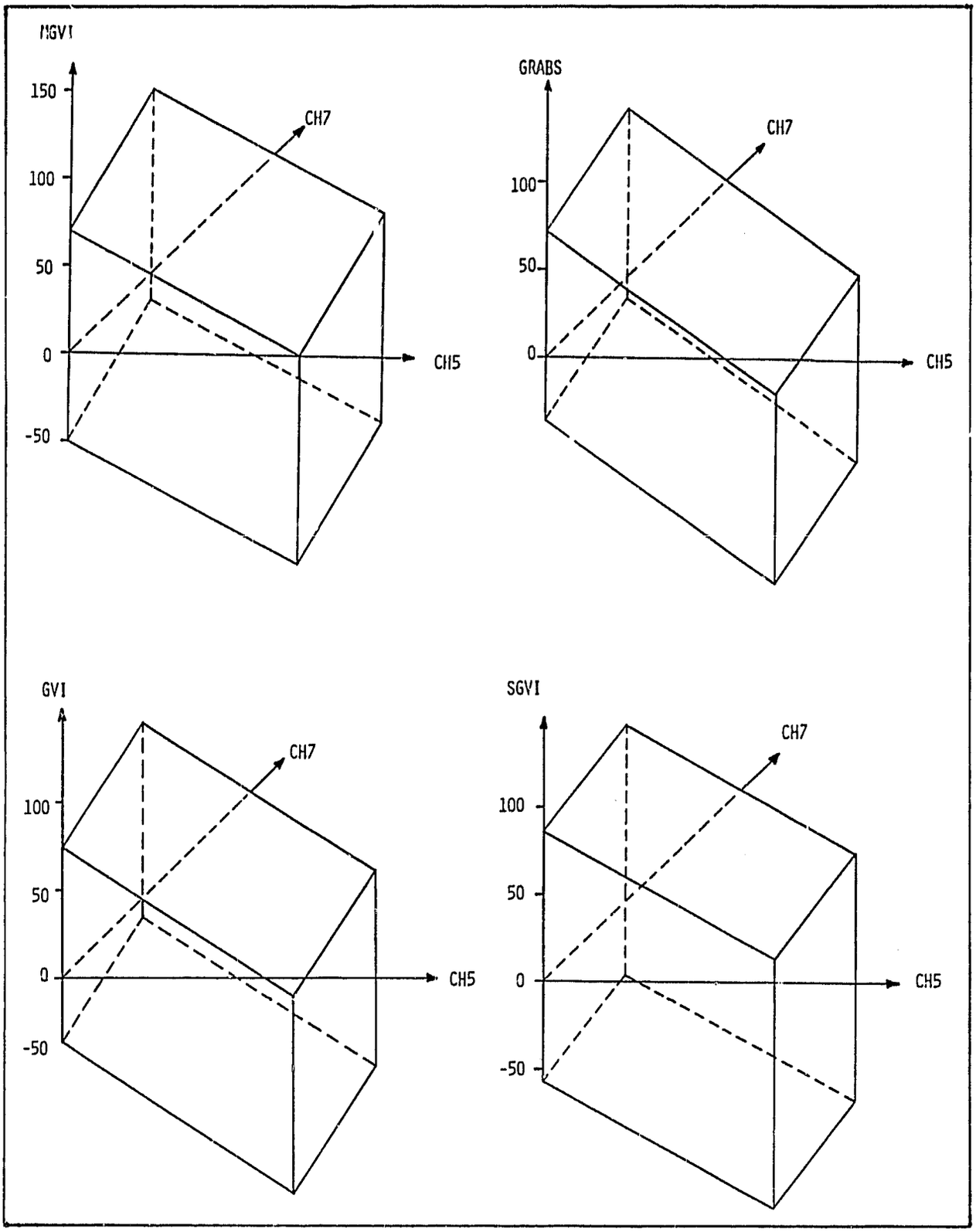

MGVI
CH6
150
100
50
0
-50
CH5
GVI
CH6
150
100
50
0
CH5
GRABS
CH6
150
100
50
0
CH5
SGVI
CH6
150
100
50
0
-50
CH5

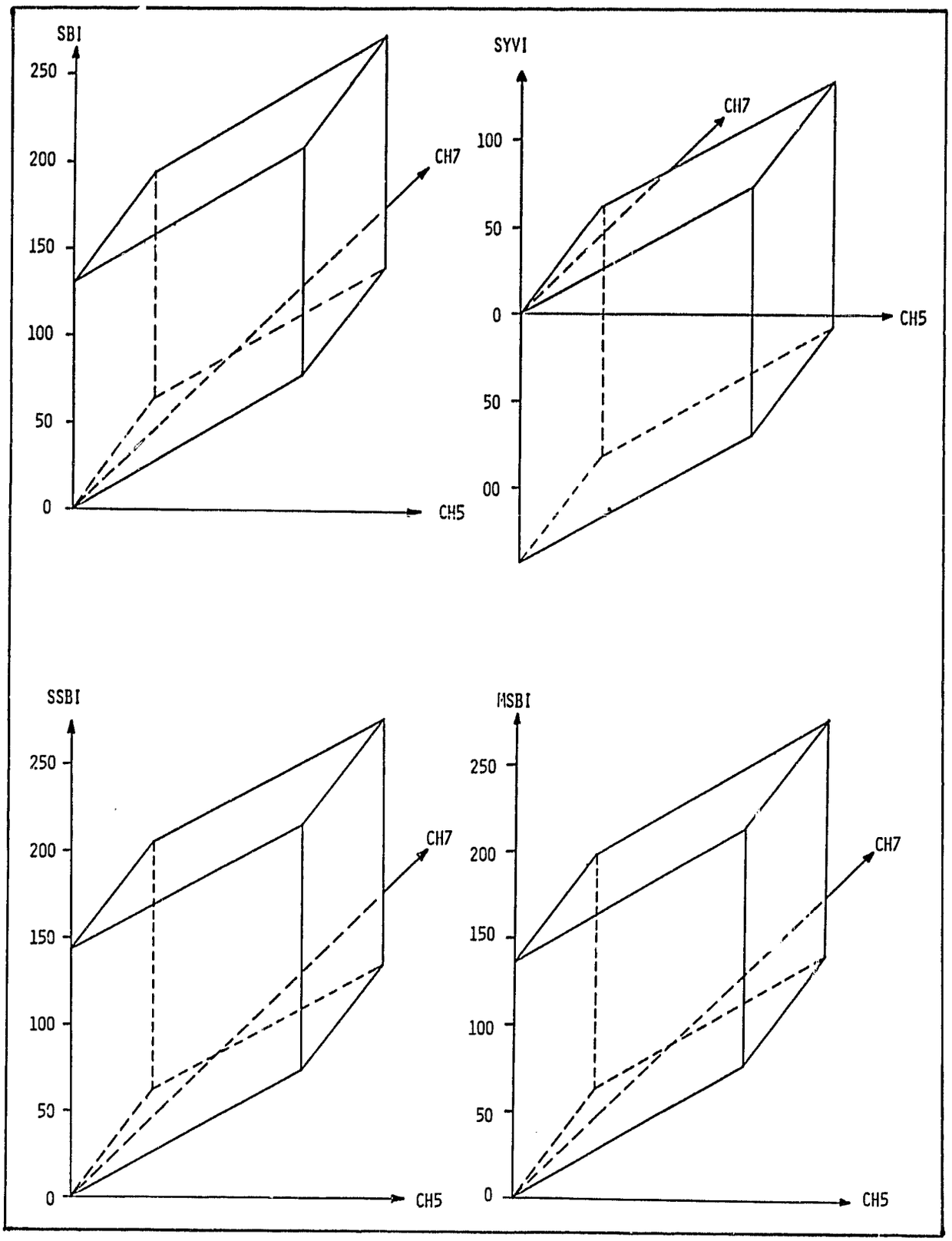

SSBI
250
200
150
100
50
0
CH6
CH5
SNSI
200
150
100
50
0
-50
CH6
CH5
SBI
250
200
150
100
50
0
CH6
CH5
MSBI
250
200
150
100
50
0
CH7
CH5

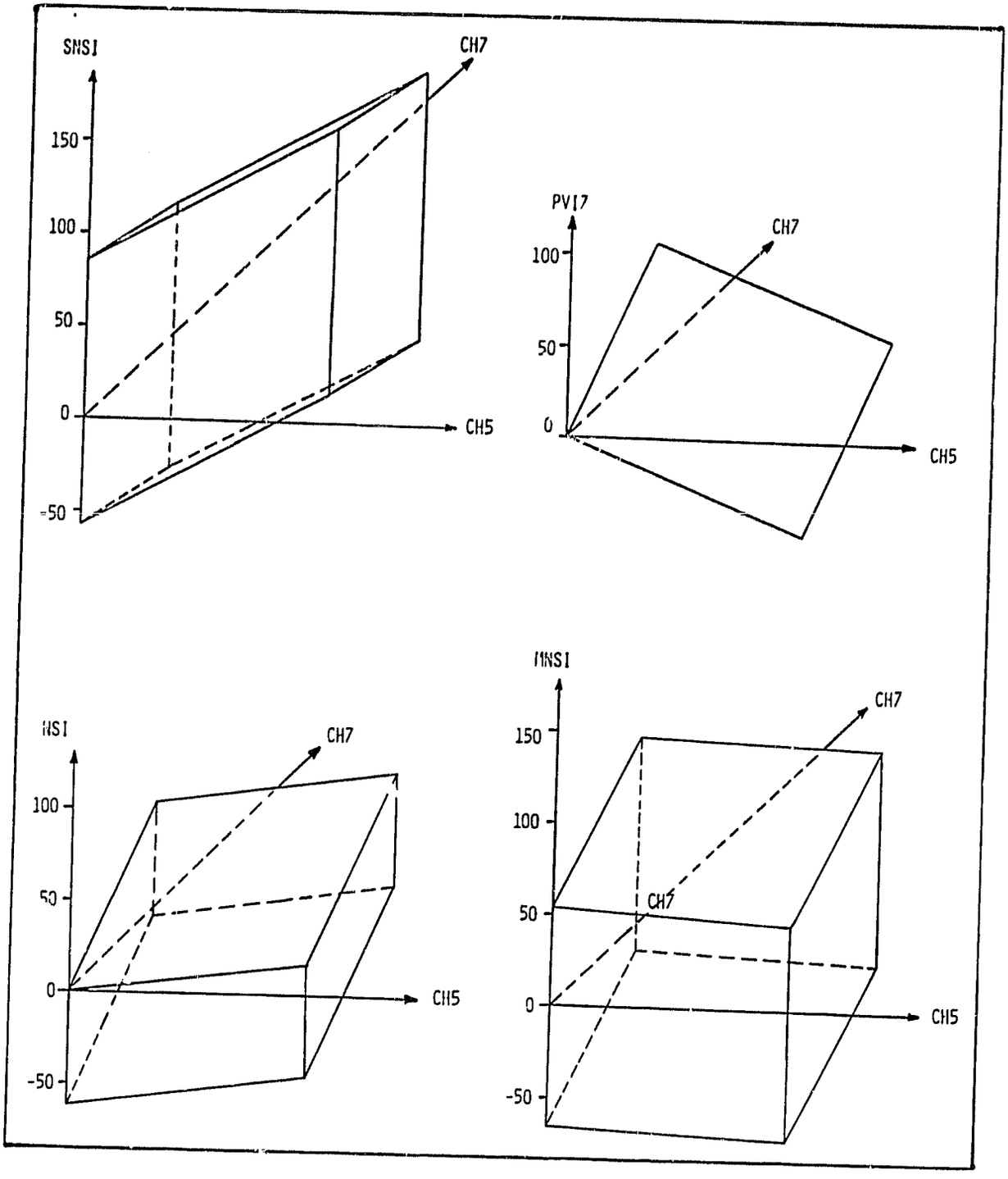

GVSB
CH6
2
1
0
CH5
MNSI
CH6
100
50
0
CH5
NSI
CH6
50
0
CH5
PVI6
CH6
150
100
50
0
CH5
SYVI
CH6
50
0
-50
CH5

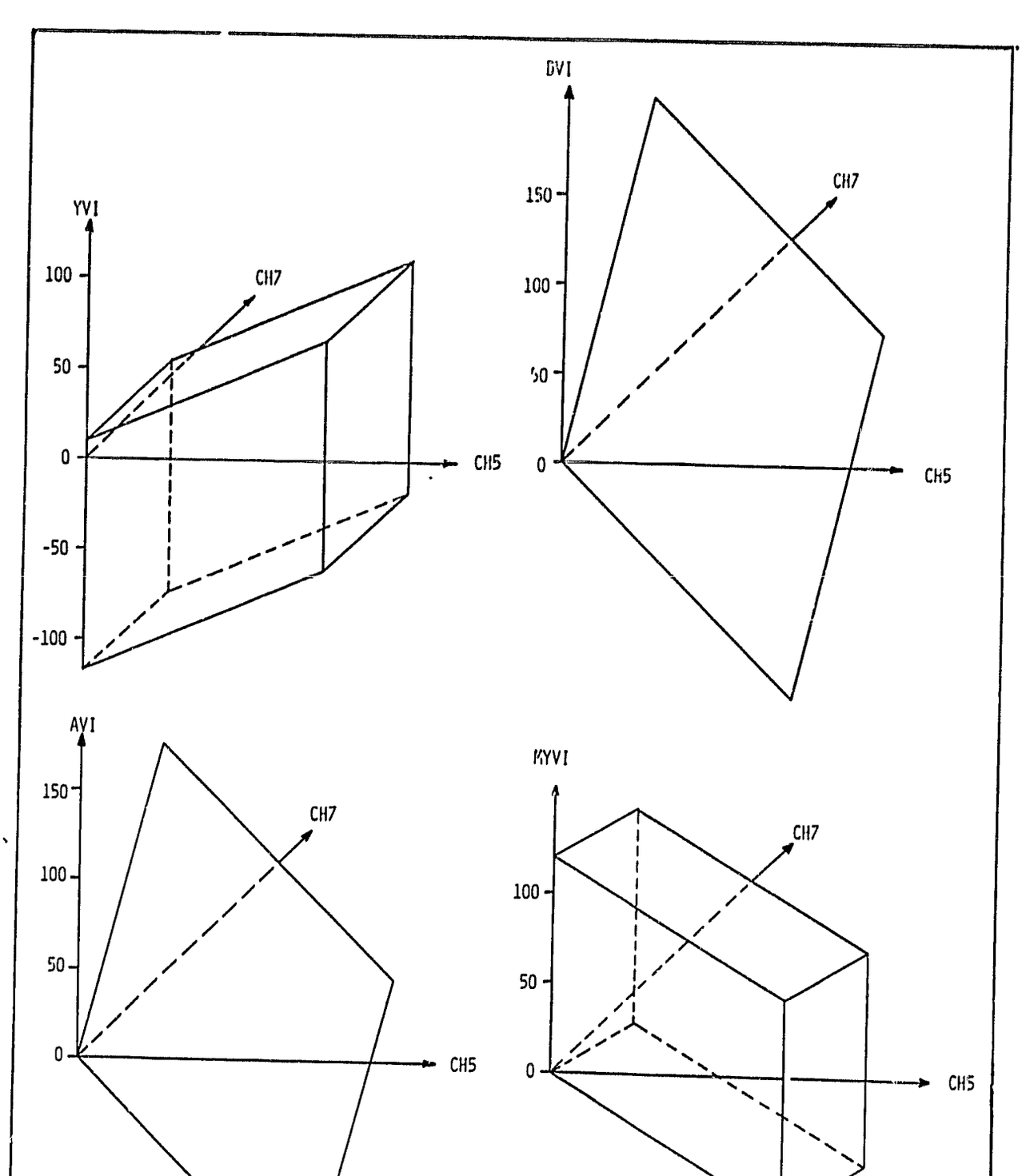

LAI
CH6
50
0
CH5
4 ≤ CH4 ≤ 128
4 ≤ CH5 ≤ 128
4 ≤ CH6 ≤ 128
4 ≤ CH7 ≤ 64
MYVI
CH6
150
100
50
0
CH5
CLAI
200
150
100
50
0
CH6
CH5
4 ≤ CH4 ≤ 128
8 ≤ CH5 ≤ 128
4 ≤ CH6 ≤ 128
4 ≤ CH7 ≤ 64
YVI
CH6
100
50
0
-50
-100
CH5


OLAI
350
300
250
200
150
100
50
0
CH6
CH5
4 ≤ CH4 ≤ 128
16 ≤ CH5 ≤ 128
8 ≤ CH6 ≤ 128
4 ≤ CH7 ≤ 64
ELAI
50
0
CH6
CH5
4 ≤ CH4 ≤ 128
16 ≤ CH5 ≤ 128
4 ≤ CH6 ≤ 128
4 ≤ CH7 ≤ 64


MGVI
150
100
50
0
-50
CH7
CH5
GRABS
100
50
0
CH7
CH5
GVI
100
50
0
-50
CH7
CH5
SGVI
100
50
0
-50
CH7
CH5


SBI
250
200
150
100
50
0
CH7
CH5
SYVI
100
50
0
50
00
CH7
CH5
SSBI
250
200
150
100
50
0
CH7
CH5
MSBI
250
200
150
100
50
0
CH7
CH5


SNSI
CH7
150
100
50
0
-50
CH5
PVI7
CH7
100
50
0
CH5
NSI
CH7
100
50
0
-50
CH5
MNSI
CH7
150
100
50
CH7
0
-50
CH5


YVI
100
50
0
-50
-100
CH7
CH5
DVI
150
100
50
0
CH7
CH5
AVI
150
100
50
0
CH7
CH5
KYVI
100
50
0
CH7
CH5

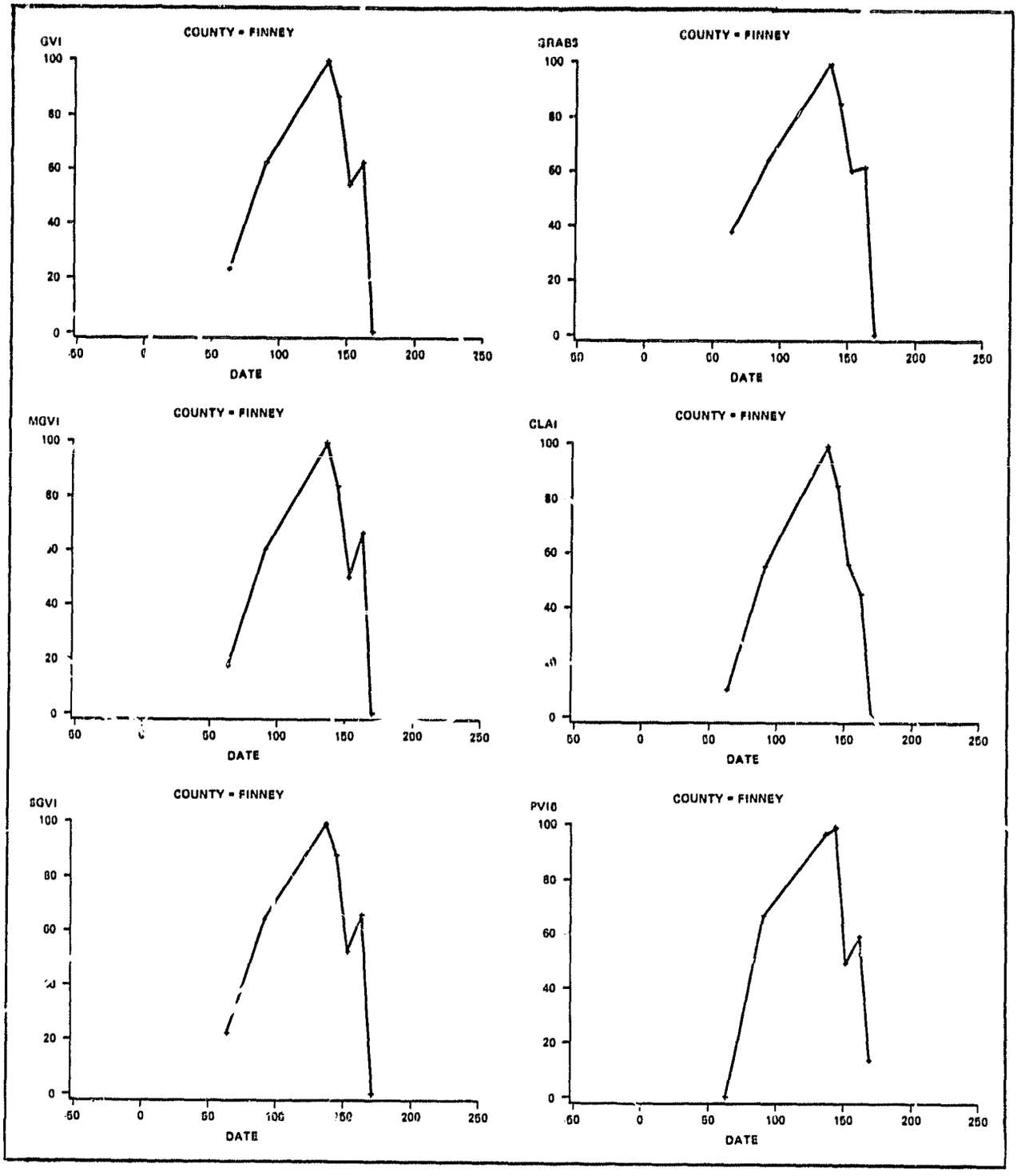
APPENDIX D

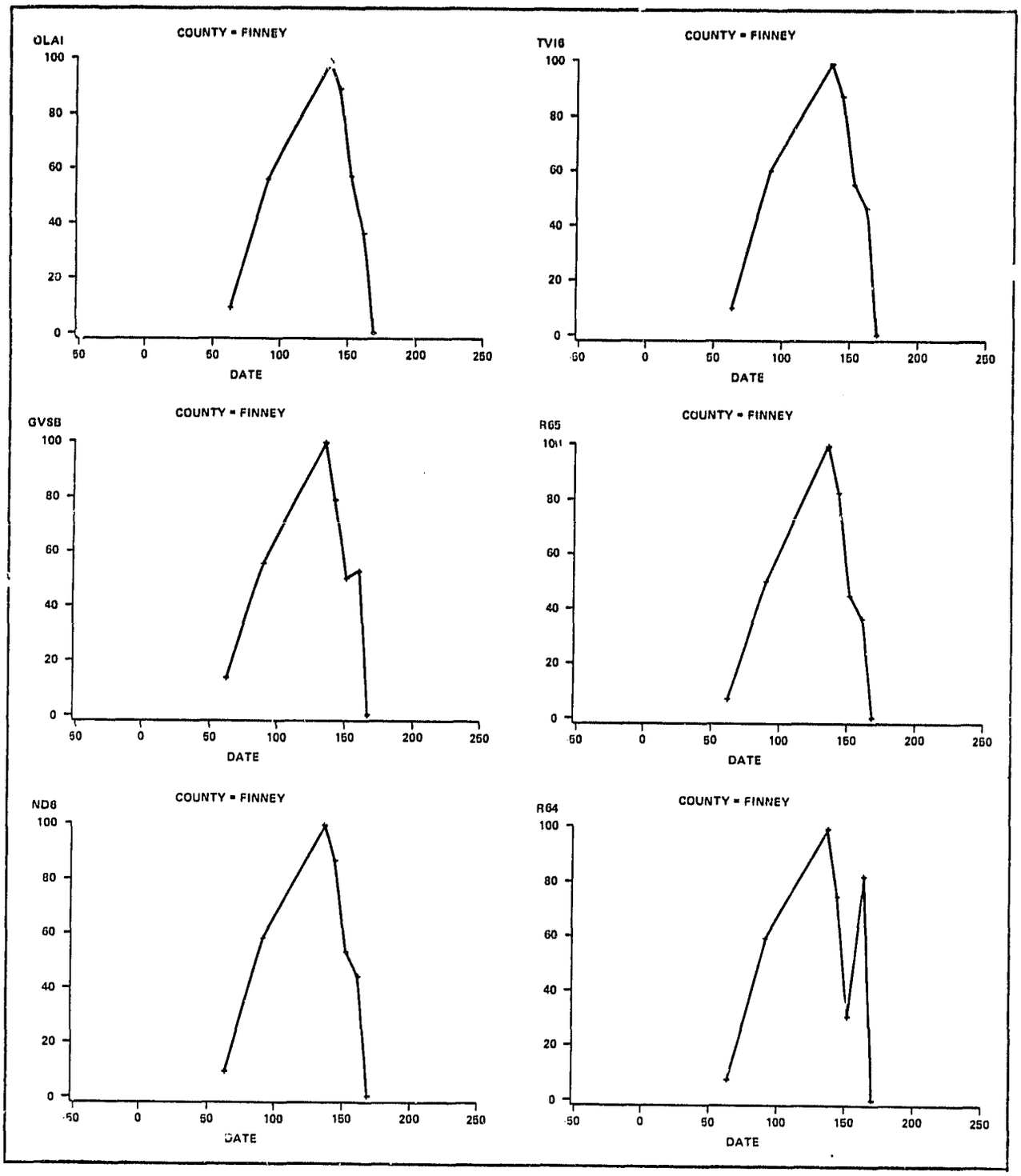
VEGETATION INDICES TRAJECTORIES

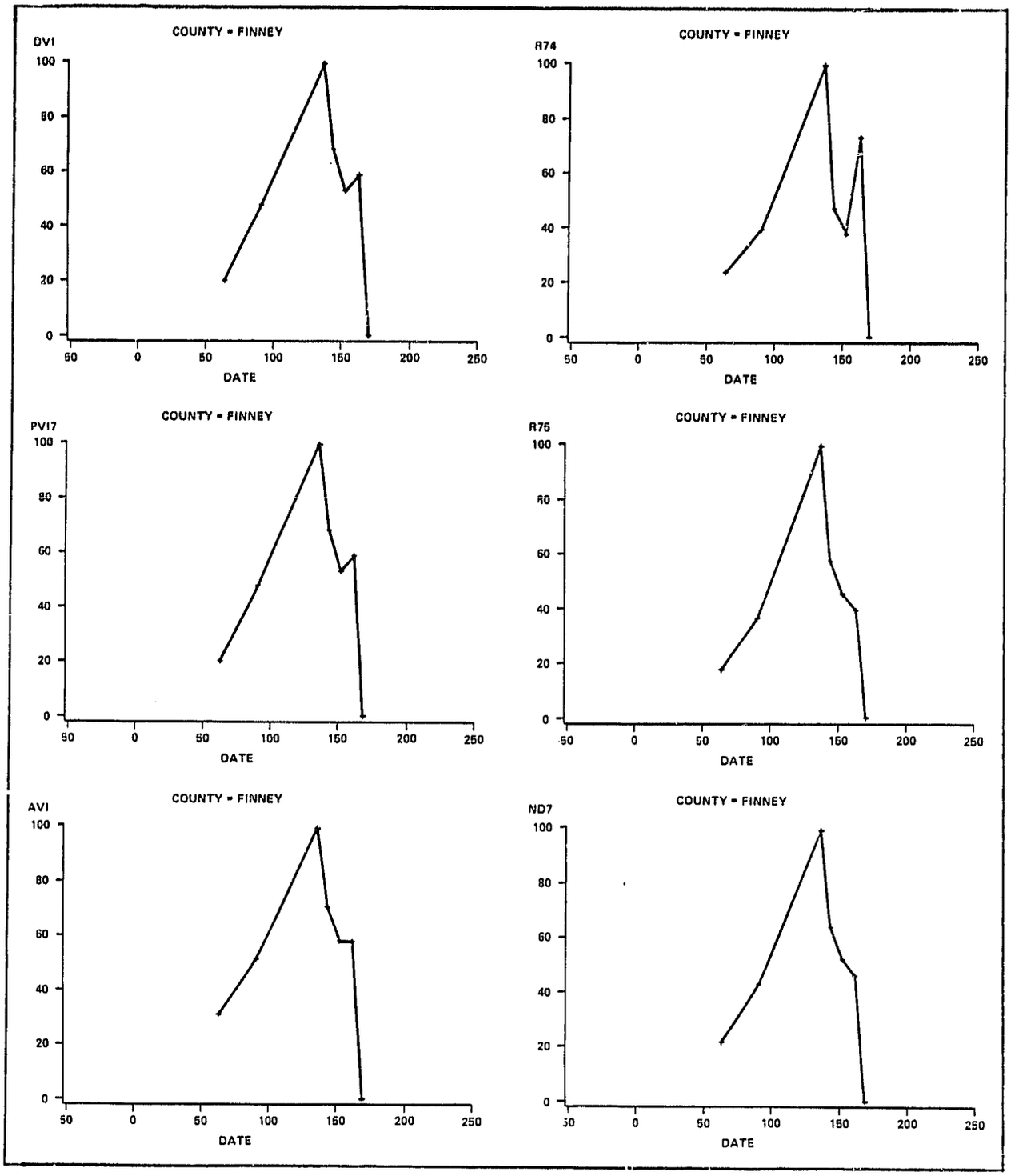
It is well known that two quantities may be functionally related and yet have zero linear correlation. This possibility was studied by graphing VIs over time. All VIs were rescaled to range from 0 to 100 to facilitate interpretations.

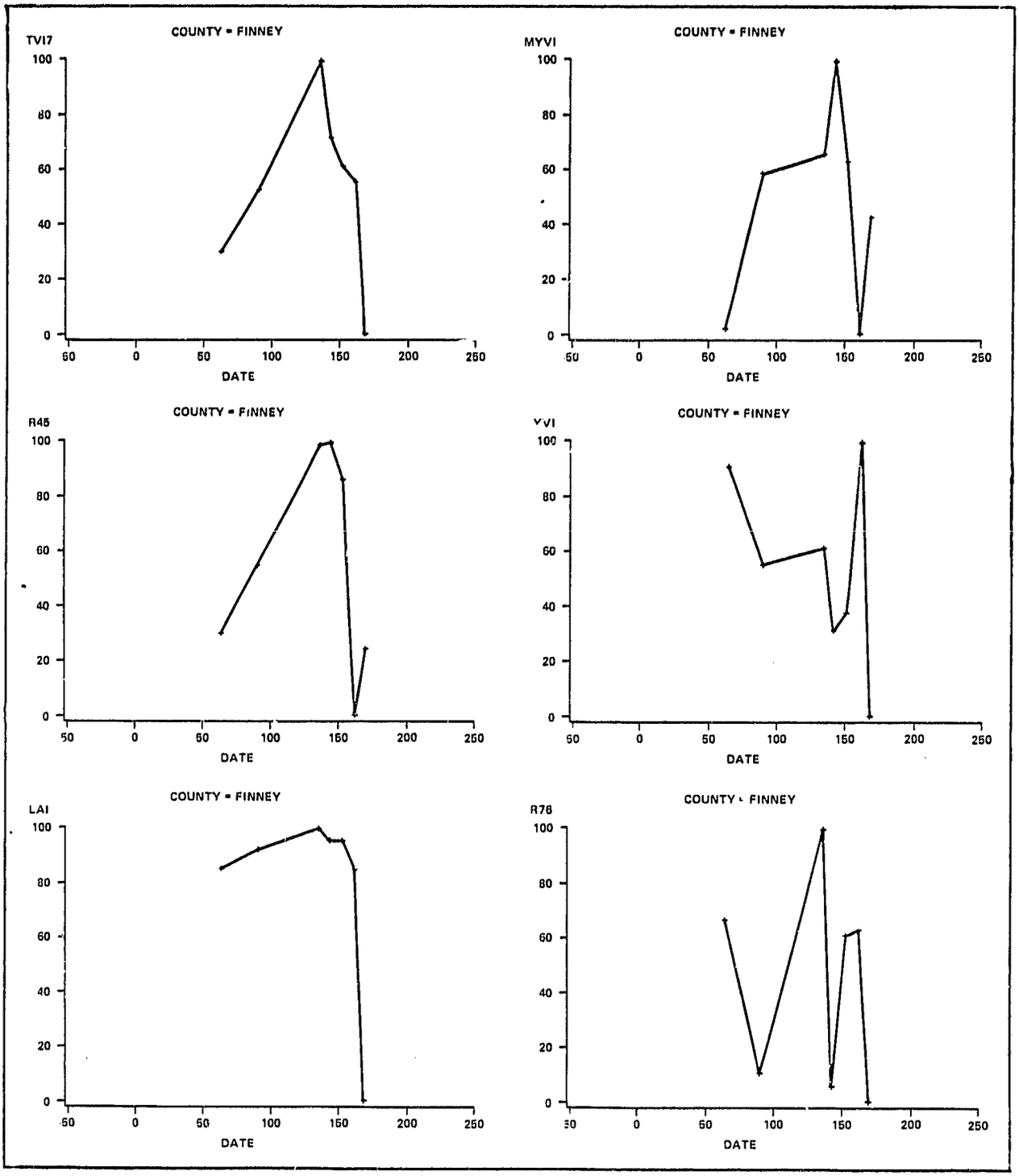
This analysis revealed that some VIs were more closely related than their bivariate correlations had indicated. In some cases, the relationships appear to be close but nonlinear; in others, the correlations break down outside the period of spring greenup to harvest.

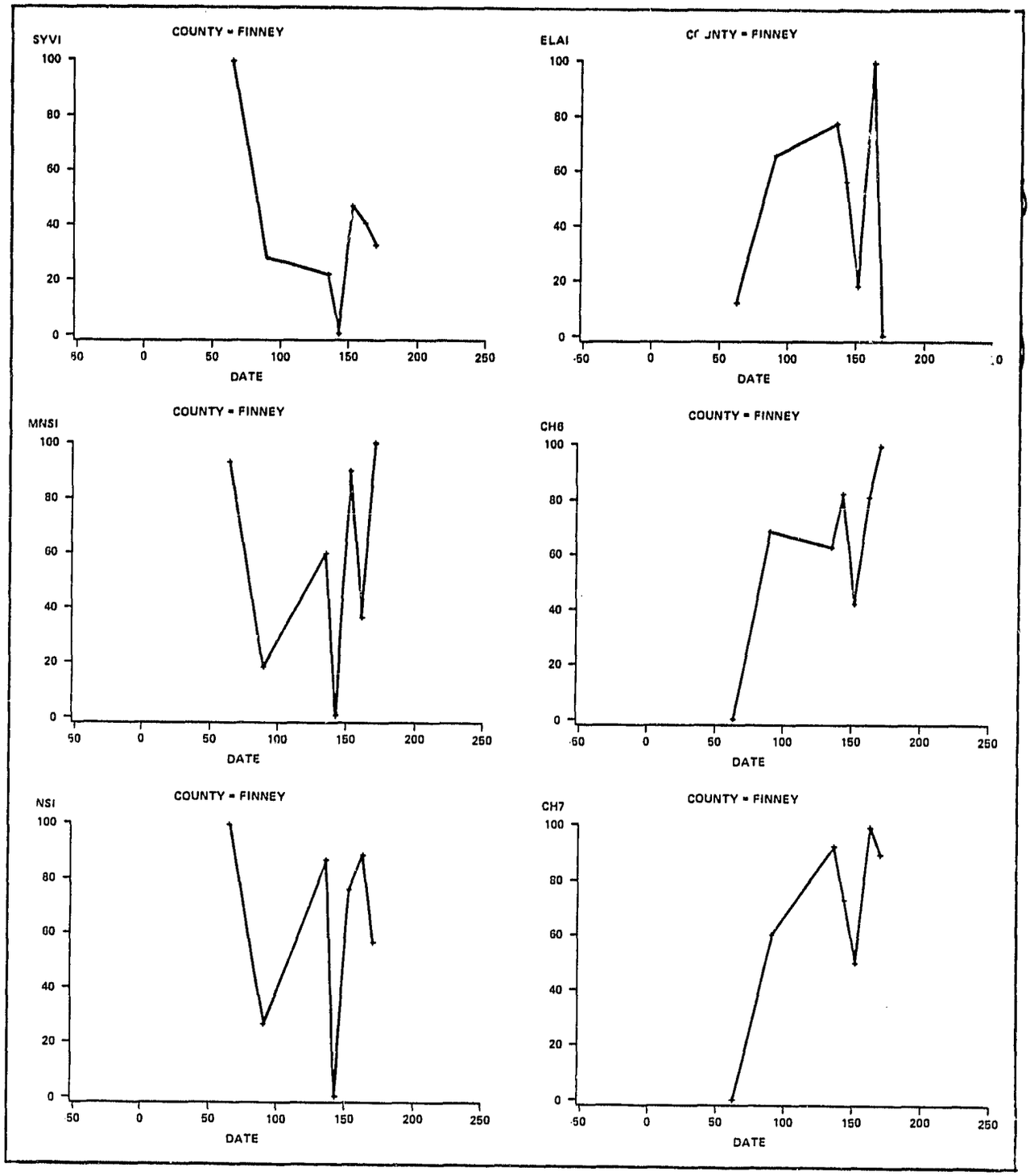
The graphs presented in this appendix are for the four sites with good acquisition histories (Yolo, Finney, Keith, and Grant counties). The trajectories are based on the field data described in Appendix A.

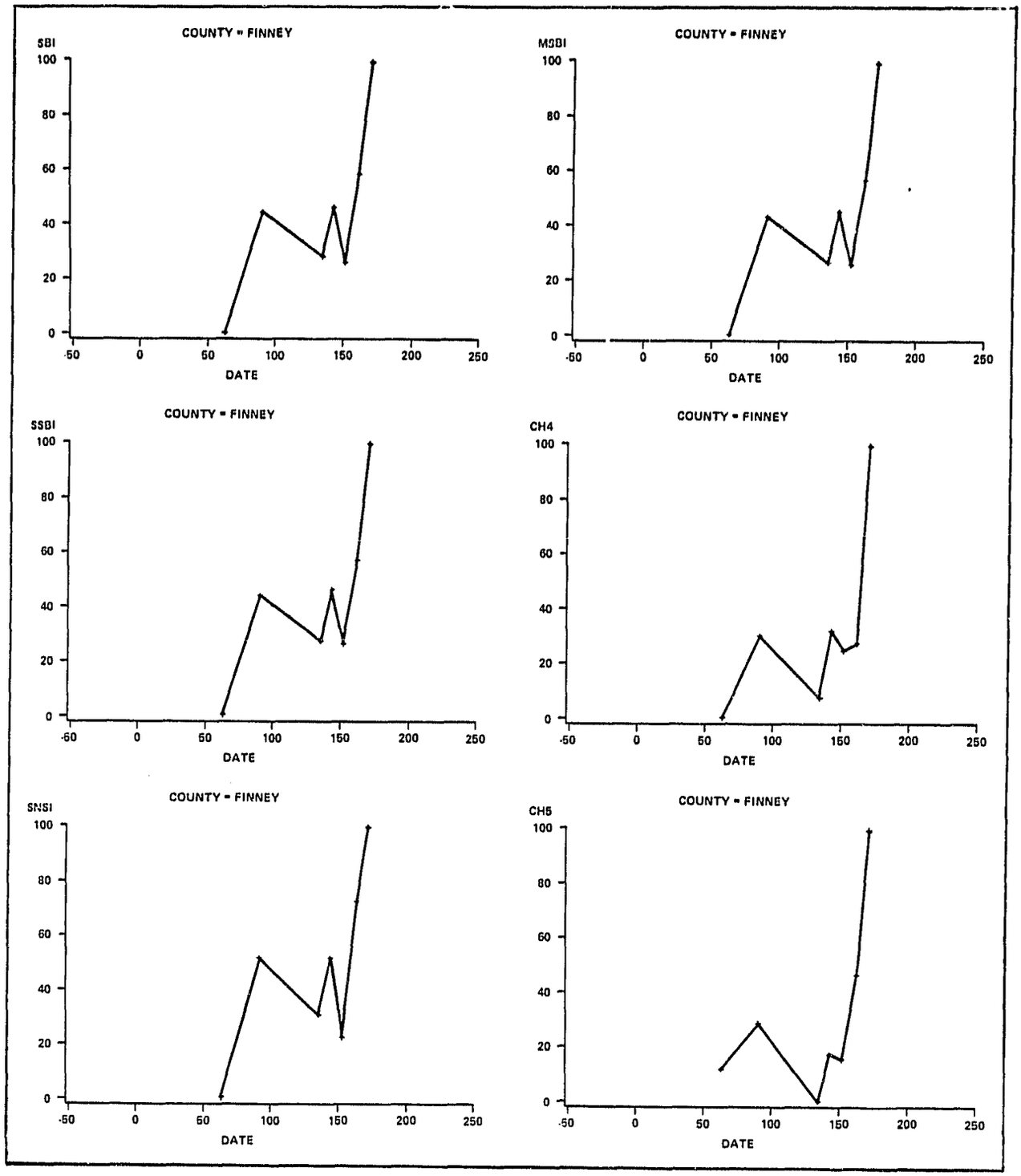

COUNTY = FINNEY
GVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
GRABS
100
80
60
40
20
0
00
0
50
100
150
200
250
DATE
COUNTY = FINNEY
MGVI
100
80
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
CLAI
100
80
60
40
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
SGVI
100
80
60
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
PVI6
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE

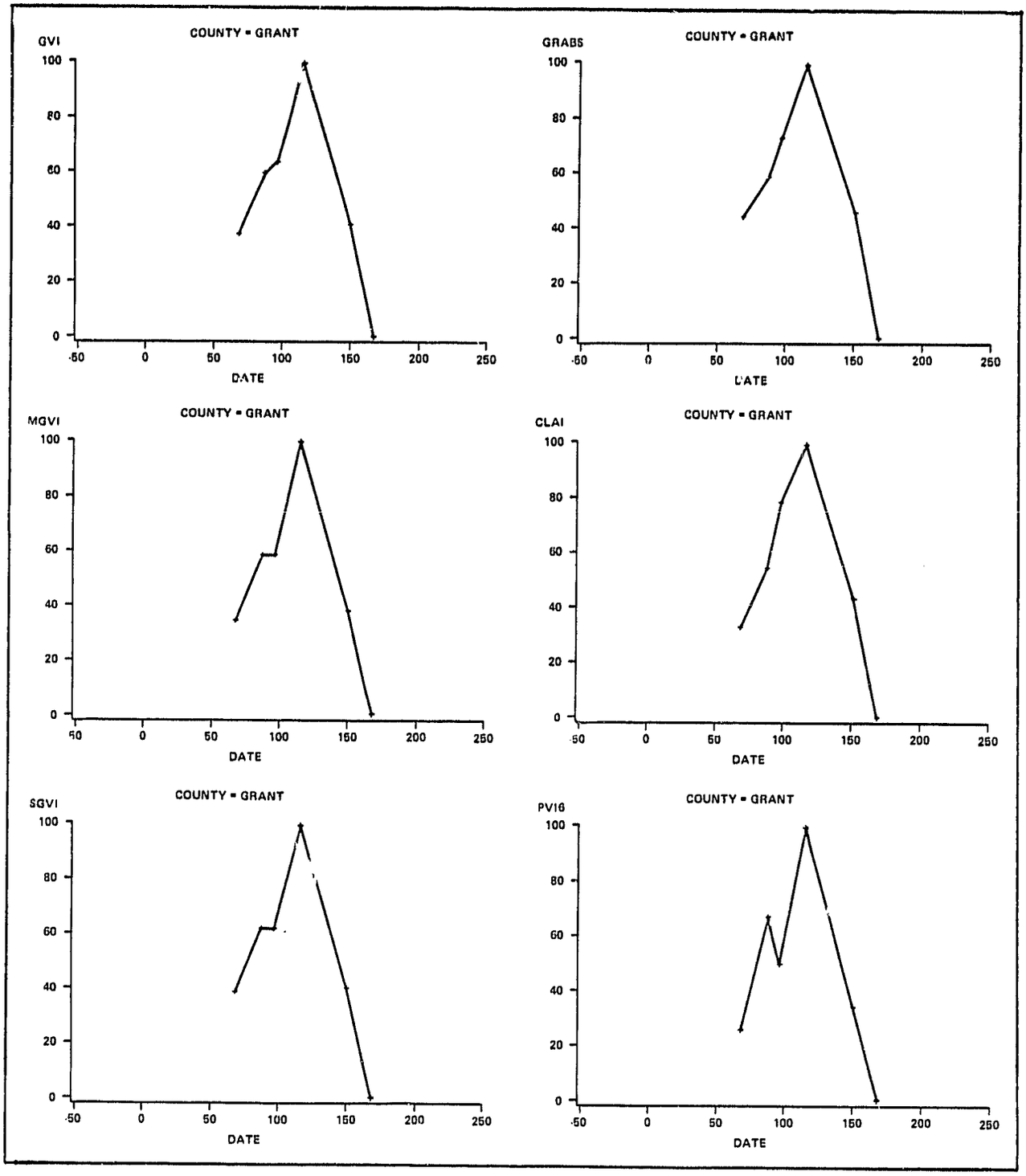

OLAI
COUNTY = FINNEY
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
TVI6
COUNTY = FINNEY
DATE
GVSB
COUNTY = FINNEY
DATE
R65
COUNTY = FINNEY
DATE
ND6
COUNTY = FINNEY
DATE
R64
COUNTY = FINNEY
DATE

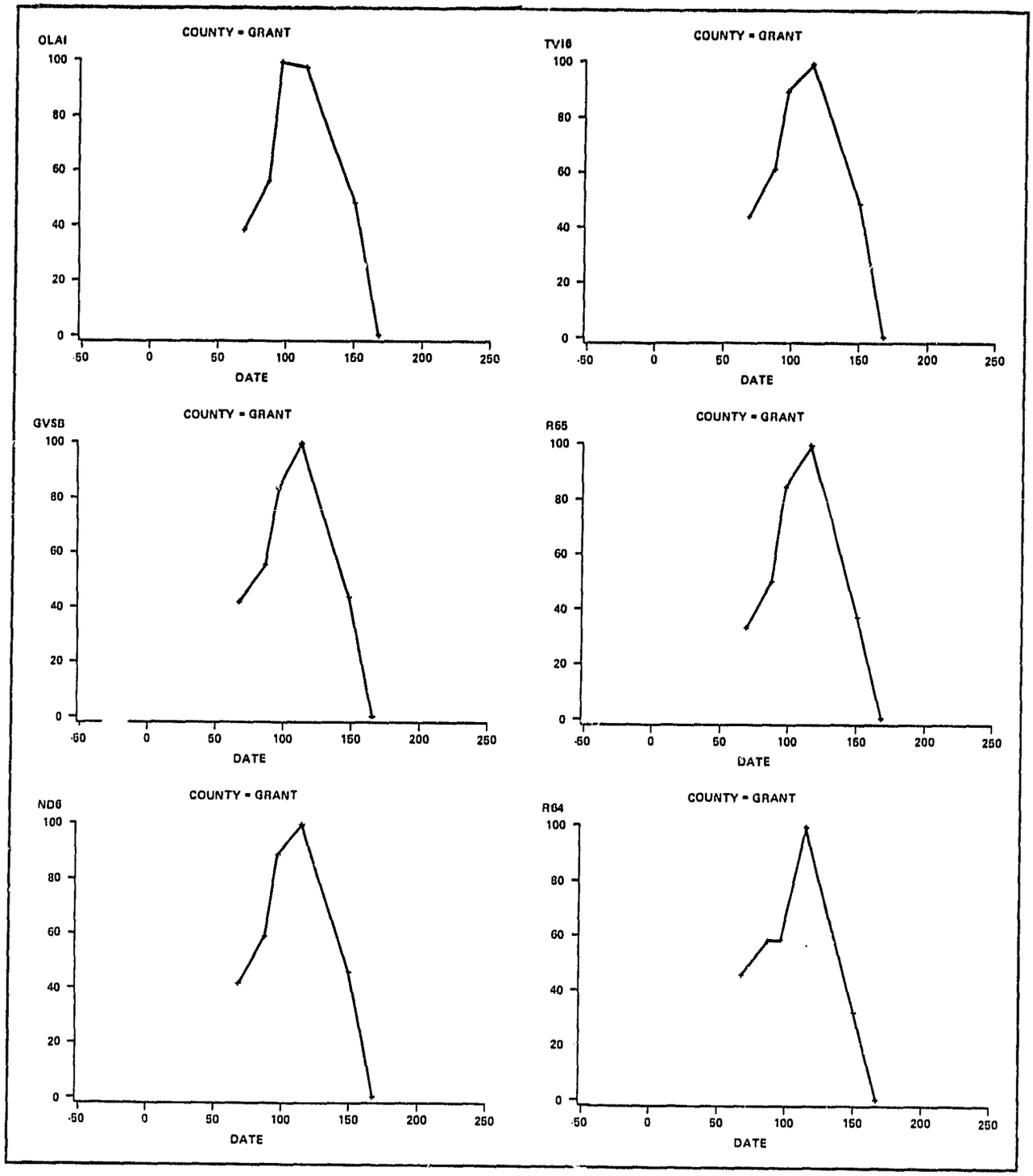

COUNTY = FINNEY
DVI
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
R74
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
PVI7
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
R75
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
AVI
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
ND7
100
80
60
40
20
0
50
0
50
100
150
200
250
DATE

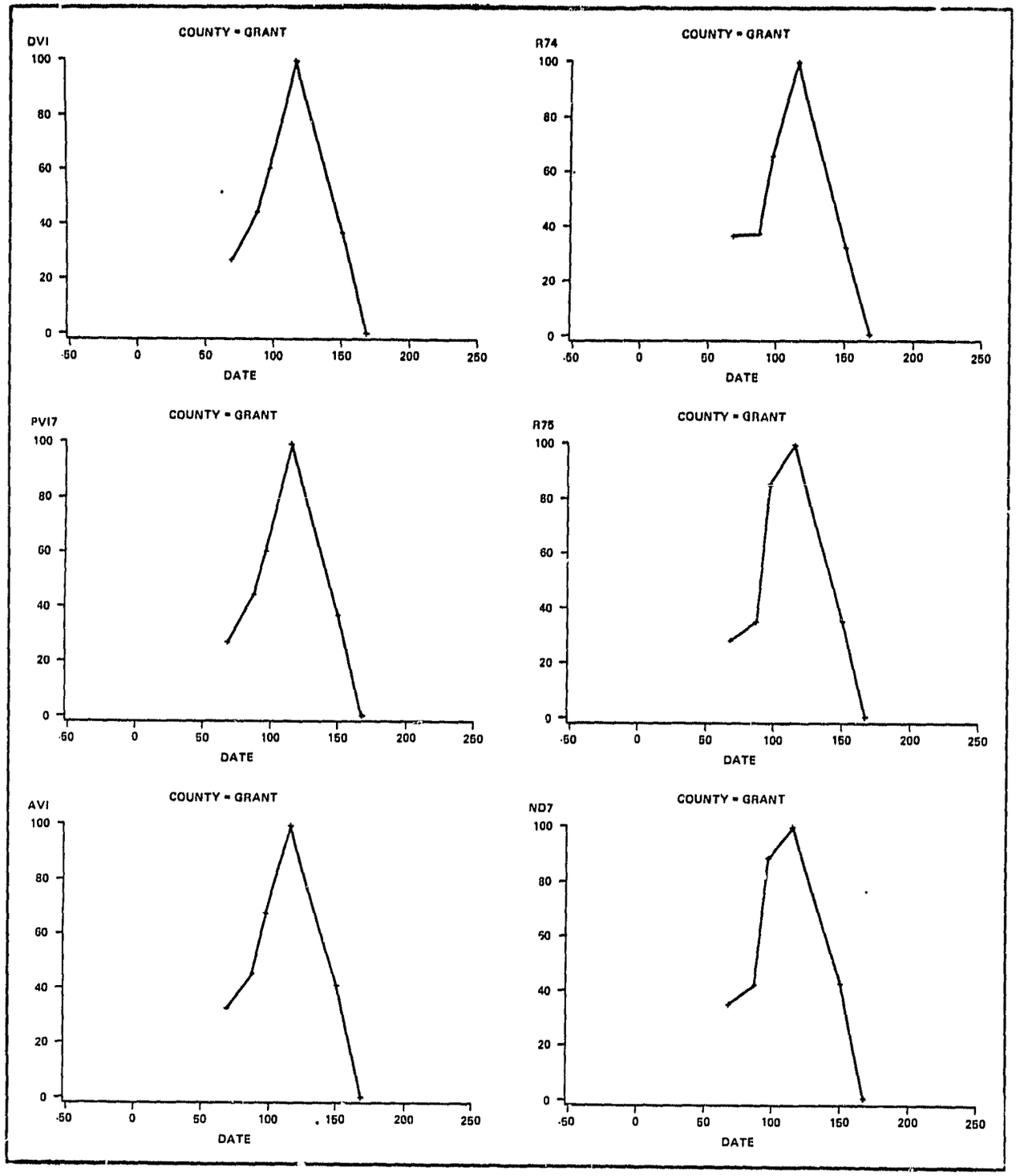

COUNTY = FINNEY
TVI7
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
MYVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
R45
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
YVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
LAI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
R76
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE

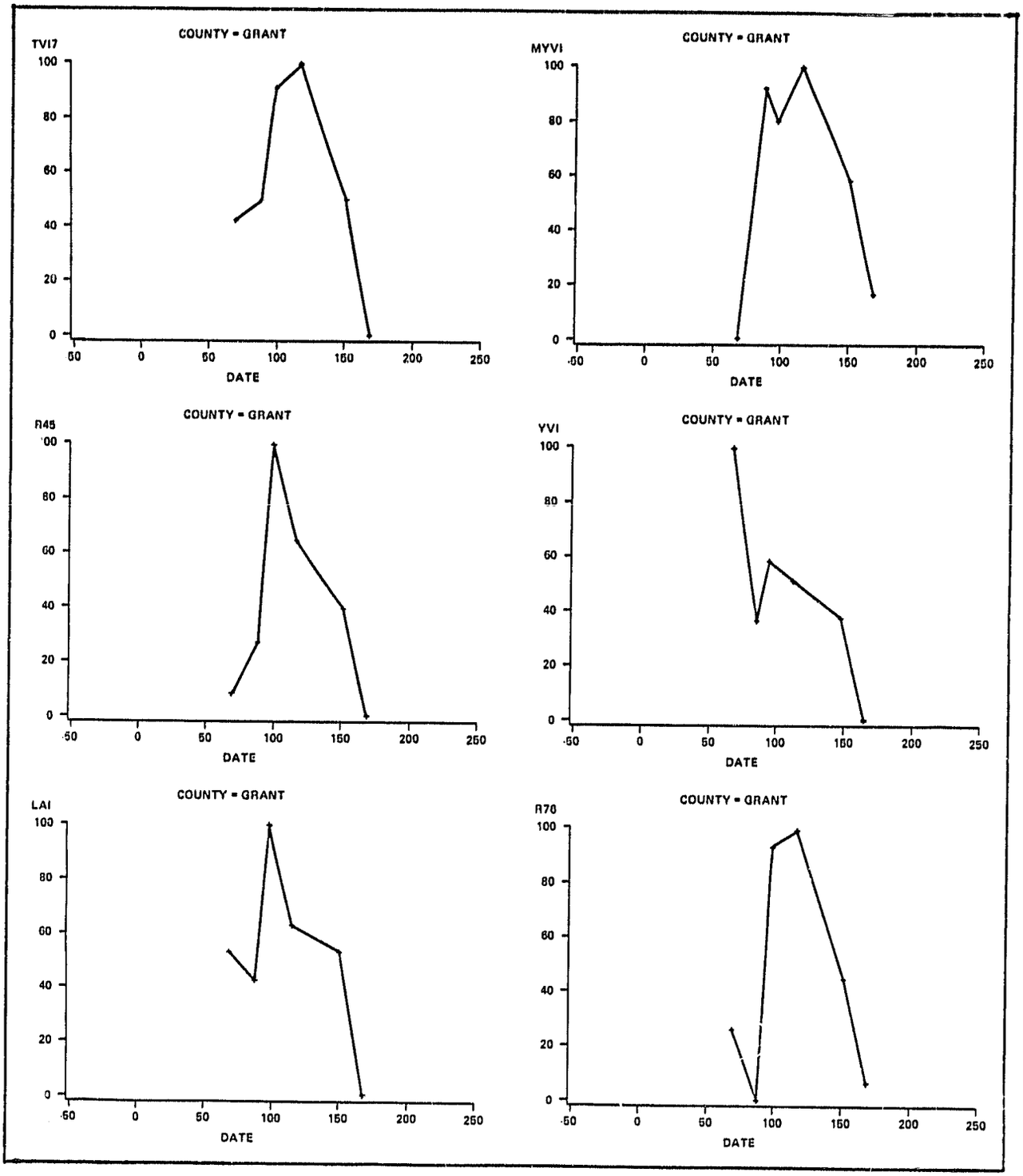

COUNTY = FINNEY
SYVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
ELAI
100
80
60
40
20
0
-50
0
50
100
150
200
DATE
COUNTY = FINNEY
MNSI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
CH6
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
NSI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
CH7
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE

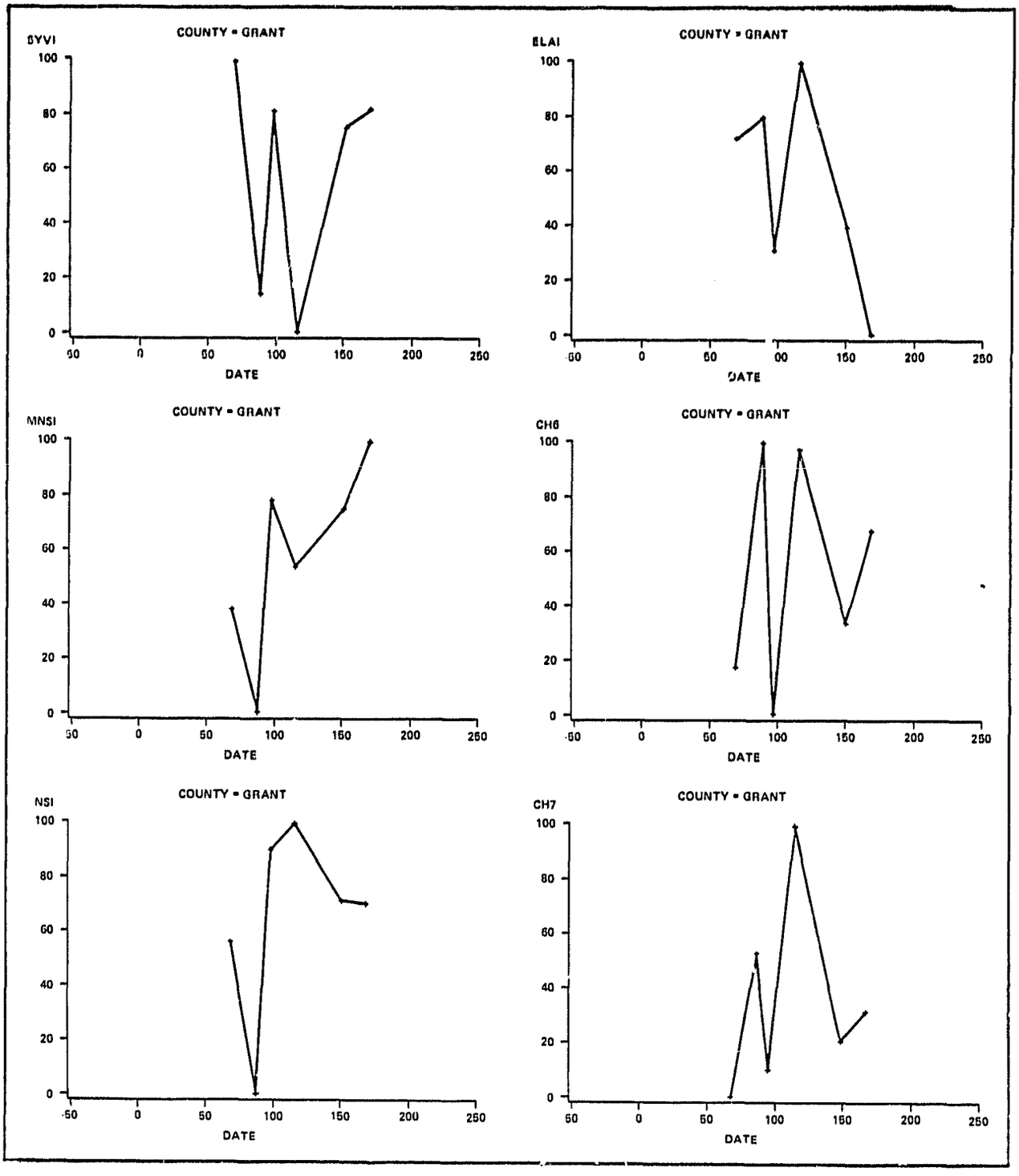

COUNTY = FINNEY
SBI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
MSBI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
SSBI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
CH4
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
SNSI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = FINNEY
CH5
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE

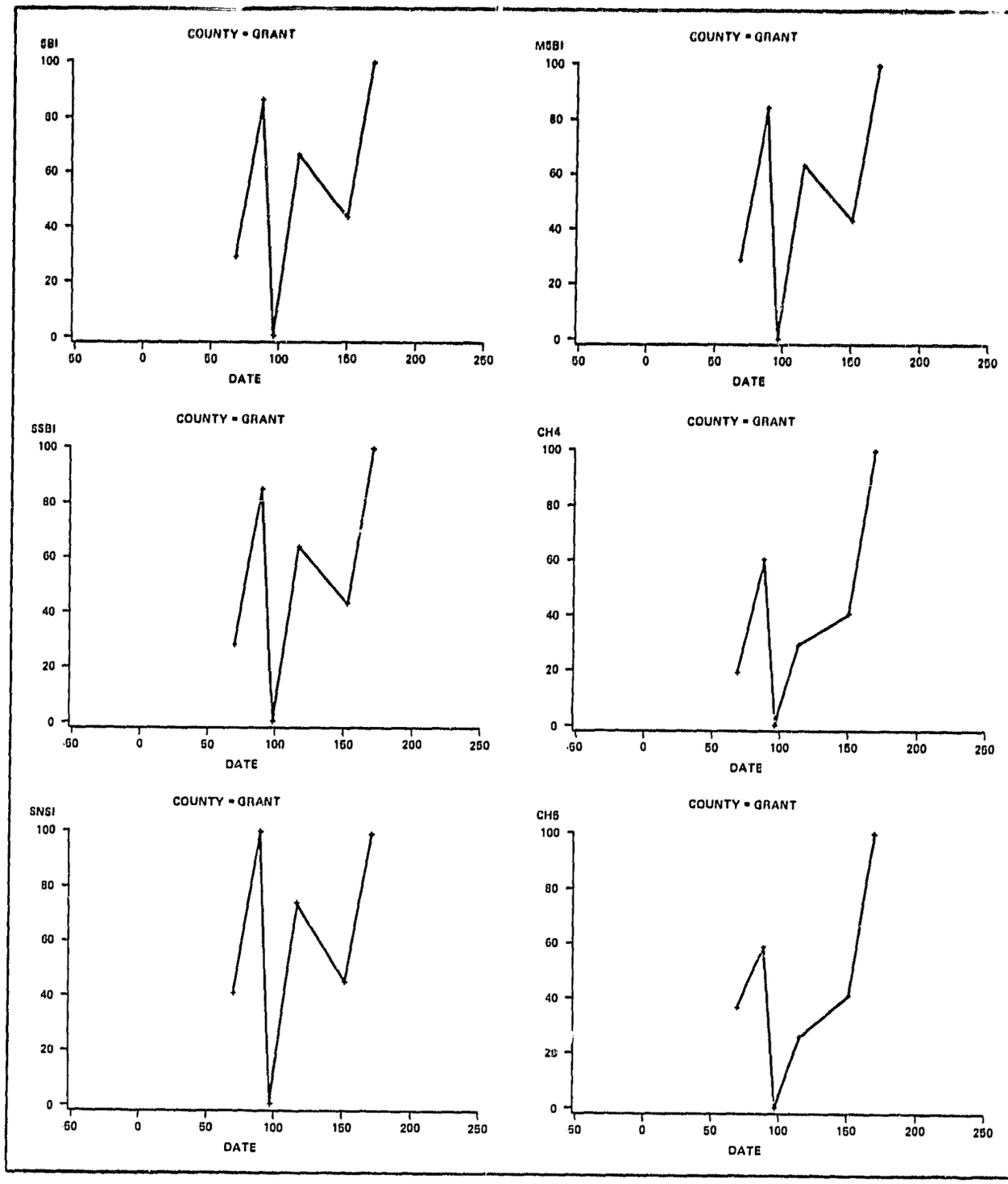

GVI
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
GRABS
COUNTY = GRANT
DATE
MGVI
COUNTY = GRANT
DATE
CLAI
COUNTY = GRANT
DATE
SGVI
COUNTY = GRANT
DATE
PVIG
COUNTY = GRANT
DATE


OLAI
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
TVI6
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
GVSB
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
R65
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
ND6
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
R64
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE


COUNTY = GRANT
DVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
R74
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
PVI7
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
R75
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
AVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
ND7
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE


COUNTY = GRANT
TVI7
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
MYVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
R45
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
YVI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
LAI
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
COUNTY = GRANT
R70
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE


SYVI
COUNTY = GRANT
100
80
60
40
20
0
-50
0
50
100
150
200
250
DATE
ELAI
COUNTY = GRANT
DATE
MNSI
COUNTY = GRANT
DATE
CH6
COUNTY = GRANT
DATE
NSI
COUNTY = GRANT
DATE
CH7
COUNTY = GRANT
DATE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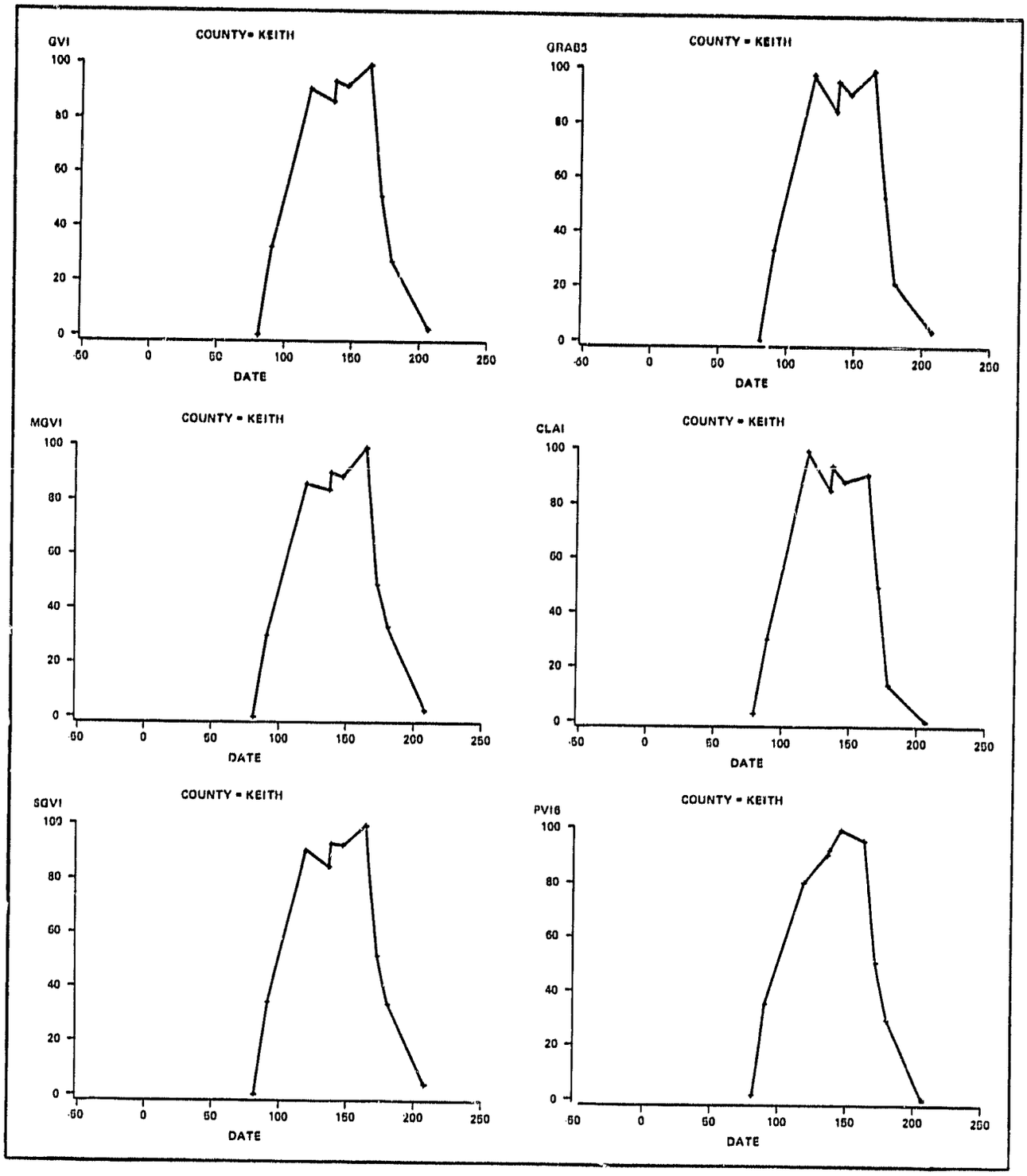
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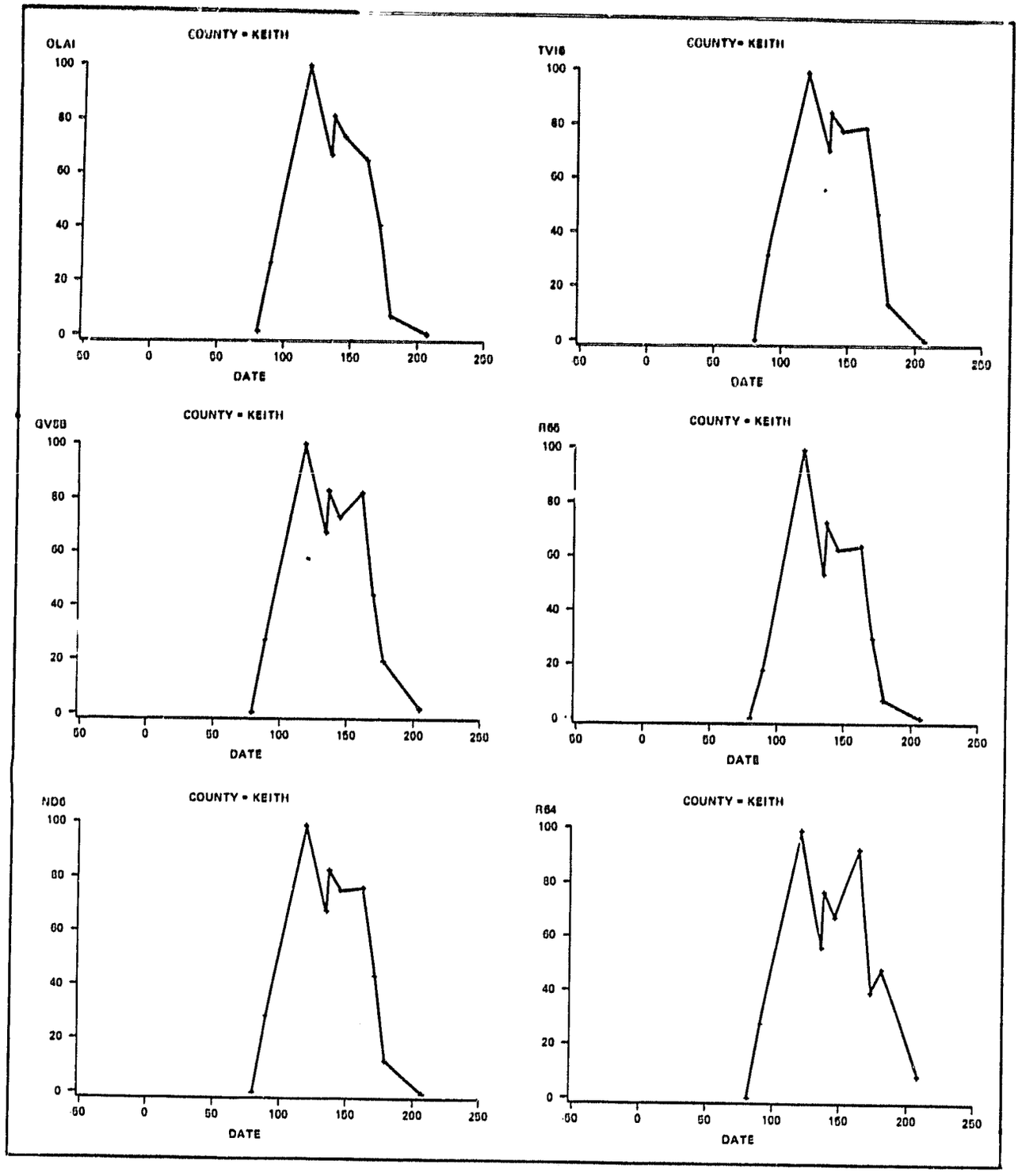
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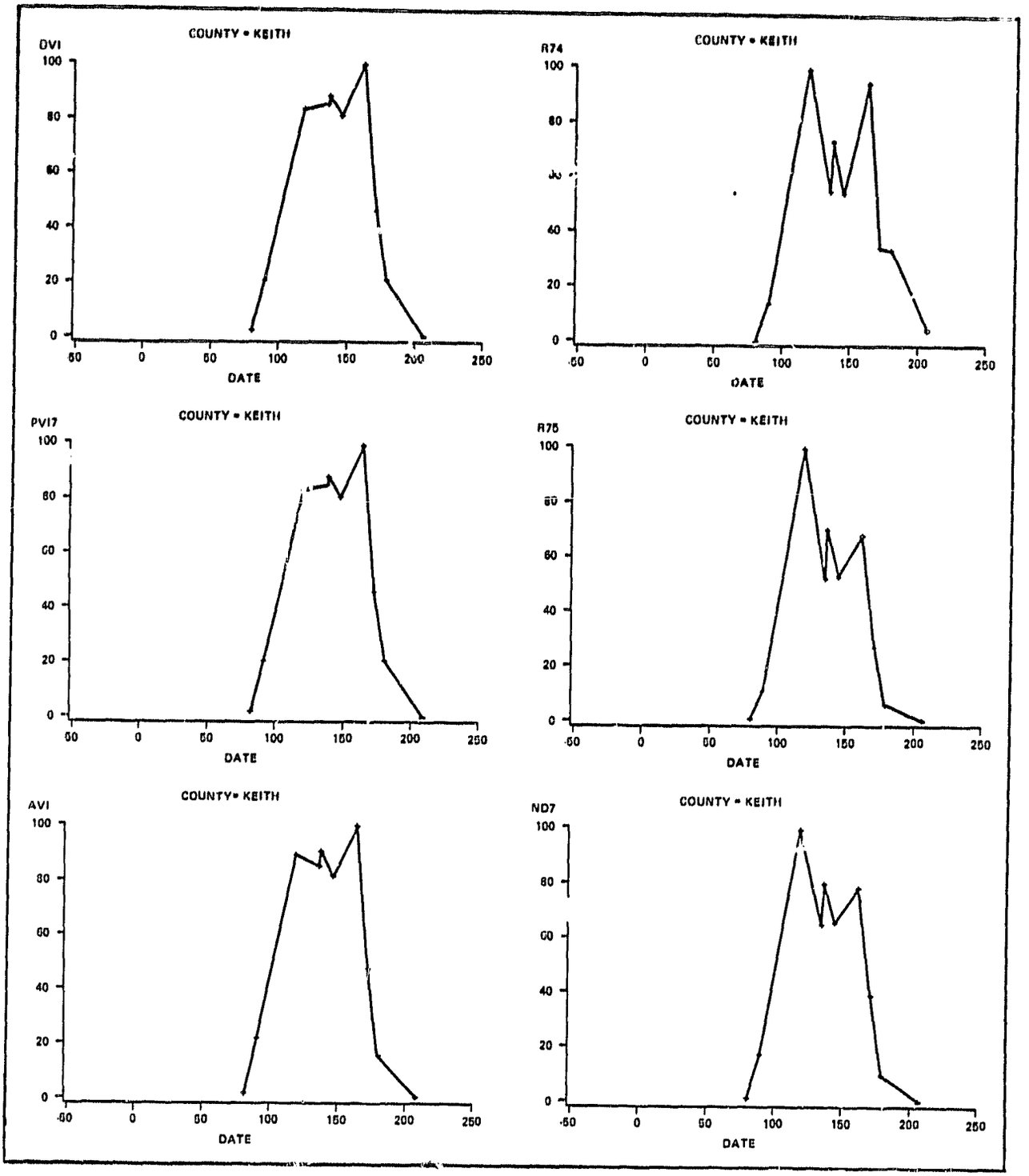
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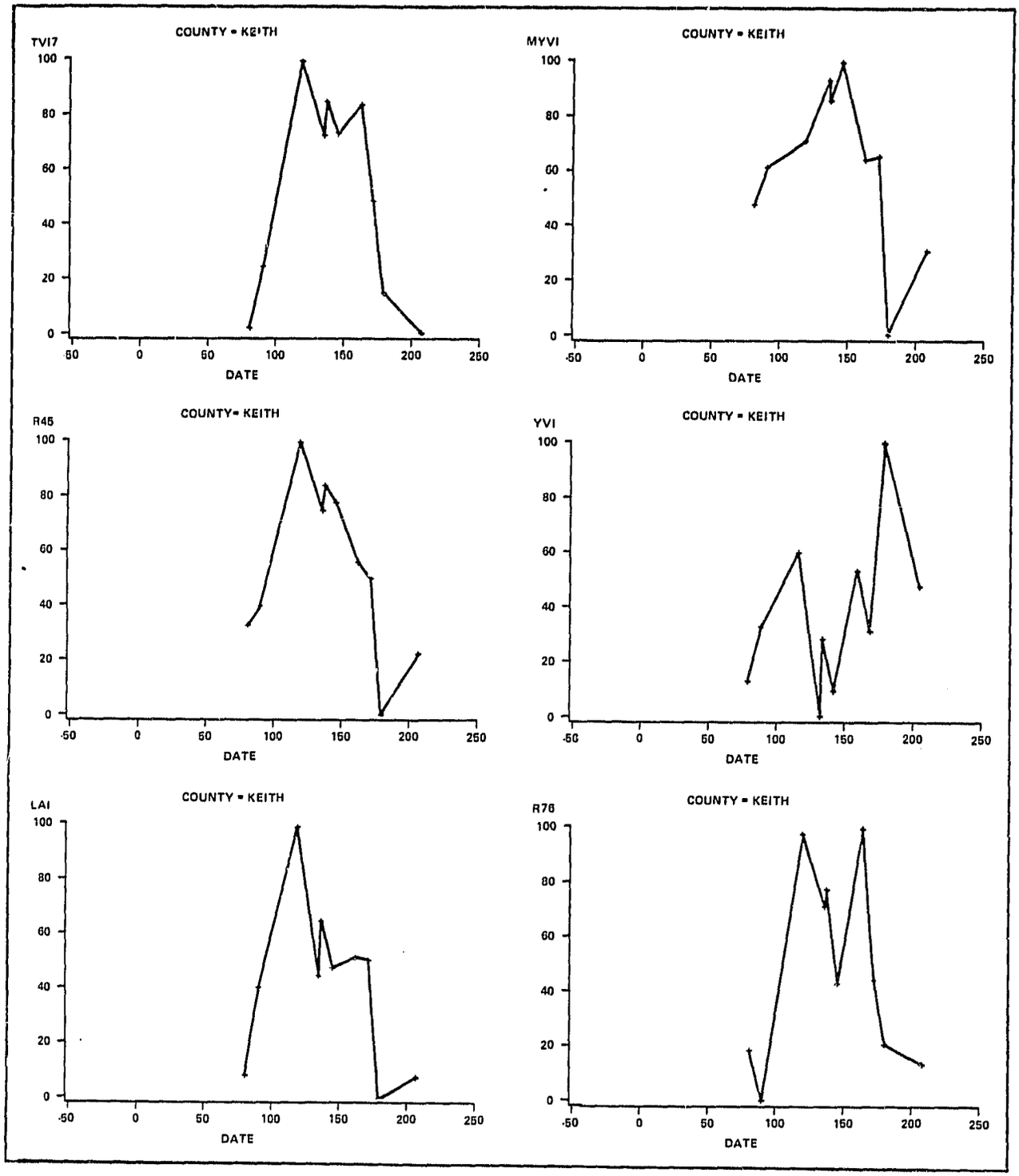
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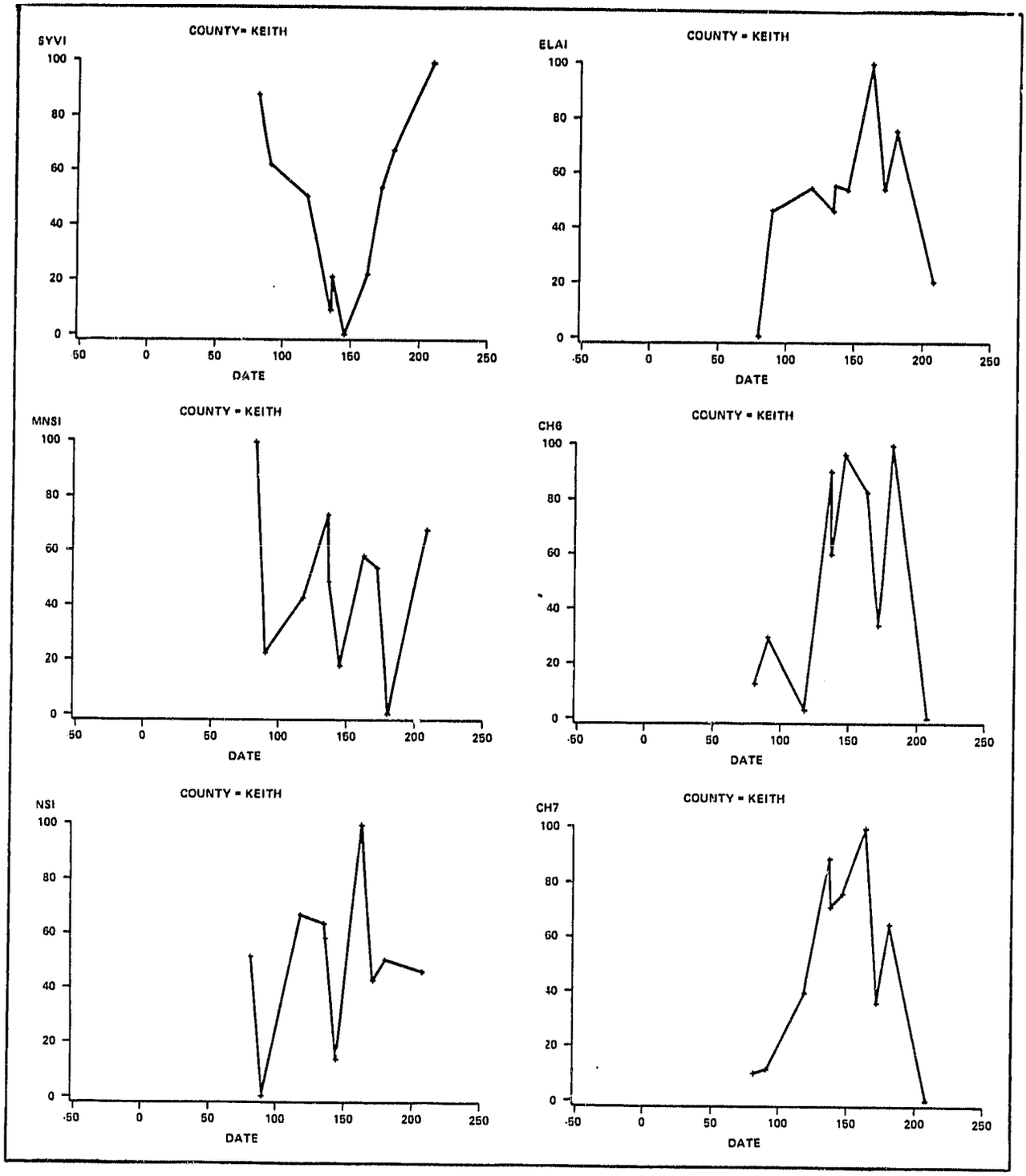
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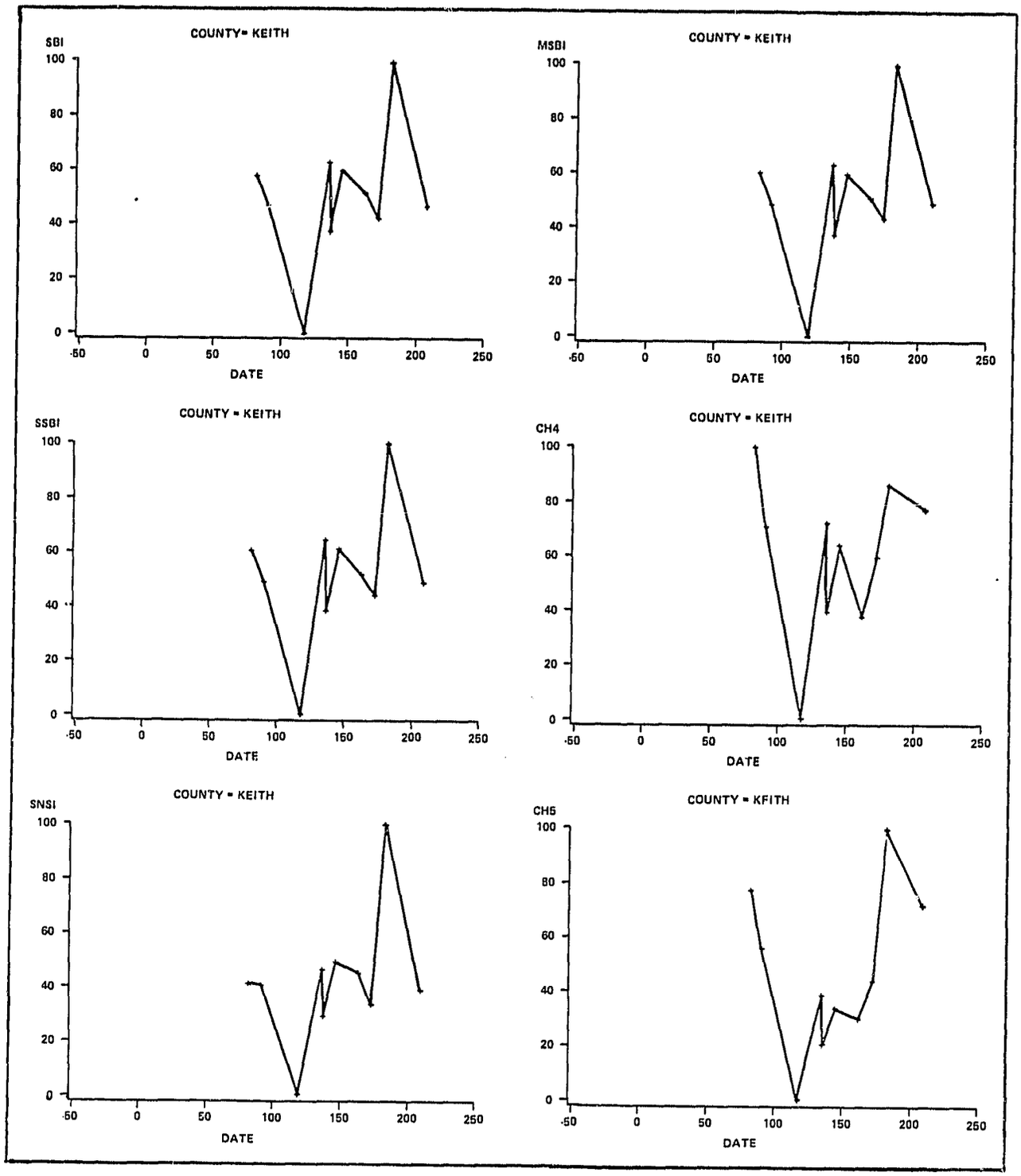
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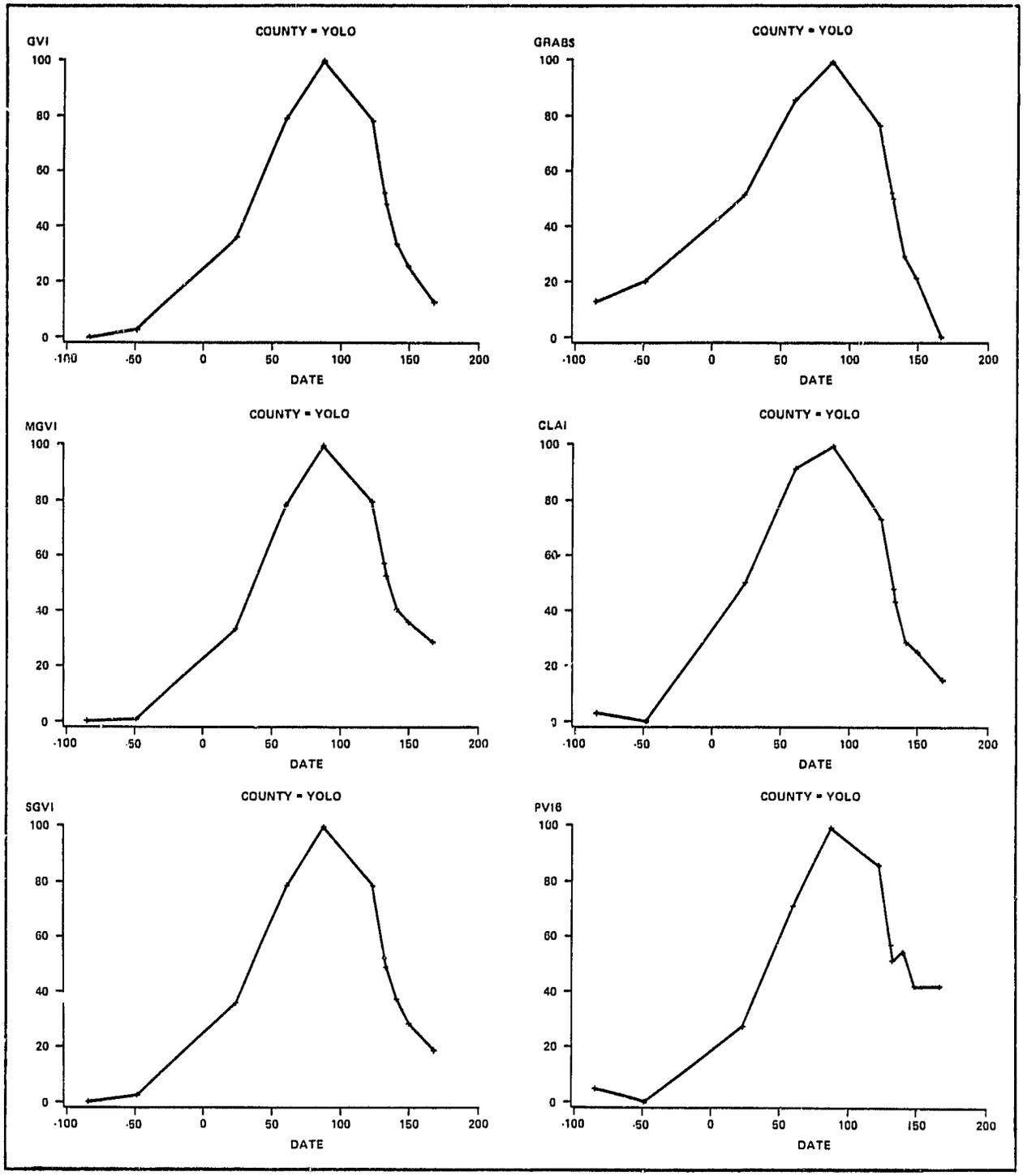
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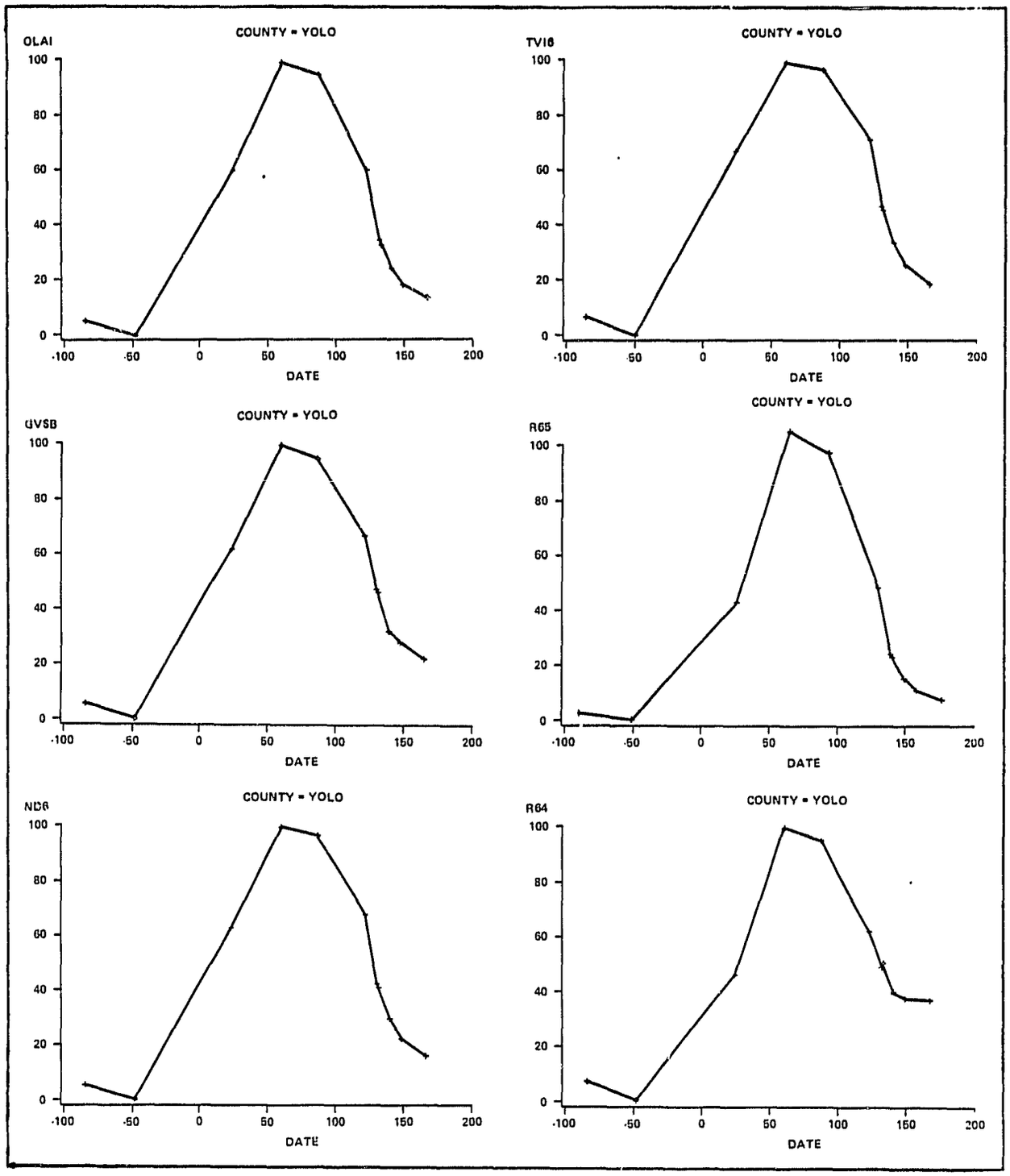
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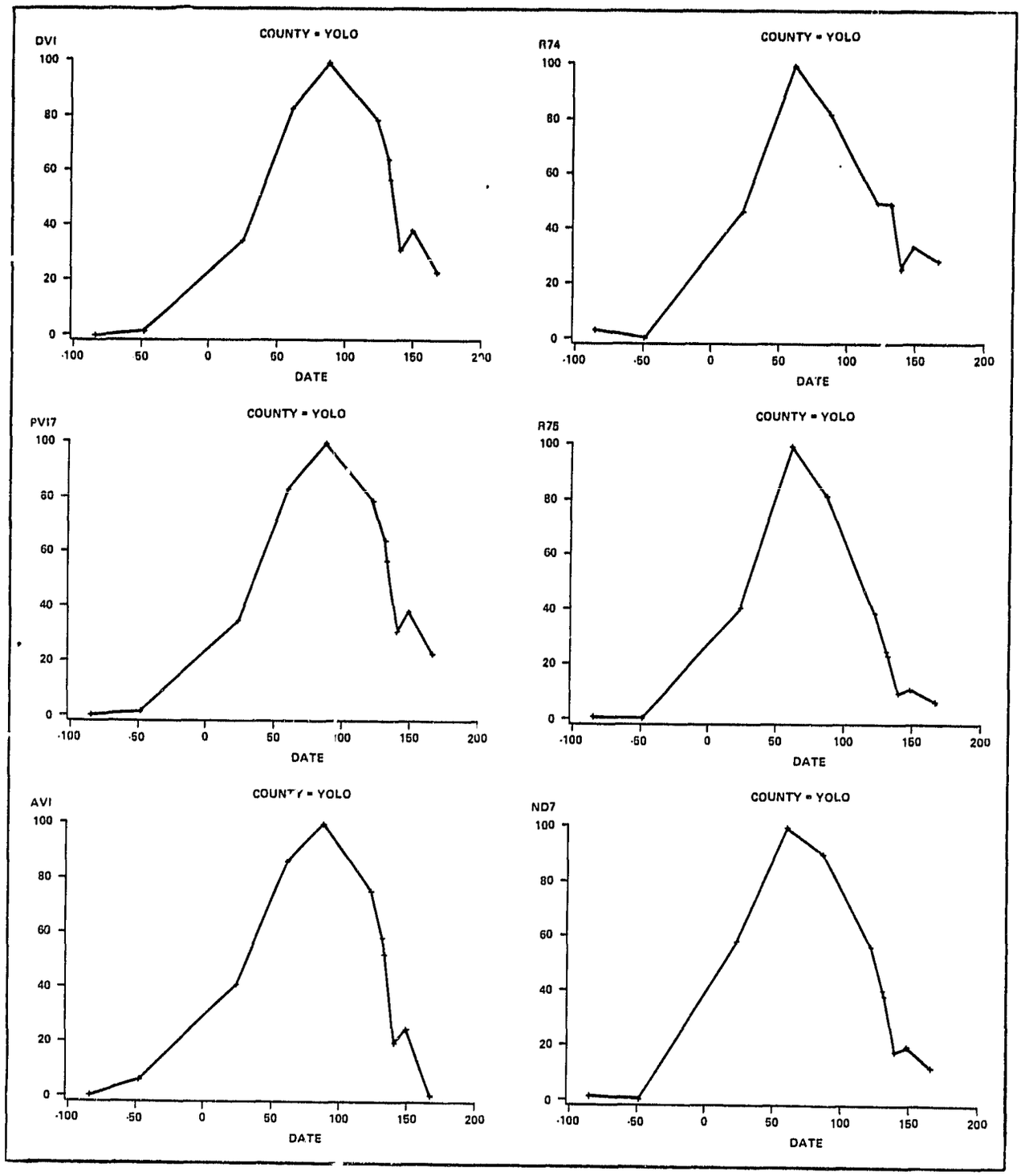
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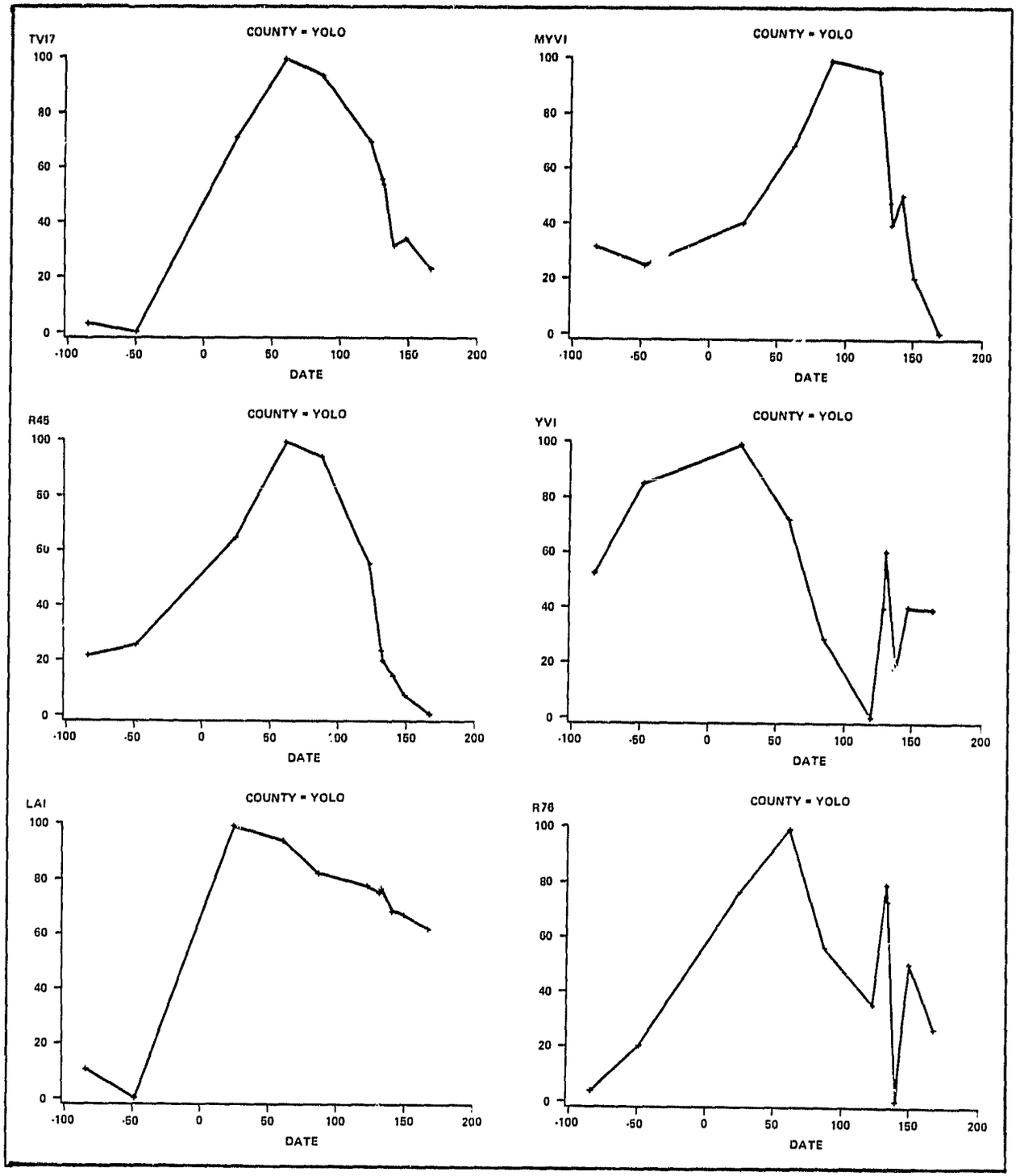
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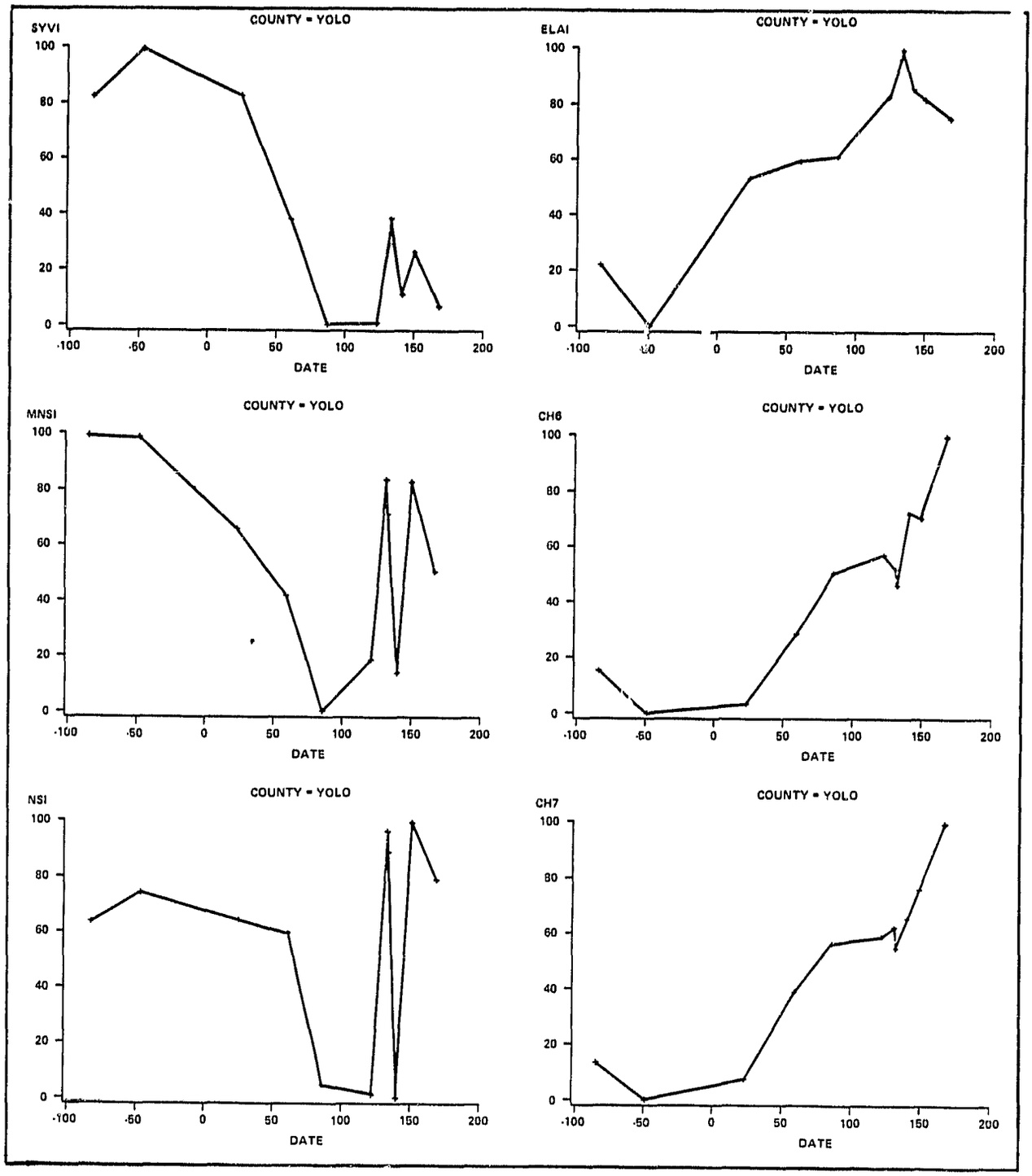
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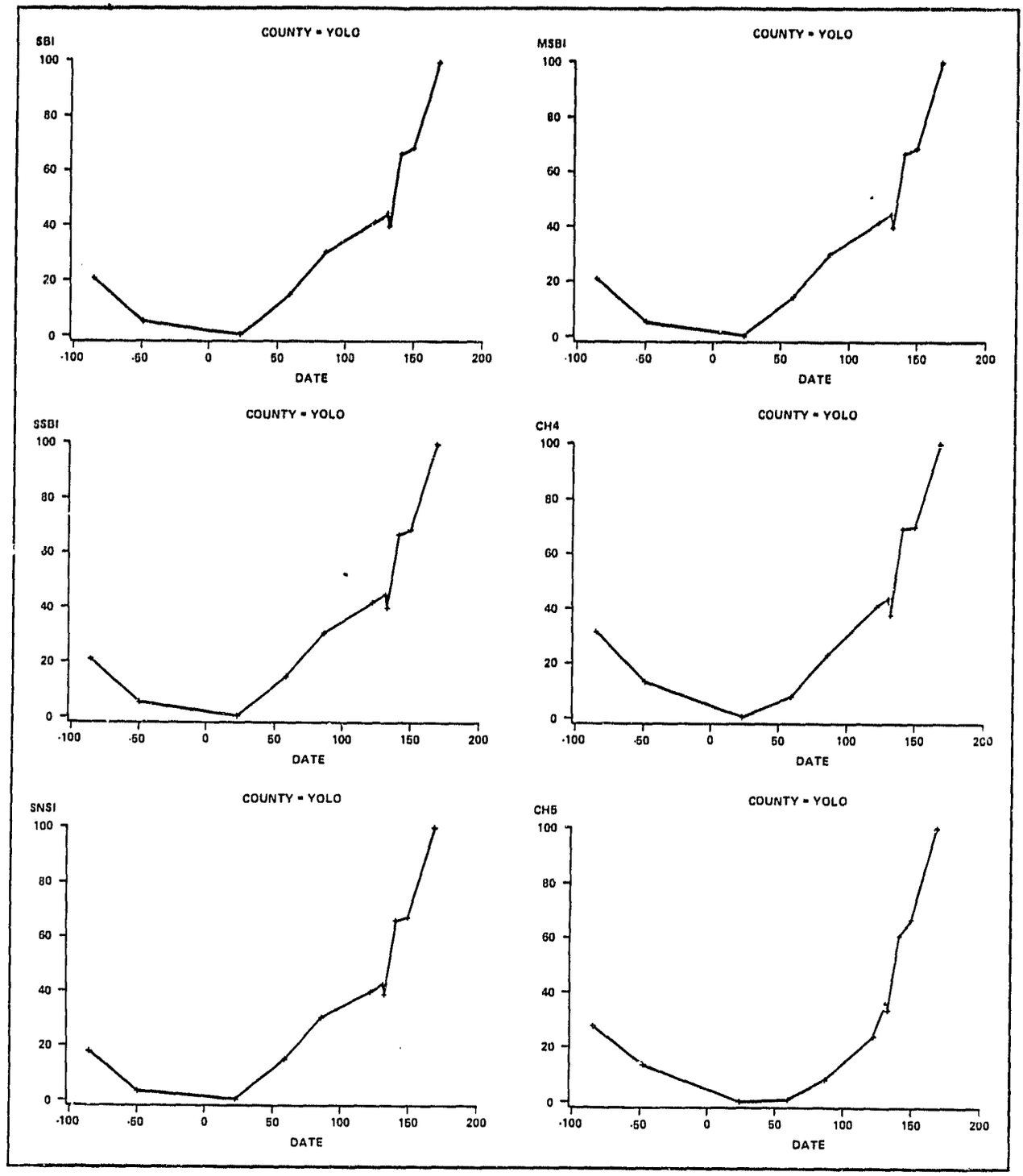
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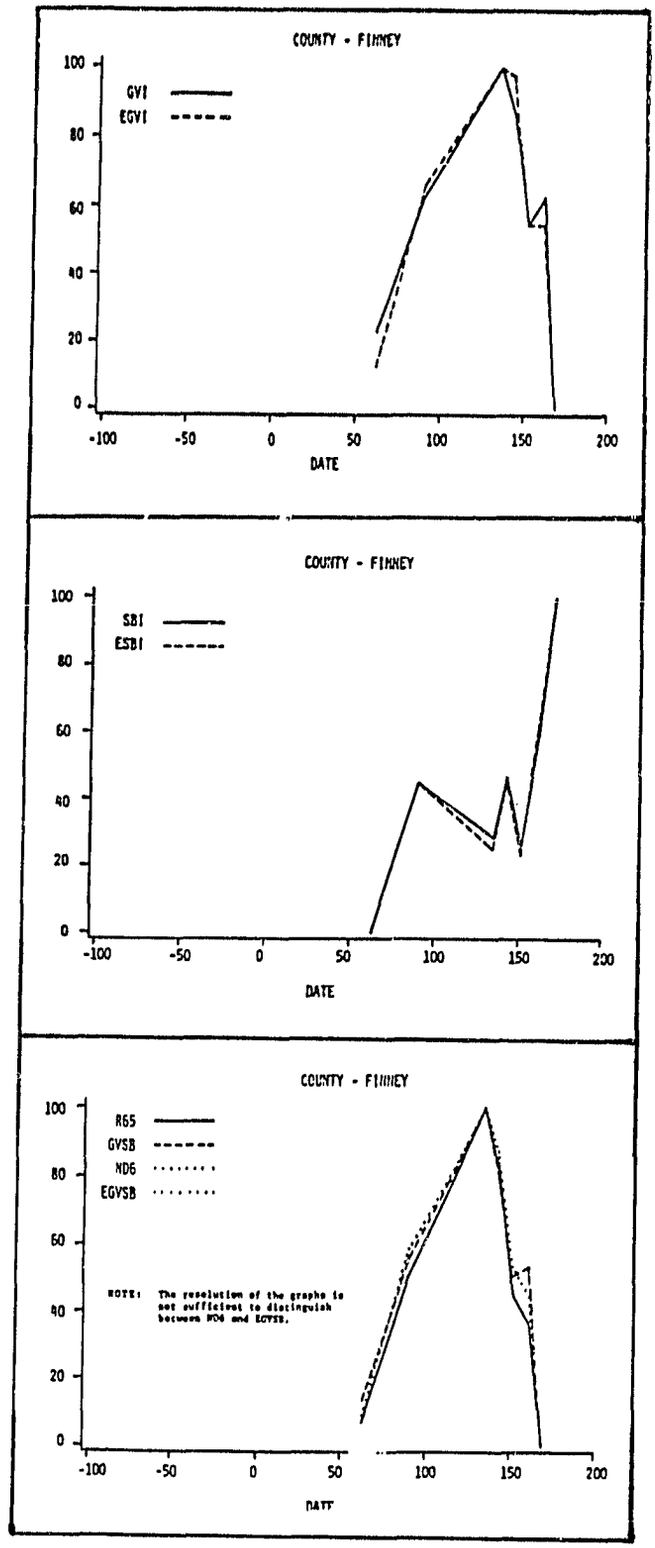
APPENDIX E

VEGETATION INDICES EQUIVALENTS AND APPROXIMATIONS ILLUSTRATED WITH TRAJECTORY PLOTS



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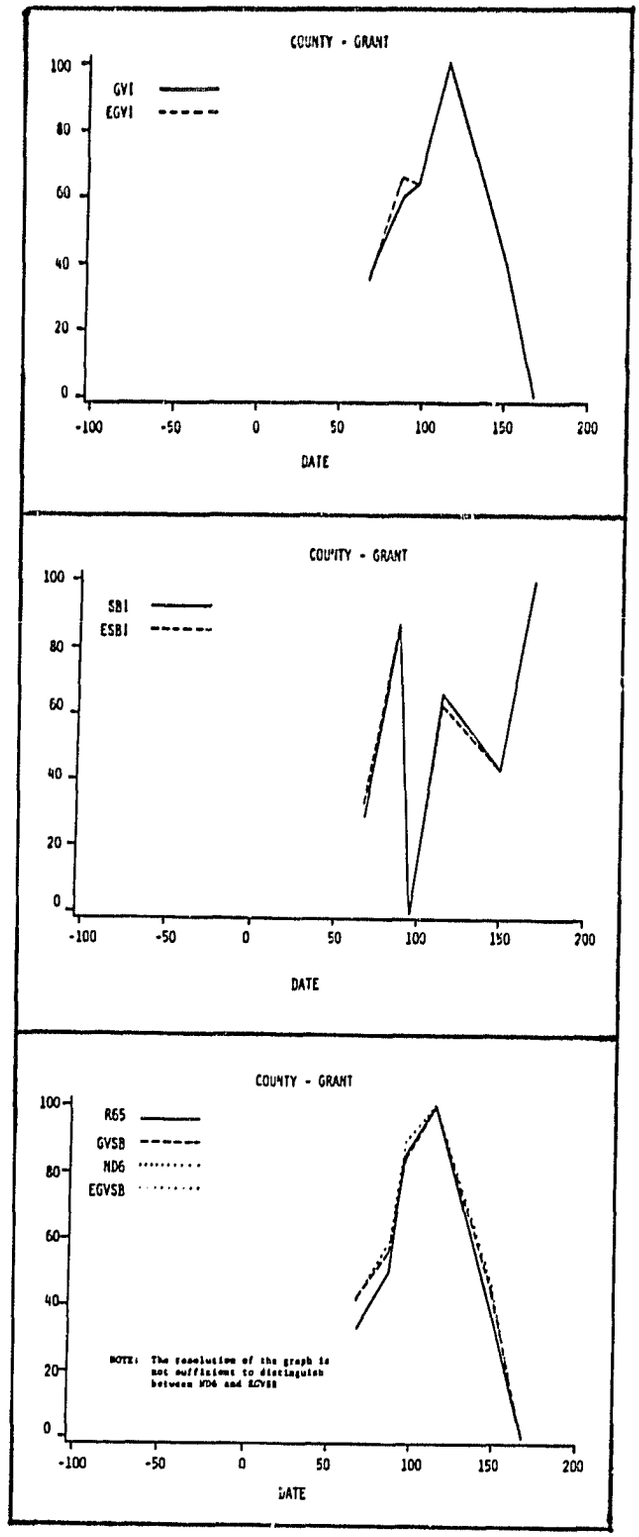

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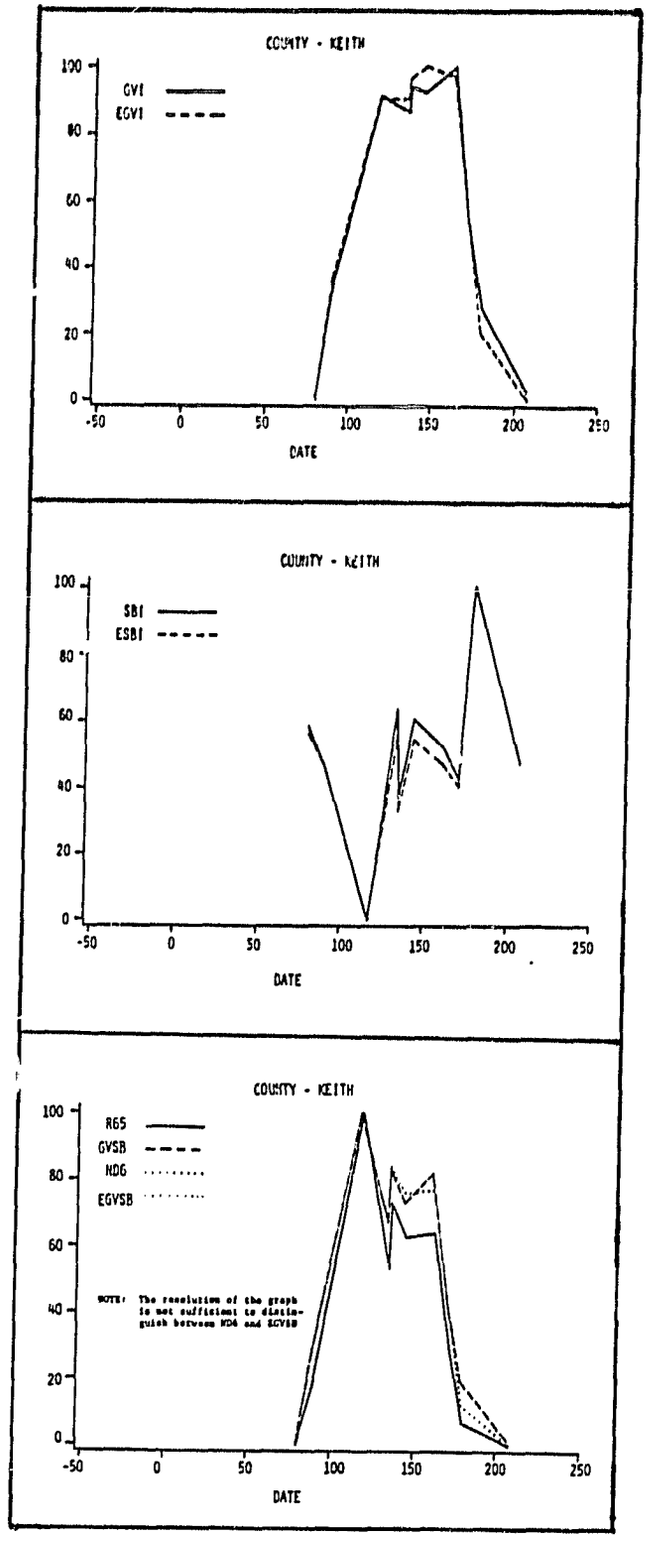

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