JSC 09391

CROP IDENTIFICATION TECHNOLOGY ASSESSMENT FOR REMOTE SENSING (CITARS)

VOLUME VIII

DATA PROCESSING AT THE EARTH OBSERVATIONS DIVISION LYNDON B. JOHNSON SPACE CENTER

PART 7

MULTITEMPORAL ANALYSIS OF FAYETTE COUNTY, ILLINOIS

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

May 1975

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MULTITEMPORAL ANALYSIS OF FAYETTE COUNTY, ILLINOIS

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HOUSTON, TEXAS

May 1975

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PREFACE

Volume VIII, Part 7: Fayette County, Illinois, describes the multitemporal data analysis and results for the Fayette County test segment of the Crop Identification Technology Assessment for Remote Sensing. Part 1: Huntington County, Indiana, covers the data collection, registration, and preprocessing for all six segments and the data analysis for the Huntington County segment. The data analyses of the other segments and their results appear in

Part 2: Shelby County, Indiana

Part 3: White County, Indiana

Part 4: Livingston County, Illinois

Part 5: Fayette County, Illinois

Part 6: Lee County, Illinois

All the parts have the nonmetric units of measure used by the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture.

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GLOSSARY

ADP — automatic data processing

ASCS — Agricultural Stabilization and Conservation Service, U.S. Department of Agriculture

CITARS — Crop Identification Technology Assessment for Remote Sensing

EOD — Earth Observations Division, Lyndon B. Johnson Space Center, National Aeronautics and Space Administration

ERTS-1 — the first Earth Resources Technology Satellite, which was launched in June 1972, orbits the Earth 14 times a day from an altitude of 915 kilometers, and scans the same scene every 18 days

FAY610 — designation that data were obtained over Fayette County, Illinois, on June 10, 1973

FAY629 — designation that data were obtained over Fayette County, Illinois, on June 29, 1973

FAY717 — designation that data were obtained over Fayette County, Illinois, on July 17, 1973

FAY821 — designation that data were obtained over Fayette County, Illinois, on August 21, 1973

ID — Identification

ISOCLS — Iterative Self-Organizing Clustering System, a computer program developed by the EOD, which uses a clustering algorithm to group homogeneous spectral data

JSC — Lyndon B. Johnson Space Center, National Aeronautics and Space Administration, Houston, Texas

LARS — Laboratory for Applications of Remote Sensing of Purdue University

LARSYS — a system of classification programs developed at the LARS

MSS — Multispectral scanner

NASA — National Aeronautics and Space Administration

Other — class of data which includes all ground features except the three major crops of corn, soybeans, and wheat

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1.0 INTRODUCTION

Part 7 of Volume VIII of the Crop Identification Technology Assessment for Remote Sensing (CITARS) will report the results of multitemporal processing by the Earth Observations Division (EOD) of the Lyndon B. Johnson Space Center (JSC), National Aeronautics and Space Administration (NASA), on segment 5, Fayette County, Illinois. The automatic data processing (ADP) and multitemporal data analysis procedures utilized were set out in the original Task Design Plan, Volume I of the CITARS.

In this investigation classification performance results for six distinct categories (corn, soybeans, wheat, water, woods, and "other") were generated both on a single-pass and on a temporal basis. This report discusses the problems encountered in processing the ERTS-1 data with respect to the generation of valid statistics, the quality of training and test field boundaries, and the interpretation of the final results. In the final analysis the results are compared with those generated from single-pass data and those of manual photointerpretation procedures using sequential aircraft photographic coverage of the same area. In this manner the classification of crop types and an estimation of their separability were accomplished.

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2.0 BACKGROUND

2.1 DATA ACQUISITION

The primary purpose of this study was to evaluate the existing capability of automatically identifying specific crop types utilizing sequential data coverage over a test area. Since the Earth Resources Technology Satellite (ERTS-1) provided data coverage of the area over a 15-day period, it presented the opportunity to examine and monitor crop changes during their growing seasons (crop calendars).

Ground-truth information on specific training fields within the test area was acquired coincidentally with the ERTS-1 overpasses. This information is the basis on which the automatic data processor was trained to classify crop types and to estimate their separability.

2.2 SELECTION OF THE TEST SEGMENT FOR MULTITEMPORAL ANALYSIS

The specific test segment in Fayette County, Illinois, was selected for multitemporal analysis for several reasons:

1. It contained data from four sequential passes of the ERTS-1, which were cloud free for all practical purposes.
2. Up-to-date ground-truth information was available.
3. Other single-pass tests and analyses which could be used for comparison were being performed. (See Part 5 of this Volume VIII for the results of these tests and analyses.)

4. The crop types for which data were being collected (corn, soybeans, and wheat) are the same types to be included in the follow-on project.

The multitemporal analysis of the CITARS data was limited to Fayette County, Illinois, primarily because of condition 1 above – it was the only test site where essentially cloud-free, ADP-acceptable data were collected sequentially during the corn and soybean growing periods.

2.3 PROCEDURES

The training and test fields selected by the Laboratory for Applications of Remote Sensing of Purdue University (LARS) varied in size from 1 to 40 pixels with the average size being between 8 and 10 pixels. The fields selected for the evaluation of wheat were the smallest, ranging from three to four pixels. All of the training fields used for the ADP analysis were selected on the basis of crop identifications made by field personnel from the Agricultural Stabilization and Conservation Service (ASCS), U.S. Department of Agriculture. The ASCS data were gathered coincidentally with each of the ERTS-1 passes so that the information on crop type, field size, crop condition, and other pertinent data would be kept current.

The major crops considered in this evaluation were corn and soybeans. Initially it was not the intent of the multitemporal analysis portion of this project to evaluate wheat. However, approximately 50 percent of the time farmers in this particular area plant soybeans in harvested wheatfields, thus necessitating the evaluation of wheat in the analysis. For this reason portions of the data were collected after harvest and the validity of some of the data is questionable. In order to evaluate the analysis properly, confusion crops such as hay, clover, and other grains were also identified and classified as "other."

An accurate crop calendar for the Fayette County segment would have been a very helpful device; however, none was available for use in the analysis. A crop calendar was generated from the information that was available, and an attempt was made to make assumptions based on this information. It is recommended that in future programs an accurate crop calendar be made available prior to ADP analysis.

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3.0 INVESTIGATION AND ANALYSIS

The investigation conducted by the EOD at JSC assessed the utility of ERTS-1 multispectral scanner (MSS) data in accomplishing the objectives of the CITARS program. The general objective of the multitemporal portion of the CITARS investigation was to evaluate the improvements, if any, in detecting, identifying, and delineating crop types within a given test area using sequential data passes during a specific period. The comparison to be evaluated is based on the results from single-pass as opposed to multipass classification performances.

3.1 DATA ACQUISITION PERIODS

Four sets of ERTS-1 MSS data from the Fayette County test segment were used in the investigation:

Data set*	Period	Date	Pass
FAY610	I	6/10/73	2
FAY629	II	6/29/73	2
FAY717	III	7/17/73	2
FAY821	V	8/21/73	2

Data for period IV (August 3, 1973) were not used because of excessive cloud cover over the test segment.

*The data set designation FAY indicates Fayette County; the three-digit number represents the date of the 1973 ERTS-1 overflight.

3.2 SINGLE-PASS CLASSIFICATION

The single-pass classification summaries for periods I, II, III, and V are presented in table I. Because corn and soybeans were at the bare-soil stage during period I, those fields were placed in the category "other." After period II most of the wheat had been harvested and was no longer considered a category.

The single-pass classification performances indicate that, based on the statistical inputs of the class cluster signatures, the classifier was unable to separate specific crop types very efficiently. Attempts were made to find a logical reason for the inadequate crop evaluations. Each step of the data processing cycle – from training field selection to classification – was evaluated. After a thorough investigation of the training and test fields, their coordinates, ground-truth data, image interpretation procedures, clustering results, and finally the classification performances, it was decided that the following factors contributed to the unsatisfactory results.

3.2.1 Selection of Training and Test Fields

Because of uncertainty in the registration of the ERTS-1 data with respect to the test segment photographic mosaics, on several occasions fields were selected too close to the field boundary areas. In some cases these fields extended into other crop areas, resulting in deficient classification performances.

3.2.2 Variability in Physical Conditions

Nonhomogeneity of physical conditions, both within and between the selected fields, was a major contributor to the unsatisfactory results of this project.

3.2.3 Small Sample Size of Training Field

A third, somewhat related factor was the relatively small sample size of the training field for generation of statistics. The small sample size did not adequately represent class variations and, because of location errors and the variations in physical conditions, the statistics resulting from the clustering did not represent the crop types accurately. Abnormally large signature variances resulted.

3.2.4 Clustering Method

All the training fields for each major class (corn, soybeans, wheat, and "other") were clustered by the Iterative Self-Organizing Clustering System (ISOCLS), and signatures were generated. Several widely separated crop signatures resulted for some fields, as indicated for wheat in figure 1. Different selection criteria were employed in an effort to distinguish the crop types more accurately, but the results did not improve significantly.

3.3 MULTITEMPORAL ANALYSIS

The multitemporal analyses were accomplished by processing several periods together using the same clustering results and the same test fields as for the single-pass analyses. Periods I and II were processed together first, then periods II and III, and finally periods III and V. The results are given in table II.

Comparisons of single-pass and multitemporal results did not improve the classification results significantly. Even though the single-pass clustering results varied within and between the test and training field sets, it was expected that combining statistics on a temporal basis would improve the recognition factor by an additional 10 percent.

3.3.1 Data Preparation

Because of inconsistencies in the results using the EOD standard processing method 1 (SP1), the multitemporal analysis of the CITARS data was undertaken. This action, which deviated from established procedures, was attempted in order to gain a better understanding of the reasons for the inconsistencies and to improve the classification results. Because the training statistics for EOD-SP1 were obviously not altogether representative of the crop types involved, serious discrepancies in the crop classifications resulted. Using multitemporal processing, the following attempts were made to improve the results.

1. A different set of training fields was selected.
2. Homogeneity of the fields and the field size were the primary criteria in selecting the training fields; therefore, it was not entirely a random field selection.
3. Instead of developing statistics by clustering the training fields only, the total test area was clustered (the "cluster-all" method), and the training statistics for the training fields were developed from the clusters appearing within those fields.

When the classification results for single-pass and multitemporal processing for period I were compared, a substantial amount of improvement was noted (table II). The cluster-all method of generating training statistics indicated an improvement in classification results over the EOD-SP1 procedure, as noted in table III. The training signatures from this method indicated the presence of a more closely knit set of statistics for each crop type.

The cluster results also identified several abnormalities or anomalies within specific fields or areas which, when associated with the ground truth, verified hail damage and disease in some areas, both of which affected the condition of the crops. In other cases, fields were found to be heavily watered either by normal irrigation or by flooding that occurred during the ERTS-1 data acquisition on June 29, 1973.

3.3.2 Processing of Multitemporal Data

The data processing approach for the multitemporal analysis of the CITARS data over the Fayette County test segment is described in figure 2.

3.3.2.1 <u>Tape merge and registration</u>.- Gray maps were generated for each of the four periods (ERTS-1 passes), and a set of 25 control points common to each of the maps was selected. These points were the bases for merging the four tapes received from the LARS and for the transformation required to register the tapes to a base map. The results of the registration indicated an overall average residual error of plus or minus one pixel (data point) over the test area (table IV). A problem of unknown origin became apparent toward the lower right (southeast) corner of the period V data, where residuals of up to four pixels were accumulated from the best fit. Since that particular area contained very few fields and since testing the remainder of the area resulted in good correlation, the merging of the tapes was accepted for further processing and analysis.

3.3.2.2 Generation of training statistics.- Two methods were utilized to generate statistics for classification: the EOD-SP1 clustering procedure and the cluster-all procedure.

The specified separating criteria for the EOD-SP1 procedure were modified. The parameters originally specified[1] for allowing flexibility in streamlining the clustering process to fit a particular application were considered slightly larger than necessary. These parameters were set to the following values: STDMAX = 2.5 , DLMIN = 2.5 , NMIN = 5 , and ITMAX = 7 . For various reasons such as cloud cover, human errors, and misregistrations, the field boundaries for Fayette County changed consistently during the early stages of the project; thus, some of the preliminary accomplished work had to be redone. Confusion resulted, and it is possible that not all analysts were using the same field boundaries. The training fields used for the multitemporal analysis are listed in table V. In clustering the total Fayette County test segment, the same cluster-splitting parameters were employed; however, the total clusters were held to 30 because of limitations imposed by

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[1]See appendix I of the Task Design Plan, Volume I of the CITARS.

the Univac 1108 using the EOD version of the LARSYS classification program. Once the cluster map was generated, all of the training fields listed in table V were outlined on the map, and the clusters falling within the field boundaries were listed (table VI). This list assisted in assigning all of the clusters to a specific crop type or to the category "other." Table VI lists the clusters in alphanumeric order and the number of times that the specific cluster appeared within a specific field boundary. For instance, cluster 2 appeared only one time within a specified wheat training field and four times within one of the category "other" training fields. The data in table VI resulted from clustering the total Fayette County test segment utilizing ERTS-1 data from channels 2, 3, and 4 from each of periods I, II, III, and V (12 channels) together. The crop type identified under the "Remarks" column indicates how the training statistics for that specific cluster were used in the final classification. For instance, the statistics for cluster 2 were used for one category of "other," whereas the statistics for cluster 3 were used as one signature for soybeans.

The training statistics (class means and standard deviations) for the classification summary shown in table I resulted from clustering only field centers. These are given in appendix A. The training statistics for the classification summary for periods I, II, III, and V (table III), which are related to the cluster analysis (table VI) mentioned above, are included as appendix B.

In order to gain an insight into the reasons for the confusion of some crops with others and the reasons why some crops were thresholded (not classified), a form of crop calendar was developed (table VII). This calendar is considered an interim product only and was generated from ground-truth information and cropping practices within the Fayette County area.

TABLE I.– CLASSIFICATION SUMMARY FOR SINGLE-PASS ANALYSIS

Data set	Class identified by ground truth	Percentage classified as				Thresh-olded, %	Performance, %	
		Corn	Soybeans	Wheat	Other		Average	Overall
FAY610	Wheat			36.9	63.1			
	Other			13.2	78.4	8.4		
	All classes						50.8	40.5
FAY629	Corn	59.9	2.3	22.8	12.7	2.3		
	Soybeans	3.9	13.6	12.3	62.8	7.4		
	Wheat	20.0	12.3	33.8	26.2	7.7		
	Other	8.9	4.5	6.4	72.1	8.1		
	All classes						50.3	41.5
FAY717	Corn	85.4	0.4		13.8	0.4		
	Soybeans	1.3	39.8		51.6	7.3		
	Other	7.8	8.0		76.4	7.8		
	All classes						60.3	58.0
FAY821	Corn	73.7	3.9		22.4			
	Soybeans	1.3	61.6		36.2	0.9		
	Other	4.3	7.8		81.8	6.1		
	All classes						63.9	63.6

TABLE II.– CLASSIFICATION SUMMARY USING MULTITEMPORAL ANALYSIS

Combined data set	Class identified by ground truth	Percentage classified as				Thresh- olded, %	Performance, %	
		Corn	Soybeans	Wheat	Other		Average	Overall
FAY610 and FAY629	Wheat			30.8	67.7	1.5		
	Other			8.9	83.3	7.8		
	All classes						53.8	57.5
FAY629 and FAY717	Corn	89.3	0.4	2.8	2.5	5.0		
	Soybeans	3.1	71.4	2.5	2.5	20.5		
	Wheat	9.2	16.9	29.2	30.8	13.9		
	Other	2.2	3.1	8.7	70.7	15.3		
	All classes						61.9	67.2
FAY717 and FAY821	Corn	87.2	0.4		11.0	1.4		
	Soybeans	0.3	79.9		4.7	15.1		
	Other	1.9	5.2		78.9	14.4		
	All classes						64.5	71.6

TABLE III.– CLASSIFICATION RESULTS USING CLUSTER-ALL METHOD

Combined data set	Class identified by ground truth	Percentage classified as				Thresh-olded, %	Performance, %	
		Corn	Soybeans	Wheat	Other		Average	Overall
For total area								
FAY610, FAY629, and FAY717[a]	Corn	91.7	1.8		4.7	1.8		
	Soybeans	4.0	88.4		7.3	0.3		
	Other	16.5	6.0		74.2	3.3		
	All classes						61.1	65.9
FAY610, FAY629, FAY717, and FAY821[a]	Corn	93.1	0.4		4.7	1.8		
	Soybeans	0.8	93.9		4.5	0.8		
	Other	16.2	6.0		74.9	0.3		
	All classes						69.6	71.6
For NASA-selected wheatfields								
FAY610[b]	Wheat			76.9	23.1			
	Other			5.6	91.3	4.2		
FAY610 and FAY629[b]	Wheat			72.3	27.7			
				33.6	58.1	8.3		

[a]Channel 1 is deleted from these data sets. The total area was clustered and evaluated for channels 2, 3, and 4 only.

[b]Only clustered fields were used in these evaluations.

TABLE IV.— RESIDUAL DISTRIBUTIONS RESULTING FROM REGISTRATION OF TAPES

Line sample	Column sample				
	50	110	170	230	290
FAY610 versus FAY629					
50	(0,0)	(0,0)	(0,-1)	(1,0)	(0,0)
150	(0,0)	(0,0)	(1,0)	(0,0)	(0,0)
250	(0,0)	(0,0)	(1,0)	(0,0)	(0,0)
350	(0,0)	(0,0)	(0,0)	(0,0)	(-1,1)
450	(0,0)	(0,0)	(0,0)	(-1,1)	(-1,1)
FAY610 versus FAY717					
50	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)
150	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)
250	(0,0)	(0,0)	(1,0)	(1,0)	(0,0)
350	(0,0)	/[a]	(1,0)	(0,0)	(1,1)
450	(0,0)	(1,-1)	(1,0)	(0,0)	(1,0)
FAY610 versus FAY821					
50	(0,0)	(0,0)	(0,0)	/	(0,0)
150	(0,0)	/	(0,0)	(0,0)	(1,-1)
250	(0,0)	/	(1,-1)	(2,1)	/
350	(0,0)	(1,-1)	(1,-1)	(1,-1)	(2,-1)
450	/	(2,-1)	(2,-2)	(2,-1)	(4,-1)

[a]Slash mark indicates no comparison was made at this point because of deficient data.

TABLE IV.— RESIDUAL DISTRIBUTIONS RESULTING FROM REGISTRATION OF TAPES — Concluded

Line sample	Column sample				
	50	110	170	230	290
FAY717 versus FAY821					
50	(0,0)	(0,0)	(0,-1)	(0,-1)	(0,0)
150	(0,0)	/[a]	(0,-1)	(0,-1)	(0,-1)
250	/	/	(0,-1)	(1,-1)	/
350	(0,0)	(-1,2)	(0,-1)	(1,-1)	(1,-1)
450	/	(0,0)	(1,-1)	(1,-1)	(3,-1)

[a]Slash mark indicates no comparison was made at this point because of deficient data.

TABLE V.— TRAINING FIELDS FOR MULTITEMPORAL ANALYSIS

Field ID	Field coordinates				Data points
			Corn		
5-57-30	409	412	114	117	16
5-64-70	144	145	125	127	6
5-73-09	324	326	130	131	6
5-95-26	369	370	168	169	4
5-95-30	367	370	162	164	12
			Soybeans		
5-05-41	161	162	59	59	2
5-05-49	166	167	62	62	2
5-10-52	272	274	59	62	12
5-18-03	425	426	54	56	6
5-27-08	407	412	134	134	6
5-27-43	206	209	94	94	4
5-64-63	140	140	124	126	3
5-73-10A	324	327	126	126	4
5-73-10B	324	325	127	127	2
5-85-01	150	151	151	151	2
5-85-07A	155	156	152	159	16
5-88-66	230	231	156	158	6
5-100-03	473	474	153	155	6
			Wheat		
5-05-48	166	167	66	67	4
5-12-09	301	301	55	55	1
5-34-06	346	347	83	83	2
5-52-01	309	314	110	110	6
5-52-02	309	312	117	117	4
5-57-23	405	406	117	119	6
5-74-01	357	357	131	133	3
5-76-01A	401	401	128	131	4
5-76-01B	402	402	127	130	4
5-77-11A	410	411	130	131	4
5-77-11B	412	412	128	131	4

TABLE V.— TRAINING FIELDS FOR MULTITEMPORAL ANALYSIS - Concluded

Field ID	Field coordinates				Data points
Brush					
5-57-27	411	413	123	123	3
Clover					
5-22-43	99	102	94	94	4
Water[a]					
	53	53	137	139	3
	56	56	133	136	4
	60	60	130	132	3
	275	276	134	139	12
	276	277	115	121	14
	277	277	141	149	9
	278	278	104	117	14
Weeds					
5-12-12A	305	306	53	55	6
5-55-44A	376	380	116	118	15
5-55-44B	378	380	119	122	12
5-100-08	474	476	148	149	6
Woods[a]					
	81	83	84	89	18
	460	471	115	122	96

[a]Water and woods do not carry field ID's.

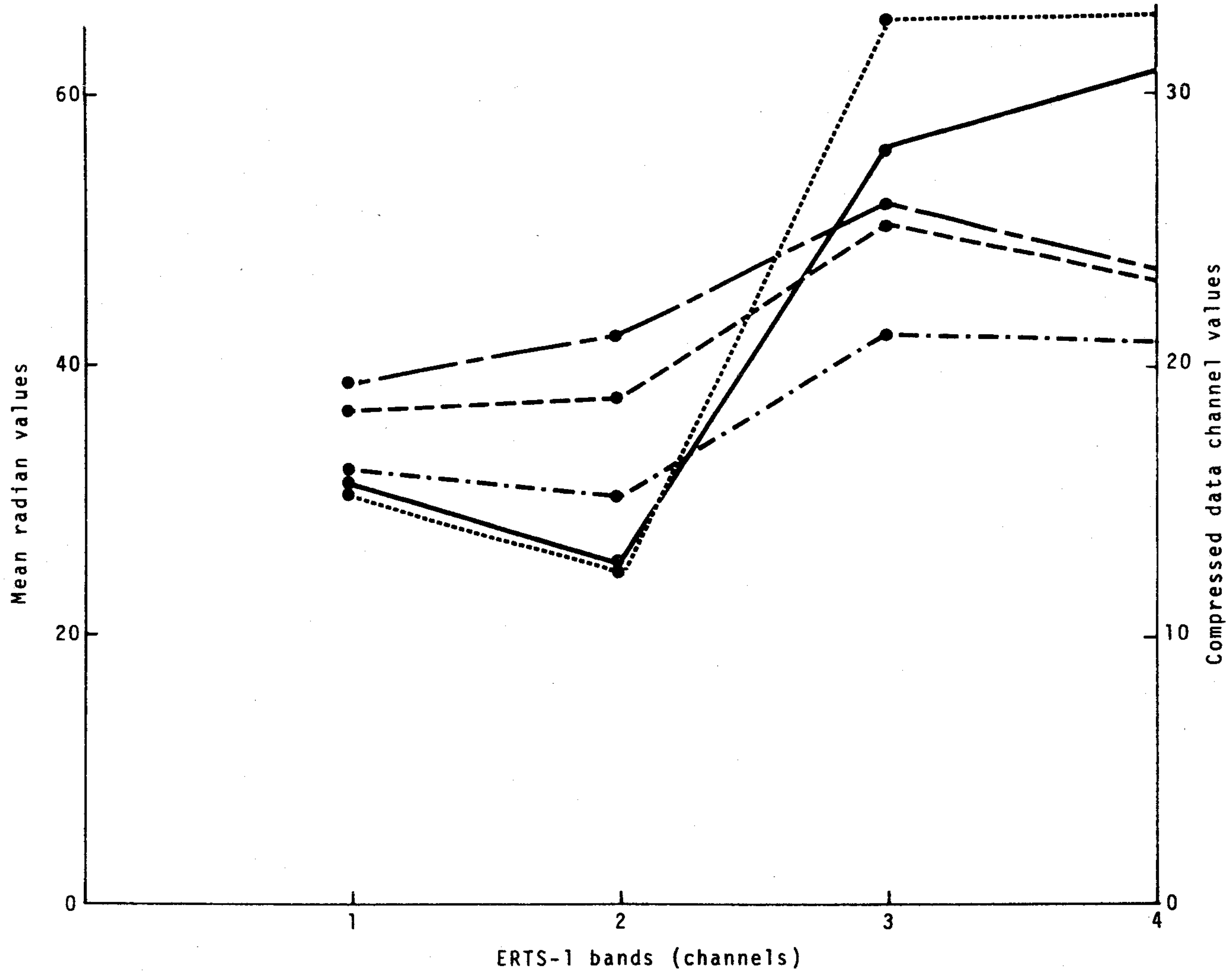
TABLE VI.– CLUSTER ANALYSIS

Cluster	Corn	Soybeans	Wheat	Other	Remarks
2			1	4	Other
3		25		7	Soybeans
4					Other
5		2	2	2	Wheat → soybeans[a]
6		2	5	8	Wheat → other
7			11		Wheat → other
8		2	6	10	Wheat → other
9			3		Wheat → other
A	4				Corn
B	2	1			Other
C	18	3			Corn
D		12		14	Bare soil → soybeans
E					Woods
F					Water
G	2	4		1	Other
H		1			Other
I		1			Other
J		16			Soybeans
K	11		5		Corn
L		2		12	Other
M	3	5	2		Other
N		23		9	Bare soil → soybeans
O			1		Other
P		21	10		Wheat → soybeans
Q			3	1	Wheat → other
R	3				Corn
S	24		2		Corn
T					Other
U				4	Other

[a]Arrow (→) means second vegetation was present after harvesting or classifying the first.

TABLE VII.— APPROXIMATE CROP CALENDAR FOR FAYETTE COUNTY, ILLINOIS

Crop type	Period I (6/10/73)	Period II (6/29/73)	Period III (7/17/73)	Period V (8/20/73)
Corn	Crop emergence, mostly bare ground.	Partial plant canopy; some bare soil; similar to pasture.	Full plant canopy; tasseling; can be confused with pasture.	Plant florescence, mostly blooming; beginning to ripen.
Soybeans	Bare soil, very little plant material above ground.	Crop emergence, strong soil response; similar to grain.	Partial plant canopy, similar to grain; separable from corn.	Full plant canopy; practically no soil response.
Wheat	Plant florescence, mostly blooming; beginning to ripen; some harvesting.	Plant senescence, fully ripened; partial harvest.	Fully harvested; companion crop beginning to show.	Total response is from companion crop — soybeans or "other."
Alfalfa	Hay is full green; good infrared reflectance; similar to wheat.	Prior to mowing; very green; good infrared reflectance.	Mowing in progress; in several different stages as mowing proceeds and harvest is removed.	Mostly all cut and some regrowth.
Pasture	Resembles wheat and alfalfa, although texture is somewhat different.	Similar to corn; slight bare soil response.	In green stage; similar to corn and alfalfa.	In green stage; very similar to corn, soybeans, and alfalfa.



NOTE: Each graph line depicts a signature for wheat using the same set of training fields.

Figure 1.— Graph showing variations in signatures for wheat.

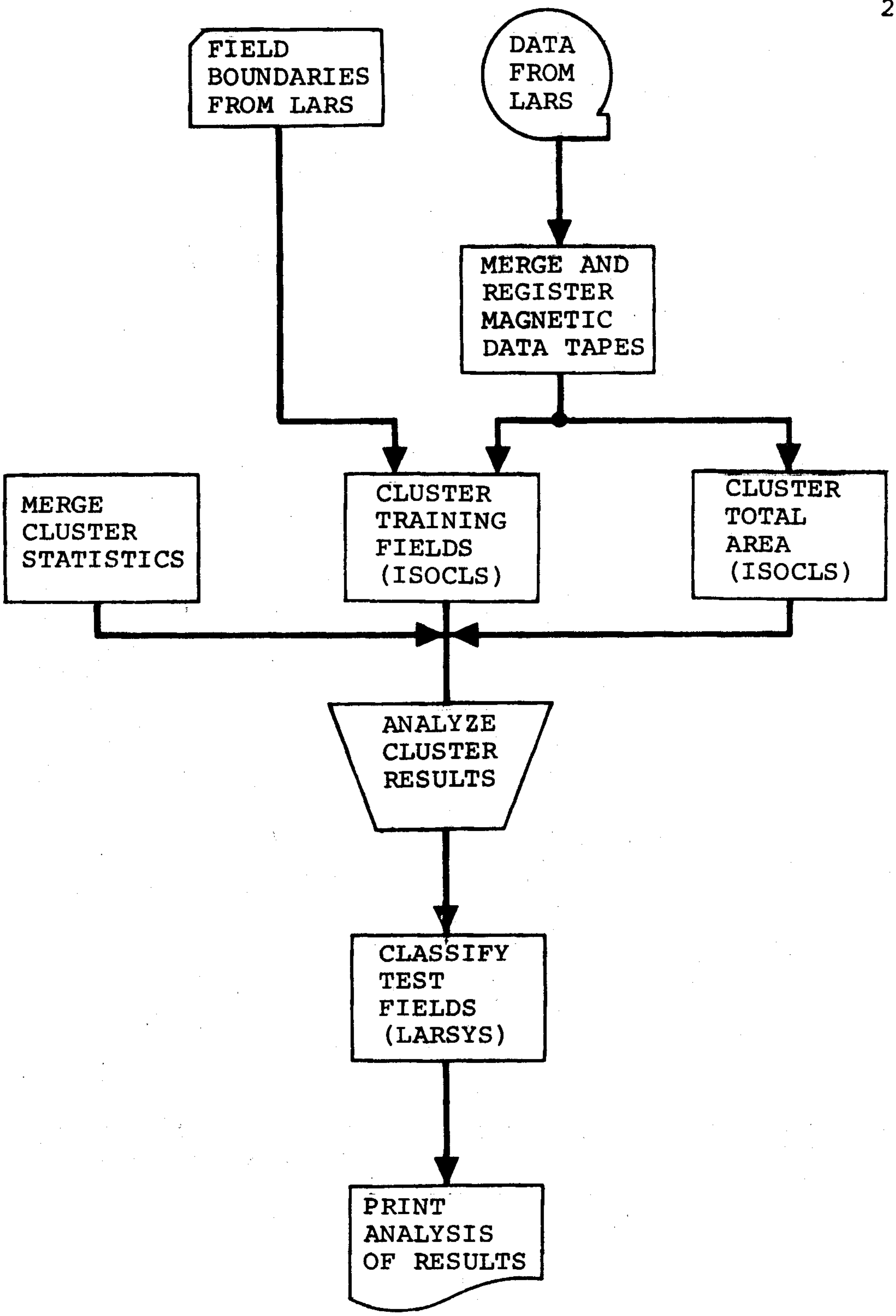


Figure 2.- Diagram showing flow of data for multitemporal analysis.

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4.0 SUMMARY AND CONCLUSIONS

It is apparent that the final classification results of the CITARS project were not very conclusive. On a single-pass basis, as shown in table I, the best recognition for wheat was 37 percent, with most of the confusion occurring when corn and alfalfa were present. Probably the best period for classifying wheat in the central Illinois region would be approximately a month earlier. In the case of corn and soybeans, again the best recognition results occurred during their peak-green (full-canopy) stage, with soybeans ripening approximately a month later than corn. Although showing slight improvement, the multitemporal recognition analysis (table II) definitely showed confusion in the individual crop signatures, as shown by the relatively high rate of thresholding for both wheat and soybeans.

Classification results were improved moderately utilizing the cluster-all method of generating statistics. A cluster analysis similar to that shown in table VI related each cluster to a specific crop type, which takes maximum advantage of the spectral signature for that crop type.

A set of segment crop proportion summaries was developed utilizing the cluster results and classifying both the test and photointerpreted fields. These results are set out in appendix C. For comparison purposes, the results for photointerpretation are included also.

The unsatisfactory classification results of the project are not unique, either to the CITARS or to the procedures and techniques used. It is apparent that the problems encountered, such as the variability of field statistics, numbers and sizes of training fields, and excessive cloud cover, were not addressed specifically with the intention of solving or making appropriate allowances for them. These impediments should have been anticipated before the onset of the project; or, alternatively, at least one facet of the project should have intentionally attacked and attempted to solve them.

The results showed that multitemporal analysis has an advantage over the single-pass classification analysis. The cluster-all technique for generating statistics was more effective for grouping of classes. Both of these facets need additional development and analysis in order to make the necessary improvements which the preliminary results seem to indicate.

The original plan was well designed on a theoretical basis. However, the restricted objectives of the CITARS task placed emphasis on the analysis-of-variance results rather than on the project itself and therefore did not allow for extensive analysis and development of techniques. More effort should have been placed on the day-to-day activity of the project, on techniques research, and on the making of management decisions when difficulties arose.

Understandably, in some ways the final results, good or bad, have a satisfactory aspect; however, it would have been very advantageous had they been as good or better than the procedures that generated them.

APPENDIX A

TRAINING STATISTICS FOR SINGLE-PASS CLASSIFICATION SUMMARY

APPENDIX A

TRAINING STATISTICS FOR SINGLE-PASS CLASSIFICATION SUMMARY

Tables A-I through A-IV show the training statistics for FAY610, FAY629, FAY717, and FAY821.

TABLE A-I.– TRAINING STATISTICS FOR FAY610

(a) Means

Class	Channel			
	1	2	3	4
Corn 1	33.20	29.60	53.40	29.40
Corn 2	29.50	26.33	36.67	18.50
Corn 3	29.50	22.44	53.44	31.11
Corn 4	32.08	28.31	46.00	24.46
Soybeans 1	41.86	46.57	52.43	25.86
Soybeans 2	28.87	20.12	62.00	34.62
Soybeans 3	33.58	34.09	40.94	20.36
Soybeans 4	37.75	36.85	49.10	25.20
Wheat 1	36.33	37.56	51.89	27.11
Wheat 2	31.75	27.50	43.08	22.33
Wheat 3	30.67	24.17	59.17	35.00
Wheat 4	31.90	26.30	52.80	29.20
Other 1	40.18	38.39	25.63	6.18
Other 2	29.90	23.10	21.30	6.50
Other 3	23.18	13.27	59.18	41.45
Other 4	23.52	13.88	53.30	33.13
Other 5	23.21	13.24	59.79	35.68
Other 6	42.29	48.14	50.29	24.43
Other 7	29.00	20.11	57.56	34.78
Other 8	36.64	36.43	38.43	18.57
Other 9	32.87	30.50	40.25	19.12
Other 10	39.25	40.62	44.12	21.87

TABLE A-I.– TRAINING STATISTICS FOR FAY610

(b) Standard deviations

Class	Channel			
	1	2	3	4
Corn 1	2.04	2.94	1.50	2.15
Corn 2	1.26	.94	2.21	1.26
Corn 3	1.21	1.34	1.61	1.05
Corn 4	1.33	2.27	2.29	1.55
Soybeans 1	1.81	2.56	5.23	2.10
Soybeans 2	1.05	2.42	5.45	4.41
Soybeans 3	7.52	3.65	4.71	2.65
Soybeans 4	2.55	4.77	4.25	2.25
Wheat 1	1.33	2.45	2.42	1.59
Wheat 2	.83	2.06	1.89	1.80
Wheat 3	.47	1.34	2.73	2.71
Wheat 4	1.22	2.15	2.09	1.17
Other 1	2.08	2.07	2.46	.98
Other 2	1.22	2.07	5.46	3.72
Other 3	.94	.45	1.70	3.82
Other 4	.72	.63	1.66	1.37
Other 5	.90	.77	6.82	1.28
Other 6	1.58	2.36	3.06	.90
Other 7	1.83	2.38	4.30	4.76
Other 8	1.04	1.68	1.59	.90
Other 9	1.36	2.55	2.44	1.17
Other 10	.83	1.80	1.90	1.62

TABLE A-I.— TRAINING STATISTICS FOR FAY610

(c) Covariance matrices

Corn 1

4.16			
5.28	8.64		
1.52	1.36	2.24	
-1.88	-2.04	1.44	4.64

Corn 2

1.58			
.67	.89		
1.67	1.44	4.89	
1.25	1.00	1.83	1.58

Corn 3

1.47			
1.17	1.80		
1.11	.80	2.58	
.17	.06	.95	1.10

Corn 4

1.76			
2.51	5.14		
.15	1.15	5.23	
.20	1.09	3.31	2.40

Soybeans 1

3.27			
2.37	6.53		
6.78	12.47	27.39	
3.27	4.37	10.35	4.41

Soybeans 2

1.11			
1.89	5.86		
-2.75	-9.25	29.75	
-2.80	-7.58	23.00	19.48

Soybeans 3

56.61			
1.98	13.36		
8.52	7.22	22.18	
2.55	3.76	11.66	7.02

Soybeans 4

6.49			
9.01	22.73		
1.98	-5.03	18.09	
-.85	-6.12	7.93	5.06

TABLE A-I.— TRAINING STATISTICS FOR FAY610

(c) Covariance matrices — Continued

Wheat 1

1.78			
2.26	6.02		
.93	-2.38	5.88	
.30	-1.62	3.35	2.54

Wheat 2

.69			
.79	4.25		
-.06	-2.46	3.58	
-.25	-2.75	3.06	3.22

Wheat 3

.22			
.22	1.81		
1.06	1.64	7.47	
1.17	2.00	6.17	7.33

Wheat 4

1.49			
2.33	4.61		
.68	1.56	4.36	
-.58	-.26	1.14	1.36

Other 1

4.31			
1.26	4.28		
-.26	2.84	6.07	
.35	.28	1.33	.97

Other 2

1.49			
2.51	4.29		
-1.57	-3.23	29.81	
-.95	-1.95	19.35	13.85

Other 3

.88			
-.14	.20		
.33	-.14	2.88	
.74	.42	-1.90	14.61

Other 4

.52			
.04	.40		
-.24	-.05	2.75	
-.00	-.32	1.08	1.88

TABLE A-I.– TRAINING STATISTICS FOR FAY610

(c) Covariance matrices – Concluded

Other 5

.81			
.16	.59		
-.13	1.67	46.52	
.18	-.07	-3.10	1.63

Other 6

2.49			
1.39	5.55		
3.49	5.10	9.35	
1.31	.37	2.02	.82

Other 7

3.33			
3.44	5.65		
.11	-2.62	18.47	
-3.11	-7.31	18.12	22.62

Other 8

1.09			
.44	2.82		
.51	1.53	2.53	
.70	.61	.83	.82

Other 9

1.86			
3.06	6.50		
-.09	-2.12	5.94	
-.11	-.81	2.34	1.36

Other 10

.69			
.59	3.23		
-.03	2.05	3.61	
-.34	1.45	2.39	2.61

TABLE A-II.— TRAINING STATISTICS FOR FAY629

(a) Means

Class	Channel			
	5	6	7	8
Corn 1	28.75	24.12	33.62	17.00
Corn 2	29.32	22.21	53.16	30.74
Corn 3	31.45	27.09	43.64	22.82
Soybeans 1	41.22	44.22	55.11	27.00
Soybeans 2	29.50	19.87	61.12	34.00
Soybeans 3	32.83	30.67	33.00	16.17
Wheat 1	37.25	39.75	51.50	27.00
Wheat 2	31.83	27.33	43.08	22.25
Wheat 3	30.80	24.40	60.20	36.00
Wheat 4	32.71	31.00	33.71	20.29
Wheat 5	31.78	24.89	54.00	30.22
Other 1	39.86	38.14	25.61	6.24
Other 2	28.00	20.80	33.40	16.00
Other 3	30.40	23.80	20.20	5.60
Other 4	23.20	13.30	58.80	41.60
Other 5	23.42	13.61	54.22	34.01
Other 6	23.69	14.37	54.75	29.69
Other 7	23.18	13.29	63.41	36.29
Other 8	41.62	46.75	48.62	24.00
Other 9	37.94	38.50	40.81	20.19
Other 10	33.50	31.40	38.80	18.50
Other 11	27.60	18.20	56.90	33.90

TABLE A-II.— TRAINING STATISTICS FOR FAY629

(b) Standard deviations

Class	Channel			
	5	6	7	8
Corn 1	1.39	1.76	2.23	1.58
Corn 2	1.13	1.28	1.78	1.07
Corn 3	1.23	1.83	2.57	1.90
Soybeans 1	1.99	4.39	4.36	1.56
Soybeans 2	1.87	2.80	5.75	3.91
Soybeans 3	2.41	3.40	4.83	3.18
Wheat 1	1.56	2.54	1.00	.87
Wheat 2	.99	1.60	2.36	1.96
Wheat 3	.40	1.36	2.04	1.90
Wheat 4	1.03	2.27	10.96	3.57
Wheat 5	.92	1.10	1.94	1.31
Other 1	2.01	2.08	2.48	1.20
Other 2	1.67	2.48	3.38	4.20
Other 3	.49	.98	3.49	3.38
Other 4	.98	.46	1.25	3.98
Other 5	.81	.69	1.99	1.31
Other 6	.58	.60	6.50	3.29
Other 7	.92	.75	8.31	1.77
Other 8	1.11	3.07	2.69	.71
Other 9	1.30	1.80	2.38	1.47
Other 10	1.80	2.80	1.89	1.02
Other 11	1.50	1.33	3.59	3.99

TABLE A-II.– TRAINING STATISTICS FOR FAY629

(c) Covariance matrices

Corn 1

1.94			
1.03	3.11		
1.66	3.17	4.98	
1.88	2.00	2.13	2.50

Corn 2

1.27			
.72	1.64		
.85	.91	3.19	
.19	-.26	.83	1.14

Corn 3

1.52			
1.78	3.36		
.62	-.42	6.60	
.63	.02	4.66	3.60

Soybeans 1

3.95			
4.84	19.28		
5.31	-.02	18.99	
2.22	-.67	6.11	2.44

Soybeans 2

3.50			
4.31	7.86		
-5.44	-12.48	33.11	
-3.50	-8.75	21.50	15.25

Soybeans 3

5.81			
7.94	11.56		
11.50	15.17	23.33	
7.36	10.06	14.83	10.14

Wheat 1

2.44			
3.56	6.44		
.38	.38	1.00	
-.12	.13	.25	.75

Wheat 2

.97			
1.22	2.56		
.93	.97	5.58	
.71	.75	4.40	3.85

TABLE A-II.– TRAINING STATISTICS FOR FAY629

(c) Covariance matrices – Continued

Wheat 3

.16			
.08	1.84		
.44	.92	4.16	
.60	1.20	2.40	3.60

Wheat 4

1.06			
.71	5.14		
3.49	17.29	120.20	
-.92	-5.86	-38.78	12.78

Wheat 5

.84			
.31	1.21		
.00	-.22	3.78	
-.84	-.75	.67	1.73

Other 1

4.04			
1.55	4.33		
-.30	2.53	6.16	
-.21	-.28	1.52	1.45

Other 2

2.80			
3.40	6.16		
-.60	-1.32	11.44	
-1.60	-2.80	14.00	17.60

Other 3

.24			
.48	.96		
-1.08	-2.16	12.16	
-.84	-1.68	11.28	11.44

Other 4

.96			
-.16	.21		
.44	-.04	1.56	
.78	.42	-1.48	15.84

Other 5

.66			
.13	.48		
-.14	-.33	3.97	
.17	-.22	1.64	1.72

TABLE A-II.– TRAINING STATISTICS FOR FAY629

(c) Covariance matrices – Concluded

Other 6

.34			
-.13	.36		
-.39	1.22	42.19	
-.35	-.01	-7.39	10.84

Other 7

.85			
.12	.56		
.16	2.82	69.07	
-.17	-.44	-8.41	3.15

Other 8

1.23			
1.66	9.44		
1.73	7.16	7.23	
.63	.75	1.13	.50

Other 9

1.68			
1.09	3.25		
1.93	2.84	5.65	
1.26	1.09	2.54	2.15

Other 10

3.25			
4.50	7.84		
-2.90	-4.52	3.56	
-1.25	-1.90	1.50	1.05

Other 11

2.24			
1.08	1.76		
-.34	1.42	12.89	
-3.34	-.88	10.79	15.89

TABLE A-III.— TRAINING STATISTICS FOR FAY717

(a) Means

Class	Channel			
	9	10	11	12
Corn 1	39.33	38.17	63.92	35.08
Corn 2	31.50	22.33	70.50	45.17
Corn 3	30.47	21.20	60.40	39.07
Corn 4	31.64	22.36	64.18	39.27
Soybeans 1	50.45	54.27	65.91	33.18
Soybeans 2	37.79	33.53	60.84	32.58
Soybeans 3	46.00	47.06	61.18	30.65
Wheat 1	38.40	42.00	50.60	26.60
Wheat 2	32.67	25.11	55.00	30.56
Wheat 3	30.60	20.80	62.20	36.60
Other 1	25.75	15.50	34.00	18.50
Other 2	33.65	23.29	15.63	3.39
Other 3	26.75	16.11	59.89	36.93
Other 4	26.14	15.36	55.55	34.10
Other 5	26.27	15.68	56.82	36.36
Other 6	25.68	15.21	52.68	33.26
Other 7	53.14	60.71	62.00	29.57
Other 8	28.83	22.00	53.50	31.83
Other 9	41.62	40.12	64.37	34.12
Other 10	35.18	32.50	33.45	16.77
Other 11	45.55	48.05	56.82	28.05

TABLE A-III.– TRAINING STATISTICS FOR FAY717

(b) Standard deviations

Class	Channel			
	9	10	11	12
Corn 1	2.72	6.88	4.25	2.93
Corn 2	1.80	.94	2.29	1.46
Corn 3	1.36	1.17	1.25	1.81
Corn 4	1.49	.64	.94	.75
Soybeans 1	3.09	4.16	1.83	1.40
Soybeans 2	1.61	2.48	3.54	3.62
Soybeans 3	1.33	2.21	3.63	1.75
Wheat 1	2.33	1.26	1.62	2.33
Wheat 2	1.05	3.07	1.89	1.89
Wheat 3	.80	1.47	1.78	1.02
Other 1	.83	.50	8.25	4.39
Other 2	2.48	2.38	1.28	.97
Other 3	.63	.62	1.05	1.31
Other 4	.89	.53	.76	.75
Other 5	.75	.55	.78	.71
Other 6	1.22	.41	.98	1.02
Other 7	1.46	2.31	2.62	1.76
Other 8	.90	1.15	5.85	3.72
Other 9	3.31	3.72	4.12	1.27
Other 10	2.01	2.71	2.71	1.62
Other 11	2.71	4.13	5.77	3.11

TABLE A-III.— TRAINING STATISTICS FOR FAY717

(c) Covariance matrices

Corn 1

7.39			
17.44	47.31		
3.19	1.68	18.08	
-2.11	-9.35	9.59	8.58

Corn 2

3.25			
1.17	.89		
2.25	.50	5.25	
1.58	.28	1.25	2.14

Corn 3

1.85			
1.31	1.36		
-.25	-.81	1.57	
-1.30	-1.55	1.57	3.26

Corn 4

2.23			
.59	.41		
-1.02	-.34	.88	
-.17	-.01	.31	.56

Soybeans 1

9.52			
11.24	17.29		
1.04	-.25	3.36	
-2.17	-3.50	1.47	1.97

Soybeans 2

2.59			
3.06	6.14		
-.51	-2.34	12.55	
-1.98	-3.78	9.99	13.09

Soybeans 3

1.77			
1.29	4.88		
.77	3.23	13.20	
.82	1.02	4.47	3.05

Wheat 1

5.44			
1.20	1.60		
-1.44	-.80	2.64	
-1.04	-2.40	2.64	5.44

TABLE A-III.— TRAINING STATISTICS FOR FAY717

(c) Covariance matrices — Continued

Wheat 2

1.11			
2.37	9.43		
.44	-1.22	3.56	
.19	-1.73	3.00	3.58

Wheat 3

.64			
.12	2.16		
-.12	-.26	3.16	
.04	.12	.28	1.04

Other 1

.69			
.13	.25		
-6.50	.00	68.00	
-3.12	.50	35.00	19.25

Other 2

6.15			
5.20	5.66		
-.97	-.36	1.65	
-1.37	-1.33	.38	.94

Other 3

.40			
-.12	.38		
.01	-.10	1.10	
.34	-.10	.67	1.71

Other 4

.79			
-.03	.28		
.11	-.08	-.58	
.13	.06	.19	.56

Other 5

.56			
.09	.31		
.05	-.10	.60	
.17	.07	-.12	.50

Other 6

1.48			
-.14	.17		
.22	.07	.95	
.50	-.16	.19	1.04

TABLE A-III.– TRAINING STATISTICS FOR FAY717

(c) Covariance matrices – Concluded

Other 7

2.12			
1.04	5.35		
1.71	5.86	6.86	
1.20	3.88	4.43	3.10

Other 8

.81			
.33	1.33		
5.08	1.33	34.25	
3.14	.33	21.58	13.81

Other 9

10.98			
10.80	13.86		
10.14	11.20	16.98	
.92	.73	3.45	1.61

Other 10

4.06			
5.09	7.34		
4.51	6.18	7.34	
2.63	3.80	3.38	2.63

Other 11

7.34			
8.07	17.04		
2.78	4.60	33.24	
1.29	1.00	16.55	9.68

TABLE A-IV.— TRAINING STATISTICS FOR FAY821

(a) Means

Class	Channel			
	13	14	15	16
Corn 1	34.00	28.57	50.14	28.00
Corn 2	28.33	20.04	52.07	32.37
Corn 3	28.10	21.10	48.20	28.30
Soybeans 1	26.61	15.33	68.06	43.56
Soybeans 2	29.00	22.11	53.33	29.78
Soybeans 3	28.14	18.67	64.81	38.86
Soybeans 4	26.56	16.25	61.87	40.19
Wheat 1	47.12	54.87	56.62	26.00
Wheat 2	30.10	22.60	49.60	27.00
Wheat 3	34.40	31.00	43.00	20.80
Other 1	27.19	16.88	12.42	3.19
Other 2	23.50	13.73	48.54	29.48
Other 3	23.62	14.10	44.79	27.88
Other 4	49.50	60.17	61.17	27.67
Other 5	28.60	19.10	59.10	34.10
Other 6	38.17	41.00	41.33	19.50
Other 7	26.60	20.20	38.00	20.80
Other 8	30.20	22.44	52.64	29.20

TABLE A-IV.– TRAINING STATISTICS FOR FAY821

(b) Standard deviations

Class	Channel			
	13	14	15	16
Corn 1	2.62	2.87	3.44	1.69
Corn 2	1.22	1.23	1.94	1.36
Corn 3	1.51	2.12	1.40	.90
Soybeans 1	.89	.94	1.65	1.34
Soybeans 2	1.25	2.13	3.23	2.78
Soybeans 3	2.38	3.27	1.87	1.81
Soybeans 4	1.32	.75	1.32	1.55
Wheat 1	2.32	1.96	1.73	.87
Wheat 2	.83	1.69	2.29	1.55
Wheat 3	3.72	5.55	2.19	.40
Other 1	1.03	1.14	2.64	1.73
Other 2	1.40	.81	1.46	1.09
Other 3	1.19	.58	1.05	1.00
Other 4	2.06	1.95	2.11	.75
Other 5	2.52	3.51	2.83	1.26
Other 6	1.77	2.00	2.56	.76
Other 7	1.02	1.17	2.28	3.12
Other 8	2.58	3.71	2.50	1.96

TABLE A-IV.- TRAINING STATISTICS FOR FAY821

(c) Covariance matrices

Corn 1

6.86			
7.14	8.24		
5.29	4.63	11.84	
.57	.00	3.86	2.86

Corn 2

1.48			
.62	1.52		
.64	-.08	3.77	
-.16	-.49	1.75	1.86

Corn 3

2.29			
2.19	4.49		
-.12	.38	1.96	
-.03	.37	.54	.81

Soybeans 1

.79			
.24	.89		
.36	-.46	2.72	
-.06	-.69	1.30	1.80

Soybeans 2

1.56			
1.22	4.54		
-.78	1.30	10.44	
-.44	1.69	8.74	7.73

Soybeans 3

5.65			
6.52	10.70		
1.74	2.75	3.49	
-.93	-1.05	.07	3.27

Soybeans 4

1.75			
.23	.56		
-.37	-.66	1.73	
-1.36	-.55	.90	2.40

Wheat 1

5.36			
2.64	3.86		
3.42	1.20	2.98	
1.38	.75	1.13	.75

TABLE A-IV.– TRAINING STATISTICS FOR FAY821

(c) Covariance matrices – Continued

Wheat 2

.69			
1.04	2.84		
-.46	-.36	5.24	
-.80	-1.60	2.80	2.40

Wheat 3

13.84			
20.40	30.80		
6.60	10.60	4.80	
-.32	-.80	-.60	.16

Other 1

1.07			
.14	1.29		
-.60	-1.37	6.99	
-.71	-.72	3.77	3.00

Other 2

1.96			
.29	.66		
-.34	-.25	2.14	
.24	.29	.10	1.18

Other 3

1.41			
.13	.33		
.03	.04	1.10	
.01	-.04	.53	1.00

Other 4

4.25			
3.58	3.81		
3.58	2.47	4.47	
1.17	.72	1.56	.56

Other 5

6.34			
7.74	12.29		
4.39	5.84	7.99	
.94	1.39	2.84	1.59

Other 6

3.14			
2.67	4.00		
3.28	3.50	6.56	
1.08	1.50	1.17	.58

TABLE A-IV.– TRAINING STATISTICS FOR FAY821

(c) Covariance matrices – Concluded

Other 7

1.04			
1.08	1.36		
-1.20	-2.20	5.20	
-2.68	-3.56	6.20	9.76

Other 8

6.64			
8.55	13.77		
2.71	2.68	6.23	
-.48	-1.25	3.15	3.84

B-0a

APPENDIX B

TRAINING STATISTICS FOR CLASSIFICATION SUMMARY FOR PERIODS I, II, III, AND V

APPENDIX B

TRAINING STATISTICS FOR CLASSIFICATION SUMMARY FOR PERIODS I, II, III, AND V

Pages B-2 through B-19 show the covariance matrices for clusters 1 through 30, means, and standard deviations.

COVARIANCE MATRIX FOR CLUSTER 1

53.13											
17.88	36.37										
-.76	11.00	15.25									
25.11	12.20	1.80	45.26								
10.94	23.62	8.35	16.44	33.13							
.56	7.89	7.79	.37	10.09	14.39						
4.91	6.46	2.65	1.19	6.83	4.43	88.32					
-.00	9.84	7.27	3.00	7.88	6.23	13.11	62.77				
-3.63	3.10	3.79	-2.20	2.56	3.30	.75	23.58	15.37			
7.98	6.36	1.90	10.31	8.59	2.53	9.58	-6.94	-5.77	73.01		
2.05	-6.52	-2.24	4.13	-3.06	-.83	-1.13	-6.10	-2.23	2.13	34.48	
-.65	-5.72	-1.46	-.20	-4.05	-.65	-3.39	-.40	1.12	-16.20	19.83	17.81

COVARIANCE MATRIX FOR CLUSTER 2

40.09											
10.27	23.09										
-2.15	5.19	25.14									
4.21	3.05	2.56	39.99								
2.36	13.03	2.07	6.77	22.79							
.08	2.35	14.21	-2.42	6.32	23.71						
.19	3.10	.69	-6.01	.71	1.23	63.36					
2.07	4.59	2.40	.61	2.85	1.41	15.77	43.20				
1.89	1.80	.85	1.76	1.57	.34	-1.64	13.81	17.94			
2.55	-1.03	-.16	-.87	-3.43	-1.14	-.45	-5.05	-2.26	66.88		
-1.41	3.10	1.88	-1.09	.75	.29	3.64	4.91	2.80	9.11	26.97	
-1.40	2.19	1.40	-.27	.78	.36	2.09	5.04	3.04	-9.59	15.02	13.71

COVARIANCE MATRIX FOR CLUSTER 3

11.33											
1.49	23.20										
-.31	3.59	9.12									
7.43	1.31	.24	10.47								
1.50	15.47	1.95	2.07	22.11							
.46	1.99	6.17	.29	3.28	8.74						
3.83	.02	-.45	4.01	-.09	-.64	47.30					
-.74	.39	.55	-.59	-.50	.71	9.08	47.06				
-.72	-.07	.46	-.73	-.46	.57	-.71	15.00	14.47			
.65	.51	.11	.74	.40	-.06	2.04	.22	-.24	5.20		
-.15	1.32	-.05	-.19	.98	-.19	-.74	.37	.37	-1.82	14.37	
-.36	.57	-.19	-.38	.31	-.22	-2.27	.41	.77	-2.99	8.32	7.67

COVARIANCE MATRIX FOR CLUSTER 4

15.80											
-1.17	16.92										
-3.15	5.27	13.04									
6.98	2.11	.97	16.20								
1.35	.70	-1.73	-1.58	13.62							
1.06	-2.21	6.27	-3.20	4.93	13.40						
2.75	-2.29	-.44	.07	-1.43	.22	40.44					
1.79	1.02	-.29	.70	.67	-.33	2.51	23.87				
.91	.90	.04	.78	.24	-.49	-6.39	10.50	14.87			
-5.35	-2.40	-2.99	-3.96	.56	-1.54	-4.45	-8.47	-8.12	106.68		
-.68	-.12	-.88	.67	-1.01	-1.13	4.09	-3.52	-3.17	28.17	31.47	
.63	-.14	.00	.87	-.75	-.19	3.42	-.34	.10	-2.86	12.97	9.63

COVARIANCE MATRIX FOR CLUSTER 5

25.37											
5.60	23.06										
-1.44	2.94	12.80									
10.99	1.14	-.50	26.09								
.69	16.57	.20	3.83	23.51							
-2.14	-.70	8.12	-2.18	2.84	13.05						
.76	-5.99	-2.89	-.67	-5.19	-1.89	75.77					
1.69	-.77	-.12	1.16	-.24	.13	9.02	36.26				
.53	.41	.38	.54	.44	.36	-7.50	12.19	12.43			
-1.71	1.16	.18	-2.22	1.16	-.93	4.53	-2.33	-3.16	55.43		
-.02	.37	2.21	1.43	-.46	.61	9.13	-.24	-.19	.51	30.84	
.46	.19	1.44	1.68	-.43	.65	4.52	.94	1.31	-13.76	19.53	18.06

COVARIANCE MATRIX FOR CLUSTER 6

12.35											
1.77	22.65										
-2.24	7.03	10.46									
8.81	1.98	-1.00	14.76								
2.57	11.04	2.51	1.03	27.36							
-.55	3.25	5.38	-2.88	8.66	11.66						
4.96	4.79	1.53	3.85	4.95	2.11	31.42					
1.80	.58	-.13	1.98	-.47	-.52	-3.53	45.54				
.29	-.59	-.21	.85	-.84	-.59	-8.29	16.94	15.76			
3.94	3.76	.82	3.86	3.69	.54	6.41	-.22	-1.37	31.57		
1.75	2.85	1.24	2.22	3.27	1.54	6.16	2.16	1.39	3.28	33.59	
.18	.86	.74	.56	1.04	.79	1.97	1.82	1.75	-4.82	19.97	15.27

COVARIANCE MATRIX FOR CLUSTER 7

19.72											
.88	18.90										
-7.11	4.72	16.62									
10.63	1.57	-1.80	17.77								
1.70	11.05	-.63	.95	21.29							
-3.36	.13	6.30	-6.50	3.48	14.86						
3.77	-3.40	-1.40	1.22	-2.10	-.69	65.52					
-4.29	-1.58	2.21	-3.88	-2.88	1.69	5.94	36.96				
-3.21	-.86	1.92	-2.65	-2.46	1.27	-5.98	16.60	13.32			
-11.89	5.96	9.62	-10.37	3.86	6.91	-29.94	16.90	15.41	142.03		
-3.97	-2.11	1.31	-4.12	-2.39	1.85	-2.09	2.14	2.92	31.38	30.68	
-1.02	-2.71	-.37	-1.38	-2.87	.42	3.58	-.60	.00	-4.66	12.93	10.27

COVARIANCE MATRIX FOR CLUSTER 8

17.06											
.01	23.91										
-3.05	7.43	14.59									
7.00	3.11	1.45	19.40								
3.83	2.94	.42	1.02	24.38							
1.68	.54	5.09	-3.21	8.28	15.64						
3.72	1.05	.52	1.74	2.36	2.01	36.23					
-.19	-.08	-.15	-.48	.35	.10	1.76	13.92				
-.63	-.03	.34	-.13	-.25	-.06	-5.68	4.70	8.61			
1.61	.38	.66	1.57	.61	.59	6.36	-.34	-1.94	31.77		
-.46	-.18	.12	-.47	1.14	.83	3.99	-1.94	-2.26	2.69	20.11	
-.72	-.41	.14	-.75	.30	.56	1.43	-.95	-.77	-4.40	11.57	9.94

COVARIANCE MATRIX FOR CLUSTER 9

77.10											
30.08	45.49										
2.33	8.10	23.67									
49.50	29.77	1.20	77.04								
19.67	28.74	5.37	31.24	49.41							
.65	5.35	20.42	2.84	8.06	23.42						
21.10	2.6?	-1.85	16.41	3.23	-.58	91.80					
-5.95	-.80	.45	-5.56	-1.11	.60	7.96	56.20				
-6.81	-.01	1.28	-3.32	.72	1.43	-11.01	16.29	23.10			
2.67	3.37	1.70	3.64	4.97	1.93	6.56	-2.71	-1.80	28.99		
-.04	-5.54	-1.99	-2.42	-6.95	-2.49	13.24	7.00	.97	-9.97	41.20	
-1.37	-4.92	-1.86	-3.59	-6.57	-2.24	6.24	5.63	1.50	-14.59	28.53	24.25

COVARIANCE MATRIX FOR CLUSTER 10

27.48											
2.15	27.47										
-2.77	2.77	18.16									
7.99	1.46	.92	33.29								
2.04	15.03	-.13	4.42	32.03							
1.04	.12	9.86	-3.66	3.53	19.66						
-.95	-.44	.07	-3.77	-.41	.80	20.63					
.59	2.70	1.25	-2.28	1.04	1.02	.92	49.58				
.77	1.24	.21	.51	.96	.29	-4.53	14.16	15.12			
-2.49	.42	.79	-1.64	.66	1.06	1.20	-.38	-1.13	24.14		
-.73	2.79	.94	-1.56	2.70	.83	1.72	5.34	3.23	.48	26.85	
.50	1.85	.43	-.39	1.43	.28	.50	3.10	2.94	-5.58	16.50	13.69

COVARIANCE MATRIX FOR CLUSTER 11

23.63											
2.09	16.94										
-2.04	6.89	14.17									
10.39	1.43	.62	23.38								
.59	4.73	.43	-.77	17.81							
.38	1.47	7.72	-3.61	7.22	14.34						
-3.16	.06	.29	-3.33	-.62	-.75	41.87					
.59	-1.19	-1.30	.98	-1.20	-1.37	-.77	32.75				
.16	-1.25	-.41	1.37	-1.12	-.65	-5.38	14.58	16.06			
-1.09	.39	-.22	-.29	.19	-.45	4.93	-1.25	-2.28	39.82		
-1.65	1.81	1.58	1.19	1.69	.99	-1.11	.51	.96	2.79	19.85	
-.63	.68	1.02	1.25	.74	.70	-2.38	1.16	1.88	-8.06	11.68	11.42

COVARIANCE MATRIX FOR CLUSTER 12

11.41											
.49	7.86										
-1.74	2.58	8.94									
7.25	1.33	-.45	11.37								
1.47	.61	-.36	-.05	10.05							
-.02	.11	4.41	-1.98	3.29	9.53						
4.19	-.27	-.34	2.76	-.10	.26	20.89					
2.72	1.04	.38	2.30	.68	.17	2.91	28.81				
.26	.64	.91	.32	-.26	.27	-4.00	10.54	13.08			
.29	.03	.12	.24	-.23	-.21	2.94	-.14	-2.23	24.71		
.39	-.06	.16	.53	-.24	.15	3.19	2.16	.48	4.61	17.04	
.08	-.10	.43	.17	-.52	.20	.60	1.93	2.42	-3.06	8.71	8.32

COVARIANCE MATRIX FOR CLUSTER 13

20.40											
-.96	19.47										
-3.21	5.91	10.42									
15.64	-.69	-1.97	21.13								
-.30	15.67	3.95	-.47	21.22							
-1.93	4.28	8.49	-2.65	6.37	10.02						
1.27	.51	-.36	1.04	.97	-.11	39.70					
2.33	.01	-.43	2.14	.26	-.19	3.03	31.73				
1.03	-.34	-.42	1.10	-.26	-.35	-.88	8.78	6.93			
-.17	3.62	1.16	-.59	2.49	.82	4.06	2.28	.28	33.75		
1.80	.64	-.33	1.80	.40	-.37	1.79	-1.23	-.83	.73	22.39	
1.49	-.41	-.32	1.62	-.33	-.32	-.24	-.26	.11	-7.01	12.92	11.19

COVARIANCE MATRIX FOR CLUSTER 14

7.03											
-.51	19.11										
-3.14	7.10	19.69									
3.28	-.22	-1.61	9.04								
.22	7.98	3.83	-1.95	20.89							
-1.09	4.40	10.55	-4.83	8.95	22.59						
2.16	.10	-.82	1.46	.13	-.68	10.24					
.26	1.34	1.11	-.39	1.38	1.03	1.14	28.66				
-.67	1.68	1.64	-.73	1.27	1.57	-2.20	4.20	5.62			
.95	.02	-.20	1.46	-.11	-.60	2.07	-.00	-.78	7.52		
-.47	.59	.61	-.29	1.46	1.22	.73	-.11	.14	.76	10.74	
-.66	.69	.62	-.73	1.30	1.32	-.42	-.09	.54	-1.68	5.96	5.32

COVARIANCE MATRIX FOR CLUSTER 15

62.02											
18.64	75.09										
-9.95	39.17	31.01									
51.58	26.19	-.92	57.37								
24.00	59.14	21.36	19.37	72.87							
-2.27	22.22	14.29	-7.03	35.90	25.80						
31.35	24.16	5.40	31.09	23.48	4.44	67.39					
19.21	39.31	15.51	19.74	38.71	14.30	28.64	114.94				
6.65	24.00	11.13	7.66	22.97	9.45	13.09	74.94	53.63			
18.57	19.27	5.02	17.80	20.41	6.06	19.00	25.07	13.53	21.19		
33.72	59.38	19.05	28.97	68.73	26.79	41.84	93.99	60.41	31.13	200.47	
18.36	35.56	11.82	15.64	41.08	16.23	23.32	59.22	39.06	16.62	128.15	84.27

COVARIANCE MATRIX FOR CLUSTER 16

30.71											
13.17	54.58										
-2.45	15.24	26.44									
22.42	15.21	2.96	32.09								
13.28	33.05	5.71	13.23	60.04							
1.17	5.36	12.55	-1.73	18.20	27.25						
4.34	-4.84	.49	2.74	-5.18	.57	49.81					
-1.20	6.99	4.32	.73	3.02	2.23	.07	39.99				
-1.19	5.97	3.87	.36	3.02	2.52	-7.56	22.44	19.62			
.12	.39	1.80	-.49	1.44	3.22	6.36	.78	-1.19	29.09		
.26	-2.94	.18	-1.22	.39	2.86	10.50	-5.04	-5.13	4.16	40.13	
.01	-2.35	.25	-.87	-.57	1.73	5.37	-2.61	-2.25	-3.38	24.84	18.69

COVARIANCE MATRIX FOR CLUSTER 17

28.68											
-2.49	33.64										
-7.18	10.89	14.89									
19.41	-3.54	-4.30	30.57								
-2.40	19.69	9.10	-5.74	33.90							
-4.54	10.07	11.80	-7.94	13.56	15.47						
1.60	-3.55	-1.85	1.00	-3.51	-1.73	100.27					
4.30	-5.01	-2.70	3.32	-4.55	-2.07	9.86	40.18				
.74	-2.40	-1.12	.83	-3.54	-1.66	-1.39	15.38	10.95			
-5.94	10.15	5.47	-3.14	8.88	4.86	6.04	-14.24	-9.18	77.47		
1.08	-2.45	.03	5.72	-3.39	-2.20	-.10	-3.25	-1.97	4.32	36.44	
1.88	-5.49	-1.95	4.29	-5.56	-3.49	-2.06	1.74	1.53	-16.71	22.23	20.59

COVARIANCE MATRIX FOR CLUSTER 18

24.35											
-1.16	33.97										
-5.93	12.39	22.11									
7.95	1.54	.74	17.24								
2.07	19.86	3.95	-1.57	37.64							
.07	4.61	11.34	-4.41	9.09	19.79						
-.70	-.73	.30	.66	-1.55	-1.06	104.27					
2.62	4.15	3.18	1.55	2.89	2.52	16.31	46.44				
-.39	1.42	1.91	.25	.77	1.29	6.14	15.75	14.97			
.13	2.42	1.41	.69	1.19	-.36	.20	-5.95	-3.82	65.68		
-1.16	2.23	.06	2.48	1.35	-1.18	.85	-.25	1.24	-.67	34.91	
-1.08	.86	.05	1.22	.48	-.46	.67	2.51	2.39	-14.68	21.62	18.66

COVARIANCE MATRIX FOR CLUSTER 19

17.77											
.55	22.92										
-2.67	9.46	15.71									
9.19	2.98	1.17	17.52								
2.80	8.98	4.78	.44	21.85							
.39	5.00	9.55	-1.92	9.44	14.82						
.17	2.95	2.86	-.47	2.91	3.11	31.10					
3.63	.39	-.03	1.82	1.27	.45	.82	46.58				
2.16	-.34	-.37	1.85	-.09	-.41	-5.96	18.64	17.48			
.83	.79	.17	.37	.52	.31	.73	-.23	-.62	10.47		
-.81	.79	-.11	-.38	.46	-.33	-.21	-.34	.32	-1.68	14.96	
-.56	-.37	-.37	-.35	-.35	-.52	-.10	.35	.75	-4.38	9.57	9.49

COVARIANCE MATRIX FOR CLUSTER 20

14.24											
.62	17.72										
-2.03	2.87	19.59									
7.97	2.61	1.18	15.18								
2.87	3.71	-1.89	.57	16.84							
1.14	-1.79	11.11	-2.07	2.36	19.69						
2.93	1.01	.18	1.59	1.26	1.10	21.50					
3.41	1.32	-.29	3.08	.60	-.69	1.31	31.22				
1.49	-.43	-.35	1.31	-.56	-.55	-5.34	12.13	14.39			
.52	-.42	.13	.30	-.05	.26	.32	1.49	1.23	5.20		
.11	2.22	1.58	.72	1.47	1.14	4.43	-.13	-2.43	-.02	20.46	
.33	1.13	.81	.66	.60	.77	2.34	.26	-.36	-1.13	11.41	9.12

COVARIANCE MATRIX FOR CLUSTER 21

14.91											
1.32	16.32										
-6.00	4.55	24.09									
9.62	.87	-4.83	16.51								
.89	6.91	2.85	1.53	14.18							
-5.68	3.45	20.51	-6.51	4.60	22.85						
-1.10	3.64	14.62	-3.27	2.50	14.39	68.62					
-5.63	-.24	10.35	-5.23	.31	10.18	17.83	63.59				
-3.54	-.56	4.91	-3.05	-.41	4.81	1.10	29.74	20.73			
3.07	.84	-1.79	3.50	.66	-2.07	4.31	-.86	-1.31	19.55		
-2.92	-.39	7.07	-3.61	-.49	7.44	5.65	11.11	6.42	-6.90	34.67	
-3.52	-.19	7.62	-3.82	-.00	7.97	5.87	10.39	6.12	-9.02	23.47	19.73

COVARIANCE MATRIX FOR CLUSTER 22

11.12											
-.49	19.56										
-2.70	4.45	23.55									
4.57	2.13	1.35	11.95								
-.36	7.57	-3.31	-.13	[illegible]							
[illegible]	[illegible]	9.96	-2.49	3.74	[illegible]						
.09	-.39	.53	-1.14	.11	.86	15.78					
1.31	3.43	1.69	1.55	1.75	1.18	2.13	21.23				
1.28	1.35	1.35	2.40	-.14	.38	-2.81	8.47	11.57			
.69	-.25	1.42	1.18	-.84	.19	1.33	1.10	1.08	15.83		
-1.22	2.25	3.07	.49	1.27	1.19	[illegible]	1.48	2.22	1.07	24.55	
-.77	1.15	1.28	.29	.58	.48	.19	.71	1.98	-2.88	14.81	11.96

COVARIANCE MATRIX FOR CLUSTER 23

15.25											
5.68	[illegible]										
1.58	6.69	12.96									
12.76	7.06	1.41	16.93								
8.53	23.64	3.36	7.87	34.07							
2.38	4.75	9.18	.87	8.65	14.67						
7.71	3.36	2.72	6.10	3.23	2.73	[illegible]					
3.53	6.92	4.49	3.17	4.74	3.36	[illegible]	62.81				
1.12	4.98	3.17	.99	3.05	2.14	[illegible]	25.02	18.87			
-.37	-.53	-.35	.33	-.36	-.56	2.90	-1.75	-1.21	11.28		
-1.01	1.26	.70	-.67	.48	.22	-3.25	5.12	3.08	-3.59	22.50	
-.30	1.82	1.07	-.22	1.33	1.05	[illegible]	[illegible]	4.70	-5.67	15.47	[illegible]

COVARIANCE MATRIX FOR CLUSTER 24

32.75											
-2.98	38.77										
-11.29	17.21	30.01									
13.47	4.27	1.39	26.73								
5.85	2.46	-3.89	-3.18	36.07							
1.80	-1.62	6.33	-8.53	15.87	25.63						
6.30	1.14	-.36	1.29	5.33	4.83	53.99					
.74	1.45	.58	.09	.39	-.95	12.40	66.44				
-1.03	1.75	2.97	1.67	-1.54	-.91	.43	20.23	22.05			
1.75	2.74	1.57	4.32	3.14	.23	11.88	4.77	1.71	36.48		
1.34	-1.92	-4.23	-2.45	6.46	5.60	18.27	11.86	8.72	5.27	64.72	
.71	-1.96	-2.79	-2.46	3.67	4.02	8.53	6.32	6.56	-4.08	41.96	31.06

COVARIANCE MATRIX FOR CLUSTER 25

21.79											
.56	18.86										
-2.58	4.43	12.81									
10.33	-2.23	-1.74	20.13								
-2.36	10.53	2.57	.16	18.39							
-2.28	2.79	9.64	-2.21	4.13	11.81						
3.53	-4.01	-2.32	1.61	-4.53	-2.53	55.98					
-.83	.68	-.43	-1.14	.97	-.27	4.59	38.82				
-1.68	.85	.36	-1.40	1.23	.34	-6.53	18.31	17.70			
-2.62	-.32	.22	-1.13	-.09	-.03	-.52	1.09	.78	16.80		
3.27	1.38	-.30	2.85	1.19	-.57	1.64	.73	-.34	-3.38	18.79	
2.91	.88	-.32	2.18	.77	-.35	.57	1.05	.29	-7.31	12.26	11.90

COVARIANCE MATRIX FOR CLUSTER 26

10.19											
-.17	18.61										
-2.32	4.94	15.59									
2.82	1.44	.94	10.83								
1.75	4.16	-.68	.23	19.92							
.91	.16	5.25	-1.76	5.18	13.88						
1.09	.46	.87	.01	.71	1.05	16.19					
.44	.27	-.46	-.48	-.55	-.74	.52	31.67				
.28	.33	.04	.05	-.13	-.21	-2.95	7.43	8.52			
-.52	1.08	.94	.38	.87	.80	1.18	-.53	-.93	30.92		
-1.03	-.08	.49	-.47	.42	.57	2.79	-1.53	-.68	1.39	24.62	
-.35	-.29	.05	-.41	.04	.30	1.35	-.91	-.04	-5.77	14.80	12.08

COVARIANCE MATRIX FOR CLUSTER 27

18.21											
.69	20.79										
-1.85	5.72	15.90									
7.08	1.30	-.29	18.70								
1.46	8.10	2.56	1.15	21.52							
.88	2.07	9.16	-2.82	7.03	18.04						
.80	-.21	2.09	-1.80	-.01	3.49	17.11					
.11	.56	1.34	-.85	.10	1.86	3.88	25.54				
.05	.88	1.69	.34	.28	1.21	-.97	12.80	14.90			
-.81	.64	.13	.54	-.50	-.70	1.84	-1.39	-1.64	36.78		
.76	1.11	2.00	1.23	2.34	2.36	2.25	2.55	1.52	4.62	20.71	
.87	.53	1.82	.39	1.70	2.58	1.70	2.85	2.33	-5.78	11.51	10.92

COVARIANCE MATRIX FOR CLUSTER 28

17.50											
3.39	46.97										
-2.64	-2.25	14.99									
14.78	4.22	-1.32	19.29								
4.14	35.08	-6.35	4.60	48.19							
-1.66	-7.26	8.86	-3.46	-2.20	15.86						
8.63	-1.25	-.03	6.71	-.26	1.55	31.24					
4.56	-1.57	-.70	2.88	-1.50	.37	7.18	24.46				
.24	-.33	.39	.09	-.54	.61	-3.94	8.54	10.44			
2.06	2.45	.48	1.28	2.76	.92	4.74	.81	-2.09	21.70		
.81	-1.53	-.42	-.32	.10	1.48	1.68	3.31	1.02	1.52	29.16	
-.33	-1.67	-.19	-.84	-.60	1.12	-.86	2.31	2.32	-4.78	17.74	14.89

COVARIANCE MATRIX FOR CLUSTER 29

16.31											
-1.48	19.32										
-3.73	4.34	12.27									
9.13	.05	.07	17.22								
-.18	9.48	.15	-2.14	20.91							
-1.28	1.16	6.11	-3.80	5.17	11.07						
-2.60	.21	2.23	-3.26	-.43	2.68	36.44					
1.89	-2.73	-.10	2.44	-2.75	-.55	1.21	38.68				
1.75	-1.57	.05	2.34	-1.95	-.56	-4.16	13.91	13.45			
-1.43	1.21	.68	-1.00	1.55	.66	-3.43	1.27	.92	44.46		
-1.47	1.94	1.27	.35	1.83	.27	-1.36	.23	.43	5.05	21.52	
.06	.50	.71	.98	.49	.20	-.01	1.93	1.48	-6.38	11.83	11.14

COVARIANCE MATRIX FOR CLUSTER 30

12.27											
.11	27.97										
-3.44	10.41	23.16									
4.83	3.22	1.38	14.67								
3.83	6.22	.64	-.04	29.05							
1.85	1.98	4.13	-4.05	10.79	22.67						
.87	3.53	3.05	-.64	3.73	2.92	25.44					
2.64	-3.62	-.76	2.69	-3.47	-1.53	.72	51.80				
1.14	-2.19	-.33	2.22	-2.24	-.97	-3.56	18.99	17.47			
.20	4.30	3.00	.81	2.79	2.54	4.75	.42	-.02	30.42		
-.72	-2.86	-1.34	-.67	.47	.71	5.97	2.73	2.51	5.70	39.36	
-.53	-3.12	-1.43	-.70	-.59	.06	2.87	2.43	2.49	-2.91	24.02	17.83

MEANS

CLUSTER	CH(2)	CH(3)	CH(4)	CH(6)	CH(7)	CH(8)	CH(10)	CH(11)	CH(12)	CH(14)	CH(15)	CH(16)
1	49.90	56.52	26.66	49.71	56.42	26.50	60.74	70.00	33.74	27.44	61.18	34.65
2	37.71	59.21	30.89	36.91	59.21	31.06	39.31	58.86	31.05	29.31	51.56	27.60
3	36.21	44.65	22.91	36.40	44.60	22.81	41.99	62.06	32.47	16.79	65.83	41.23
4	27.37	53.42	29.53	27.64	53.31	29.36	28.76	61.67	34.98	32.83	53.03	28.05
5	45.84	54.87	26.75	45.56	54.95	26.80	42.78	58.82	30.26	25.49	54.60	30.71
6	19.54	65.43	38.97	19.63	65.05	38.86	23.41	60.63	35.89	20.29	50.07	28.98
7	32.66	40.78	19.54	32.25	40.79	19.58	39.27	52.47	26.74	34.66	52.15	26.82
8	25.60	51.55	28.75	26.04	51.21	28.44	27.93	55.01	30.84	23.59	46.38	25.65
9	55.16	65.44	31.33	55.13	65.28	31.33	40.63	62.94	33.31	20.76	60.11	35.90
10	31.88	60.05	32.83	32.62	60.01	32.46	27.61	61.25	35.57	22.48	52.29	30.06
11	34.36	49.06	25.57	33.11	49.27	25.39	42.04	62.80	32.99	24.16	54.34	29.13
12	25.21	45.84	25.25	25.12	46.20	25.47	24.35	61.14	37.02	20.81	51.60	30.57
13	35.36	43.98	22.46	35.22	43.94	22.44	53.63	60.27	29.64	24.11	58.61	33.57
14	15.09	56.11	35.28	15.39	55.79	34.93	17.44	56.80	35.40	15.78	45.52	27.44
15	37.30	34.12	11.26	37.59	34.06	10.95	26.96	26.34	10.58	20.56	26.54	11.92
16	27.26	35.28	17.17	27.42	35.77	17.25	28.81	48.05	25.79	22.01	46.79	26.00
17	36.77	47.28	23.98	36.11	47.53	24.27	64.33	74.91	36.47	25.08	58.86	34.01
18	24.94	57.24	32.43	23.83	57.52	33.03	47.16	59.03	30.01	25.13	55.87	31.49
19	30.49	48.72	26.39	30.89	48.43	26.05	30.70	61.39	34.74	17.67	64.17	39.62
20	25.35	52.75	29.77	25.69	52.32	29.37	24.47	61.77	37.08	19.54	53.85	32.09
21	42.70	44.52	17.66	42.71	44.60	17.69	40.22	52.43	26.40	22.62	54.16	30.34
22	20.42	56.19	33.59	20.25	56.54	34.08	21.44	63.55	38.50	19.41	50.79	29.92
23	30.72	35.92	18.63	30.65	36.09	18.74	38.21	50.94	26.36	17.79	63.82	38.72
24	25.90	48.27	24.97	25.09	49.63	24.21	29.14	41.52	22.05	22.88	44.16	23.78
25	41.69	52.26	26.66	41.91	52.25	26.65	40.62	63.74	33.71	18.54	63.43	38.95
26	23.05	58.66	33.87	22.89	58.88	34.16	26.25	57.23	33.04	22.83	49.36	27.82
27	34.04	48.22	24.75	34.38	47.93	24.39	27.22	59.96	34.90	22.46	50.92	29.28
28	25.78	38.04	21.21	26.00	37.51	20.68	25.75	59.67	35.18	20.04	51.73	30.75
29	31.33	44.76	23.16	31.23	44.96	23.28	36.91	55.42	29.47	22.37	55.43	31.94
30	19.06	54.28	32.12	19.01	54.60	32.57	22.96	49.21	28.56	19.76	43.90	24.80

STANDARD DEVIATIONS

CLUSTER	CH(2)	CH(3)	CH(4)	CH(6)	CH(7)	CH(8)	CH(10)	CH(11)	CH(12)	CH(14)	CH(15)	CH(16)
1	7.29	6.03	3.93	6.73	5.75	3.79	9.40	7.92	3.92	8.54	5.87	4.22
2	6.33	4.80	5.01	6.32	4.77	4.87	7.96	6.57	4.24	8.18	5.19	3.70
3	3.36	4.81	3.02	3.23	4.70	2.95	6.87	6.85	3.80	2.28	3.77	2.76
4	3.97	4.11	3.61	4.02	3.69	3.66	6.34	4.88	3.85	10.33	5.61	3.10
5	5.03	4.89	3.59	5.11	4.85	3.61	8.70	6.02	3.53	7.44	5.55	4.25
6	3.51	4.75	3.23	3.84	5.22	3.41	5.60	6.74	3.97	5.62	5.79	3.91
7	4.44	4.35	4.09	4.21	4.61	3.85	8.09	6.08	3.65	11.92	5.54	3.20
8	4.13	4.88	3.82	4.49	4.93	3.95	6.02	3.72	2.93	5.63	4.48	3.07
9	8.78	6.74	4.86	8.78	6.95	4.84	9.58	7.50	4.80	5.38	6.42	4.92
10	5.24	5.24	4.26	5.77	5.65	4.43	4.54	7.04	3.89	4.91	5.18	3.70
11	4.86	4.11	3.76	4.83	4.22	3.79	6.47	5.72	4.01	6.31	4.45	3.38
12	3.37	2.79	2.99	3.37	3.16	3.08	4.57	5.36	3.61	4.97	4.12	2.88
13	4.51	4.41	3.23	4.59	4.60	3.16	5.54	5.63	2.63	5.81	4.73	3.34
14	2.65	4.35	4.43	3.01	4.55	4.74	3.20	5.34	2.36	2.74	3.26	2.30
15	7.87	8.67	5.57	7.57	8.54	5.08	8.21	10.72	7.32	4.60	19.16	9.18
16	5.54	7.39	5.14	5.66	7.75	5.22	7.06	6.32	4.43	5.39	6.33	4.32
17	5.35	5.80	3.86	5.53	5.82	3.93	10.91	6.34	3.31	8.80	6.04	4.54
18	4.93	5.83	4.77	4.15	5.71	4.44	10.21	6.81	3.87	8.10	5.91	4.32
19	4.21	4.78	3.96	4.18	4.67	3.85	5.58	6.82	4.18	3.24	3.86	3.08
20	3.77	4.20	4.42	3.89	4.09	4.43	4.64	5.59	3.79	2.28	4.51	3.01
21	3.86	4.09	4.91	4.06	4.02	4.78	8.28	7.97	4.55	4.42	5.89	4.44
22	3.33	4.42	4.85	3.46	4.52	4.75	3.97	4.60	3.40	3.98	4.95	3.46
23	3.90	5.58	3.60	4.11	5.84	3.83	8.15	7.92	4.34	3.36	4.74	3.83
24	5.72	6.23	5.48	5.17	6.00	5.06	7.35	8.15	4.70	6.04	8.04	5.57
25	4.67	4.34	3.59	4.48	4.28	3.43	7.48	6.23	4.29	4.10	4.33	3.45
26	3.19	4.30	3.94	3.29	4.45	3.72	4.02	5.62	2.91	5.56	4.95	3.47
27	4.26	4.56	3.99	4.32	4.63	4.25	4.14	5.05	3.86	6.06	4.55	3.30
28	4.18	6.85	3.87	4.39	6.94	3.98	5.59	4.91	3.21	4.66	5.40	3.86
29	4.04	4.37	3.51	4.15	4.57	3.33	6.03	6.22	3.67	6.67	4.63	3.33
30	3.50	5.28	4.81	3.83	5.37	4.76	5.04	7.19	4.19	5.52	6.27	4.22

APPENDIX C

CROP PROPORTION SUMMARIES USING MULTITEMPORAL ANALYSIS

APPENDIX C

CROP PROPORTION SUMMARIES USING MULTITEMPORAL ANALYSIS

Tables C-I through C-V show the crop proportion summaries for FAY610, FAY629, FAY717, and FAY821.

TABLE C-I.— CROP PROPORTION SUMMARY FOR FAY610 AND FAY629

Section	Percentage of section identified as			
	Corn	Soybeans	Wheat	Other
5-02	20.5	43.8	19.6	16.1
5-11	21.2	51.9	12.5	14.4
5-15	23.2	42.9	15.0	18.9
5-16	33.1	19.0	19.1	28.8
5-17	24.0	15.4	20.0	40.6
5-19	21.4	16.1	17.1	45.4
5-20	18.5	28.4	14.5	38.6
5-26	25.1	53.0	14.1	7.8
5-29	32.5	17.8	23.1	26.6
5-33	39.9	26.0	23.2	10.9
5-34	33.1	33.1	18.1	15.7
5-36	45.0	19.4	22.7	12.9
5-41	12.5	7.8	7.8	71.9
5-45	18.7	25.6	11.2	44.5
5-52	20.8	28.3	21.0	29.9
5-56	30.3	5.0	22.9	41.8
5-58	11.9	2.7	8.8	76.6
5-67	15.6	5.9	13.9	64.6
5-68	21.1	7.9	16.8	54.2
5-70	8.3	1.3	5.6	84.8
5-74	27.1	0.4	5.2	67.3
5-76	18.5	2.6	13.5	65.4
5-80	4.5	2.9	3.3	89.3
5-90	11.1	2.3	8.9	77.7
5-94	8.8	0.5	8.8	81.9

TABLE C-II.– CROP PROPORTION SUMMARY FOR FAY629 AND FAY717

Section	Percentage of section identified as			
	Corn	Soybeans	Wheat[a]	Other
5-02	9.9	31.7	13.6	58.4
5-11	16.8	33.2	5.1	50.1
5-15	6.3	20.4	6.6	66.8
5-16	16.6	15.0	12.3	68.3
5-17	7.4	12.5	11.1	69.0
5-19	8.6	11.3	8.9	80.2
5-20	9.9	24.6	8.0	65.5
5-26	32.3	44.8	8.9	22.9
5-29	23.6	13.9	13.7	62.5
5-33	25.0	18.9	12.6	56.2
5-34	22.6	19.2	10.0	58.2
5-36	63.2	9.2	7.9	27.6
5-41	10.9	9.4	6.0	79.7
5-45	20.0	27.3	8.8	52.8
5-52	20.6	18.2	13.6	61.3
5-56	43.3	13.1	10.5	43.6
5-58	12.6	6.2	7.1	74.1
5-67	15.2	27.8	20.0	47.0
5-68	26.0	33.8	15.1	40.2
5-70	7.7	13.3	9.6	79.1
5-74	31.3	16.8	13.3	51.9
5-76	41.5	25.9	8.0	32.6
5-80	5.8	12.1	7.8	81.1
5-90	14.8	17.8	10.3	67.4
5-94	2.9	6.1	11.4	91.0

[a]Because of the practice of planting soybeans or the presence of other vegetation after wheat harvest, after period I wheat is included in some instances in its own category as well as in soybeans or "other." For this reason, percentages for some sections exceed 100.

TABLE C-III.– CROP PROPORTION SUMMARY FOR FAY717 AND FAY821

Section	Percentage of section identified as			
	Corn	Soybeans	Wheat[a]	Other
5-02	10.4	29.9	15.2	59.7
5-11	13.6	33.7	8.3	52.8
5-15	3.6	22.0	7.7	74.4
5-16	17.4	20.9	19.5	61.7
5-17	8.2	11.6	14.7	80.2
5-19	13.4	15.8	11.5	70.9
5-20	13.1	26.3	8.5	60.5
5-26	27.6	48.0	7.6	24.4
5-29	19.4	15.5	14.0	65.2
5-33	14.7	23.9	11.3	61.4
5-34	12.6	24.7	10.1	62.6
5-36	58.5	5.4	8.6	36.2
5-41	6.7	6.2	8.7	87.2
5-45	15.6	28.6	12.1	55.6
5-52	11.0	17.8	17.3	71.2
5-56	36.0	17.0	16.0	47.0
5-58	11.9	6.6	12.8	81.6
5-67	13.9	25.7	21.3	60.4
5-68	17.2	32.9	14.4	49.9
5-70	3.6	11.3	12.8	85.2
5-74	17.0	13.0	18.6	70.0
5-76	38.9	31.7	11.3	29.3
5-80	4.2	5.6	14.1	90.2
5-90	22.0	9.6	15.7	68.4
5-94	5.7	5.8	11.6	89.2

[a]Because of the practice of planting soybeans or the presence of other vegetation after wheat harvest, after period I wheat is included in some instances in its own category as well as in soybeans or "other." For this reason, percentages for some sections exceed 100.

TABLE C-IV.— CROP PROPORTION SUMMARY FOR FAY610, FAY629, FAY717, AND FAY821

Section	Percentage of section identified as			
	Corn	Soybeans	Wheat[a]	Other
5-02	19.6	41.4	26.2	39.0
5-11	18.0	58.7	17.5	23.3
5-15	9.8	65.3	17.9	24.9
5-16	29.9	25.0	31.8	45.1
5-17	18.0	25.4	33.4	56.6
5-19	21.7	32.5	27.1	45.7
5-20	14.4	40.1	28.0	45.5
5-26	36.4	53.4	4.7	10.3
5-29	31.8	26.8	32.3	41.4
5-33	29.6	41.9	20.1	21.5
5-34	27.6	50.0	16.7	22.4
5-36	67.2	14.1	14.7	15.9
5-41	12.9	18.1	14.9	69.0
5-45	23.1	35.9	19.6	41.0
5-52	27.8	39.0	18.2	29.1
5-56	49.3	30.3	18.6	24.3
5-58	22.1	15.5	31.4	66.6
5-67	30.9	25.4	28.1	43.7
5-68	32.7	40.9	12.9	26.4
5-70	9.0	20.3	24.1	70.7
5-74	33.3	23.0	23.2	42.7
5-76	35.9	38.7	27.6	25.4
5-80	15.0	28.8	20.1	56.2
5-90	25.6	21.3	33.1	53.2
5-94	21.4	7.0	56.8	71.6

[a]Because of the practice of planting soybeans or the presence of other vegetation after wheat harvest, after period I wheat is included in some instances in its own category as well as in soybeans or "other." For this reason, percentages for some sections exceed 100.

TABLE C-V.— CROP PROPORTION SUMMARY FOR FAY610, FAY629, FAY717, AND FAY821 BASED ON PHOTOINTERPRETATION

Section	Percentage of section identified as			
	Corn	Soybeans	Wheat[a]	Other
5-02	19.8	41.7	15	38.5
5-11	15.9	70.2	—	13.9
5-15	9.3	33.3	—	57.4
5-16	15.9	29.1	—	55.0
5-17	7.7	23.0	20	69.3
5-19	11.7	23.2	—	65.1
5-20	6.8	38.2	—	55.0
5-26	37.9	54.1	—	8.0
5-29	18.4	21.0	28	60.6
5-33	27.4	43.4	7	29.2
5-34	26.1	44.7	7	29.2
5-36	69.3	9.9	—	20.8
5-41	10.8	14.4	1	74.8
5-45	19.9	37.5	13	42.6
5-52	—	—	—	—
5-56	54.2	18.4	6	27.4
5-58	6.5	16.2	5	77.3
5-67	11.4	35.4	14	53.2
5-68	—	—	—	—
5-70	—	—	—	—
5-74	—	—	—	—
5-76	—	—	—	—
5-80	1.7	15.5	—	82.8
5-90	—	—	—	—
5-94	6.3	1.5	3	92.2

[a]Because of the practice of planting soybeans or the presence of other vegetation after wheat harvest, after period I wheat is included in some instances in its own category as well as in soybeans or "other." For this reason, percentages for some sections exceed 100.