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EVALUATION AND COMPARISON OF ERTS MEASUREMENTS OF MAJOR CROPS AND SOIL ASSOCIATIONS FOR SELECTED SITES IN THE CENTRAL UNITED STATES

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15. Supplementary Notes

16. Abstract Results of research performed at Purdue University during the first six months of the ERTS-1 Central States Contract are reported. Of the six test sites, usable digital CCT data were received for three of them during this reporting period. An effective cooperative ground observation team was established in the 10-county Lubbock (Texas) Regional Test Site. Six farmer cooperators in each county observe and report pertinent soils and crops data at the time of each ERTS pass. Gross geologic and soil association features were delineated and mapped from ERTS-1 digital data. Ten spectral classes representing different land features and eight spectral classes of water in the Lavon Reservoir area of Collin County were mapped. Spectrally separable classes which were identified in the Lubbock Test Site include cotton, grain sorghum, winter wheat, native rangeland, improved rangeland, salt lakes, playas, urban areas, roads, industrial areas, and other cultivated areas. Research using overlay of time-sequential ERTS frames of data from Lynn County (Texas) was initiated.

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PREFACE

A. Objectives

The objectives of the research reported herein are outlined in the Data Analysis Plan for the Investigation "Evaluation and Comparison of ERTS Measurements of Major Crops and Soil Associations for Selected Sites in the Central United States," ERTS-1 Proposal Number SR050. The broad objective of the proposal is to evaluate the utility of ERTS-1 measurements for use in identifying, locating, characterizing and mapping differences in vegetation and soils over a wide range of climatic, geographical, and ecological conditions in the Central United States.

B. Scope of Work

ERTS-1 measurements are being obtained over six widely separated test sites. These include (1) Boone and Hendricks Counties, Indiana, (2) Wells County, North Dakota, (3) Humboldt County, Iowa, (4) McPherson County, Nebraska, (5) Greeley County, Kansas, and (6) a 10-county area centering around Lubbock, Texas. Fifty-six ground observation sites, each of approximately 10 kilometers in length, have been designated for the Lubbock Regional Test Site. Observations of agricultural significance have been collected on the ERTS overpass dates during the period from August 16 to October 9. They will be continued during the 1973 growing season. Digital computer techniques, including the LARSYS multispectral analysis ERTS data in digital form. Ground observation data are used to provide training sets for computer implemented analysis and for testing results of pattern recognition analysis.

C. Conclusions

This report is an interim progress report and no final conclusions on the study seem to be appropriate at this time. Significant results in the delineation and mapping of many earth surface features are described herein. However, these results are not conclusive.

D. Summary of Recommendations

It is recommended that the time lag between coverage and receipt of images and CCT data be reduced if possible so that data quality may be evaluated and ground observations made sooner if the data is considered acceptable.

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LIST OF ILLUSTRATIONS

Introduction:

This report presents a summary of the research results achieved during the initial six monthos of this contract.

The first three months were devoted to (1) preparation of a ground observation program for the Lubbock Regional Test Site and (2) preliminary digital analysis of two ERTS frames, neither of which was in the test sites for this experiment.

During the final three months of this reporting period a considerable amount of analysis has been performed with data from the Lubbock Regional Test Site. Much attention has also been given to the development of a more effective and efficient data analysis procedure.

Although there is yet much to be learned about the characteristics of ERTS MSS digital data and about the best methods for analyzing and interpreting these kinds of data, much progress has been made. Researchers in this investigation have developed an appreciation for the kinds of useful information which can be extracted from ERTS. Perhaps the most important progress which has been made during this reporting period is that made in learning how to handle and process the large quantities of data from the ERTS systems.

Much thought has also been given to procedures for interfacing and correlating ground observation data with ERTS data.

ERTS Data Received

During this reporting period CCT's were received for 74 frames of ERTS MSS data over the six test sites of this investigation. CCT's for sixteen of these frames have been reformatted for analysis with the LARSYS software system. Thirteen additional frames of data are of good quality and are ready for reformatting.

Twenty-seven of the frames of data received are not within the test sites of this experiment. The remaining eighteen frames are ususable because of cloud cover.

Usable data have been received for the following test sites: (1) Boone and Hendricks Counties, Indiana; (2) Wells County, North Dakota; and (3) Lubbock (Texas) Regional Test Site.

No usable data have been received for Greeley County, Kansas; Humboldt County, Iowa; and McPherson County, Nebraska.

Many MSS frames of CCT data have been received for the Lubbock Regional Test Site. Figure 1 presents a summary of usable tapes which cover all or a significant portion of this test site.

Analysis of ERTS Lake Texoma Frame:

NASA Scene I.D. 1002-16312
Date of ERTS Pass: July 28, 1972
LARS Run Number 72001406

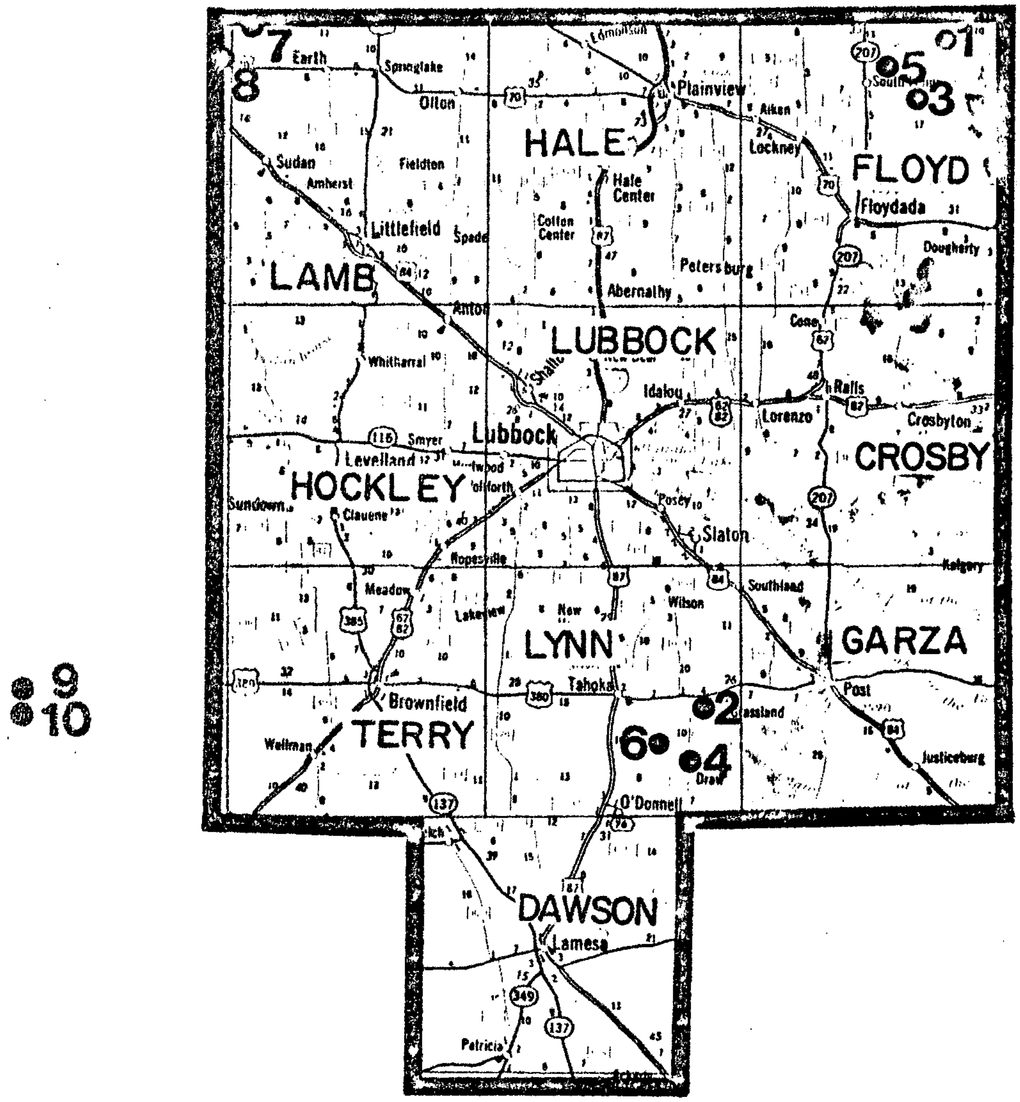
Investigators under this NASA contract chose three specific areas in the Lake Texoma frame to study in detail, each of the subframes falling in the lower part of this frame south of Red River.

A. Collin County (Texas) Subframe:

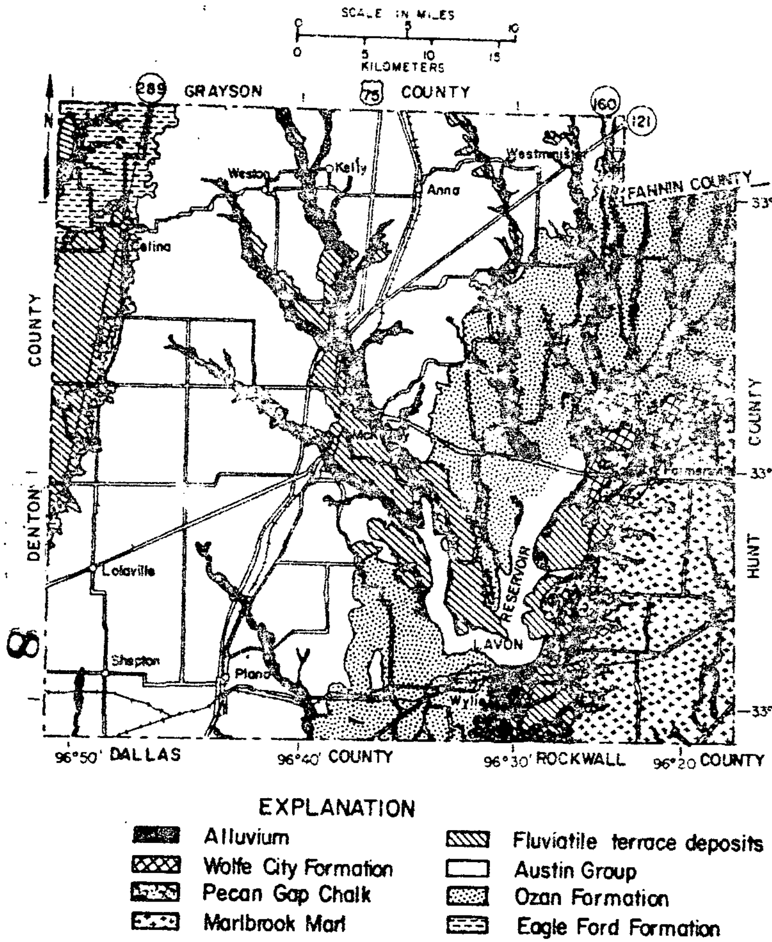
Collin County, an area of 2270 km^2, is near the northern boundary of the Gulf Coastal Plain of Texas. It is in the second tier of counties south of Red River, the boundary of the Coastal Plain physiographic province. The county may be classified as dissected, Coastal Plain upland. Drainage is southward into the Trinity River system. Elevations range from a maximum of about 250m above sea level on the Austin scarp in the western part of the county to a low of about 150m at Lavon Reservoir. Collin County was chosen for this study because it contains a wide variety of soils, geologic, and agricultural features of interest.

The LARSYS software system was used to analyze the ERTS MSS digital data from Collin County. Using a combination of both non-supervised and supervised pattern recognition techniques it was possible to map the gross natural drainage patterns of the County. Existing geology and soil maps were the major source of ground information (Figure 2). In many cases, these spectral patterns also correspond closely to differences in soil associations and geologic parent materials (Figure 3A). From spectral maps a prominent escarpment is readily identified in the western part of the county. This escarpment represents a division between soil associations, geologic materials, and types of agriculture. To the west of the escarpment, the average reflectance is considerably higher than east of the escarpment. Causes for these differences may be related to two factors for this particular set of data (Figure 3B). First, the surface soils are lighter in color west of

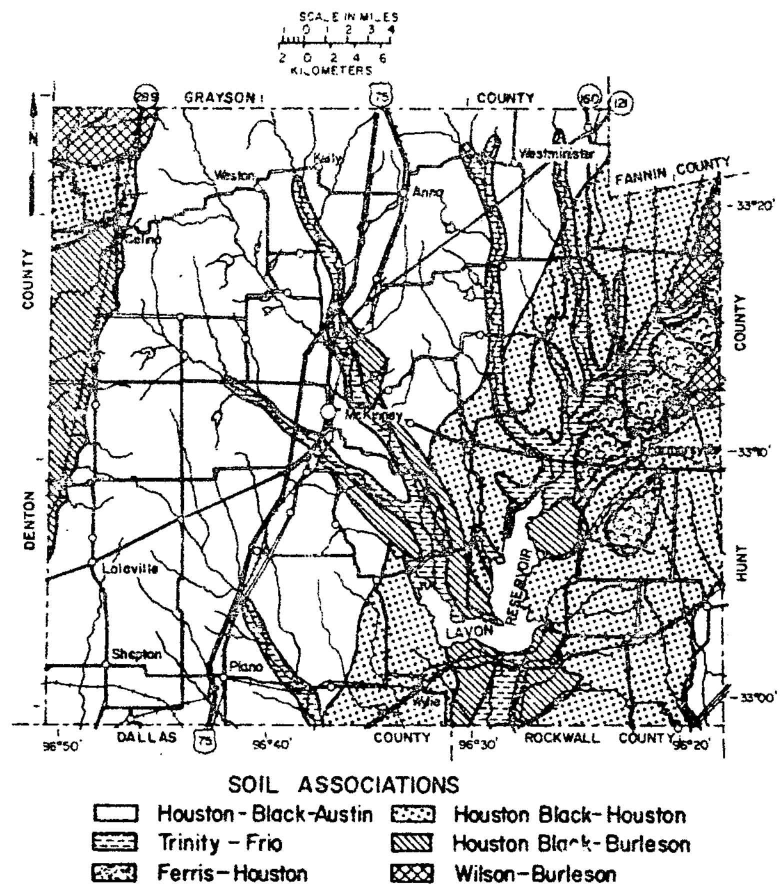
Figure 1. Location of Frame Centers of ERTS MSS Data Lubbock (Texas) Regional Test Site.



Scene-ID		Date of Flight	Area Covered by Clouds
1.	1078-16522	October 9, 1972	0
2.	1078-16524	October 9, 1972	0
3.	1096-16524	October 27, 1972	All portions of: Hale, Floyd, Lubbock, & Cosby Co.
4.	1096-16530	October 27, 1972	Crosby, Lubbock & Dawson & portions of Lynn.
5.	1114-16525	November 14, 1972	Eastern 1/2 of Floyd, Crosby
6.	1114-16532	November 14, 1972	Portions of Crosby, Garza
7.	1079-16580	October 10, 1972	Portions of Lamb
8.	1097-16582	October 28, 1972	0
9.	1079-16583	October 10, 1972	Portions of Lamb
10.	1097-16585	October 28, 1972	0

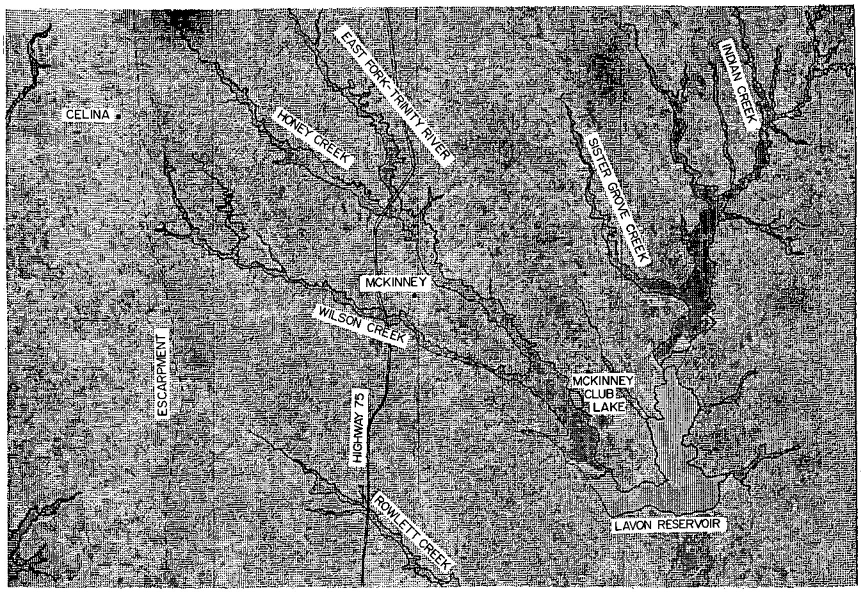


A. Geology Map



B. Soil Association Map

Figure 2. Generalized maps of Collin County, Texas, U.S.A.



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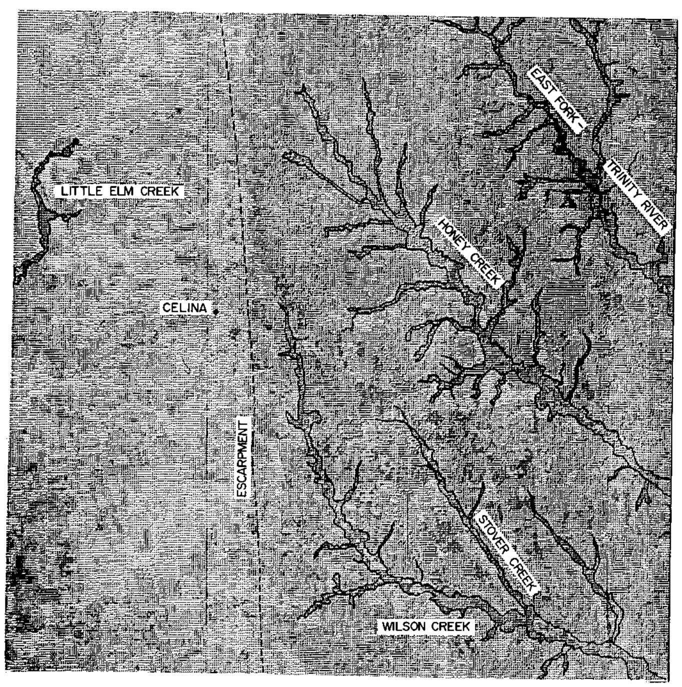


B

Figure 3. Gray-scale computer printouts, photographically reduced, showing classification of spectrally separable surficial features, such as drainage lines, vegetative cover types, and approximate position of Austin Chalk escarpment. Note increased detail at scale used in B.

the escarpment. Second, wheat and grassland are the predominant cover west of the escarpment. Most of the vegetation on the heavier, darker soils east of the escarpment is cotton, grain sorghum, and wooded areas. At the time these spectral data were obtained, these areas were green, producing a relatively low spectral response. Grass pastures and wheat stubble west of the escarpment produced relatively high reflectance.

A very useful technique for interpreting multispectral data is to calculate the ratio between the relative reflectance in the visible channels and the relative reflectance from the reflective infrared. In this study the following ratio was used:

$$R = \frac{A + B}{C}$$

where A = relative reflectance in channel 4 (0.5-0.6μm)
B = relative reflectance in channel 5 (0.6-0.7μm)
C = relative reflectance in channel 7 (0.8-1.1μm)

In general, for this set of data, low ratio values (<1) may be interpreted as green vegetation; values between 1.5 and 2.5 may be bare soil and/or plant residues. Water will produce yet higher ratio values. Different densities of green vegetative cover and percentages of exposed soil will produce yet higher ratio values. Different densities of green vegetative cover and percentages of exposed soil will produce intermediate ratio values between 1 and 2.

Although these results are preliminary, and the analysis of data was accomplished without benefit of ground observation data, quantitative spectral data from ERTS were very useful in separating and mapping gross surface features. The scene represented by the computer printout in Figure 3B is divided into eleven spectrally separable classes. One of the spectral classes is represented by the symbol "Q". This corresponds to the low reflectance areas of the drainageways. In general, these areas are covered with dense vegetation, trees, and bushes. The average R value for all Q's in the scene is 0.88. Within the drainageways interspersed with the symbol "Q" are individual "M's" or clumps of "M's". The average R value of "M's" in the scene is 1.79. This is indicative of bare soil or yellow, grassy spots in the drainageways. In the extreme northwest corner of this scene (Figure 3B) is a concentration of "+'s" with an average ratio value of 1.40. This represents a rangeland area covered with coastal Bermuda grass (<u>Cynodan dactylon</u>) which was yellow at the time of the ERTS pass.

These are examples of how quantitative spectral data may be used. Such data will become much more applicable when adequate ground observations provide for more complete interpretation.

B. Lavon Reservoir Subframe:

The objective of this study was to study in detail the spectral separability of crops, wooded areas, drainage patterns, and water quality with ERTS MSS data. The study area included the Lavon Reservoir area in the southeast quarter of Collin County, Texas.

After examining the digital data in each ERTS MSS channel on the digital imaging display system, training sets, representing major differences in cover types, were selected for analysis of the data. Visual examination on the display system of the Lavon Reservoir data allowed researchers to select 10 spectral categories of water. These 10 classes of water plus fourteen spectral classes of land features initially gave a total of 24 spectral classes identified and mapped by computer-implemented analysis.

Using the spectral statistics average ratio values were calculated for each class by dividing the reflectance values from the two visible channels (0.5-0.7μm) by the reflectance values from the infrared channels (0.7-1.1μm). Ratio values lower than 1.00 were arbitrarily classed as green vegetation; values between 1 and 2 were thought to be soil, roads, geologic features, or other non-green vegetation. Values greater than 2 generally turned out to be water.

On the basis of these ratio values several of the original 24 spectral classes were combined to give a final classification of 8 categories of water and 10 categories of land-vegetation features.

The eight spectral categories of water probably differed in depth, turbidity, sediment load, and algal growth. Ground observations indicate that depth of water was 3.5m in the northern part and 11m in the southernmost part of the reservoir. In the southwest part of the lake a distinct spectral class proved to be shallow water interspersed with a high population of dead tree stumps.

Other features which seemed to be identifiable spectrally were cotton, wooded areas, and grazing lands.

C. Fannin County (Texas) Subframe:

An area (Fannin County, Texas) with a relatively simple geology was chosen for testing the geologic mapping possibilities with computer-implemented analysis of ERTS MSS digital data. A geologic map of Fannin County is presented in Figure 4.

Five major processing algorithms of the LARSYS software system were used in this study: (1) CLUSTER, (2) STATISTICS,

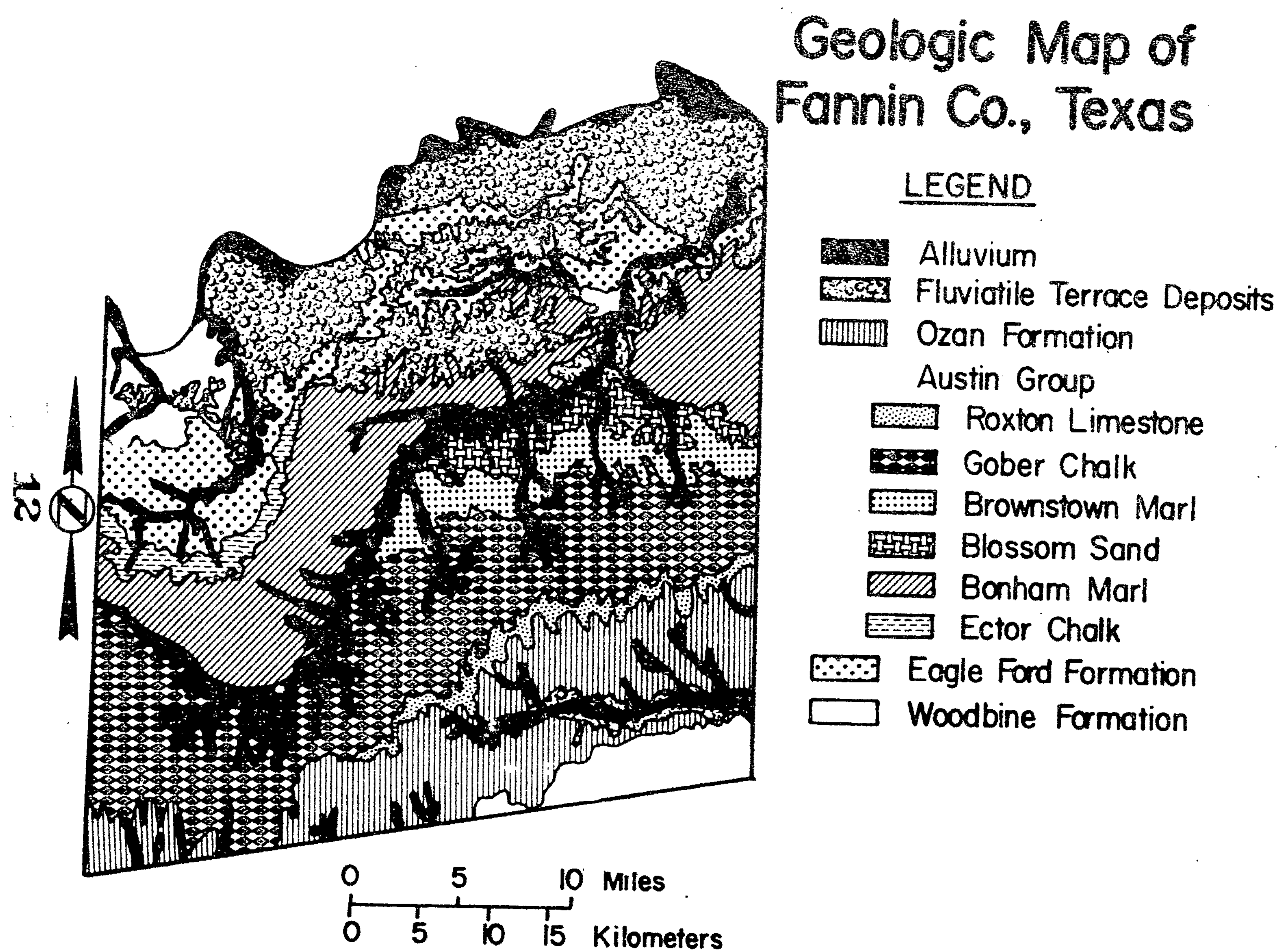


Figure 4. Geologic Map of Fannin County, Texas.

(3) CLASSIFYPOINTS, (4) PRINTRESULTS, and (5) NEWPHOTO.

The CLUSTER program is an unsupervised classifier that groups data vectors into classes. Mean vectors and covariance matrices are calculated by the STATISTICS program and are then used in the CLASSIFYPOINTS program which performs a maximum likelihood classification on a point-by-point basis over the entire area. Results from the above analysis are displayed using: (1) the PRINTRESULTS program to make alphanumeric maps, and (2) the NEWPHOTO program to display the results on the digital imaging display system.

The Digital Image Display System receives an image from an IBM System 360/Model 67 computer, stores this data in a video buffer, and after converting the digital data to an analog signal, displays the image in a raster scanning mode on a standard television screen. An interactive capability to edit, annotate, or modify the image is provided through a light pen and a program function keyboard. An additional photographic copying capability is also provided.

Two methods were used to select the training areas from the data for classification. A nonsupervised classification was performed initially. This method allowed the LARSYS system to select and refine the training areas. Manually selected training areas were utilized during the second phase of classification using the published map as ground truth.

A subset of Fannin County was chosen for classification using nonsupervised classification was made of a slightly larger area using twenty classes. From this printout, areas were selected which contained six adjacent points in the same class. This was done in an attempt to eliminate areas which contained points that were influenced by more than one type of surface cover. Using these areas thirteen nonsupervised classifications were performed. The separability information provided by the clustering program indicated that the twelve and fifteen class combinations contained the most separable classes. The classes defined by the clustering program were used to make classifications which were then displayed and analyzed.

Further analysis was done on these three classifications using a procedure developed by the investigators. Ratios of the reflected visible energy (channels 4 and 5) divided by the reflected red and infrared energy (channels 6 and 7) were calculated $(\frac{4+5}{6+7})$

3

and grouped according to numerical size. Classes which have similar ratios do not necessarily have similar intensities.

Two methods of manually selecting training areas were investigated: (1) training areas were selected from spectrally heterogeneous ground cover, and (2) training areas were selected from areas believed to be nonvegetated soil. A transparent overlay was made from the geologic map at the same scale as the computer printout map. Using this overlay, training areas were selected from each geologic unit, without regard to surface cover type. These were used in the statistics and classification programs. The resulting classification was displayed in printout map form and also on the digital display.

Areas of nonvegetated soil, thought to be cultivated areas, were located and displayed on a printout map. The ratio procedure previously defined was used to identify these areas. Using the geologic overlay, training areas were chosen from nonvegetated areas within each rock type and used as a basis for a classification. In addition, training areas of water and vegetation were used in the classification. Results of this classification were also displayed in a printout map and on the digital display.

Classifications of the MSS data were displayed using a line printer and the digital display. Printout maps are generally unsatisfactory for detailed analysis because of their size and resolution limitations. On the other hand the smaller pictures from the digital display allow the researcher the flexibility to make overlays, examine several classifications simultaneously, and compare features in each classification.

Two methods of evaluating results are available in the LARSYS system: aesthetically controlled performance, and numerical correctness. A computer-made map with a high percentage of correctness is useless from a geological user's standpoint if the map does not show boundaries or possible boundaries between the materials present. Therefore, a classification was "good" if it showed boundaries between materials, regardless of the numerical percent correct.

One of the most spectrally distinct materials in MSS data is water. Large rivers, lakes, and some small streams can easily be identified in the classified area. Most of the smaller tributaries are lined with dense green vegetation which can be easily mapped as streams because of the drainage pattern (dendritic to modified rectangular in Fannin County).

Many of the drainage features in Fannin County were easily identified and mapped (Figure 5). This classification was produced by combining the 12 original classes on the basis of ratios. Several features are apparent on the photograph: A appears to be meander scars made by the Red River, B is an active meander, C is a tributary of one of the reservoirs in the county, and D and E are streams draining into the Red River.

Boundaries were drawn, between what appears to be different materials, on several of the digital display photos. These photos were chosen because they appeared to indicate one or more boundaries. If these drawn boundaries are compared with a geologic map of similar scale, it is apparent that most of the inferred boundaries are correct.

Figure 6 shows the approximate location of mapped contacts between rock units (numbered, dashed lines) and boundaries drawn because of spectral differences (lettered, solid lines). As can be seen on the photograph, lines A and C and part of lines D and E most nearly match with mapped contacts 1, 2, 3, and 4 respectively. The computer classification shows differences in material at lines B, F, G, and H which were not mapped as rock contacts. The apparent descrepancies may be the result of topographic and/or land use effects. Lines A and B mark the approximate edges of a low plateau which may result in the difference in reflectance. Areas enclosed by lines H are thought be be dense green vegetation in the stream valleys.

Analysis of ERTS Data from Wells County, North Dakota

NASA Scene I.D.: 1044-16595
Date of ERTS Pass: 5 September 1972
LARS Run Number: 72035100

Wells County, North Dakota, was included in this ERTS investigation because it is representative of a very important group of soils and a significant agricultural region. The objective of the study is to analyze ERTS MSS data obtained throughout the year and to determine the spectral changes which occur. Spectral analysis will be performed with the LARSYS software system to delineate and map soils differences, to identify crops, and to evaluate crop conditions.

Nonsupervised (clustering) computer techniques were used to analyze the first ERTS data received from Wells County. Preliminary results indicate that many terrain and cultural features can be observed. Soil associations appear to be separable, and surface drainage patterns can easily be distinguished in the ERTS data.

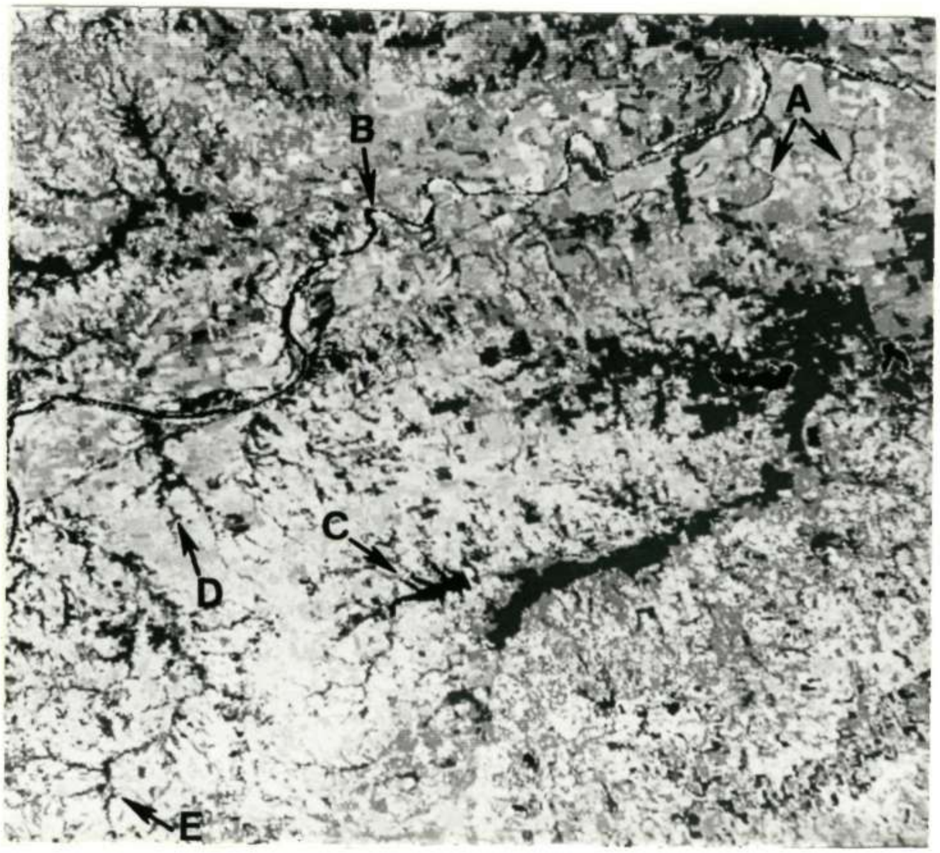


Figure 5. Drainage features in Fannin County, Texas from computer produced classification results.

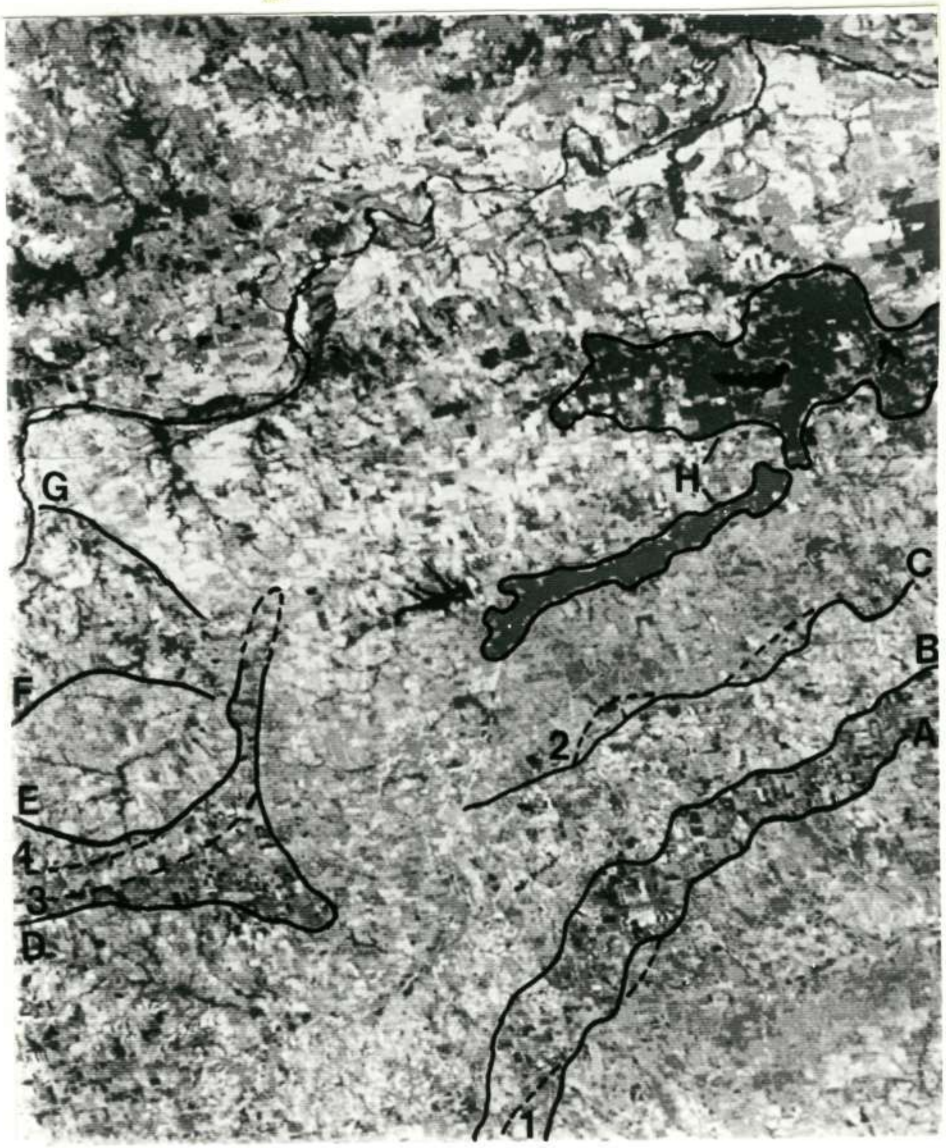


Figure 6. Geologic interpretation of a computer classification of Fannin County, Texas.

The accuracy of the analytical results from the 5 September frame of ERTS MSS data is now being tested with color and color infrared photography obtained by a NASA underflight mission in September. Existing soil surveys and geologic maps are also being used as sources of ground information.

Analysis of ERTS Data from the Lubbock (Texas) Regional Test Site:

	Scene I.D.	Date of ERTS Pass	LARS Run Number
1.	1078-16524	Oct. 9, 1972	72036900
2.	1079-16583	Oct. 10, 1972	72035500
3.	1114-16532	Nov. 14, 1972	72045000
4.	1132-16532	Dec. 2, 1972	72056800

A major effort under this contract is now being expended in the analysis and interpretation of ERTS MSS data obtained over the 10-county (31,000 square kilometers) Lubbock Regional Test Site.

A. Ground Observation Data Collection Program:

In order to have adequate ground observation data for training the computer for classification purposes and for testing computer-generated classification results, a cooperative ground observation program was developed. Through the cooperation of the Cooperative Extension Service (U.S. Department of Agriculture) in the Lubbock (Texas) District, six cooperating farmers were recruited in each of the ten counties of the test site. Each of the cooperating farmers agreed to make and report observations at the time of each ERTS pass over Lubbock. Each observer identifies each field and reports conditions of crops along a segment of county road 6 to 10 kilometers in length. The sixty segments being observed are well distributed throughout the ten county region.

"Guidelines for Ground Observations" was prepared for use by the ground observers (See Appendix A). A special one-page form for reporting ground observations was designed jointly by the principal investigator, a county agricultural agent and cooperating farmers from the Lubbock area (Appendix B). The list of cooperating farmers and agricultural extension personnel is attached (Appendix C).

B. Lynn County, Texas

Lynn County, an area of 3,140 km^2, is on that part of the southern Great Plains known locally as the South Plains. Relief in the county appears to be nearly level. However, there is a general slope to the southeast of 2 to 3 meters per kilometer. The smooth surface is pitted with many shallow lakes, or playas, 3 to 9 meters deep and 1 to 15 hectares in area and generally surrounded by gentle slopes. The lakes are dry except during wet years or rainy seasons. Several intermittent salt lakes, from 5 to 225 hectares in area and 6 to 15 meters deep, occur in the county.

Approximately three-fourths of the county is in cropland and one-fourth in range and pasturelands. The soils of Lynn County developed from thick beds of porous, friable, unconsolidated, loamy materials that are rich in lime and plant materials. These materials were probably transported by water from the higher lying areas to the west, then shifted and reworked by wind. The soils of the county have sandier surface soils and less compact, less blocky, and more permeable subsoils than the soils that comprise the "hardlands" to the north.

Since the county has a wide variety of soils and several easily identifiable landmarks, it was chosen for detailed study with ERTS MSS digital data. It is also noteworthy that during the months of August, September, and October the cooperating ground observers in Lynn County performed very well and reported soils and crop conditions at the time of each ERTS pass.

Initial examination of ERTS data was performed on the digital image display system. This allowed the researchers to locate the boundaries of the county.

The nonsupervised LARSYS classification program was then used to produce several maps of the county, each having 16 spectral classes. The first map had an ordering of alphanumeric symbols such that the class having the highest relative total reflectance (0.5-1.1μm) was represented by the symbol covering the smallest area (giving the "brightest" appearance) on the printout; the spectral class having the lowest relative total reflectance was represented by the symbol covering the largest area (giving the "darkest" appearance) on the printout. The other 14 classes were represented in decreasing order of their relative total reflectance by symbols giving an increasingly darker shade of grayness.

The second map presented 16 levels of grayness beginning with the "brightest" class which gave the highest relative reflectance in the visible channels (0.5-0.7μm) and ending with the "darkest" class which gave the lowest relative visible reflectance. A similar ordering of symbol grayness was prepared with the arrangement of the 16 classes according to their descending relative reflectance values in the infrared (0.7-1.1μm). The fourth computer map representation of Lynn County consisted of spectral classes representing the ratio values determined by dividing the average relative visible reflectance values for a class by the average relative infrared reflectance value for that class.

In many instances one or more of these arrangements provides a way of combining classes when the class values are very similar.

The use of these techniques made it possible to identify, delineate, and map playas, individual cultivated fields, major highways, some county roads, urban areas, natural drainageways, old salt lakes, native rangelands, and grass soils and geologic patterns.

C. Lubbock County, Texas

Lubbock County is located at the heart of the Southern Great Plains. The city of Lubbock is the important agricultural, economic, industrial, and cultural hub of a large area of West Texas and New Mexico. The county covers an area in excess of 3,100 km^2 and the physiography is similar in many ways to that of Lynn County, described in the preceeding section.

Although no study with ERTS-1 data was made of the entire county during this reporting period, significant results have been obtained in the analysis of ERTS-1 MSS data of the city of Lubbock and the immediately surrounding agricultural lands.

Using the LARSYS nonsupervised classification programs an analysis of the city of Lubbock subframe produced the following spectrally separable classes: densely built up central business district, broad artery streets lined with businesses, dense residential areas, suburban (more open) residential areas, university campus (relatively open area), parks, lakes, cultivated fields, interstate and other major transportation corridors, and industrial complexes.

Plans for Future Research:

The plans for the immediate future are to locate the addresses in the ERTS data of segments of each of the cooperative ground observers. The objective will be to use the ground observation data to train the computer for identification of crops, crop conditions, and soil conditions.

Work will also begin soon in using the computer capability to overlay data from one ERTS pass onto data from succeeding passes over the same site.

During February and March the principal investigator will also report initial analysis of ERTS-1 MSS data to the cooperating county agricultural agents and ground observers in the Lubbock Regional Test Site. Detailed plans will be formulated for the ground observations operations for the 1973 growing season.

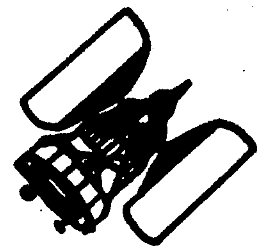
APPENDIX

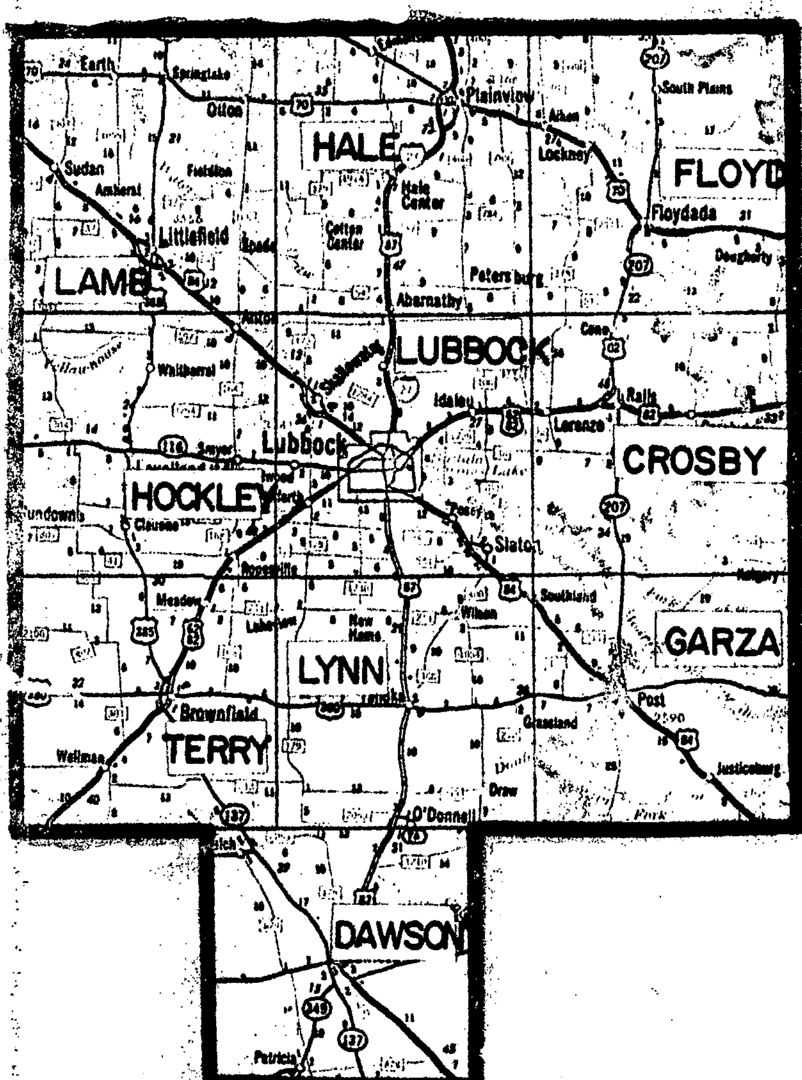
A. Guidelines for Ground Observations (Lubbock Regional Test Site)

B. Ground Observations Form for ERTS Experiment (Lubbock Regional Test Site)

C. Master List--County Agricultural Agents and Cooperating Ground Observers (Lubbock Regional Test Site)

Guidelines for Ground Observations





Lubbock Regional Test Site

Earth Resources Technology Satellite Experiment

23

Coordinated by Laboratory for Applications of Remote Sensing, Purdue University

GUIDELINES FOR GROUND OBSERVATIONS

LUBBOCK REGIONAL TEST SITE

EARTH RESOURCES TECHNOLOGY SATELLITE EXPERIMENT

Data obtained by sensors on ERTS as it passes over the Lubbock Regional Test Site every 18 days will be received by the Laboratory for Applications of Remote Sensing, Purdue University, as recorded electronic signals on magnetic tape. The data will be analyzed by computer.

In order to train the computer to identify and map different surface features of interest, it is necessary to have a sampling of accurate ground observations for use as a training set in machine processing. This is why you, the volunteer ground observer, are so important to the success of this experiment.

A number of suggestions are given herein to aid in the successful completion of ground observations each time ERTS obtains data over the Lubbock Regional Test Site.

WHEN TO MAKE OBSERVATIONS

ERTS-1 is scheduled to pass over the Lubbock Regional Test Site on the following dates:

August	16
September	3
September	21
October	9
October	27
November	14

↓

until August 1973

We hope that you will be willing and agreeable to make observations along your road segment for each of the passes up to and through October 9. During the fall and winter months we will analyze and evaluate our procedures and results. Any necessary improvements and procedural changes will be made and reported to you in sufficient time for observations to begin in the spring of 1973.

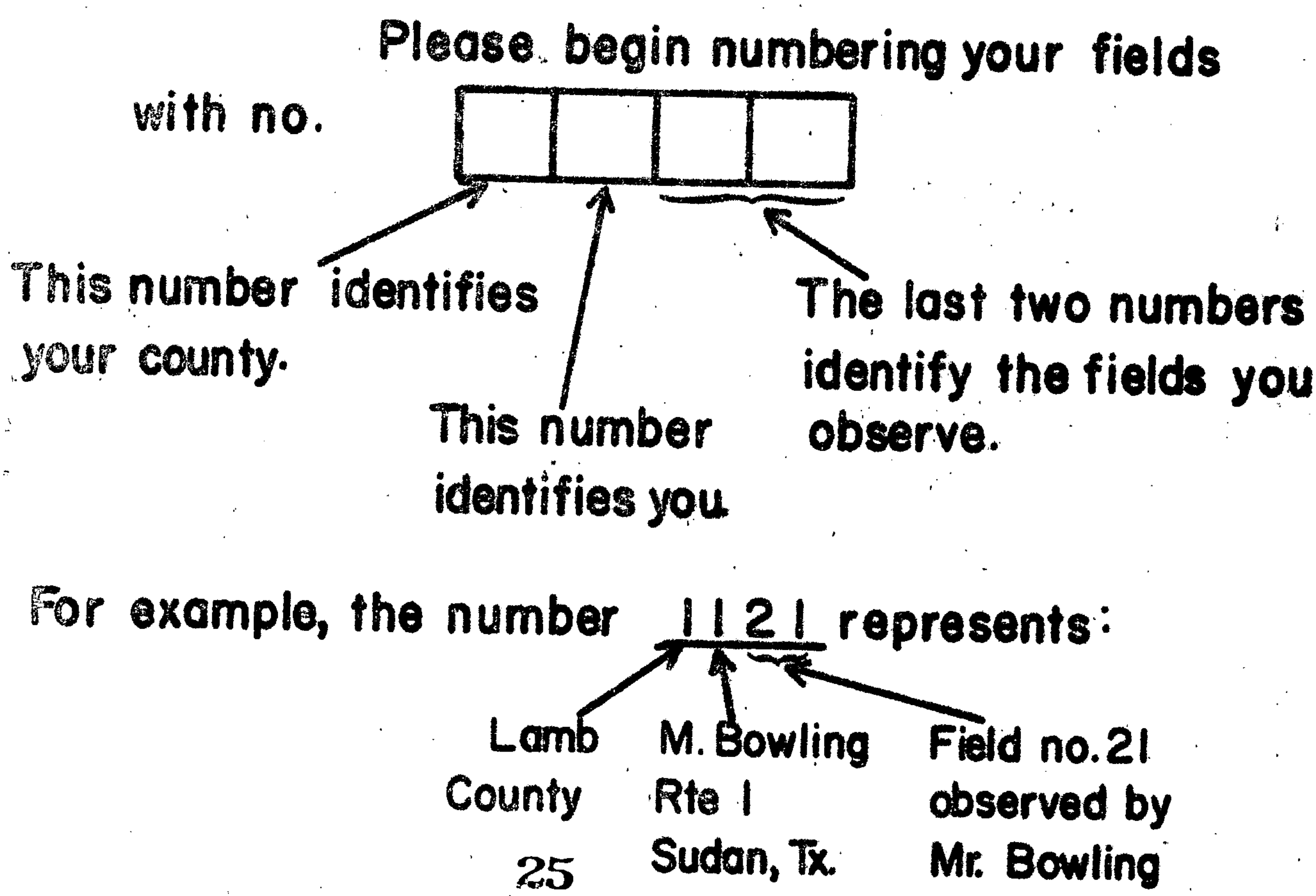
You will also be notified if there is any change in the dates of ERTS pass over of your county.

AREA TO BE OBSERVED

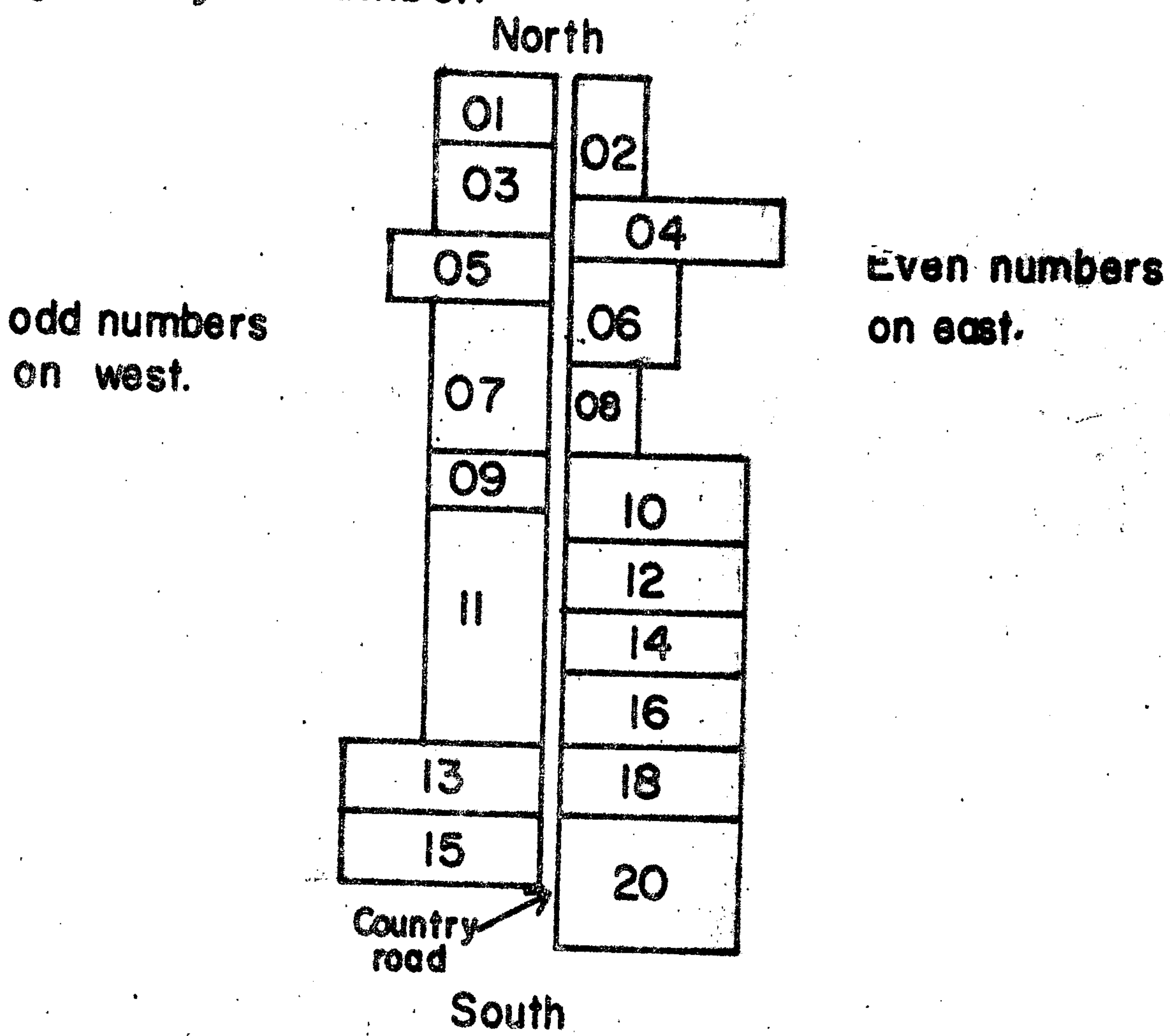
Each volunteer ground observer has been requested to make observations of every field (crop, pasture, farmstead, other) on each side of a specified segment of road. It is important that we have a map (can be rough drawing) of the area you are observing, showing the relative size, shape, and location of field and the field number.

METHOD OF NUMBERING FIELDS

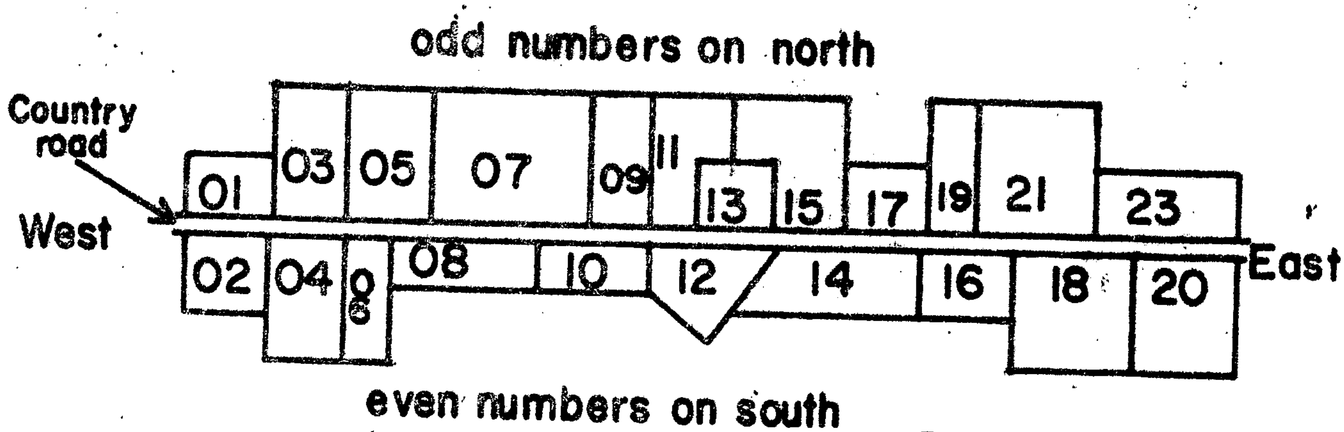
It is absolutely essential that your field numbering system correspond with ours because we must use your field number and observation data to train the computer.



If your road segment runs north-south, please number as follows, writing the field numbers as the last two digits of your number.



If your road segment runs east-west, please number as follows:



If you have other variations, the main consideration is to make sure that every field (crop, pasture, playa lake, weeded area, farmstead) which borders your road segment is numbered.

HOW TO MARK GROUP OBSERVATION FORM

Field No.: Every field to be observed in the 10 county Lubbock Regional Test Site must have a unique four digit number. Write the appropriate number at the top of each column on the Ground Observation Form.

First digit is for county

Lamb	1	Crosby	6
Hale	2	Terry	7
Floyd	3	Lynn	8
Hockley	4	Garza	9
Lubbock	5	Dawson	0

Second digit is for the observer.

Your number is __ __ __ __.

Third and fourth digits are for the number you assign to a field.

1. Crop (Land Use) please place X in the appropriate blank.
2. Planting pattern: please place X in the appropriate blank.
3. Growing conditions: More than one condition may apply; place X in the appropriate blanks.
4. % Ground Cover (growing crop or crop residue): Mark one space only under this heading. Estimate the percent of the ground surface which is covered by green vegetation or crop residue.
5. Stage of Residue: Mark the appropriate boxes which will best indicate the stage of residue of the most recent crop if crop has been harvested.
6. Other conditions: Mark the boxes which best describe the surface soil and/or the growing crop.
7. Row direction: Self explanatory.

Example:

GROUND OBSERVATIONS
FOR ERTS EXPERIMENT

	Field No. 1101	Field No. 1102	Field No. 1103	Field No. 1104	Field No. 1105	Field No. 1106	Field No. 1107	Field No. 1108
1. Crop (Land Use)								
Cotton	X							X
Grain Sorghum		X			X			
Soybeans						X		
Forage Sorghum								
Alfalfa							X	
Pasture			X	X				
Farmstead								
Other								
2. Planting Pattern								
Solid			X	X				
2 and 1	X							

Aug. 16, 1972

OTHER CONSIDERATIONS

If you have any questions regarding these guidelines or this experiment, please consult your County Agent.

GROUND OBSERVATIONS
FOR ERTS EXPERIMENT

	Field No.	Field No.	Field No.	Field No.	Field No.	Field No.	Field No.	Field No.
1. Crop (Land Use)								
Wheat								
Cotton								
Grain Sorghum (milo)								
Soybeans								
Forage Sorghum								
Alfalfa								
Pasture								
Farmstead								
Other								
2. Planting Pattern								
Solid								
2 and 1								
2 and 2								
2 and 4								
4 and 4								
4 and 2								
Double Row								
Drilled								
Other								
3. Growing Conditions								
Dryland								
Irrigated								
Pre-Boot								
Boot								
Heading								
Square								
Bloom								
Mature								
Other								
4. % Ground Cover (Growing Crop/Residue)								
0								
25								
50								
75								
100								
5. Stage of Residue								
Harvested								
Pasture								
Shredded								
Disked								
Moldboarded								
Other								
6. Soil Conditions								
Fresh Plowed								
Crusted								
Active Wind Erosion								
Dry (Surface Soil)								
Wet (Surface Soil)								
Other								
7. Crop Conditions								
Clean (Few Weeds)								
Weedy								
Succulent (Plants)								
Stress (Crop Wilted)								
Visible Hail Damage								
Other								
8. Row Direction								
North-South								
East-West								
Contour								
Other								

Ground Observer ______________________ County ______________ ________
(Name) Date

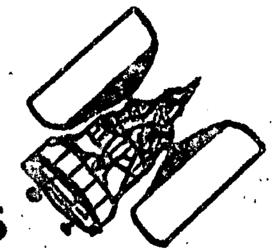
LABORATORY FOR APPLICATIONS OF REMOTE SENSING, PURDUE UNIVERSITY

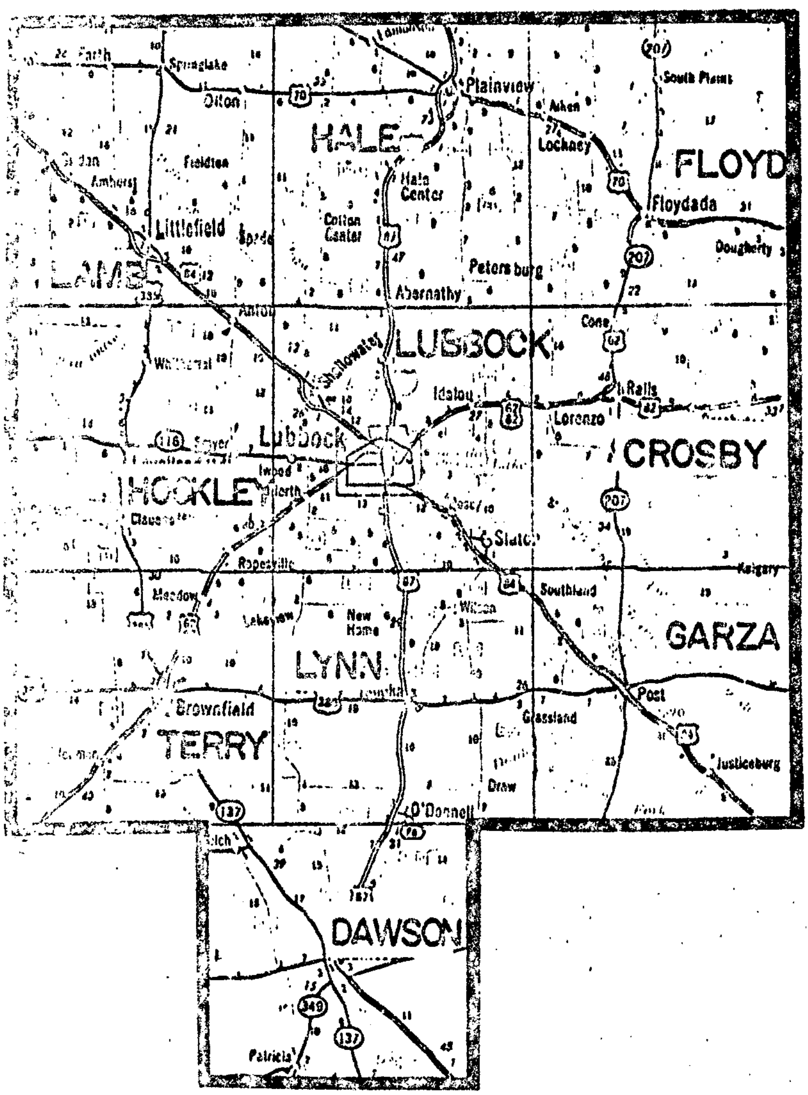
Master List

County Agricultural Agents

And

Cooperating Ground Observers





Lubbock Regional Test Site

Earth Resources Technology Satellite Experiment

(National Aeronautics and Space Administration)

Coordinated by Laboratory for Applications of Remote Sensing, Purdue University

August 1972

Coordinator of the Lubbock Regional Test Site Experiment:

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	Cooperators	
61	Otis English Route 2 Crosbyton, Texas 79322	806/697-2644 (H)
62	Max Joiner Box 515 Lorenzo, Texas 79343	806/634-5956 (H)
63	Wilbur Leon Route 1 Petersburg, Texas 79250	806/667-2279 (H)
64	Lawrence McDowell Route 1 McAdoo, Texas 79243	806/697-2483 (H)
65	Johnny Nunley Route 1 Ralls, Texas 79357	806/649-2788 (H)
66	Charlie Wheeler Box 599 Crosbyton, Texas 79322	806/675-2240 (H)

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Route D
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31 Eugene Beedy
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33 Mickey D. Hammonds
Route 2
Floydada, Texas 79235

34 Vernie Moore
Route 4
Floydada, Texas 79235 — 806/983-2006 (H)

35 Weldon Pruitt
Route 3
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36 Albert Scheele
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Justiceburg, Texas 79330

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93 C. R. (Pete) Lancaster
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Post, Texas 79356 — 806/996-3664 (H)

94 B. L. Thomas
Route 2 — 806/996-2804
Post, Texas 79356 — Southland

95 Jerry Thuett
Route 3 — 806/495-3017 (H)
Post, Texas 79356 — Post

Hale County (County No. 2)

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Plainview, Texas 79072 — Petersburg

22 Joe Leach
Route 3 — 806/296-9344
Plainview, Texas 79072

23 Dr. Tom Longnecker
Box 1870 — 806/293-5720 (H)
Plainview, Texas 79072 — 806/889-3315 (O)

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Petersburg, Texas 79250 — 806/667-3754 (H)

25 E. E. Masters
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Hale Center, Texas 79041 — Cotton Center

26 E. J. Pope, Jr.
Route 2 — 806/757-2815 (H)
Abernathy, Texas 79073 — County Line

Hockley County (County No. 4)

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Route 3
Levelland, Texas — 806/894-5889 (H)

42 Bill Jackson
Route 1
Levelland, Texas 79336 806/297-4124 (H)

43 Gene Nugent
County Agents Office
Levelland, Texas 79336 806/894-3159 (H)

44 E. L. Schlottman
Route 3
Levelland, Texas 79336 806/933-2788 (H)

45 Bill Thompson
Citizens Coop Gin, Route 1
Shallowater, Texas 79363 806/997-4535 (H)

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12 Nollie Embry
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13 Jack Feagley
Star Route 2
Littlefield, Texas 79339 806/262-4441 (H)

14 Norman Hinchliffe
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Earth, Texas 79031 806/257-3762 (H)

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Olton, Texas 71064 806/285-2281 (H)

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17	Arlen Simpson 115 E. 20th St. Littlefield, Texas 79339	806/385-5890 (H)

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<u>County Agent</u>

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52	W. B. Criswell Route 1 Idalou, Texas 79329	806/892-2090 (H)
53	F. H. Griffin Route 1 Box 67 Slaton, Texas 79364	806/828-3065 (H)
54	Milton Kirksey Box 266 Wolfforth, Texas 79382	806/799-0010 (H)
55	Dr. Charles W. Wendt Agricultural Research and Extension Center Route 3 Lubbock, Texas 79401	806/763-9451 (O)
56	Charles W. Woods Route 2, Box 109 Lubbock, Texas 79415	806/762-8697 (H)

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82 Elbert Crawford
Route 2
Tahoka, Texas 79373 806/439-5185 (H)

83 Tom Mason
Route 1
Tahoka, Texas 79373 806/327-5632 (H)

84 Howard Moore
Route 2
O'Donnell, Texas 79351 806/465-3404 (H)

85 Lit H. Moore
Route 1
Wilson, Texas 79381 806/863-2593 (H)

86 Jiggs Swann
Route 1
Wilson, Texas 79381 806/996-2691 (H)

Terry County (County No. 7)

County Agent

James A. Foy
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Brownfield, Texas 79316 806/637-4060 (O)

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Welch, Texas 79377 806/489-3832 (H)

72	Earl Brown, Jr. 1304 E. Cardwell Brownfield, Texas	79316	806/637-6662 (H)
73	Gerald Jordan Route 4 Brownfield, Texas	79316	806/585-2267 (H)
74	Gordon Patton 1312 E. Reppto Brownfield, Texas	79316	806/637-3730 (H)
75	Gary Tatum Route 1 Brownfield, Texas	79316	806/585-4111 (H)
76	Billy Yeatts Route 4 Brownfield, Texas	79316	806/522-3977 (H)