1980 AgRISTARS DC/LC
Project Summary
Crop Area Estimates for Kansas and Iowa

by
David D. Kleweno
Charles E. Miller

U. S. Department of Agriculture
Economics and Statistics Service
Statistical Research Division

March 1981
ESS Staff Report
No. AGESS-810414

1980 AgRISTARS DC/LC Project Summary, Crop Area Estimates for Kansas and Iowa: by David D. Kleweno, Charles E. Miller, U.S. Department of Agriculture, Economics and Statistics Service, Statistical Research Division, Washington, D.C. 20250, ESS Staff Report No. AGESS810414 , March 1981.

ABSTRACT

This report describes the major crop area estimation element of the 1980 AgRISTARS DC/LC project as implemented by the ESS. Data from NASA earth resources monitoring satellites, LANDSAT II and III, were used in conjunction with conventionally gathered ground data to provide 1980 crop area estimates of harvested winter wheat in Kansas and planted soybeans and corn in Iowa. The major objective of providing these estimates to the Crop Reporting Board prior to each crops annual review was impeded by poor quality and untimely delivery of LANDSAT data. Both Kansas and Iowa SSO's provided a significant contribution to the 1980 project by successfully implementing several pre-analysis functions heretofore performed in a strictly research mode.

Keywords: LANDSAT, AgRISTARS, DC/LC, Regression estimate, Crop area estimation

ACKNOWLEDGMENTS

The authors wish to extend a special thanks to Charles Caudill and Rich Allen for their technical and managerial support; to George Hanuschak for his asserted project implementation efforts; to Mike Craig, Marty Holko and especially to Jim Mergerson for an assiduous analysis effort; and to Paul Cook and Sandy Stutson for strong leadership in the registration phase of the project. Thanks also go to Peggy Pearsall for her reformatting efforts and to the support group; Sandy Stutson, George Harrell, Eric Hendry, Lillian Schwartz, Pearl Jackson, and Tjuana Fisher. Phil Doctor and Stephanie Moss in the Kansas and Iowa SSO's respectively, provided the leadership necessary for a successful decentralization effort. Fine typing efforts were contributed by Bessie Johnson.

TABLE OF CONTENTS

INTRODUCTION

This report summarizes the work performed under the major crop area estimation element of the 1980 AgRISTARS (Agriculture and Resources Inventory Surveys through Aerospace Remote Sensing) Domestic Crops and Land Cover (DC/LC) Project. It will not provide a detailed account of each analysis phase, but rather a synopsis of those functions thought most informative to the Economics and Statistics Service (ESS) user. The format of the report is as follows:

I. Background and Objectives
II. State Statistical Office Impact
III. LANDSAT Data Acquisition and Management
IV. Data Analysis and Estimation Results
V. Summary

A general review for all the states is presented in Sections I,II, and V while individual state reports are given in Sections III and IV. Questions on general analysis procedures, statistical theory, or current ESS procedures are referred to the paper by Hanuschak, et. al. [1/].

I. Background and Objectives

AgRISTARS is a joint research program between USDA, NASA, NOAA, USDI and AID established to investigate the use of remote sensing in agriculture. The Remote Sensing Branch (RSB) of ESS assumed the responsibility for implementing the DC/LC project which is one of eight projects under the AgRISTARS program.

LANDSAT data are combined with conventional ground-gathered survey data to provide timely, more precise, year end major crop area estimates in selected states. The DC/LC project initially started with two states in 1980 and will add two states per year to a total of ten states. Kansas and Iowa were chosen as the first two states for the project. The primary objective in each state was to obtain crop area estimates with reduced sampling errors: harvested winter wheat in Kansas prior to December 1, 1980 and planted corn and soybeans in Iowa prior to December 23, 1980.

In 1980, Kansas also completed a Land Cover study. The results will be summarized in a separate report.

II. State Statistical Office Impact

The State Statistical Office (SSO) in each of the two states played an integral part in the outcome of the DC/LC project. Field boundary, acreage, and crop type data collected by the Kansas and Iowa SSO's during the June Enumerative Survey (JES) and a special follow-up survey in Iowa were used to establish training fields for computer classification of crop/land cover types using LANDSAT digital data. After collecting the data an intensive field level edit was made by each state followed by digitization and plotting of the segment data.

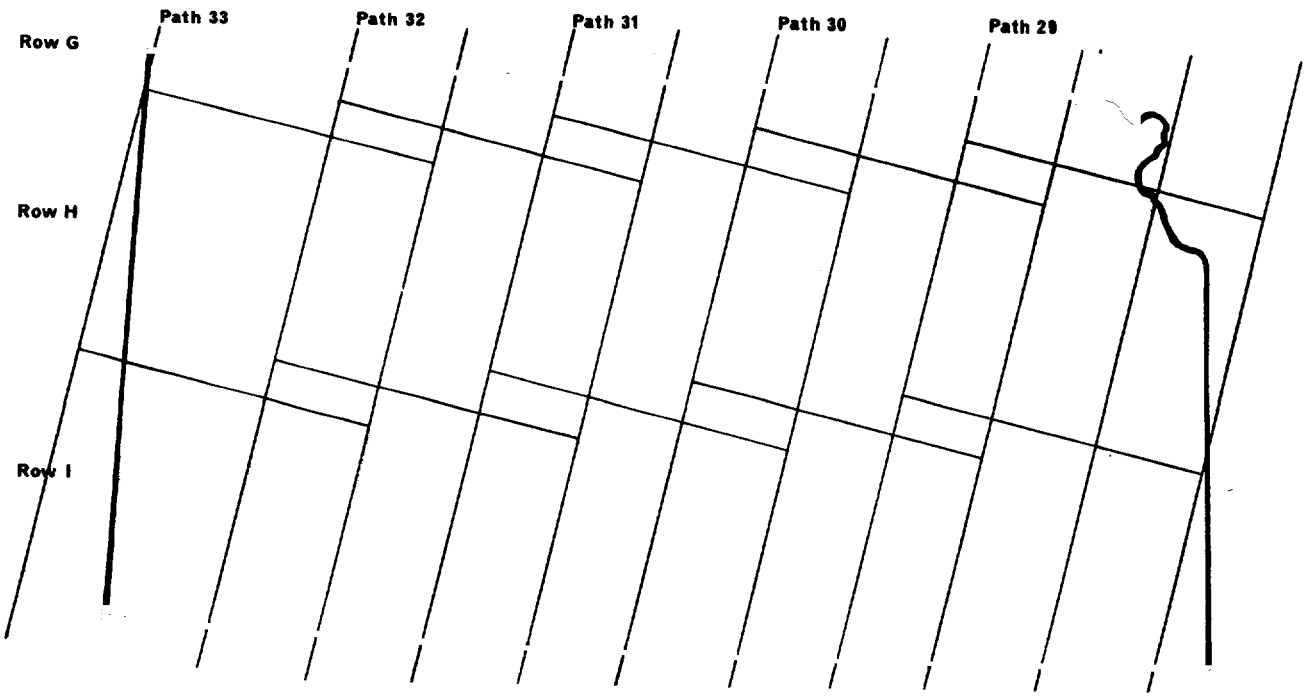
Prior to FY80 these functions were handled by the RSB staff. In view of an expanding program, it was apparent that several of the pre-analysis functions mentioned above could be more effectively performed in the SSO. Kansas and Iowa both eagerly accepted this challenge. After a few modifications, these functions were successfully transferred from a research environment to an operational framework, a significant step forward. Decentralization of pre-analysis functions to the SSO will continue as technological advances are made.

III. LANDSAT Data Acquisition and Management

A. Kansas - Nineteen LANDSAT scenes are required to provide full coverage over the State of Kansas, Figure 1.

Figure 1

Kansas LANDSAT Scene Locations



For the period of April 1, 1980 - May 30,1980 each of the 19 scenes had four potential LANDSAT III imagery dates. Acquisition of 1980 Kansas LANDSAT II imagery was not available within the April-May crop window as the satellite was non-operational until June.

A standing order for paper products, transparencies, and CCT's was placed with EROS Data Center (EDC) early in 1980. The auto request corresponding to the crop windows specified the acceptable cloud cover and band quality (5 or 8). By mid-May it was learned that band quality for most of the LANDSAT III MSS data was being downgraded from 5 and 8 to 2 and 0 because of line skip anomaly's affecting 30 percent of the scene and degraded LANDSAT data resulting from pre-processing problems. The auto and manual orders were modified to allow receipt of a limited quantity of data with band quality of 2.

In an attempt to improve the quality of the Kansas LANDSAT data, NASA Goddard reprocessed many of the digital tapes, some several times. Although it was important to strive for quality data, reprocessing caused many delays and slowed receipt of the LANDSAT products. Timeliness of the project using quality LANDSAT data was impeded.

Delivery of LANDSAT products involved two phases. The data was first transmitted from the satellite to NASA Goddard where it was pre-processed, processed and sent via DOMSAT to EDC. EDC in turn processed the data tape (P-Tape), filled the data order, and mailed the products to ESS. A brief explanation of the delivery times associated with each of these phases follow.

Data products were ordered for 40 of a total 76 possible scenes (including 4 early June LANDSAT II scenes). The remaining 36 scenes were not ordered because of poor data quality, cloud problems, and lack of availability at EDC.

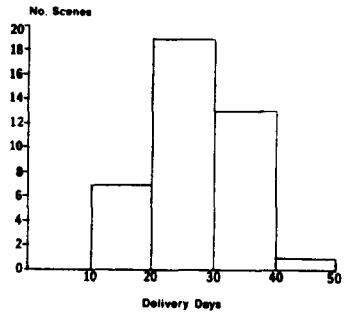
For the 40 scenes, data delivery time from NASA Goddard to EDC was extremely variable, Figure 2a. Most of the data were delivered to EDC within three months of satellite acquisition. Data delivery delays were attributed mostly to re-processing problems.

Figure 2

LANDSAT Data Delivery Time, Kansas:

a. From Satellite Acquisition Until Catalogued (EDC) 40 Scenes

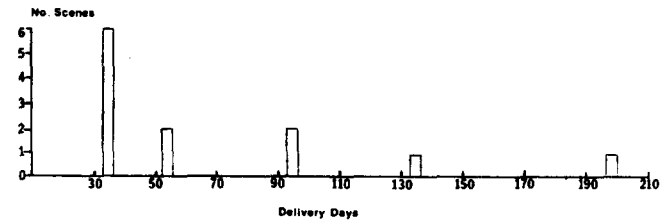
b. EDC To ESS – All Paper Products Ordered, 40 Scenes



c. EDC To ESS – All Tapes Ordered, 27 Scenes

d. Satellite Acquisition To ESS – All Tapes Ordered, 27 Scenes

e. Satellite Acquisition To ESS – Tapes Analyzed, 12 Scenes



Paper products and transparencies shipped from EDC generally arrived after that of the corresponding CCT. Although this was expected, during the first several months the time disparity between the two seemed somewhat large. Data delivery times of paper and transparency products from EDC to ESS for the forty scenes are shown in Figure 2b. Slightly over one-half of the products arrived at ESS within one month of the order date.

Only 27 CCT's were ordered from the 40 possible scenes. Nineteen of 27 CCT's were received from EDC within 20 days, Figure 2c. For these same 27 CCT's 20 were received within 90 days of satellite acquisition, Figure 2d.

In total, 12 scenes were used in the Kansas 1980 analysis. Six of 12 were received within 40 days of satellite acquisition, Figure 2e. The remaining six were greatly dispersed.

The entire registration process including preparation, reformatting, system downtime, etc., took an average of 21 days for each scene, Figure 3. Locating the control points and performing the actual registration steps (using grey scales) took an average of 11 hours per scene, Figure 4. Difficulty in locating usable control points in 3 of the 12 scenes increased the overall average scene registration time of 9 hours by approximately 2 hours to 11 hours. Analysis and estimation time for each analysis district took an average of 19 days, Figure 5.

Figure 3

Reformating and Registration Time, 12 Scenes

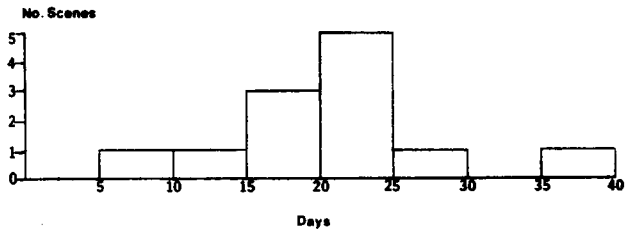


Figure 4

Registration Time, 12 Scenes

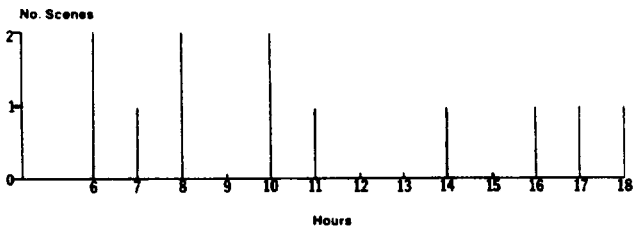
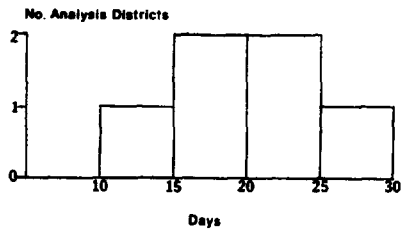


Figure 5

Analysis and Estimation Time, 6 Analysis Districts



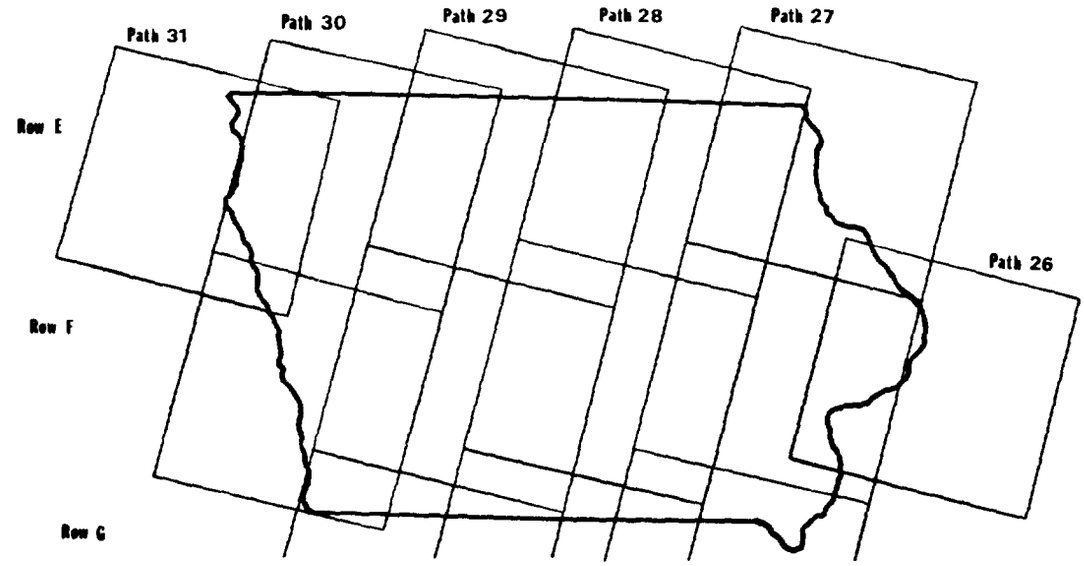
In comparing the 1978 Iowa study with the 1980 Kansas analysis, the time required for completing the registration, analysis and estimation functions appeared virtually unchanged. On the surface it appeared very little gain in time efficiency had occurred over the two year interval. In fact improvements were made and time savings had been realized, but the gain was overshadowed by several factors. Much of the time necessary for completing the entire registration function was spent waiting for tapes to be processed, mailed, and put into the system. Very little time was required for the actual analysis part of registration. This time differential is apparent after viewing Figures 3 and 4.

The time required for the 1980 analysis and estimation function was also biased upward when compared to 1978. Analysis of poor quality data produced preliminary results below normal standards. The analyst was forced to carefully review and reanalyze the data. Another factor which skewed the time relationship for analysis and estimation was in the summary program. In 1978 this function, was completed manually and the time not included as a part of the estimation function, whereas in 1980 it was part of an automated system and included in the time required for completing estimation. Again this tended to overstate the time required for analysis in 1980 compared to the 1978 Iowa study.

B. Iowa - Thirteen LANDSAT scenes are needed to fully cover the state of Iowa, see Figure 6.

Figure 6

Iowa LANDSAT Scene Locations

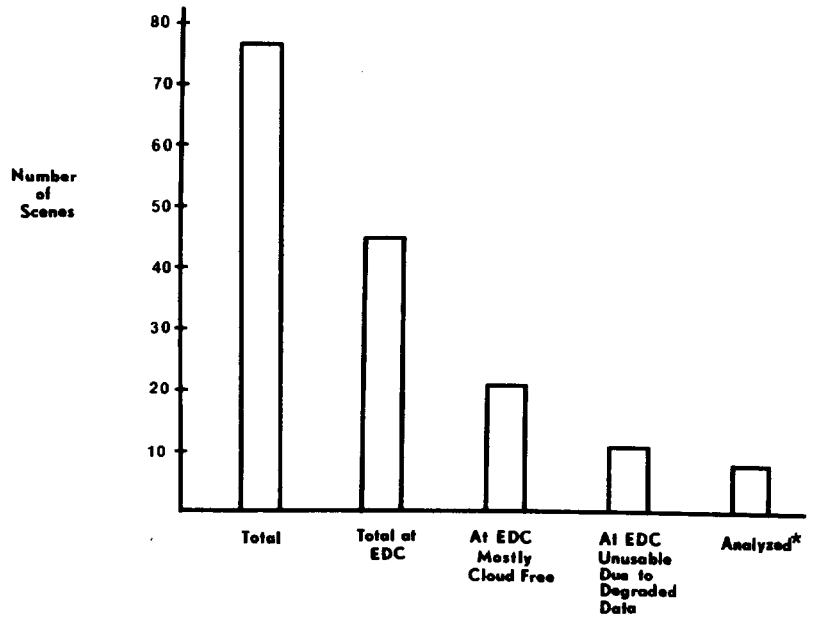


Each of the thirteen scenes had six potential image dates for the period July 15 to September 5, 1980. Acquisition of both LANDSAT II and LANDSAT III data was possible but imagery from LANDSAT II was more desirable in light of the problems experienced with the Kansas imagery. Problems in obtaining quality 1980 Kansas imagery necessitated modifying the Iowa standing request to allow visual inspection of imagery prints before manually placing CCT orders. A limited number of useable scenes were received in a timely manner by EDC from NASA Goddard. As of October 15, 1980 only two scenes out of eleven received by EDC were considered usable (<30% cloud covered) and acquired by ESS. Nine of the eleven scenes had various forms of severely degraded and poor quality data.

Figure 7 shows the status of Iowa LANDSAT imagery at EDC as of mid-February 1981 for the required crop window. In order to provide more complete coverage of the state, two LANDSAT III scenes (September 10, 1980) were acquired outside the crop window.

Figure 7

LANDSAT Imagery Summary, Iowa



*Two additional images not included. (Outside crop window)

Scene registration went smoothly after the receipt of LANDSAT data. A modified procedure was utilized, reducing the time required for processing each scene by several hours. First, control points were selected on the 1:250,000 black and white prints for both Bands 5 and 7. Using USGS topographic maps of roughly the same scale and the tablet digitizer, the latitude and longitude of each control point were obtained. The relationship of these points was then analyzed and their suitability determined to create the regression polynomial used in the LANDSAT row-column transformations. This method was deemed adequate for our needs and thus eliminated the requirement of having a CCT available for printing greyscales and then locating control points.

The average time for Iowa scene registration was four hours which included selection of control points and analysis of the resulting transformation equations. It should be noted that this average does not include time required for reformatting and shipping tapes or printing of greyscales corresponding to control points.

IV. Data Analysis & Estimation Results

The first step in analysis was to define analysis districts by determining the counties fully contained within a LANDSAT scene. Two or more scenes were analyzed together provided they were in the same pass (same date). Areas overlapping between two scenes were assigned to a specific scene by looking at cloud cover, band quality, imagery dates, and each scene's containment relative to the other. Ideally, analysis districts could be assigned for the whole state before starting analysis in a specific area.

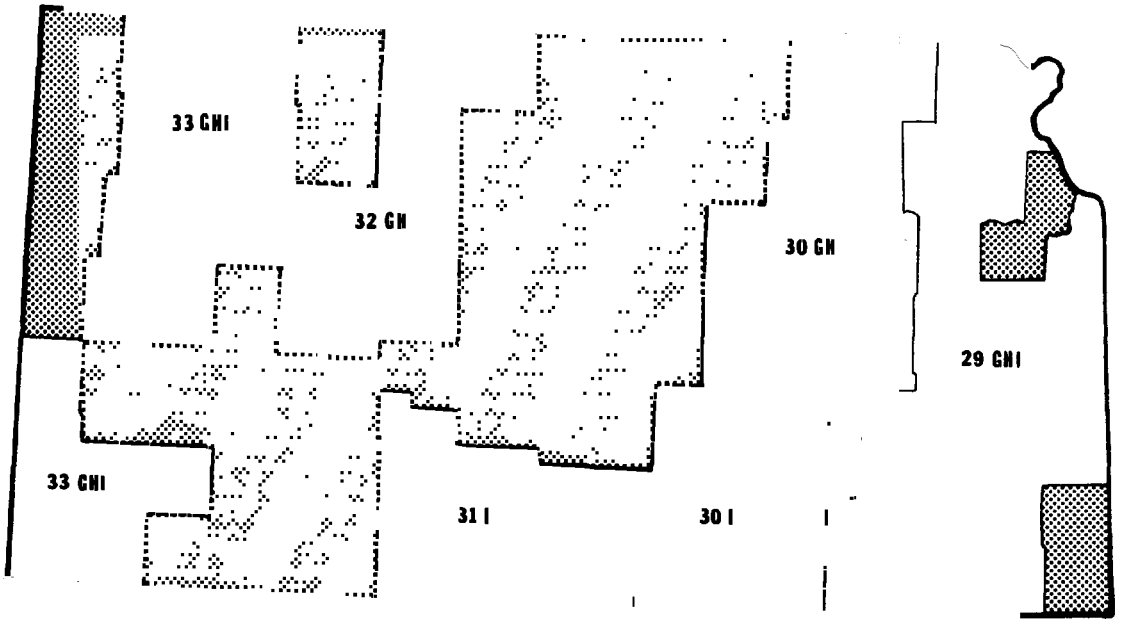
A. Kansas - In 1980, Kansas LANDSAT imagery was received in a very untimely manner. A slight delay was initially experienced as the auto order specified band quality of 5 or 8 and only quality of 0 or 2 came up in the data base at EDC. Preliminary analyses were run for three areas using LANDSAT III data having band quality 2222 and for one area using LANDSAT II data with band quality of 2255. The results did not show the gain in precision normally found by marrying ground data with the LANDSAT data having band quality of 5 or 8. The registration process also proved unusually difficult. NASA Goddard reprocessed the Kansas data having band quality of 0 or 2 several times. Not until mid-August did a scene arrive at EDC that met the established data standards of 5555 or better. For this scene nearly three months had transpired from the original satellite acquisition date.

In early October one LANDSAT II and one LANDSAT III scene became available. It became apparent that as long as the preprocessor continued to have problems that a very limited amount of reprocessed higher band quality data would become available. A decision was made at that time to re-establish the timeliness criteria for the Kansas project using a limited amount of better quality data in combination with data currently available.

Seven analysis districts were needed to cover the state, Figure 8.

Figure 8

1980 Kansas Analysis Districts



The three analysis districts used during the preliminary analysis remained unchanged other than the southern most scene of pass 30 which was replaced with a scene having better quality data. Cloud cover, poor quality data and/or lack of data availability eliminated nearly 45% (based on the 1980 county harvest area estimates) of the state's wheat area from being estimated using both LANDSAT and ground gathered data. An estimate for this area (DE) was limited to using the field level JES Direct Expansion estimator. Analysis results were sent to the Kansas SSO and presented to the Crops Branch on December 4, 1980 (see Appendix, Table 1).

The relative efficiencies by analysis district and for the state (ratio of D.E. variance to the Regression variance) were abnormally low. Very little gain in precision was obtained by marrying 1980 LANDSAT data with the 1980 JES ground gathered data. A relative efficiency for the state of at least 2.0 was expected but only 1.33 obtained.

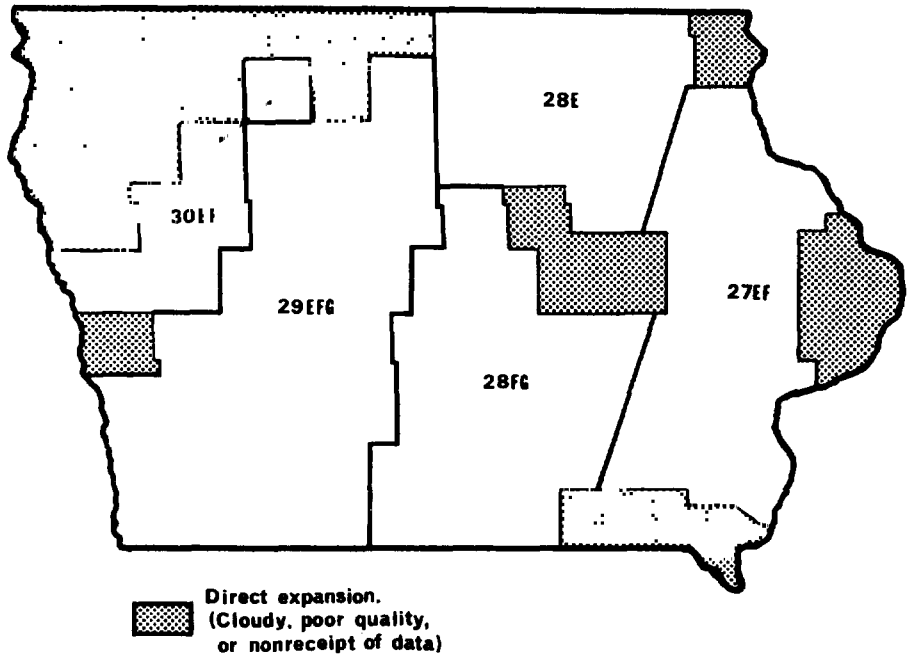
B. Iowa - Delays in delivery and poor quality data were major concerns in achieving timely and more precise estimates in 1980. Only one of the scenes within the desired crop window used in analysis had band quality

rating of 8 (excellent) in all four channels of the data. LANDSAT III imagery (July 17 to September 5) was unusable due to line skip, sheering and other problems visible on print products. One pass of LANDSAT data (9/10/80) having qualities of 8 was used in the analysis even though it was outside the desired crop window. The eight remaining scenes were acquired by LANDSAT II.

Six analysis districts were used to cover the state. The JES Direct Expansion estimator was used for 23 of the 99 counties in Iowa because of excess cloud cover and/or lack of digital coverage (see Figure 9).

Figure 9

1980 Iowa Analysis Districts



Analysis was completed in early March 1981 with the results for corn and soybeans displayed in Tables 2 and 3, respectively (see Appendix). Relative efficiencies by analysis district and for the entire state were lower than expected when compared to results obtained in 1978.[1/] It is suspected that this loss in precision is related to late imagery since five of the ten images used were acquired by the satellites in September 1980.

V. Summary

During 1980, acquisition of quality and timely LANDSAT data was severely impaired. Satellite and LANDSAT pre-processing problems lowered the digital data quality and increased the delivery time necessary for receiving LANDSAT data products. Many of the LANDSAT data quality and timeliness problems encountered during 1980 were due to ground handling complexities at NASA Goddard, not spacecraft factors. Indications are that these problems will be alleviated early in 1981.

Both Kansas and Iowa projects suffered extensively from lack of quality and timely LANDSAT data. Project timeliness was maintained using mostly poor quality LANDSAT data in Kansas. In Iowa LANDSAT data having band quality 5 or 8 were used; however, receipt of the digital data was delayed such that the planted soybeans and corn DC/LC acreage estimates were pushed more than two months beyond their December 23 deadline. The success of the crop area estimation element of the 1980 AgRISTARS DC/LC project was dampened by LANDSAT data problems. This set back was tempered, however, by the successful decentralization effort implemented by the Kansas and Iowa SSO's.

REFERENCES

1. Hanuschak, G., R. Sigman, M. Craig, M. Ozga, R. Luebbe, P. Cook, D. Kleweno, C. Miller; Obtaining Timely Crop Area Estimates Using Ground-Gathered and LANDSAT Data. Economics, Statistics and Cooperatives Service, U.S. Department of Agriculture, August 1979.

2. Craig, M., R. Sigman, M. Cardenas; Area Estimates by LANDSAT: Kansas 1976 Winter Wheat. Economics, Statistics and Cooperative Service, U.S. Department of Agriculture, August 1978.

3. Kansas Agriculture 63rd Report. Kansas Crop and Livestock Reporting Service, 63rd Annual Report and Farm Facts, Kansas State Statistical Office, Economics, Statistics and Cooperatives Service, April 1979.

APPENDIX

Table 1: 1980 Kansas Analysis Summary Harvested Winter Wheat (Hectares)

Analysis District	Imagery			JES Direct Expansion		LANDSAT Regression		Relative Efficiency
	LANDSAT	Date	Quality	Estimate (ha) 1/	CV (%)	Estimate (ha)	CV (%)	
29 GHI	II	6/5	2255	249,500	22.1	173,500	21.7	2.14
30 GH	III	4/22	2222	276,600	10.7	279,800	9.7	1.20
30 I	III	4/4	5552	458,700	8.2	431,900	5.7	2.35
31 I	II	6/7	5555	510,300	9.5	505,900	7.9	1.48
32 GH	III	5/30	5555,8888	365,800	7.3	358,800	4.6	2.58
33 GHI	III	5/13	2222	893,800	6.8	817,000	4.2	3.05
DE	-	-	-	2,485,600	4.6	2,485,600	4.6	1.00
State Total				5,240,300	3.0	5,052,500	2.7	1.33

1/ JES Direct Expansion estimate using data edited at the field level.

Table 2: 1980 Iowa Analysis Summary Planted Corn (Hectares)

Analysis District	Imagery			JES Direct Expansion		LANDSAT Regression		Relative Efficiency
	LANDSAT	Date	Quality	Estimate (ha) 1/	CV (%)	Estimate (ha)	CV (%)	
27 EF	III	9/10	8888	972,100	7.2	933,800	4.3	3.03
28 E	II	9/02	8888	693,700	5.1	753,100	3.2	2.14
28 FG	II	7/28	5555	690,000	5.6	687,500	4.3	1.81
29 EFG	II	9/03	5888	1,457,100	4.5	1,472,400	3.1	2.04
30 EF	II	8/17	8858,5555	419,900	5.5	425,600	3.9	1.97
DE	-	-	-	1,530,800	3.5	1,530,800	3.5	1.00
State Total				5,763,600	2.1	5,803,200	1.6	1.85

1/ JES Direct Expansion estimate using data edited at the field level.

Table 3: 1980 Iowa Analysis Summary Planted Soybeans (Hectares)

Analysis District	Imagery			JES Direct Expansion		LANDSAT Regression		Relative Efficiency
	LANDSAT	Date	Quality	Estimate (ha) 1/	CV (%)	Estimate (ha)	CV (%)	
27 EF	III	9/10	8888	350,800	13.3	370,600	10.3	1.50
28 E	II	9/02	8888	401,850	11.4	403,500	9.7	1.37
28 FG	II	7/28	5555	445,750	9.6	419,050	7.7	1.84
29 EFG	II	9/03	5888	1,120,500	5.6	1,045,100	4.3	1.97
30 EF	II	8/17	8858,5555	237,850	10.1	239,350	3.9	6.40
DE	-	-	-	813,650	6.4	813,650	6.4	1.00
State Total				3,370,400	3.4	3,291,350	2.9	1.52

1/ JES Direct Expansion estimate using data edited at the field level.

U.S. GOVERNMENT PRINTING OFFICE 1981-0-340-932/89