Information Note 012272

1971 CORN BLIGHT WATCH EXPERIMENT DATA PROCESSING, ANALYSIS, AND INTERPRETATION

by

Terry L. Phillips and Staff

Laboratory for Applications of Remote Sensing (LARS)

Purdue University

West Lafayette, Indiana

Presented at the Fourth Annual Earth Resources Program Review, Manned Spacecraft Center (NASA), Houston, Texas, January 17, 1972.

1971 CORN BLIGHT WATCH EXPERIMENT DATA PROCESSING, ANALYSIS, AND INTERPRETATION

by

Terry L. Phillips and Staff
Laboratory for Applications of Remote Sensing
Purdue University
Lafayette, Indiana

INTRODUCTION

The nature of the Corn Blight Watch Experiment and available resources to conduct the experiment dictated that there be several centers of activity supporting the overall objectives. Mr. Robert MacDonald described in an attached paper the experiment overview and participants. Dr. Marvin Bauer described the corn blight problem. In other attached papers Mr. Richard Allen discussed the sampling model and ground data measurements program while Mr. Ronald Blilie presented the aircraft data acquisition for the experiment. In this paper the Corn Blight Watch Experiment will be described from the point of view of data processing, analysis, and interpretation procedures. Data availability will be illustrated by discussing the data flow for the experiment and the data catalog system. Descriptions of the analysis procedures, a storage and retrieval system called the Corn Blight Record, and a capability for results summarization will be presented to show the methods used in obtaining the results discussed in Dr. Christian Johannsen's paper.

Early planning meetings for the experiment resulted in the concept of a central data reduction center where all preprocessing and processing functions would be performed. The data collected would be delivered to this center and a final output would be sent to the USDA Information Center in Washington. The advantage of a central site was that maximum communications between the individuals performing separate reduction functions would occur. Also, the time required for transferring data between data reduction locations would be minimized. The central reduction site concept was considered optimum for achieving the greatest possibility of success for the experiment; however, the resources available to the experiment did not permit its implementation. An alternate plan was conceived and implemented. Centers were identified where resources were made available to perform particular processing functions. A data flow plan which maximized the efficiency of data transfer and minimized the data delivery time was designed.

The principal data acquisition centers were: NASA/MSC for the collection of high-altitude photography, Willow Run Laboratories at the University of Michigan for collection of multispectral data, and the ASCS and CES county personnel to serve as ground enumerators. The principal data processing centers were: NASA/MSC for the processing of high altitude film and the identification of frames showing the segments identified in the sampling plan; the Statistical Reporting Service of USDA in Washington, which assumed the responsibility for collecting, editing, and collating all ground observations, drawing inferences from them, and delivering products to the data reduction center at LARS; the Willow Run Laboratories at the University of Michigan, which accepted the responsibility to process 15 flightlines of multispectral data and report the results to the LARS/Purdue Data Reducation Center; and the LARS/Purdue data reduction center, where the other flightlines of multispectral data were to be reduced and the 210 segments of photography were to be interpreted. LARS was also responsible for collating and analyzing all interpreted results and for reporting them to SRS in Washington and to other participants in the experiment.

Since the principal data reduction center was located at LARS/Purdue and most data products were handled at this center, a method of keeping track of data products was required. Therefore, a data storage and retrieval system was established and maintained to aid in accessing the data collected.

The purpose of the system was to:

- Store data products in an organized library.
- Maintain a record of all data stored and reduced for future access.
- Report to the photointerpreters and multispectral data reduction teams all required information in a format that allowed the simplest access possible by the teams.
- Record data reduction results from photographic and multispectral scanner data reduction teams and merge the results with the data collected.
- Report data reduction results to the Statistical Reporting Service in Washington and to other participants in the experiment.

DATA FLOW

The Corn Blight Watch Experiment was conducted in three phases. The data flow plan is best presented by describing the transfer of data from data acquisition centers to and between the data processing centers for each phase. The data flow plan is graphically shown on diagrams which include each center and each transfer of data between the centers. Each center is shown on the diagrams as a node with an abbreviation for the center. These abbreviations are identified in Table 1.

Phase 1

During Phase 1, baseline data for the entire Corn Blight Watch Experiment were collected between April 15 and May 15. Data Acquisition for Phase 1 included the collection of black and white photography over each of the 210 sample sites and the interviewing of tract operators by ASCS enumerators. Processing included the reduction of photography to a scale of 1:20,000, the outlining of tracts and fields on the reduced photography, and the reporting of farm operator interviews through SRS to the data reduction center at LARS. Figure 1 shows the data flow for Phase 1.

NASA flew two six-inch focal length cameras at 50,000 feet to obtain two original exposures of 36 flightlines containing the 210 samples sites. The scale of this black and white panchromatic photography was 1:100,000. The segments were located, enlarged to a scale of 1:20,000, and three identical prints of each site were delivered to SRS in Washington. A duplicate set of the original photography was also sent to ASCS. All baseline photography was collected with less than 10% cloud cover present. For some segments not photographed within the time period or cloud cover conditions, existing ASCS photography was used.

At SRS the segment was outlined on one copy of each print and this was sent with initial interview forms to the Agricultural Stabilization and Conservation Service county enumerators. Each farm operation in the segment was outlined and visited by the ASCS enumerator. During the interviews a field ID was assigned to each field, field boundaries and ID annotations were added to the photograph, and the initial interview forms were filled out for each field in the segment. The annotated photographs and completed initial interview forms were

delivered to SRS. The annotations were copied onto the other two sets of prints and the data on the forms were coded, punched, edited, and recorded in digital format. One set of baseline photographs and a digital copy of the initial interview data were sent to the Data Reduction Center at LARS/Purdue. A second set of baseline photographs was sent to the Cooperative Extension Service in each state where segments were located.

Phase 2

In Phase 2, between May 10 and May 30, color IR photography was collected over the 210 segments and multispectral scanner data were collected over the 30 intensive study area segments. This data was analyzed for soils characteristics to provide soils background information for corn fields in the segments. The flow diagram for Phase 2 is shown in Figure 2.

Phase 3

Eight missions were conducted during Phase 3 between June 14 and October 13, 1971. During this phase, color IR photography was collected every 14 days over all 210 segments and multispectral measurements were collected every 14 days over the 30 segments in the Intensive Study Area. Early in each 14-day period, ground observations of up to 12 corn fields in each segment were acquired. These data were processed and sent to the data reduction center at LARS. Fifteen segments of multispectral data and accompanying ground observations were sent to the data reduction center at WRL. The photographic and multispectral data were analyzed and results recorded by the data storage and retrieval system. The analysis results were reduced and reported to SRS in Washington and to other participants in the Corn Blight Watch Experiment. The major data transfers for Phase 3 are shown in Figure 3.

During Phase 3 a new mission was started every other Monday, June 14, June 28, July 12, July 26, August 9, August 23, September 6, and September 20. Each mission was completed in 21 days and results were punched, checked, collated, and reported 23 days after the mission had began.

Only 14 days were scheduled for the collection of color IR and multispectral data. Data were collected initially over segments when cloud cover was 30% or less. If time and weather permitted, reflights were made when data on initial collection over segments resulted in

more than 10% cloud cover. All such repeated flights were made when segments in question were expected to be covered by clouds 10% or less.

As in Phase 2, color IR photography (film type 2443) was collected at a scale of 1:120,000 over 36 flightlines. NASA/MSC identified the frame numbers to be analyzed and indicated the best frames when re-flights were taken. NASA/MSC sent two transparencies and two positive contact prints of all color IR photography to the data reduction center at LARS.

The WRL aircraft collected multispectral data over the 30 segments in the Intensive Study Area. All data over the segments were checked at the data reduction center at LARS and immediately sent to the analysis center for processing.

When required by the analysis teams, low-altitude large-scale photography was collected over a number of segments within the Intensive Study Area. These data were analyzed in conjunction with ground measurements to establish the exact condition of a number of fields. This information was used both to evaluate the performance of interpretation or of machine processed data results and to determine the source of any difficulty in data reduction.

Six to twelve corn fields in each of the 210 segments were designated by SRS to be visited by CES and data forms were distributed to each enumerator. Their biweekly reports were sent to the SRS state offices during the first week of the period, and, for the 30 flightlines in the Intensive Study Area, results were phoned to the Data Reduction Center at LARS and WRL. In each of 24 segments, up to 6 fields were designated to be visited by ASCS enumerators to provide test field information for data reduction results. These reports were also channeled to the SRS state offices where they were edited, coded, and punched onto data cards. At SRS in Washington, they were error checked, copied onto digital data tapes, and listed on ground observation printouts. The biweekly data were delivered to the Data Reduction Center, and Ground Observation Summaries, described later, were distributed to the analysis teams by day 10 of each biweekly period, the same day as photographic data were available.

Data Catalog

The Data Catalog, a previously existing system at LARS, was used for the Corn Blight Watch Experiment. This data storage and retrieval subsystem includes a method of storing film, analog tapes, and digitized

tapes for access by the data reduction teams. The Data Catalog subsystem uses an indexing scheme and computer programs for listing information about the storage location of available data.

Figure 4 shows a block diagram for the Data Catalog subsystem. As the data was received, it was stored in a physical location specifically suited for the storage of particular data types. For example, the baseline photographs were stored in a map file cabinet where they did not have to be folded or otherwise mutilated. The 9x9-inch prints were stored in a file cabinet and the roll film was stored in storage bins specifically constructed for 9-inch rolls and 70-mm rolls of film. The analog tapes were stored in an environment specifically suited for analog tapes as were the digital tapes. At LARS, 15 flightlines recorded on the analog tapes were digitized, reformatted, and stored on digital tapes. The remaining 15 flightlines of analog data were entered into the Data Catalog and sent to the University of Michigan. Each set of data, i.e., analog tape, digital tape and physical roll of film, was assigned a storage bin number for retrieval.

The next step in cataloging data was to record the parameters of each flightline for the non-intensive area and of each segment for the Intensive Study Area on a data catalog form. The information or data index recorded included the date, time, ground heading, equipment, film type, and type of data. This information was punched on computer cards and entered into computer data files. Storage and retrieval software was written to make use of the data files in reporting to the analysis teams what data was available for analysis and its physical location. Two forms of output were implemented. The short form or table of contents included a brief description of all data collected. In most cases this listing was adequate for retrieval due to the familiarity of the analysis groups with the data collected. A reference number included on the short form pointed to a page in the long form Data Catalog. The longer description of data received included most or all of the parameters originally recorded about a flightline or segment of data. This information proved useful to interpreters less familiar with the data.

The importance of the Data Catalog was not apparent during the Corn Blight Watch Experiment, since most data was analyzed immediately upon receipt at the Data Reduction Center. Now that the experiment is over, however, the Data Catalog, the organized method of storing and indexing along with the computer-generated reports, is important in locating data. It should also be noted that with this system an on-line retrieval of the data is possible.

ANALYSIS PROCEDURES

Each of the data analysis teams was given a Ground Observation Summary for the segments to be analyzed or interpreted. A new summary was distributed each period so that pertinent information required for analysis would always be available. Although the form of the summary, shown in Figure 5, was the same each period, parameters listed were added or dropped from the format according to the needs of analysis teams. In the flight information area of the summary, the segment number, film roll number, frame number, date and time of the flight, and flight direction were listed. Next information for the corn fields visited biweekly was listed as well as some information for all other corn fields and non-corn fields in the segment.

Photointerpretation

With the film roll transparencies mounted in the Variscan, a rear projection system, the frame indicated by the Ground Observation Summary could be located by a photographic analysis team as shown in Figure 6. Using the summary and the baseline photograph, the biweekly corn fields were located and studied so the teams could train themselves on the appearances of blight levels in the segment. The number of fields used for training varied during the experiment; not all biweekly field information was used.

Next each corn field in the segment was located and interpreted, and the results were recorded on a recording form. These results were coded, punched, edited, and added to the Corn Blight Record for each of the 210 segments. The six teams of photo analysts completed their analysis by day 23 of each period. On the average each segment was analyzed by one week after the data collection date.

Multispectral Data Analysis

Fifteen segments out of 30 in the Intensive Study Area were analyzed by LARS. The analog tapes were digitized and displayed on a digital display. Figure 7 shows an analyst locating the biweekly fields using a baseline photograph and lightpen. The data from these fields were analyzed using a clustering procedure, and the results were used to determine classes for the analysis and data points for generating class

statistics. Next the channel selection program was used to pick four optimum channels for classification at Purdue and 6 optimum channels for classification at WRL. In general all channels of data collected were used during the season. There was no single best set of channels; however, a thermal channel, two reflective IR channels and a visible channel were usually selected for the classification of the segment.

At WRL a similar analysis procedure was followed using analog techniques on the other 15 segments in the Intensive Study Area. Results for all 30 segments were reported both on a total segment basis and on a field-by-field basis with LARS and WRL using the same reporting forms. It should be noted that results on a total segment basis were not obtained by photographic analysis. Instead the entire segment was classified into non-corn and corn classes of different blight levels. This is a more complicated classification than is interpreting blight levels only in corn fields. The multispectral scanner results were also completed by day 23 of the period and were finished on an average of 10 days after the segments had been flown. These results were also recorded on the Corn Blight Record.

Corn Blight Record

A record of the information obtained for every field in each of the 210 segments has been maintained on digital tape. The system designed for accomplishing this task and implemented for the Corn Blight Watch Experiment is called the Corn Blight Record and is shown in Figure 8. The initial interview data, Form A, and biweekly field observations, Form B, were merged with flight log information, multispectral analysis results, and photointerpretation results. The resulting tapes, one for the seven state area and one for the intensive study area, were the source of most of the listings and tabulations generated during the experiment. We have already discussed the Ground Observations Summary. The Ground Observation Record, which is a sorted listing of all information on the tape, was generated periodically for results analysis.

Data analysis results in the form of remote sensing analysis tabulations were generated on day 23 of each period for SRS in Washington. Expansion of results according to the sampling model for ground observations, photographic analysis, and multispectral data analysis were also generated for each period. Breakdowns of blight results for cytoplasm and for many other parameters were made. Yield calculations and other such studies are now in the process of being made. In addition, the results are now being analyzed using standard statistical techniques such as correlation, analysis of variance, and others.

One last note on the corn blight tapes should be mentioned. The format of the tape and a description of the parameters stored have been documented. The resulting document and a copy of the tape can be made for anyone requiring this data.

Results Summarization and Dissemination

In Figure 9 the data flow for dissemination of the blight analysis results is summarized. For each biweekly period, color IR photographs were sent to the county enumerators for their particular segments. Questions and training materials were sent with the prints, and results were returned for analysis and evaluation. The purpose of this aspect of the experiment was to acquaint the enumerators with small-scale photography in preparation for future technology.

Summarization of ground observations was performed by SRS within one week of data collection. Photographic and multispectral analysis results were sent to SRS within an average of two weeks after data was collected. These results were available so SRS for compiling blight reports to the USDA information center, which in turn handled press releases to the news media.

CONCLUSIONS

In conclusion this near-operational test of remote sensing systems rapidly advanced our knowledge of their potential. In addition, it is expected that the data collected will continue to be useful in future research. Data over an agriculturally important area of the country have been collected through a growing season. More than 40,000 fields were included in the initial interview records. Ground observations were obtained for 1,600 corn fields visited biweekly. The results of photointerpretation for 16,000 corn fields were recorded every two weeks, and over 300 square miles of multispectral scanner data were analyzed eight times during the growing season.

The procedures designed for handling the large amounts of data were successful. Where problems were encountered, adjustments were made to insure maximum results, available promptly and in a way that was consistant with the rapidly advancing state-of-the-art.

ACKNOWLEDGMENT

The 1971 Corn Blight Watch Experiment was planned by representatives of, and supported by, the experiment participants. The procedures summarized herein are a product of the total experimental plan; however, special appreciation goes to Mrs. S. K. Hunt and the Applications Programming group of LARS for their contributions in data management aspects of the experiment. Their work and that of other LARS staff to the experiment was supported by NASA under Grant NGL 15-005-112. References are made to the work of Mr. R. P. Mroczynski with the photointerpretation group, Dr. P. H. Swain with the LARS multispectral analysis teams, and Mr. F. Thompson with the WRL multispectral analysis teams.

Table 1. Principle Center of Data Acquisition and Processing

NASA/MSC	- NASA Manned Spacecraft Center, Houston, Texas
WRL/U. of Michigan	- Willow Run Laboratories, University of Michigan aircraft system
ASCS County	- Agricultural Stabilization and Conservation Service of USDA County Offices
SRS/Washington	- Statistical Reporting Service of USDA, Washington, D. C.
SRS/State	- Statistical Reporting Service of USDA, State Offices
CES/State	- Cooperative Extension Service of the seven states
CES/County	- Cooperative Extension Service County Agency
DRC/WRL	- Data Reduction Center, Willow Run Laboratories, University of Michigan
DRC/LARS	- Data Reduction Center, Laboratory for Applications of Remote Sensing, Purdue University
USDA Information Center	- United States Department of Agriculture: Agricultural Information Center Washington, D. C.

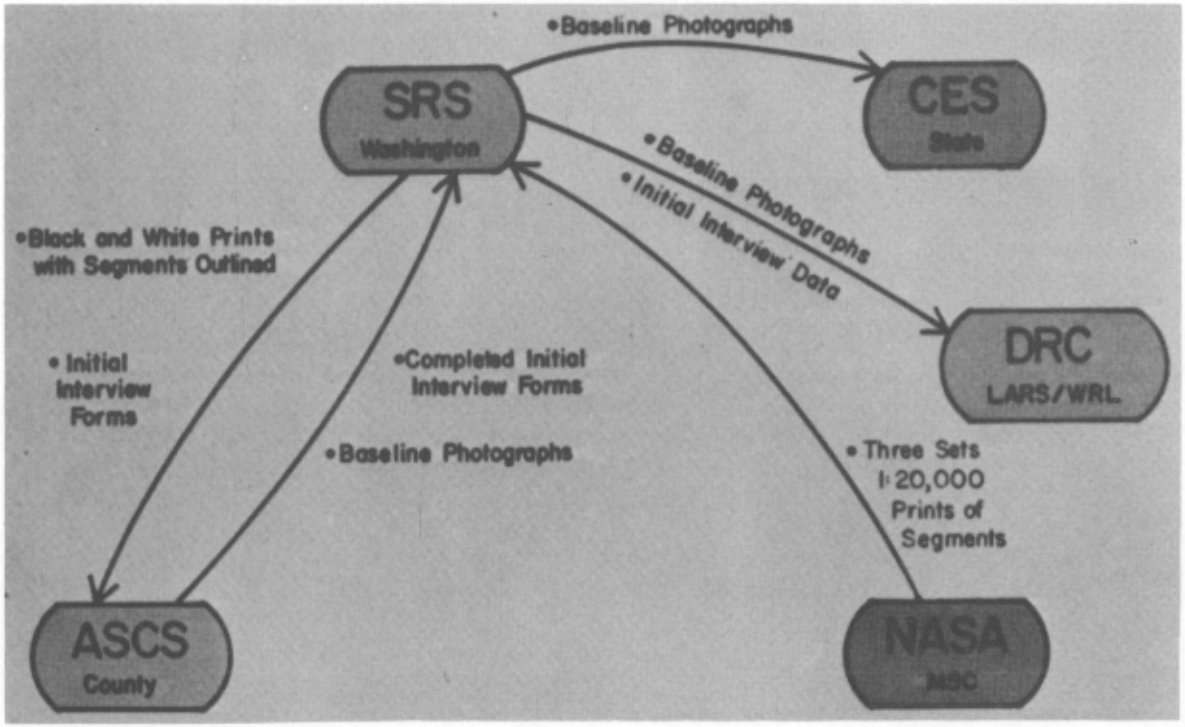

Figure 1. The data flow for obtaining baseline information is designed to provide baseline photographs to the Cooperative Extension Service of each state and baseline photographs and initial interview data to the Data Reduction Center by May 15, 1971. This aspect of the 1971 Corn Blight Watch Experiment was called Phase I, the first of three phases.

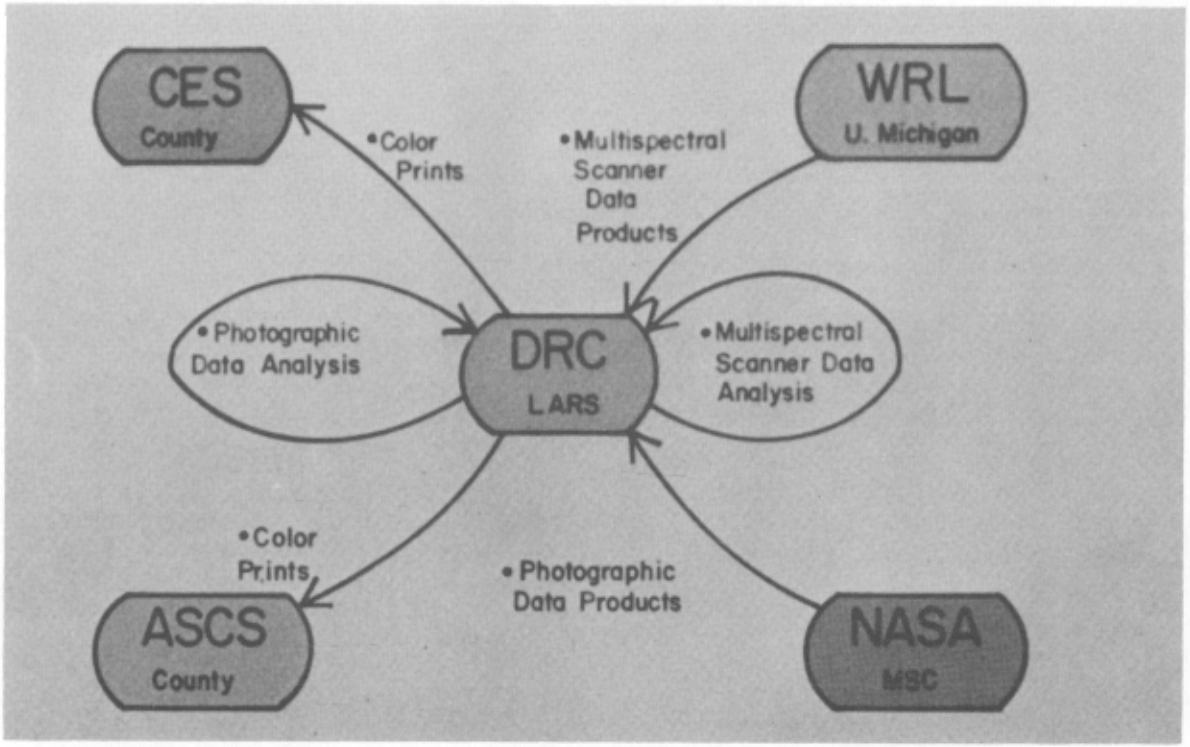

Figure 2. Phase II of three phases for the 1971 Corn Blight Watch Experiment was designed to collect data and perform analysis to determine soils background information for the corn fields. This data flow diagram shows how the objective was completed.

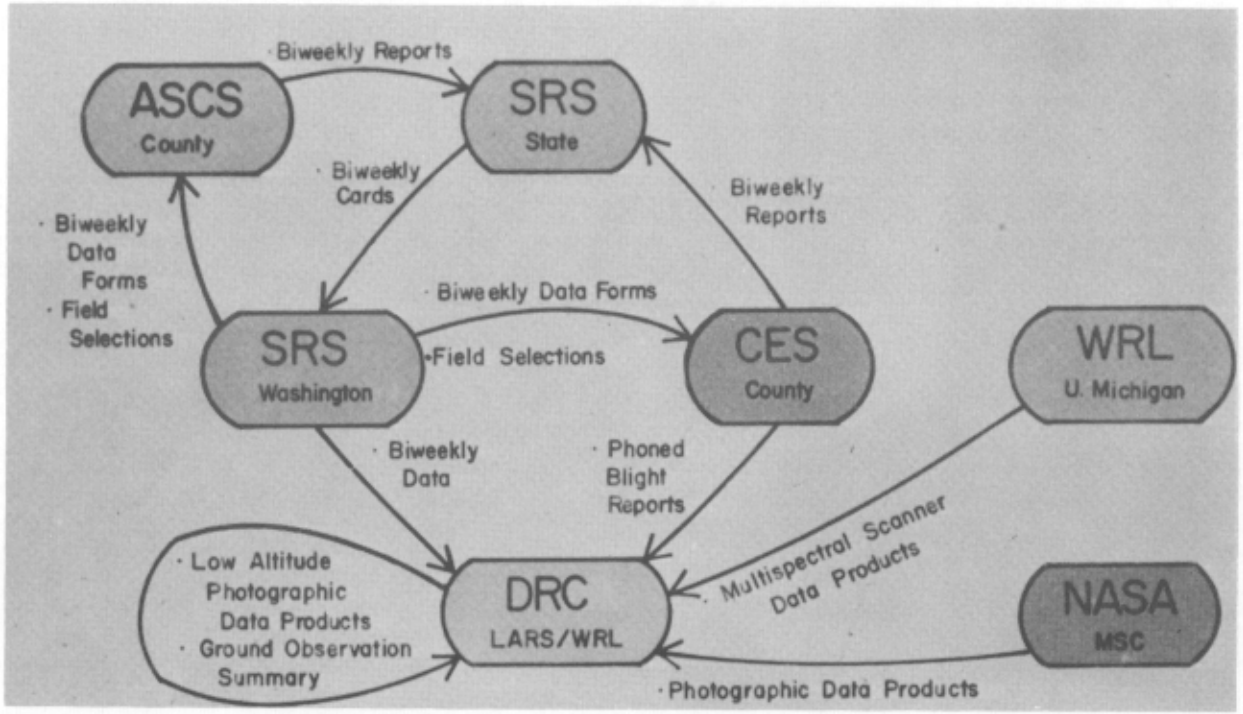

Figure 3. This data flow diagram for the last phase (Phase III) of the 1971 Corn Blight Watch Experiment shows the data acquisition for the experiment. The principal data products are biweekly field data, photographic data, and multispectral scanner data.

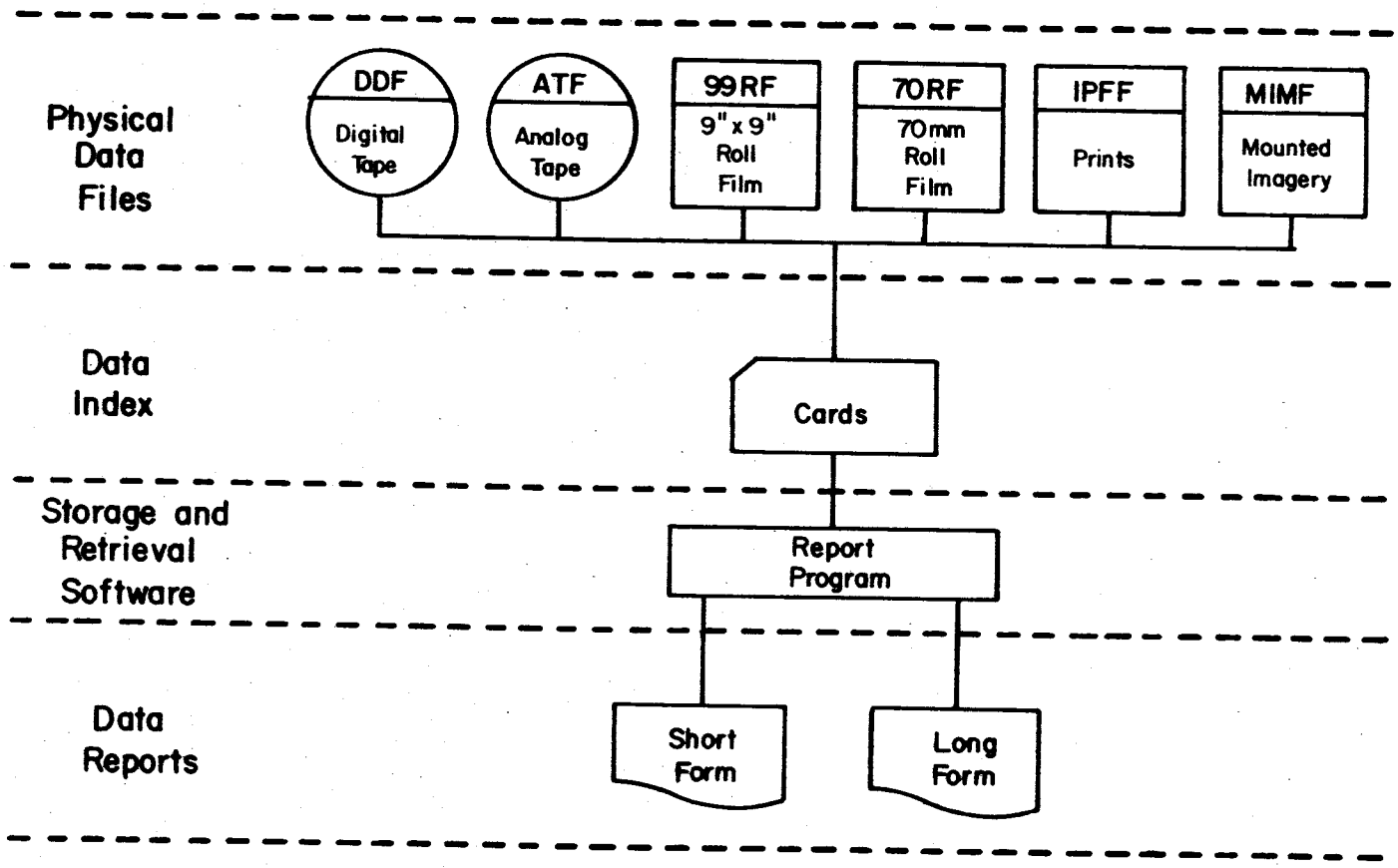

Figure 4. Data for the 1971 Corn Blight Watch Experiment was stored using a data storage and retrieval system called the Data Catalog.

1971 Corn Blight Watch Experiment
Ground Observation Summary

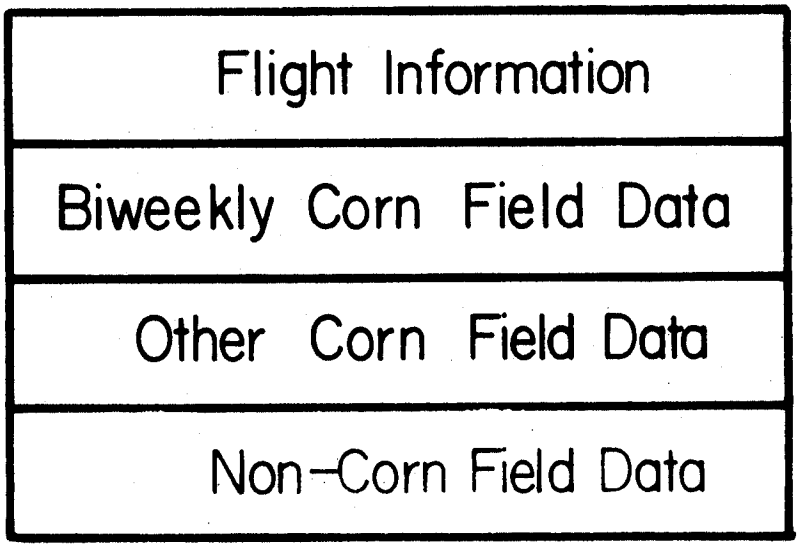

Figure 5. The Ground Observation Summary was distributed to analysis teams every two weeks. It contained the flight parameters, new biweekly training field observations (which provided the data foundation in the analysis extrapolation) and basic information of all other fields in the segment.

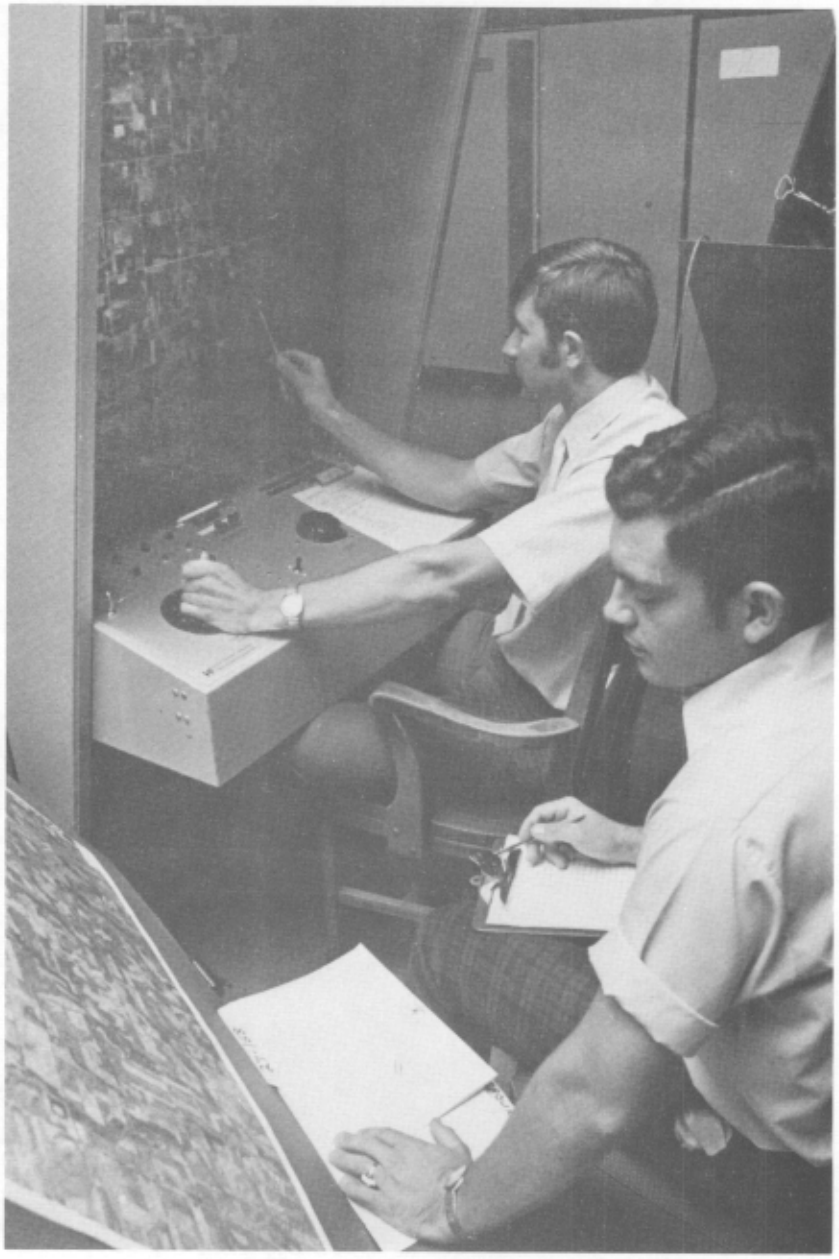

Figure 6. Most of the 210 segments in the 1971 Corn Blight Watch Experiment were analyzed using a Variscan rear-projection system for photointerpretation. Results were reported and rushed every two weeks to Washington.

Figure 7. Digital images were used to locate training fields for classification of data from the multispectral scanner. Data from 15 segments were digitally processed and the remaining 15 segments in the Intensive Study Area were processed using analog techniques for the 1971 Corn Blight Watch Experiment.

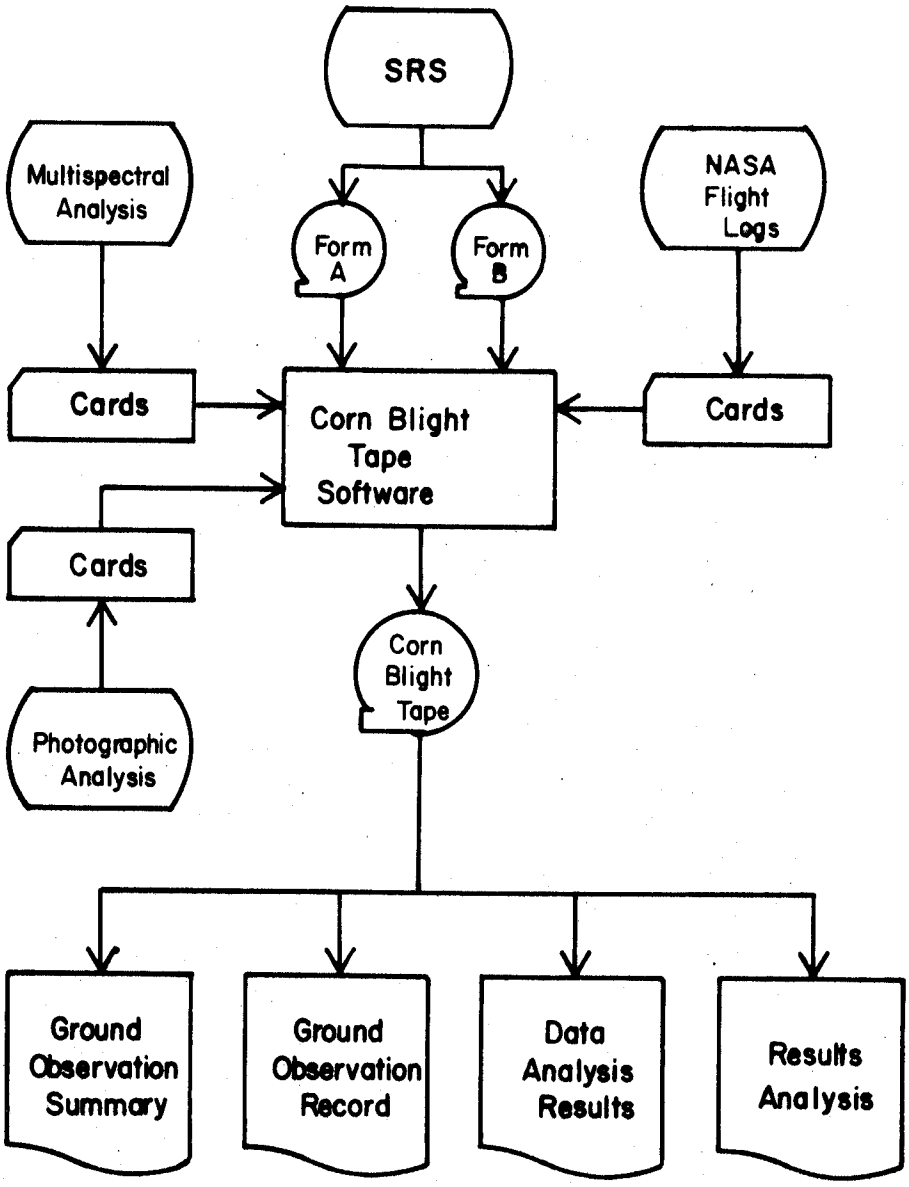

Figure 8. All ground data, flight logs, and analysis results were stored on magnetic tape. These merged data were used to report and analyze results for the 1971 Corn Blight Watch Experiment.

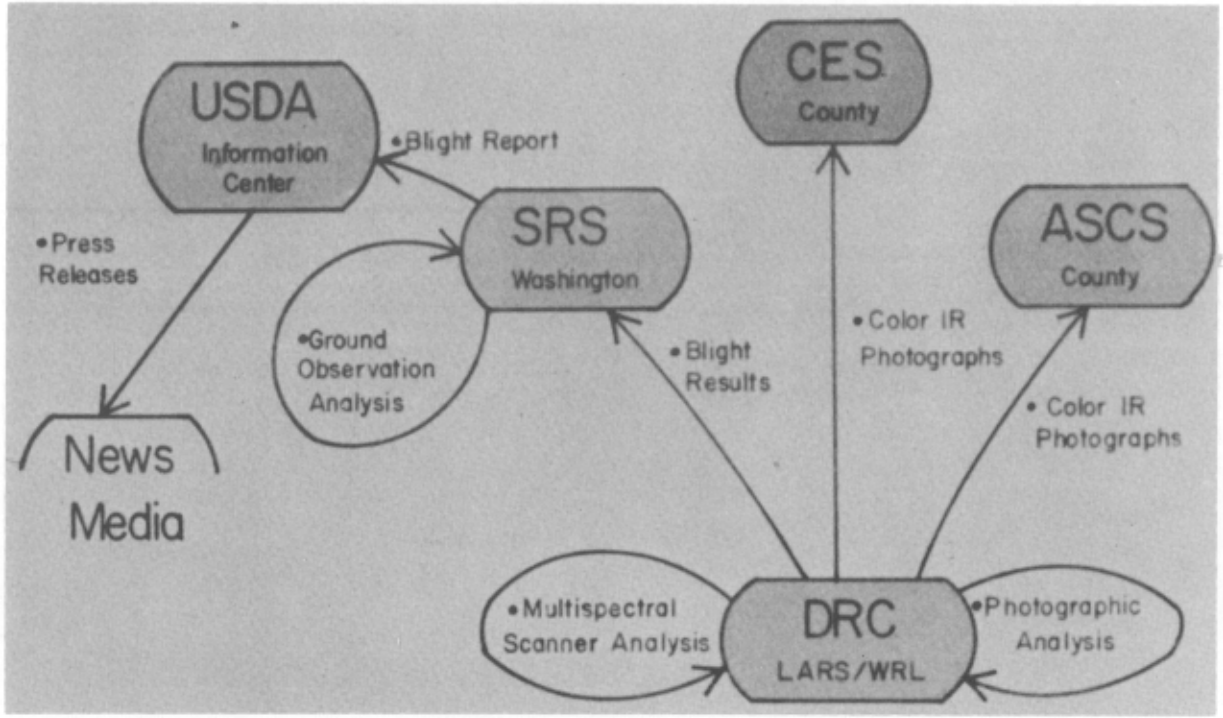

Figure 9. The data flow for results dissemination is diagrammed for Phase III of the Corn Blight Watch Experiment. This last phase of the experiment included the reporting of results to the public.