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CORN BLIGHT WATCH EXPERIMENT

FINAL REPORT

VOLUME 1

EXPERIMENT PLANNING

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

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1971 CORN BLIGHT WATCH EXPERIMENT FINAL REPORT

VOLUME 1 - EXPERIMENT PLANNING

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
EARTH RESOURCES PROGRAM
LYNDON B. JOHNSON SPACE CENTER

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1. AGL - Above Ground Level
2. ARS - Agricultural Research Service (USDA)
3. ASCS - Agricultural Stabilization and Conservation Service (USDA)
4. CBR - Corn Blight Record
5. CBWE - Corn Blight Watch Experiment
6. CBWEC - Corn Blight Watch Executive Committee
7. CCRB - Cereal Crops Research Branch (ARS)
8. CES - Cooperative Extension Service
9. CRT - Cathode Ray Tube
10. CSRS - Cooperative State Research Service (USDA)
11. DC - Data Catalog
12. DEW Line - Distant Early Warning Line
13. DRC - Data Reduction Center
14. ECOP - Extension Committee on Organization and Policy (USDA)
15. ERAP - Earth Resources Aircraft Program
16. ERS - Economic Research Service
17. ERTS - Earth Resources Technology Satellite
18. ES - Extension Service formerly called Federal Extension Service (USDA)
19. ESCOP - Experiment Station Committee on Organization and Policy (USDA)
20. FIPS - Federal Information Processing Standards (number)
21. FRSL - Forestry Remote Sensing Laboratory (Univ. of California)
22. IR - Infrared
23. LARS - Laboratory for Applications of Remote Sensing (Purdue Univ.)
24. MSB - Mapping Sciences Branch (NASA/MSC)
25. MSC - Manned Spacecraft Center (NASA); renamed Lyndon B. Johnson Space Center (JSC) in February 1973

26. MSS - Multispectral Scanner
27. NASA - National Aeronautics and Space Administration
28. PDRC - Photo Data Reduction Center
29. PI - Photointerpreter or Photointerpretation
30. PTD - Photographic Technology Division Laboratory (NASA/MSC)
31. REDAF - Research Data Facility (NASA/MSC)
32. SCLB - Southern Corn Leaf Blight
33. SRS - Statistical Reporting Service (USDA)
34. TMS - Texas Male Sterile (corn cytoplasm)
35. USAF - United States Air Force
36. USDA - United States Department of Agriculture
37. WRL - Willow Run Laboratories (University of Michigan)

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SECTION I — INTRODUCTION

I. INTRODUCTION

A. Background

The 1971 Corn Blight Watch Experiment (CBWE) was conceived to test the potential of remote sensing, while rapidly and comprehensively assessing the effects of Southern Corn Leaf Blight (SCLB). Devastation of susceptible varieties of corn caused by the SCLB epiphytotic of 1970 was expected to recur during the 1971 growing season. Use of remote sensing to monitor such a widespread phenomenon required that heretofore isolated techniques be melded into a quasi-operational methodology. The result was a system that applied not only to monitoring SCLB, but which could be adapted to many other informational needs. It was the first comprehensive test of remote sensing in agriculture.

The Need for Remote Sensing

Development of remote sensing techniques serves a pressing need for rapid data collection. Millions of dollars are spent annually for conventional collection of agricultural data to aid in market and policy decisions. The market system needs accurate and timely information to facilitate an orderly flow of goods and services from producer to consumer. Poor or insufficient information directly affects the efficiency of this system. Furthermore, as the economy becomes more complex, more and more data is needed to keep the system running smoothly.

Complete, comprehensive and accurate agricultural information is also needed to aid in the formulation of public policy. The public and its representatives, from village to nation, need accurate information in order to evaluate alternatives open to them.

The complexity of the agricultural economy has outpaced house-to-house, or field-to-field, sampling just as its statistical component has outgrown the man with a pad and pencil. In addition, the cost of conventional methods of data collection, whether by personal or telephone interview or by visits to sample plots, will continue to increase both in terms of increased labor costs and in terms of the widening gap between data needed and data supplied.

It is against this background of most stringent data needs and rising costs that interest has centered on the development of remote sensing. Sensors mounted on aircraft or satellites have the capability of scanning the earth's surface and obtaining large quantities of data very rapidly and comprehensively. In particular, remote sensing augurs well the future development of improved agricultural data collection and analysis systems. But, as with any new technology, the potential and state-of-the-art are not synonymous.

Many questions could only be answered by such a project as the

Corn Blight Watch. What kinds of information can remote sensors obtain? How do accuracy and cost compare with conventional data collection methods? Are the data worth the cost? Is there new information that only remote sensing can supply? What are the problems of data handling, reduction, and summarization? How often should observations be made? What is the optimal combination of ground observation ("ground truth") data and remotely derived information?

The SCLB Problem

In 1970, SCLB reduced U.S. corn production by about 10 percent. Agricultural scientists foresaw a similar threat to the 1971 crop. The 1970 growing season had been marked by serious lack of timely, accurate and comprehensive data on both the extent and severity of the blight. As late as September there had been much uncertainty about the number of acres infected and the severity of infection.

Southern Corn Leaf Blight is a classic example of a general problem which continually occurs in agriculture. New crop varieties tend to suppress strains of pathogens to which they are resistant and support those to which they are vulnerable. As variants of a new disease arise (through mutation or other genetic processes), they spread or are suppressed by the presence or absence of vulnerable host plants.

If a new crop variety has high agronomic merit it is likely to be used in substantial quantities over a large area. This results in a "monoculture," which facilitates the spread of new pathogens. Such a new pathogen, to which the monoculture has no resistance, will build up rapidly simply because there is a huge number of vulnerable hosts and relatively few resistant ones. The 1970 SCLB spread through such a monoculture, but it was merely the latest in a series of epiphytotic infections which have included wheat rust and potato blight.

Remote Sensing appeared to have the potential to provide useful information about the spread of corn blight. Research conducted during 1970, in which NASA-collected aerial data and ground information acquired by Purdue University's School of Agriculture were analyzed by Purdue's Laboratory for Applications of Remote Sensing, indicated that different levels of infection could be measured from aircraft equipped with specialized sensors.

Thus, two needs--the need to develop and test remote sensing and the need to trace the spread of Southern Corn Leaf Blight--came together in the 1971 Corn Blight Watch Experiment.

Experiment Organization

The description of the 1971 Corn Blight Watch Experiment was embodied, in a general sense, in the objectives set up in the joint U.S. Department of Agriculture/National Aeronautics and Space Administration Operations and Management Plan, dated May 12, 1971; then modified slightly in the CBWE Interim Report, dated September 13, 1971. The objectives were to evaluate the use of advanced remote sensing techniques and concepts to

- Detect the development and spread of corn blight during the growing season across the Corn Belt Region;
- Assess different levels of infection present in the Corn Belt;
- Amplify information acquired by ground visits to better assess current blight status and the probable impact on crop production by blight; and
- Estimate through extrapolation the applicability of these techniques to similar situations occurring in the future.

In fulfilling and expanding upon these objectives, the 1971 Corn Blight Watch was set up to consist of biweekly remote sensor coverage and ground observation of 210 sample sites across the states of Nebraska, Minnesota, Iowa, Missouri, Illinois, Indiana and Ohio. The observations were made from June through September. Selected corn fields and individual corn plants within the sample sites were examined by ground observers for signs of SCLB.

Western Indiana, represented by 30 randomly-selected sample segments, was designated as an intensive study area. Multispectral scanner measurements were collected over these segments and computer-processed to identify blight conditions.

Using field observations as "ground truth," aerial observations with color infrared photography and multispectral sensing were made and interpreted, then used in estimating the extent and severity of corn blight infection across the Corn Belt.

It is of interest to note that the total ground observations were of only 20,000 plants in the entire 360,000 square miles of the Experiment area, or, with normal planting conditions, about one acre of corn. Through analysis of aerial data, these observations were amplified to the entire 42 million acres in the study area.

In monitoring the 1971 corn crop, researchers were able to observe many more characteristics than just those resulting from leaf blight infection. These included stress factors present in corn from drought, lodging, excessive quantities of weeds, insects, hail, nutrient deficiencies and diseases other than SCLB. Ground observations describing these conditions were collected during each mission overflight.

Aerial data collected over these areas of stress was then analyzed to determine how well remote sensing could distinguish between extraneous stresses and SCLB-infected corn. Photointerpreters looked at other crops such as soybeans, wheat, oats, pasture and woodlots to determine crop identification accuracies for each mission.

The Corn Blight Watch was an experiment not only in technological organization and expertise but also in institutional and multidisciplinary cooperation and coordination. The Watch (which was the first agricultural remote sensing application of this magnitude) brought together many agencies, disciplines, and interests. The administrative body of the Watch, the Corn Blight Watch Executive Committee, contained members from 10 government organizations, the University of Michigan,and Purdue University, with many other groups participating in facets of the Experiment.

Those with major responsibilities included the U.S. Department of Agriculture's Statistical Reporting Service (SRS), Agricultural Stabilization and Conservation Service (ASCS), Extension Service (ES), Economic Research Service (ERS) and Cooperative State Research Service (CSRS). Others included the Cooperative Extension Services (CES) and the State Agricultural Experiment Stations of the seven participating states. Providing coordination and support were the National Aeronautics and Space Administration (NASA), the University of Michigan's Willow Run Laboratories (WRL) and Purdue University's Laboratory for Applications of Remote Sensing (LARS).

This organization of cooperating agencies, for which the foundation has now been laid, should be of great help in setting up data collection and distribution during experiments involving the first Earth Resources Technology Satellite (ERTS) in 1972-73. In addition, the data accumulated during the 1971 growing season should provide valuable baseline information for ERTS and be of use in such spinoff benefits as urban and agricultural planning.

Experiment Timetable

The CBWE was set up to extend from April 15 to October 15, 1971. Its first phase involved the collection of high-altitude black and white baseline photography from April 15 to May 3. High-altitude color infrared photography (1:120,000 scale) was collected over 30 flightlines, which included all of the 210 one-by-eight-mile sites, by a NASA/USAF RB-57F aircraft during the period from May 15 to June 1. During the same two-week interval, a C-47 aircraft from the University of Michigan's Willow Run Laboratories collected multispectral scanner data over the western Indiana intensive study area. This data was to be used to provide soils background information.

During mid-May, ground interviewers collected intensive information on each site. These interviewers, from the county offices of ASCS, delineated all crop fields and asked farm operators specific questions about each corn field. They were provided with current black and white aerial photographs of each site to be used as a base map.

Following this, a subsample of corn fields was selected by SRS for biweekly field observation visits during the growing season. The first field visits were to be conducted during the week of June 14 and every two weeks thereafter until September 20, by CES in each state.

Color-infrared aerial photography obtained by the RB-57F during the biweekly observation periods was to be delivered to a specially equipped data reduction center located at LARS. Here the photography would be analyzed by trained photo-interpreters making use of both a reference set of black and white master photo maps of all fields within the 210 test segments and the ground data obtained by field observers.

All corn fields in each of the sites were to be interpreted and categorized into classes on the basis of the presence of blight and, if present, the degree of infection--slight, moderate or severe. The Statistical Research Service designed a statistical model that was to use these input data to infer the degree of blight infection over the entire region. Also maps were to be prepared showing the percentage of fields infected with each blight severity level.

In the intensive study area, investigations were planned that would test advanced remote sensing technology and concepts which appeared to offer more precise data acquisition and increased automation. These included airborne multispectral sensor and machine recognition systems provided by WRL and LARS.

The multispectral scanner data was scheduled to be collected concurrently with the photographic and ground observations over the intensive study area, then computer-processed by WRL and LARS.

Corn fields in each of the intensive study area segments were to be analyzed utilizing machine recognition programs to determine blight presence and severity. This data was then to be used in the SRS statistical model to predict blight levels for the entire intensive study area.

Specifically, the target dates of the CBWE were set as detailed in Table 1.01.

Table 1.01

Corn Blight Watch Experiment Critical Dates

March 22	PHASE I	Thirty 100-mile-long, 8-mile-wide flightlines selected (by SRS).
April 1	PHASE I	Sites delineated in the 30 flightlines, plus 30 additional sites in the intensive study area in western Indiana (by SRS).
April 16 - May 2	PHASE I	Black and white photography collected for use as base maps (by NASA).
April 30 - May 4	PHASE I	Black and white negatives, three sets of 1:20,000 scale prints and line index to be in SRS office, Washington, D.C. (by NASA).
April 30 - May 6	PHASE I	SRS outlines exact areas to be enumerated.
May 7	PHASE I	Base map photography with outlined sites in county ASCS offices (by SRS).
May 5 - 7	PHASE I	Training school for photo-analysts (FRSL).
May 5 - 11	PHASE I	Training schools for ASCS enumerators (by ASCS, SRS, LARS).
May 6 - 22	PHASE I	Collect information on all fields in each site (by ASCS).
May 10 - June 1	PHASE 2	Flights to collect 1:120,000 scale color infrared photography over all sample sites for soils information (by NASA).
May 20 - June 5	PHASE 2	Selection of 6 - 10 sample corn fields in each site, delivered to county extension agents (by SRS).
May 24 - June 24	PHASE 2	Intensive training for photo-analysts (by LARS).
June 1 - 10	PHASE 2	Training schools for extension enumerators (by SRS, plant pathologist from each state, LARS).
June 15 and every two weeks thereafter through September 21	PHASE 3	Collect field data for corn blight detection (by CES).

Table 1.01 (cont.)

June 14 and every two weeks thereafter through October 3		High altitude photography collected over seven-state region and multispectral data over intensive study area (by NASA and WRL).
July 7 - October 26		Evaluate extent of infection and issue reports (by SRS).
January 15, 1972	P 3	Final report on Corn Blight Watch Experiment (joint USDA/NASA).
February 1 - 7, 1972		Evaluation seminar (evaluation of Corn Blight Watch Experiment by all participants).
		<u>Biweekly Schedule</u>
Day 1* - 14	PHASE 3	Aircraft data collection.
Days 1 - 4		Ground observation data collected.
Days 1 - 5		Telephone and/or teletype delivery of selected ground observations to WRL and LARS.
Day 8		Summarization of ground observation data.
Day 9		Listings and magnetic tapes of ground observation data to Data Reduction Center from SRS.
Day 9 and Day 16		Delivery of color IR positive transparencies to Data Reduction Center from NASA/MSC.
Day 13 and Day 20		Delivery of color contact prints to Data Reduction Center from NASA/MSC.
Day 15 and Day 22		Delivery of color contact prints to County Personnel from Data Reduction Center.
Days 1 - 14		Delivery of multispectral data tapes to LARS and WRL from WRL.
Days 10 - 21		Analysis of photography.

Table 1.01 (cont.)

Day 23	P 3	Delivery of data reduction results to SRS from Data Reduction Center.
Days 2 - 21		Analysis of multispectral data of 30 segments in intensive study area by LARS and WRL.

* Day 1 is the first day of each Phase 3 mission period.

B. Organization of Final Report

Responsibility for compilation of a Corn Blight Watch Experiment Final Report was delegated by the Executive Committee to the Laboratory for Applications of Remote Sensing in September. Organization of the Final Report was to generally follow the subject divisions made in the first draft of the Corn Blight Watch Experiment Description, dated May 11, 1971.

Using this Description, plus suggested outlines from participating agencies, LARS's Director and Aerospace Program Leader devised a preliminary three-volume scheme, and discussion with LARS personnel resulted in a detailed outline. Organization of each subsection on the outline was to be the responsibility of the subsection writer.

Rationale for the final version was made on the basis that the Experiment naturally fell into three sections: the preliminary Experiment organization, planning and design, the actual performance of the Experiment, and detailed analysis of the results. Each of these sections became a volume in the Final Report Outline.

Organization of Volume I (Planning) and Volume II (Operation) were parallel, so that those responsible for writing the original description of their section would also be responsible for detailing its operation. Volume III (Results) was organized around major data categories (see Figure 1.01).

Due to the complex and varied nature of the information to be incorporated in the Final Report, it was decided to establish a "contributing editor" system wherein personnel responsible for the operation of each subsection would prepare the final report on that section, then turn it in to a coordinator for the major subject area who would collate the writing and supportive materials.

Each major section coordinator would then submit the complete rough draft of the section to the LARS Aerospace Program Leader and a science editor who were responsible for compiling the entire report in a stylistically and logically consistent format. In addition, the science editor was to be responsible for contact with a publisher and consequent printing of the final document.

Copies of the report outline and writing assignments were sent to each of the subsection writers and coordinators. Following the general cover letter which accompanied the outline, each coordinator and contributor, was contacted, their responsibilities outlined, and each coordinator encouraged to meet with the personnel compiling the information for his section. Enclosed in each letter was a copy of the appropriate section from the May 11 Experiment Description, to be used as a structural basis for preparation of the final material. Writers were encouraged to prepare material for Volume I (which would require relatively minor rewriting of and additions to the original Description) first.

Target dates, as established by the Corn Blight Watch Experiment Committee were:

November 1	Section rough drafts for Volumes I and II to Science Editor
November 20	Volume III rough drafts to Science Editor
December 15	Final editing complete and report compiled
December 20	Layouts and materials to publisher

C. Southern Corn Leaf Blight Description

Origin and Distribution

Southern Corn Leaf Blight, caused by the fungus *Helminthosporium maydis*, had been known for many years to be widespread in tropical corn-growing areas. It had been, however, considered a minor disease in the United States since it seldom caused severe leaf damage or loss in yield. During 1969, a new race of *H. maydis*, whose origin remains undetermined, adapted itself to Texas male-sterile (TMS) cytoplasm corn. The unusual susceptibility of TMS corn to race T was first recognized in scattered fields in Illinois, Indiana, and Iowa.

Race T of *H. maydis* unexpectedly multiplied and spread very rapidly during 1970 (from late February to June) in Florida, Georgia, Alabama, Mississippi, and other southeastern states. Tremendous numbers of spores, carried by moisture-laden southerly winds, infected corn in Kentucky, Tennessee, and eastern Missouri; later through Illinois, eastern Iowa, Indiana, Ohio and other parts of the Corn Belt. By late August, the disease was found as far north as Minnesota, Michigan, and Ontario, Canada (see Figure 1.02). Widespread drought in the Western Corn Belt restricted blight development there.

Since the early 1960's male-sterile cytoplasm varieties, which lowered costs by eliminating hand-detasseling, had been widely used by seed corn companies. By 1970, an estimated 85 to 90 percent of the corn grown contained Texas male-sterile cytoplasm, meaning that 85 to 90 percent of the U.S. corn crop was susceptible to the new race T of *H. maydis*.

Corn with normal (N) cytoplasm produces pollen, and in making a cross in hybrid seed production, the seed (female) parent must have its tassels removed so that only pollen from the male parent is present to fertilize the ovaries in the ears of the seed parent. Fertility can be restored to TMS cytoplasm corn by the introduction of a "restorer" gene. This gene can be transferred by the breeding method to TMS cytoplasm corn. The offspring will produce fertile pollen required for fertilization in the farmer's fields, but susceptibility to H. maydis still remains. Thus, the basis for male sterility and that governing susceptibility are separate entities. Eradicating that susceptibility while maintaining male sterility characteristics, however, would be a long-term process extending over many growing seasons.

Symptoms

Symptoms of SCLB include tan or light-brown spots or lesions that usually appear first on the lower leaves. Under "favorable" conditions, wind or splashing rain carry spores to upper leaves, producing secondary infections. Lesions are oblong to spindle-shaped, ranging up to about 1/2 to one inch in length and 1/4 to 1/2 inch in width. On very susceptible plants the lesions increase rapidly in number, sometimes merging, severely blighting and killing the leaves (see Figure 1.03).

The spores of the old race of Southern Corn Leaf Blight are the same in size, color and shape as those of race T, the two races being only distinguishable in their effect on corn plants. Race T, which multiplies much more rapidly and is more virulent, attacks all above-ground parts of the corn plant while the old race attacks leaves only.

The lesions on the stalk, leaf sheath, and ear husks may enlarge rapidly to as much as six inches in length. The penetration of the silk end of the ear or the shuck takes seven to 14 days in damp weather and may lead to a moldy or charcoal-like rot of kernels and cob which destroys the grain. The onslaught of leaf-killing is accompanied by increased stalk rotting caused by both H. maydis and other fungi. As a result, there may be much lodging where blight is severe (see Figure 1.03).

Life Cycle

The causal fungus overwinters in the form of mycelium and spores in corn debris (stalks, kernels, cobs, and possibly leaves) both on the ground and in cribs. During the spring, more spores are formed from the mycelium and carried by the wind or splashed by raindrops onto the leaves of growing plants, where primary infection occurs. The spores may be carried many miles by the wind. Abundant spores and warm, damp weather favor an early and continuous development of the disease.

In order for spores of the fungus to germinate, penetrate the leaf and establish a disease condition, the surface of the leaves must be wet for several hours and the temperature 70-80°F. Even dew furnishes sufficient moisture for such a condition.

Under this environment, spores germinate much as do seeds. They send out germ tubes that penetrate the leaves through stomata (natural pore-like openings in the leaf surface) or directly through the outer epidermis. Soon after a leaf cell is penetrated, it dies and the fungus consumes the cell contents. As the fungus spreads, a lesion or area of dead tissue becomes evident. Without favorable moisture and temperature conditions, spores will not germinate and hence no disease condition will be established.

When conditions are favorable, the germination of fungus spores, as well as penetration and infection of the plant, occurs within six hours. On susceptible varieties, a new crop of spores is produced in 24 to 48 hours. These spores may spread to other parts of the plant and to adjacent plants, or be carried long distances before producing additional primary or secondary infections. The complete life cycle of race T - from spores, through germination, penetration, and infection, to the production of another generation of spores - may take place in a period of as little as 60 hours. Under ideal disease conditions, an entire corn field may be killed in several weeks.

Although the causal fungus is carried in the seed, H. maydis is not systemic in the corn plant. There is no evidence that the disease is transmitted to the next generation of corn.

Control

SCLB can be controlled by changing or modifying any of the three factors (weather, spores, host) that are vital to the development of the disease. Man cannot, at present, control the weather conditions. He can, however, modify the presence of a virulent pathogen - in this case Race T of H. maydis. This can be done by applying sprays (fungicides) that are toxic to the fungus and prevent spore germination and subsequent penetration of the leaves. However, most fungicides cannot stop growth of fungus once the latter is within the host tissue. In addition, sprays are expensive, require special equipment for application and, in most cases, must be applied several times.

The third alternative for control of SCLB is to change the host (corn) in some way. This can be done by returning to the use of normal cytoplasm corn, which means that seed producers will have to return to detasseling the "female" parent plants. This in fact has been done, and in 1972 SCLB should be under control as supplies of normal cytoplasm seed should be sufficient to plant all of the nation's corn crop.

Alternatively, certain cultural practices have been suggested as helpful in overcoming SCLB. They include such methods as clean plowing to bury infected corn debris, reduction in plant population per acre, lowering the application rates of nitrogen fertilizers, and rotation of crops. Thus far, however, there is no evidence that such practices do reduce the severity of the disease.

Effect on Corn Yields

The extent of the reduction in yields to corn producers nationally in 1970 as a result of corn leaf blight was difficult to estimate. However, corn leaf blight, combined with severe drought conditions in some areas, is estimated to have reduced 1970 corn production about 700 million bushels - out of a forecast total of 4.8 billion bushels - by the time harvest was completed. The forecast average yield per acre on July 1, 1970 was 83.1 bushels; in December it was estimated the harvested yield was only 71.7 bushels per acre - a reduction of 15 percent (Table 1.02). In some states the average yield loss was greater, and in many individual farm fields the crop was nearly a total loss.

In Ohio, Indiana, and Illinois, blight damage produced yields about 15 percent below normal. These states produce about one-third of the U.S. total. In the western Corn Belt, where nearly 40 percent of the crop is produced, output was a little below average, due largely to dry weather along with some blight damage.

The southern states were hard hit. The four leading corn producing states of the South (North Carolina, Tennessee, Kentucky, and Georgia) had only 70 percent of their normal crop. However, these states account for only five percent of the U.S. total.

In Pennsylvania, Maryland and Virginia, the crop was 20 percent above normal but these states produce only four or five percent of the U.S. total. Production was 14 percent above normal in the Lake States, which produce about 15 percent of the total crop.

D. 1971 Blight Outlook

The prevalence and severity of only a few crop diseases can be accurately forecast months in advance of their onset. At the present time Southern Corn Leaf Blight is not one of these. No one could predict with certainty what the extent and severity of this disease would be in 1971. However, we did consider some of the factors that would determine whether or not an epiphytotic of SCLB would occur.

Weather

Since the host and the pathogen would remain relatively unchanged in 1971, weather conditions would probably be the most critical factor in determining the prevalence and severity of SCLB. Warm, humid weather in the South might result in a buildup of large volumes of innoculum as in the 1970 growing season. Indeed, the disease had been present on Florida winter corn throughout the winter, and southerly winds could again carry this innoculum in a step-wise manner into the Corn Belt.

Warm, humid weather in the North would be ideal for disease development. On the other hand, dry weather in the South would minimize the amount of innoculum that could be airborne in a northerly direction. Cool, dry weather in the Corn Belt would provide an unfavorable environment for the disease even if innoculum

Table 1.02 Corn Production of Selected States in 1970

State	Acres Harvested	Forecast Yield Per Acre, July 1970	Estimated Yield Per Acre, December 1970	Change in Yield per Acre July to December
	(1,000 Acres)	(Bushels)	(Bushels)	(Bushels)
Florida	322	46	25	-21
Georgia	1,426	43	31	-12
North Carolina	1,345	50	50	None
Alabama	545	38	23	-15
Mississippi	248	40	28	-12
Tennessee	569	54	40	-14
Kentucky	988	74	50	-24
Pennsylvania	943	80	85	+ 5
Ohio	3,014	86	77	- 9
Indiana	5,027	94	74	-20
Illinois	10,066	95	74	-21
Iowa	9,990	100	86	-14
Missouri	2,837	76	61	-15
Nebraska	4,897	85	75	-10
Minnesota	4,594	85	85	None
Wisconsin	1,794	90	80	-10

Source: 1970 Crop Production Reports (July & December), SRS (USDA).

were carried in from the South. Dry weather in both the Southern states and in the Corn Belt would tend to reduce the prevalence and severity of SCLB throughout the U.S.

Weather conditions during the 1971 growing season could not be accurately predicted. However, climatological data indicated that even normal moisture and temperatures were apparently favorable for the spread and development of SCLB in much of the Corn Belt. Given weather good enough for growth of corn, there was likely to be some blight development in 1971. Under this assumption, the amount of disease in any area would be roughly proportional to the acreage of susceptible hybrids.

Seed Supplies

If farmers planted the same corn acreage as in 1970 there would be enough seed for the 1971 crop but not sufficient SCLB-resistant varieties to plant all of the crop. It was expected that about a billion pounds of seed corn would be available.

The Department of Agriculture conducted a survey of the seed stored by seed corn companies which produced 80 percent of the seed sold in 1970 and found that the breakdown of supply was as follows: about 18 percent were of N cytoplasm hybrids; 30 percent were partially resistant blends; and 52 percent T cytoplasm hybrids. Table 1.03 shows the distribution of 818 million pounds of the total seed supply. It was estimated that another 200 million pounds were mostly T cytoplasm distributed primarily in the East and Central Corn Belt.

Also available, but generally not recommended, was some seed of second generation (F_2) blight-tolerant hybrids and blight-tolerant open pollinated varieties. The major disadvantage of this seed was reduced productivity due to the loss or lack of hybrid vigor.

As of March 1, growers intended to plant 71.5 million acres of corn for all purposes. This acreage was six percent more than in 1970 and 11 percent more than in 1969. Intentions to plant had increased only 200,000 acres from the January 1 survey.

Acreage in the Corn Belt states was expected to be seven percent more than in 1970 and 13 percent above 1969 plantings. Farmers in Illinois and Kansas intended to plant less acreage than 1970, but farmers in other states planned increases ranging from two percent in North Dakota to 16 percent in Minnesota (see Table 1.04).

Winter Survival

Initially, it was not known how far north the fungus could successfully overwinter. However, the old race of SCLB did overwinter in the Corn Belt. Survival in the North could mean an earlier onset of the disease, but the pathogen was not expected to reproduce rapidly without extended periods of warm moist weather.

Table 1.03 Percentages of Seed Corn Supplies by Cytoplasm Type - 1971 Seeding

Area	N-Cytoplasm	T-Cytoplasm	Blends
Deep South	72	14	14
Mid-South	25	20	55
Eastern States	14	31	55
East & Central Corn Belt	27	30	43
Western Corn Belt	6	69	25
Northern States	20	52	28

Source: Corn Blight Factors in 1971. Extension Service (USDA).

Table 1.04 Acreage of Field Corn for Grain Intended to be Planted in the Corn Blight Watch Test Area 1971

State	Acres (000)	Percent of 35 State Totals[1]
Iowa	11,841	16.89
Illinois	10,442	14.90
Indiana	5,418	7.78
Ohio	3,507	5.00
Minnesota	4,300	6.13[2]
Nebraska	4,593	6.56[2]
Missouri	2,473	3.53[2]
Totals	42,574	60.74

Source: Prospective Plantings for 1971 - 35 states, January 25, 1971. Statistical Reporting Service (USDA).

1) The 35 states accounted for 98.3 percent of 1970 U.S. planted corn acreage.

2) Acreage in state adjusted by proportion of state acreage within the test area in 1970.

Winter survival could occur both in the debris of the 1970 crop and in stored grain. It was believed that some localized areas of heavy infection were started in 1970 by spores blown downwind from shelling of infected corn from the 1969 crop.

Some TMS seed would be infected with H. maydis and its germination might be reduced. Some infected kernels would emerge and die. Others would emerge and have a yellowish striping of leaves; but it was not likely that diseased seed would be the source of an epidemic in the Corn Belt.

Spread and Development

If airborne innoculum was carried into the Corn Belt as it had been in 1970, rather widespread infection could occur. If the spores survived the Corn Belt winter and spring, infection might be more localized and, initially at least, be concentrated around areas where overwintering occurred. It was possible that most susceptible fields could become infected by the end of the growing season.

Exactly when and how Southern Corn Leaf Blight might develop in 1971, however, could not be accurately predicted prior to the Experiment. Despite this, it was generally agreed upon by pathologists, agronomists, and climatologists that the likelihood of some SCLB infection in the Corn Belt in 1971 was high.

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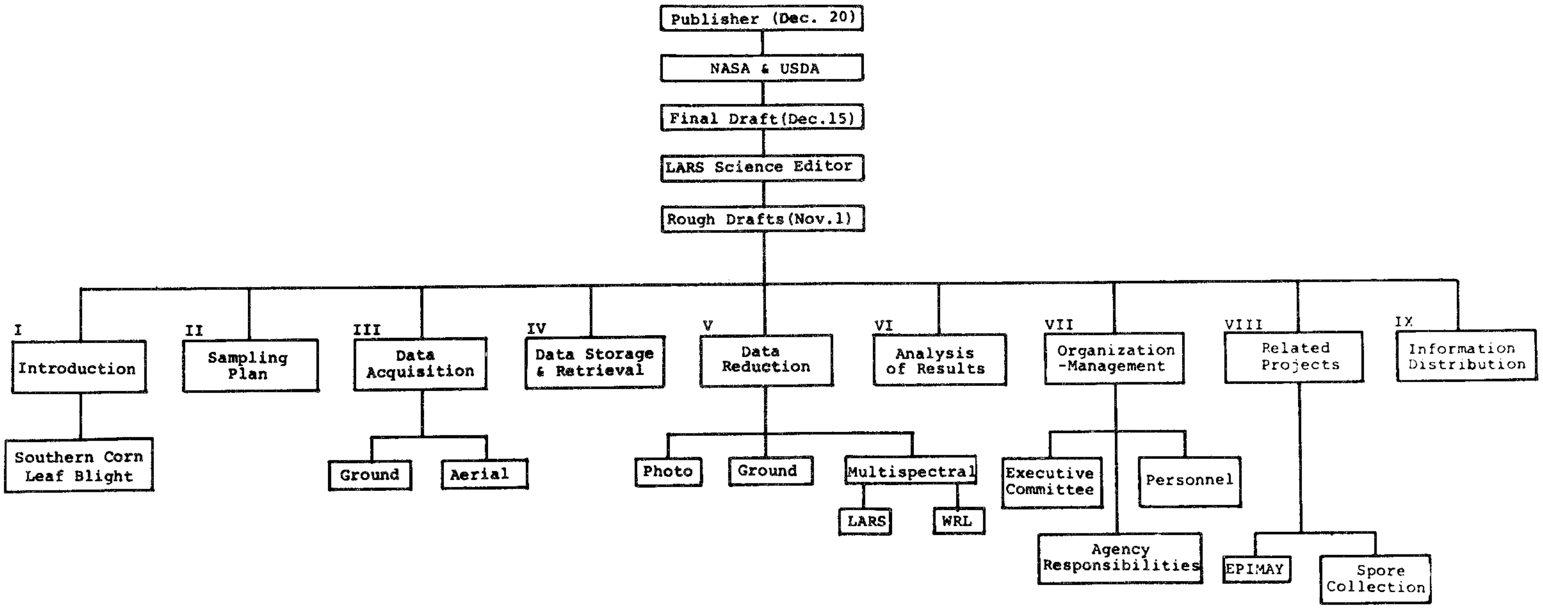
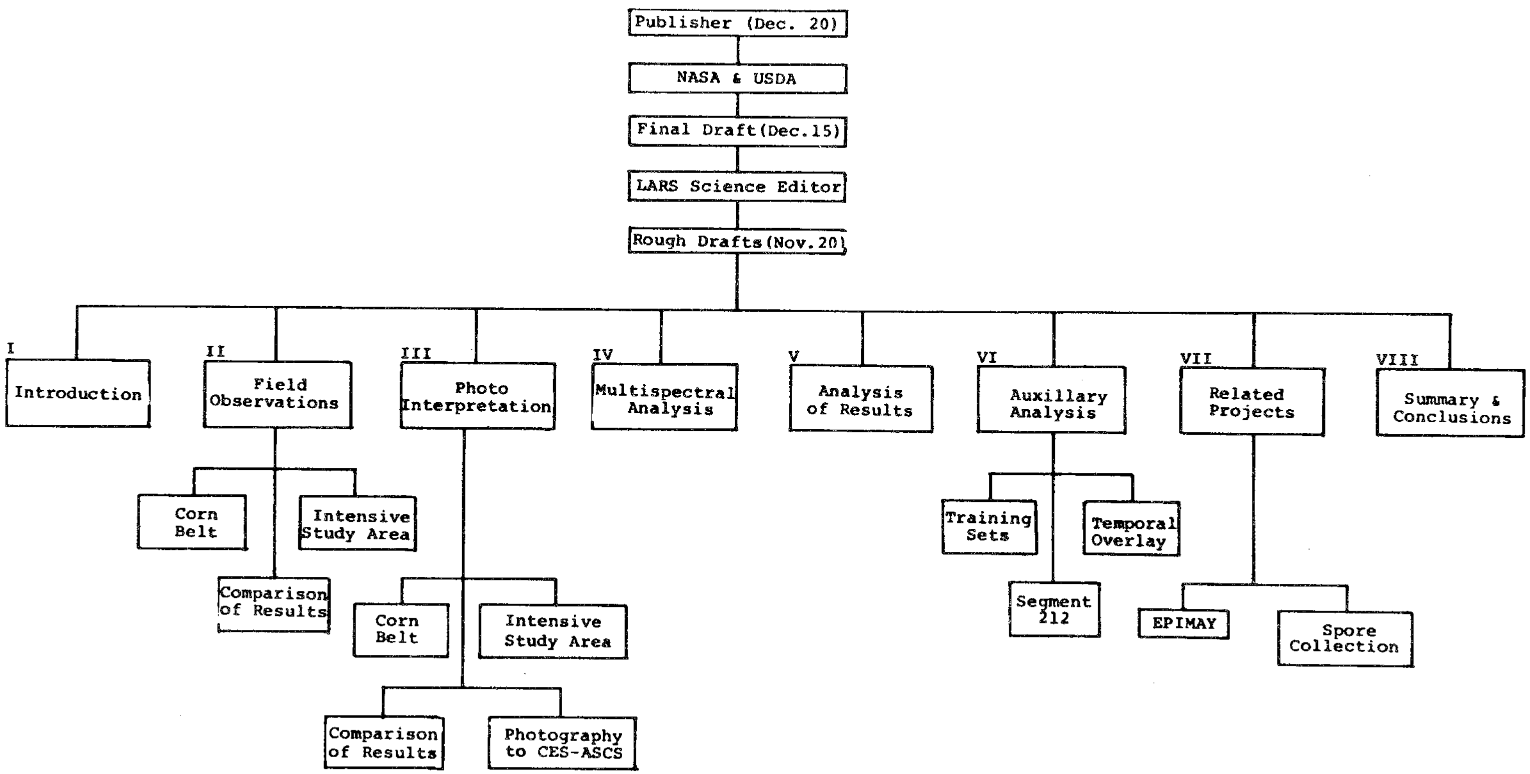


Figure 1.01 Final Report Organization, Volumes I and II



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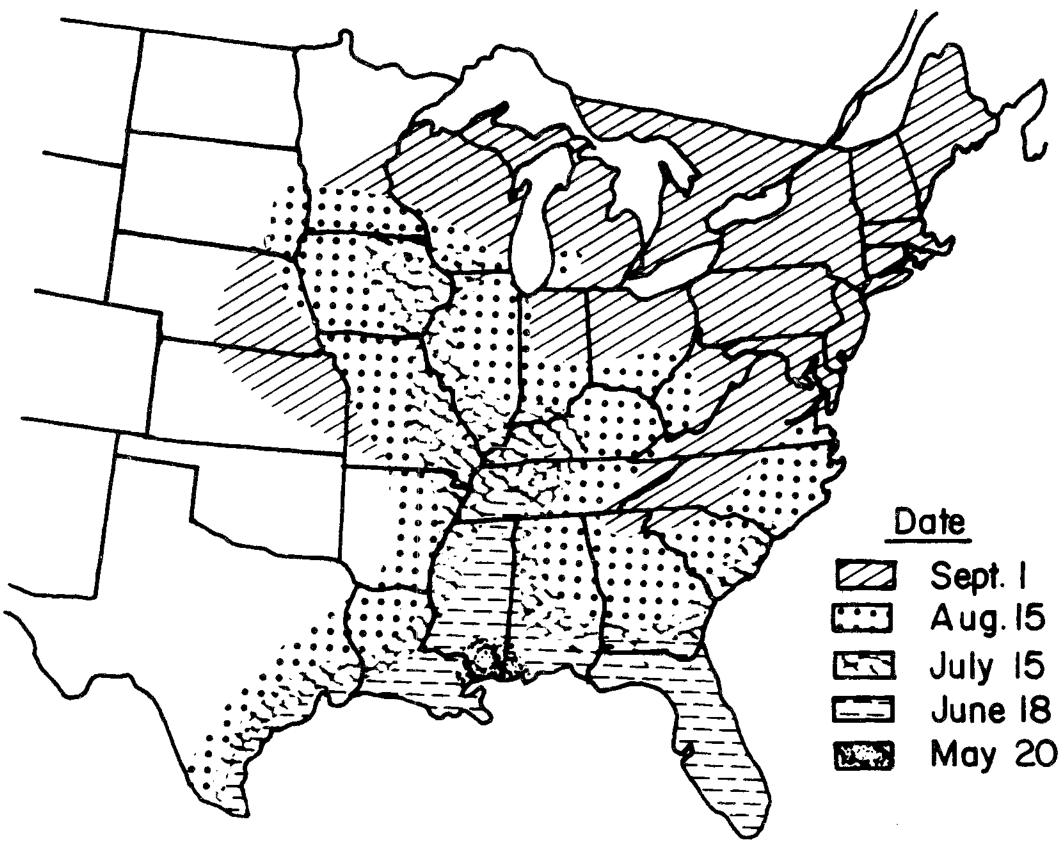
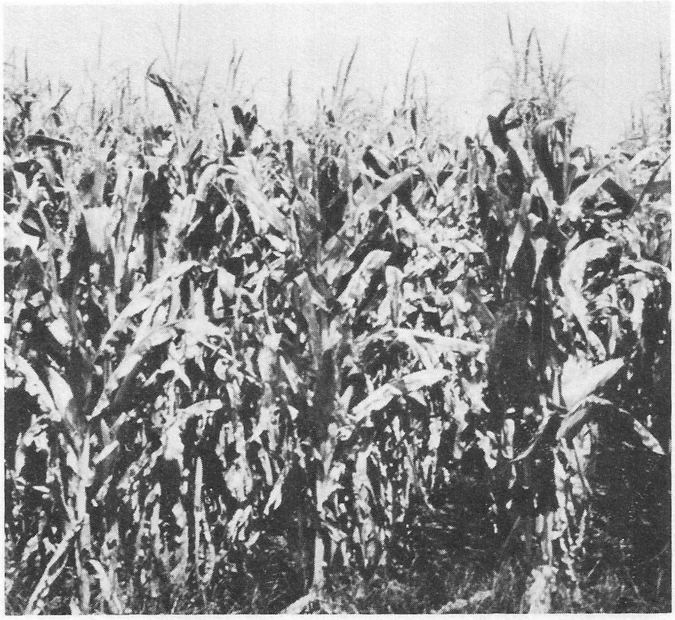


Figure 1.02 Spread of Southern Corn Leaf Blight in 1970

LEVEL 1 — SLIGHT

LEVEL 2 — MILD

Figure 1.03 Southern Corn Leaf Blight Severity Stages
(Original Photographs in Color)



LEVEL 3 — MODERATE

LEVEL 5 — VERY SEVERE

Figure 1.03 Concluded

SECTION II — SAMPLING PLAN

II. SAMPLING PLAN

The sampling plan for the Corn Blight Watch Experiment involved (1) selection of a test area, (2) determination of a segment sample design within the test area, and (3) determination of a field sample design within each segment.

A. Selection of Test Area

Detection of Southern Corn Leaf Blight through the combination of remote sensing and ground collection techniques could have been accomplished within a small geographic area, but the most important consideration in selection of a test area was the monitoring of the spread of the infection. This implied the observation of a large area. It was, therefore, desirable not only to include as much of the nation's corn crop as possible in the test area, but also to provide as wide east-west and north-south coverage as possible.

The basic constraints on the selection of a test area were manpower availability, aircraft capability, and desired precision of estimates from collected data. Manpower restrictions would not directly limit the size of the test area, but would limit the amount of ground data which could be collected. This would limit the precision of estimates which depend on the size of area samples. Therefore, although the RB-57F aircraft could cover a considerable area if allowed to fly long straight lines, this might not result in the most efficient sample design.

In setting up the test area, the most recent estimates of corn acreage were plotted (by county and by crop reporting district) for all states that might be considered in the Experiment. (Crop reporting districts are geographic groupings of counties which are included in the Statistical Reporting Service's estimating program. Most Corn Belt states are divided into nine such districts.) States initially considered included Iowa, Illinois, Minnesota, Nebraska, Indiana, South Dakota, Ohio, Missouri, Wisconsin, Kansas, and Kentucky.

It was decided to include a county in the test area only if its entire crop reporting district was included. In addition, a minimum inclusion of two crop reporting districts per state was set. This precluded a state being added to the project for the sake of only a few counties with considerable corn acreage.

The test area decided upon (Figure 1.04) included all of the states of Ohio, Indiana, Illinois, and Iowa, the eastern crop reporting districts of Nebraska, the southern crop reporting districts of Minnesota, and the northern and eastern crop reporting districts of Missouri. This area provided an east-west extent of nearly 900 miles and north-south coverage of nearly 400 miles. If SCLB entered the Corn Belt from the south as it was believed to have done in 1970, the eastern Missouri and western Illinois areas would give a good early indication of blight occurrence. The Nebraska and Minnesota counties were expected to provide indications of western and northern spread of the pathogen.

The portions of Nebraska, Minnesota and Missouri included in the test area were expected to account for at least 60 percent of the corn acreage for grain in each state. Additionally, the entire area was expected to include at least 60 percent of the nation's corn acreage for grain in 1971, based on farmers' intentions to plant (see Table 1.04).

B. Segment Size Determination

Given a test area for the project, the next step was determination of size and number of segments to be monitored within the area. SCLB was expected to have varying effects on different cytoplasms of corn, so it was desirable to have as many cytoplasms present within a segment as possible.

Since adjacent farms tend to be very homogeneous in terms of proportion of land planted to corn, varieties planted, and cultural practices, the most efficient sampling procedure for estimates from ground data alone would have been to select a large sample of small segments spread throughout the test area; but this allocation of samples in a high-altitude aircraft study would require complete photo coverage of the test area.

In the final analysis, the number and size of segments were determined to a great extent by available manpower, since it was decided that a segment should be no larger than a one-person assignment in order to reduce time and travel costs.

Agricultural Stabilization and Conservation Service indicated it could devote 1,000-1,500 man-days for field operations. On the assumptions that this input could be matched by state Extension Services, that interviewing would take about one week, and that seven to eight one-day visits would be made for field observations, it was determined that about 200 segments of land could be studied.

A rectangle, one mile by X miles, was assumed to be the desired shape. The rectangular shape would result in more "within segment" variation in cropping than would a square segment of the same area.

Segment sizes varying from four to 12 square miles were considered. The smaller sizes would be more convenient for interviewing. On the other hand, the larger sizes would provide a greater number of corn fields, but might require more than one week for collection of basic crop data. Eventually, a good compromise of ground data time requirements and expected number of corn fields per segment was arrived at with tentative adoption of a one-by-eight-mile segment size.

C. Segment Sampling Design

In order to gain the greatest

statistical benefit from the relatively small number of large segments, either a simple random or a stratified random sample of segments had to be selected. Since there would not be sufficient time to divide the entire test area into one-by-eight-mile segments, it was decided to use systematic random sampling with counties as the primary unit. One segment would then be randomly selected within each selected county.

Selection of counties and segments within counties would also have several advantages for the collection of ground data. Travel time and cost would be fairly small, the field interviewer might be acquainted with a number of the farm operators he was to contact, and there would be no problems associated with crossing county or state lines to make visits.

Three criteria were examined as possible sampling schemes for selection of counties: equal probability, probability proportional to corn acreage, and probability proportional to square root of corn acreage. Equal probability selection would yield a good geographic distribution of counties, but would result in sampling many counties with low corn acreage. Probability proportional to corn acreage would give good coverage to the heavily corn-producing counties, but would not yield a good distribution of segments for monitoring the spread of SCLB. Furthermore, this method would also allocate more than one segment to some counties.

Probability proportional to the square root of corn acreage therefore afforded a good compromise procedure. The heavier producing counties would have a higher chance of selection, but the resultant geographic distribution of counties would provide a good base for monitoring the spread of SCLB throughout the season.

A tentative selection of counties based on probability proportional to square root of corn acreage was thus prepared, with selected counties delineated on maps for review by all parties in the Experiment. This was not the final solution, however, as it became evident that it would be impossible to cover such a geographic pattern of segments considering the available aircraft and the established time constraints.

It was, therefore, necessary to alter the sampling plan. In order to provide the required photographic coverage within a two-week period, a maximum coverage of 4,000 flightline miles was estimated if flightlines were 100 miles or longer, or about 3,000 miles if individual lines were less than 50 miles.

The entire sampling plan was then reevaluated in light of the limitations imposed by the aircraft. The two-stage (flightline and segment within flightline) sampling procedure would limit the statistical precision of estimates from the Experiment. All estimates would contain variations both between flightlines and between segments within each flightline. Although segments within flightlines were expected to be relatively homogeneous, the between-flightline variance components could be large.

Assuming flightlines were not needed as a stage in the sampling process, expansions of segment totals would be subject to between-segment variation only. This between-segment component would be larger than the between-segment, within-flightline component, but should have lower total variance than the two-stage procedure.

In order to increase the statistical precision of the Experiment, it was decided to sample a portion of the test area within flightlines as a sampling stage. To accomplish this, total photo coverage was requested for a portion of the test area.

The three crop reporting districts in western Indiana were selected for coverage by the more optimal sampling scheme. Many of the resources available were concentrated there and since the scanner aircraft could not cover the seven-state area in a two-week period, all scanner flights would be made in western Indiana.

The analysts at the Laboratory for Applications of Remote Sensing and Willow Run Laboratories felt that data from 15 segments would be a substantial assignment for computer analysis. Thus, 30 western Indiana segments were designated an "intensive study area", with half of the segments to be analyzed at WRL and the other half at LARS (see Figure 1.05).

It was decided to sample the rest of the test area using the original sampling plan with 30 flightlines, each approximately 100 miles long, and each containing six segments. This gave a total of 210 segments (30 + 180) to be selected. The total flightline length exceeded the maximum limit of 4,000 flightline miles, but the extra length of the western Indiana flightlines, which cut down on between-flightline maneuvers, tended to extend that limit (see Figure 1.06).

D. Sample Field Selection

The goal in selection of fields for visits during the growing season was to sample the range of cytoplasms present in each segment. However, the number of fields per segment had to be limited to a number which could be visited in one day.

Eight to ten fields were felt to be a reasonable maximum for an assignment. Once the units were established within a field, observations were to be made on only five plants in each of the two units in a field. These observation visits were not expected to take much time.

If each of the nine cytoplasm possibilities was present in a segment and at least two fields of each were selected for purposes of estimating variances, at least 18 fields per segment would be required. In order to reduce this number, some of the possibilities had to be collapsed into broader classes or strata.

The strata used for sample field selection were (1) normal cytoplasm only, (2) Texas male sterile only, (3) blends of normal and Texas male sterile only, (4) F-2 and open-pollinated fields, and (5) all other possibilities. This fifth stratum covered several types of fields, but (except for some fields of unknown cytoplasm) each field in the stratum contained some normal cytoplasm plants and some Texas male sterile plants.

The F-2 and open-pollinated fields were combined in one stratum because both types did not usually occur in the same segment and both should cause some reduction in yield potential. There were not many of these fields (only one percent of the expanded acreage), but this lower yield potential and a theorized lower susceptibility to SCLB of the two types seemed a reasonable cause for creating the separate stratum.

If two fields were selected from each stratum present, the maximum sample size for a segment would be ten fields, with the maximum in most segments being eight fields, since F-2 and open-pollinated fields rarely occurred.

Since ten fields would be a small number for computer training purposes, the sampling rate for the Texas male sterile and blend strata was increased to three fields each in the intensive study area segments. This new maximum of 12 fields per segment could not take into account all of the possible blight situations but represented a maximum limit imposed by workload.

Studies of SCLB in 1970 had concluded that the level of infection was generally fairly uniform within fields. Since the main purpose of the Corn Blight Watch Experiment was to study blight infection, fields were selected on an equal probability basis as opposed to the "probability proportional to field size" method normally used in crop yield studies. Each field within a stratum in a segment, in other words, had the same chance of selection regardless of size.

Equal probability selection resulted in more small fields being selected than probability proportional to acreage selection would have. This larger number of small fields was expected to create some problems for scanner analysts in locating fields and in "training" the computer, but it was felt to be the best way to study the effects of SCLB.

As indicated in Table 1.05, (which summarizes the number of fields originally selected in individual segments), only one segment did not have any corn fields and only one segment contained one corn field. Since desired sample size per stratum was two fields, the selection of an odd number of fields such as seven, nine or eleven within a segment indicates that only one field was available in some strata.

Table 1.05--Number of segments by original sample size

Number of fields selected	Number of Segments		
	Nonintensive study area	Intensive study area	ASCS sample
0	1		
1	1		
2	4		
3	4		
4	7		5
5	4	2	
6	7		19
7	14	1	
8	106		
9	15	7	
10	17	13	
11		4	
12		3	
Total	180	30	24

E. Selection of Additional Sample Fields

It was envisioned that nearly all sample corn fields might be needed for training by photointerpreters and scanner analysts. There would thus be little, if any, ground data left for testing of classification results. Therefore, an additional sample of fields, to be observed by ASCS, was selected in 24 segments. These additional fields would be used for testing of results, and would also provide insurance that adequate ground data was being collected in case more data was needed for training.

The 24 segments chosen gave geographic coverage across the test area and within individual states. Five segments each were selected in Iowa, Illinois and Indiana; three segments in Ohio and two segments each in Minnesota, Nebraska and Missouri. Specific segments within these states were chosen on the basis of the number of corn fields and availability of ASCS county personnel for field observations.

Fields within the segments were selected from only the normal cytoplasm, Texas male sterile cytoplasm and blend cytoplasm strata, with two fields selected from each stratum. This systematic sample of two fields was selected from the fields remaining after the primary sample fields had been selected to preclude redundancy in coverage. At this point, the original sampling plan was complete.

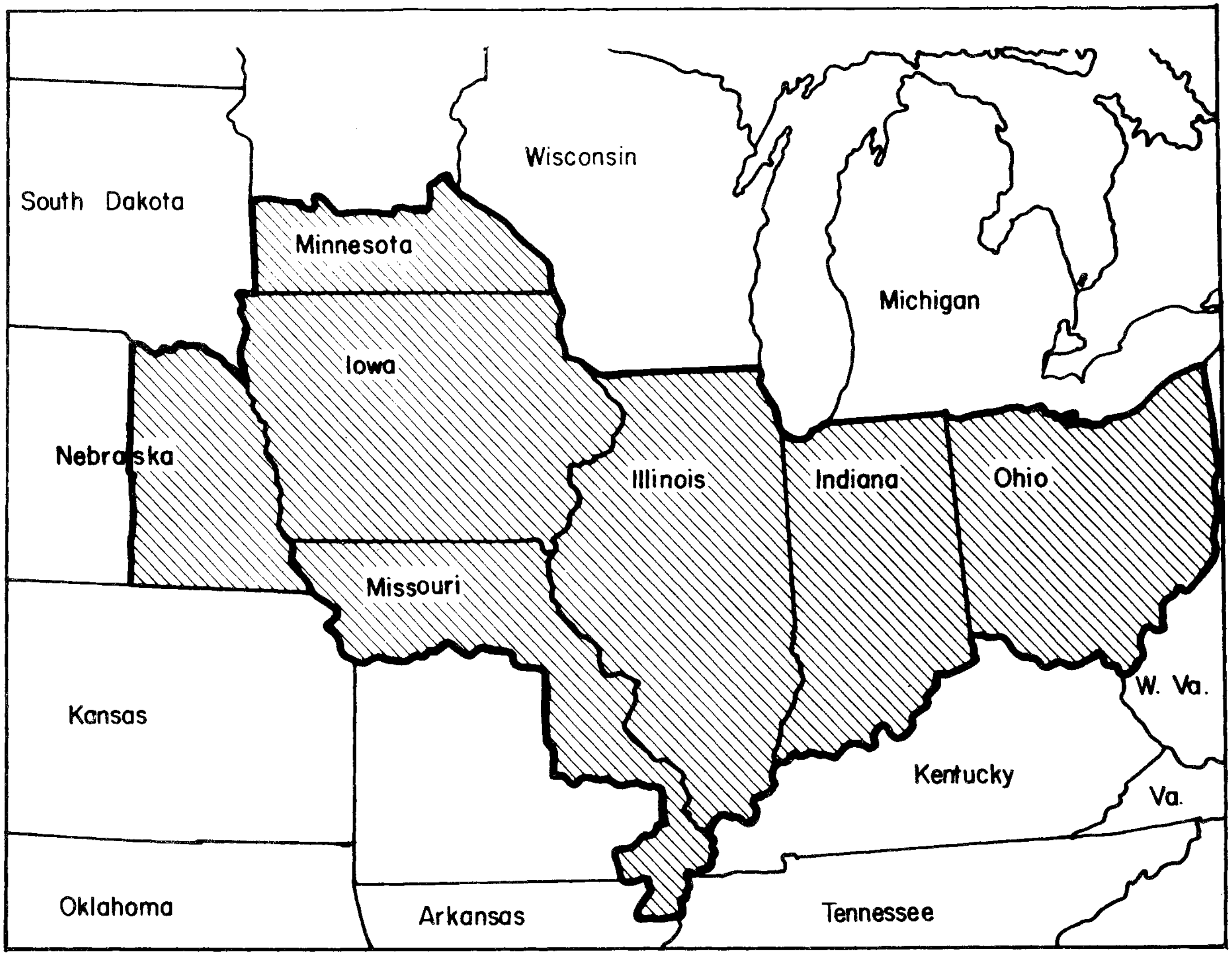


Figure 1.04 Corn Blight Watch Experiment Test Area

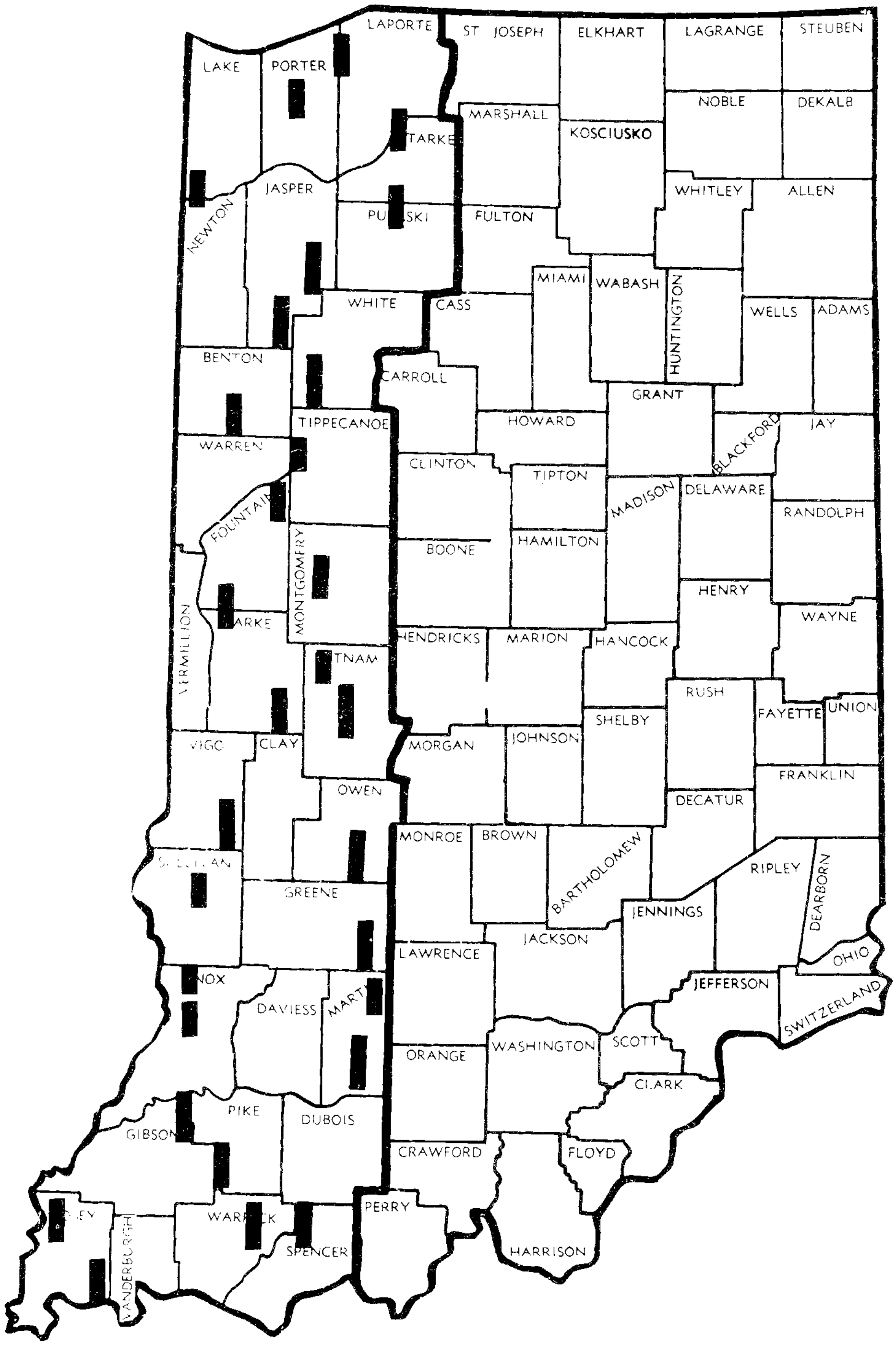


Figure 1.05 Intensive Study Area

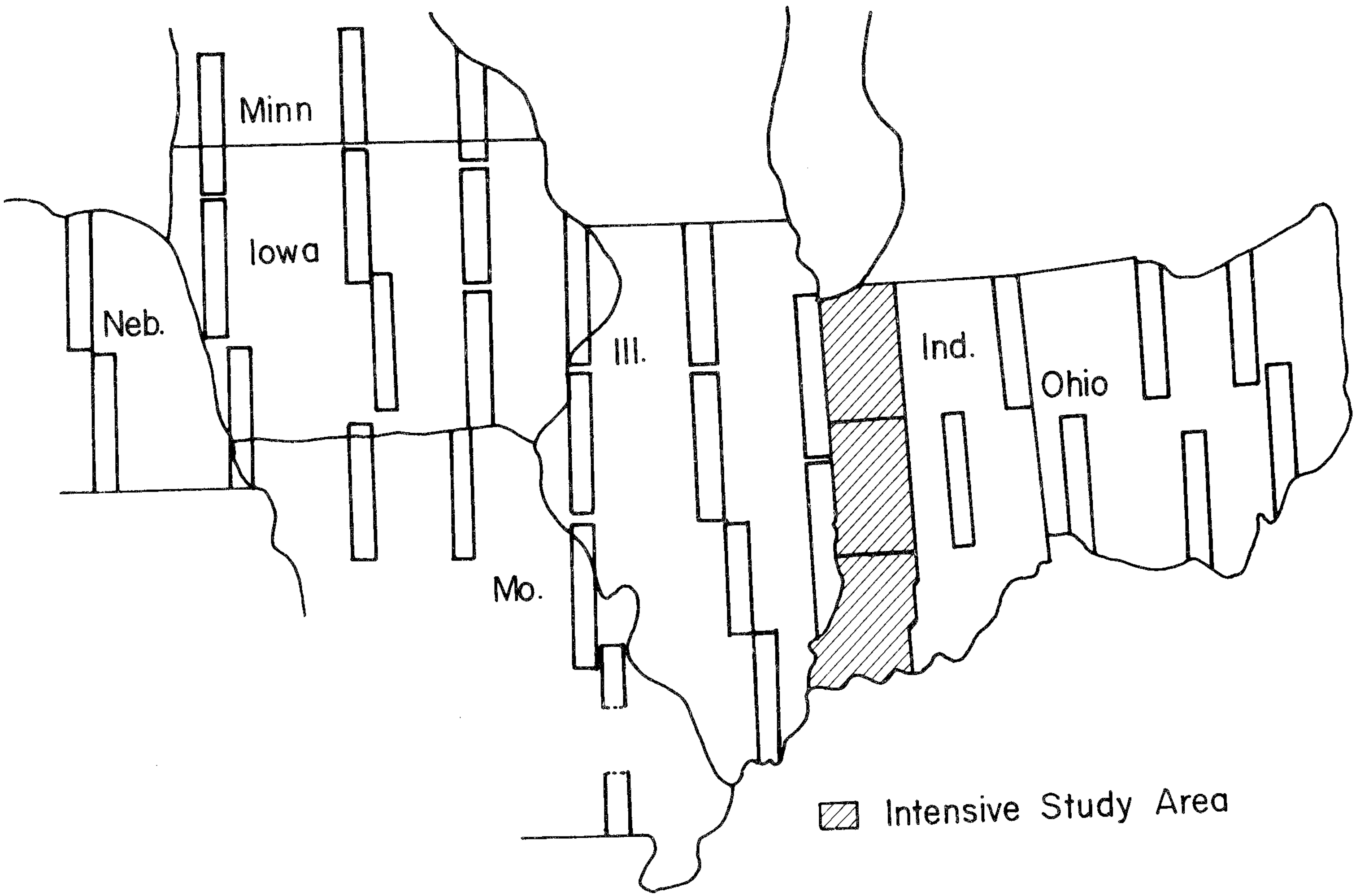


Figure 1.06 Corn Blight Watch Experiment Flightlines

SECTION III — DATA ACQUISTION

III. DATA ACQUISITION

A. Ground Data Collection

Two types of ground information - initial interview and field observation data - were to be collected during the Corn Blight Watch. These data would serve the dual purpose of:

1. Permitting those inferences of the incidence and severity of SCLB infection in the experimental area which would be made from the ground data alone; and

2. Providing training field information for photo interpretation and multispectral data analysis.

Initial Interview Survey

A "Part ID" form (see Appendix I-A) was to be completed for each segment prior to the actual start of the initial interview survey. On this form, all farm operators within the segment would be identified, such identification being obtained from county ASCS records in the form of Farm Record Cards and aerial photography. Each operator would then be sent an introductory letter explaining the Experiment and asking his cooperation.

Furthermore, all land in the segment was expected to be accounted for on the Part ID. Tracts identified as residential areas, woods, or other nonagricultural land would be listed and noted as such in order to preclude unnecessary interviewing. Any tract of land not identified by ASCS records was to be verified and listed by the enumerator during the initial interview period.

During a period from May 6 to 22, interviewers from county offices of ASCS would identify crop or land use, acreage, and location of each field in a segment. Additionally, they were to be responsible for marking the boundaries of each field on current black-and-white photography (1:20,000 scale) collected in April, 1971 during the Phase 1 flights. (See Sub Sec. B.) and concurrently assigning each field an identification number. (See Sec. V for code system.) Finally, permission would be obtained to set out two observation plots in the field.

Interviewers would complete Form A - Initial Interview for each person operating land inside the segment boundaries. Although each operator would be identified with a letter tract code, and each field delineated and numbered on an aerial photography contact print, names and addresses of the tract operators would not be entered on the Form A in the event these forms were to be used later by other agencies. Additionally, enumerators were to complete a separate column for each field. Space would be provided for nine to twelve fields on each form with supplemental forms to be used if necessary.

For each field, information would be recorded on total acres in field, acres within segment, and crop or land use.

Data on acres within segments would be obtained in the event not all of a field was located within the segment boundary. Data on all crops and land use would be coded for keypunching, using existing SRS commodity codes. This would facilitate using such data as an aid in the photointerpretation process. In the event a field was not yet planted at the time of initial interview, the interviewer would attempt to isolate corn planting intentions. In all cases where corn was or was to be planted, the following information would be obtained:

1. Acres of corn to be planted for all purposes

2. Acres intended for grain

3. Planting date

4. Type of corn planted (if field corn)

5. Hybrid name and number

6. Cytoplasm type (N, T, B, F_2, or combination of these)

7. Type of planting pattern

8. Row width

9. Plant population

10. Row direction

11. Was there corn in the field last year? Did it have blight?

12. Acres to be irrigated

For this Experiment, a corn field would be defined as a contiguous area planted to one particular hybrid and/or cytoplasm type of corn. Information on corn hybrid (question 5) would not be coded and keypunched, but might be beneficial in postsurvey analysis.

Question 6 was to be the basis on which sample fields would be selected. If type of corn seed planted was a blend, then the percent of normal cytoplasm seed would be entered. In most cases where blend seed corn was to be planted, the percentage of normal cytoplasm seed would be stamped on the seed tag. In this case, that percentage would be entered on the interview form. In addition, publicity through the county ASCS office would inform farmers in the sample areas that information relating to type of seed planted would be needed as part of the Corn Blight Watch Experiment. Questions 7 - 10 and 12 were seen as necessary aids to the remote sensing techniques to be used during the project.

Training

The ASCS personnel who would be conducting the initial interviews were to attend a one-day training school before the interviews started. The seven training schools, one for each participating state, were scheduled from May 5 to 11 and were to be conducted by representatives from ASCS, SRS, and LARS. Schools would be held at locations selected to minimize travel costs. The subjects presented would include descriptions of the Experiment plan and of procedures to be used in obtaining the necessary data. In addition, an Interviewer's Manual describing the Experiment and the procedures to be used in the initial survey would be prepared for the use of each enumerator.

Field Observation Survey

Using information garnered from the Initial Interview Survey, a sample of eight to ten corn fields per segment would be selected for biweekly observation from mid-June to mid-September. The samples were to be stratified by cytoplasm type (N, T, and B cytoplasm; F_2 and open-pollinated varieties; and combinations of these) with two fields per strata (section II details the manner in which this sampling plan was selected).

The field observations would be made by county and area agents of the Cooperative Extension Service (CES) of each state, with the first observations to be made during the week of June 14 and to continue at two-week intervals through the week of September 20. Some additional samplings and observations might be accomplished by ASCS.

The observations would be made on a regular schedule rather than attempting to coordinate the timing of aircraft overflights and field observations. Ideally, the field observations would be made the same day as the aircraft data was collected; however, extension agents would need to fit field visits into their schedule several weeks in advance, and aircraft flights could not be scheduled ahead of time. It was hoped that placing field visits on a regular basis would make the interval between visits more uniform, and that therefore visits to all segments would be at about the same time. This situation would make comparison of the field data from segment to segment more valid.

After the first mission, the average gap between field observations and aircraft flights was expected to be three and one-half days, with a maximum of seven days. Considering the probability of a flightline being flown as greatest during the first half of a mission period, Tuesday was chosen as the best day of the week for making field visits, with Monday and Wednesday as alternate dates. Furthermore, if observations were made during the first three days of the week, the forms could be edited and keypunched in the state Statistical Reporting Service offices on Friday and the data delivered to Washington, D. C. by Monday morning.

The preferred dates for making field observations were set up as June 15, June 29, July 13, July 27, August 10, August 24, September 7, and September 21. If, due to rain or other unsatisfactory conditions, observations could not be made on the preferred dates, they were to be made as close as possible thereto.

The field observation forms would be used to collect detailed information from two sample units laid out in each selected corn field. Procedures for locating and laying out units were to follow established procedures used in the SRS corn objective yield survey, with a unit to consist of a single row section 30 feet long.

The sample units would be marked with flagging ribbon and the same units observed during each field visit. Observations from 1970 indicated that blight infection was likely to be fairly uniform within a field; therefore, the number of units within a field would be limited to two. To select more than two would reduce the number of fields which could be visited.

The ground observations and measurements to be made were expected to give information on the amount of Southern Corn Leaf Blight infection, the development of the crop (maturity stage), the amount of crop cover, and the presence of other stress conditions.

The following items would be included on Form B and observed or measured:

1. Width across 10 row spaces
2. Number of plants in 30-foot unit

OBSERVATIONS OF FIRST FIVE PLANTS

3. Plants tasseled
4. Plants with blight lesions on stalks
5. Plants with evidence of stalk rot
6. Plants with ears or silked ear shoots
7. Number of ears or silked ear shoots
8. Ears or ear shoots with blight lesions
9. Ears with evidence of kernel formation
10. Ears with evidence of ear rot
11. Presence of other stress conditions such as lodging, moisture stress, extreme weediness, nutrient deficiency, diseases other than SCLB, insect damage, and hail damage
12. Representiveness of the units

OBSERVATIONS OF INDIVIDUAL PLANTS

13. Number of leaves on lower seven nodes
14. Number of leaves on lower seven nodes with blight lesions
15. Percent of lower leaf area infected by lesions

16-18. Same observations for upper leaves

19. Unit rating (0 to 5) of severity of blight infection
20. Plant height
21. Length of leaf at 7th node
22. Midpoint width of leaf at 7th node
23. Maturity stage

Counts and measurements within the 30-foot sample unit (items 1-2) were to be made to provide estimates of plant density. There was a possibility that measurement of the effects of corn blight on yield would be a valuable side product of this Experiment.

Items 3-12 refer to counts, measurements, and observations made on the first five corn stalks of each sample unit. Information on height of each plant would be measured because tassel stage and leaf area, along with plant population from items 1 and 2, determine the amount of field area covered by plant growth; which, in turn, affects the response measured on infrared photography and multispectral scanner imagery.

Information about the number of leaves with lesions and percent of leaf area affected would allow calculation of a blight damage code rather than reliance on only the enumerator's single subjective estimate of damage within the unit (item 19). Division of stalks between lower seven nodes and upper nodes was seen as necessary in order to identify leaves by location and degree of infection early in the season, since ear shoots would not have formed. This information would also be part of the model used to calculate a blight damage code. Also, plants having lesions on the lower leaves (lower seven nodes) might register differently on photography than those with the same degree of infection on only the upper leaves.

Criteria for determining degrees of blight infection were to be based on rating scales defined by plant pathologists.

Finally, the maturity stage of five ears would be used to identify the maturity of the sample unit at the time of visit. Descriptions used would be those developed by SRS for corn objective yield surveys.

Other unfavorable conditions present in the units were to be identified and recorded in item 11. In most cases, county extension personnel collecting the field observations would have experience in recognizing these conditions. However, in order to supplement this experience, training aids were to be included in an enumerator's instruction manual. These aids would include color photos showing various infection stages of blight as well as other diseases, and would be developed by LARS in cooperation with plant pathologists. Intended for field use by enumerators, they would be included with material prepared by SRS describing the procedures to be used by enumerators in laying out sample units and making the necessary observations and measurements.

Additionally, the enumerator would have the option of sending leaf samples to a laboratory in each state for positive identification of the presence of SCLB infection or other diseases. This was expected to increase the disease identification accuracy. Forms for use by both the enumerator and pathologist were to be developed.

Prior to the first mission period, 1½-day training schools would be held for all personnel who would be making field observations. The seven state schools would be conducted by the coordinator and plant pathologist of each state, plus representatives from SRS and LARS. Subjects covered were to include description of the Experiment plan, initial interview survey, and sampling plan; and instructions on locating sample units and making observations and counts.

Man-hour Requirements

It was estimated that a total of 9,300 farm operators would be contacted for information during the initial interview. Assuming an average of 15 minutes per interview, the total interviewing time would be approximately 291 man-days. Field work for the original interview portion was estimated to take six man-days per segment for interviewing. This would total 1,260 (6 x 210) man-days (4.85 man-years) for ASCS field work. In addition, the clerical operation of prelisting operators for each segment would take one to two days per segment, or an estimated 315 man-days. The grand total ASCS requirement for the initial interview portion of the Experiment was therefore expected to be approximately 1,866 man-days.

The work for the biweekly field observations in each segment was estimated to be two man-days for training, two man-days for the visit during the week of June 14 and one man-day for each of the later seven field visits. This would mean a total of 2,310 (11 x 210) man-days or 8.88 man-years. The actual figure, however, was expected to be less, since some sites would have only one type of seed cytoplasm, thus leaving a smaller number of fields to visit.

B. High-Altitude Photography

Background

During its initial meeting in February of 1971, the Corn Blight Watch Experiment Committee discussed requirements for dedicated use of aircraft in data acquisition. The preliminary operations plan specified that an RB-57F (Figure 1.07) or other high-altitude aircraft would cover flightlines over each of 210 sample areas within seven states every two weeks beginning June 15, 1971, and ending September 30, 1971, (eight two-week periods). It was also proposed that additional flightlines be selected to provide alternate coverage in event of weather contingency.

Sample segments randomly selected within the test area would have originally required as much as 405,000 square miles of coverage, which translated into over 160 hours of flight time per two-week period. In order to reduce these large flight requirements, segments were located contiguously in a series of north-south flightlines. With the 30 flightlines thus arranged, plus an intensive study area in western Indiana, it was estimated that local coverage could be completed in a minimum of four five-hour flights.

Climatological forecasts indicated that optimal photographic conditions would be available from three to six days per month in September. Thus, 10 to 35 percent of the available days would be climatologically optimum for aerial photography. Using 25 percent as a planning figure for the overall experiment period, this indicated that four days of optimal photographic conditions would exist for each two-week mission. On this basis it was estimated that four to six flights would be required to complete each two-week mission.

Using a projected five hours per flight and assuming a centrally-located staging base, the two-week flight time was approximately 30 hours, for a total of 240 hours for the 16-week experiment period. Added to this estimate would be a minimum of ten hours required to ferry the aircraft for scheduled or nonscheduled maintenance.

Later, color infrared photography coverage over all segments prior to the emergence of the corn was requested in order to provide soils background data. Additionally, the existing USDA black-and-white imagery (to be used for baseline land-use maps) proved to be generally inadequate and out-of-date, requiring another mission by the RB-57F to obtain black-and-white photography over the seven-state and the intensive study areas. These additional requirements of color infrared and black-and-white photography advanced the start date of the RB-57F effort to mid-April and required an additional 60 hours of flight time. Thus, in total the 1971 Corn Blight Watch would require an estimated 310 RB-57F flight hours.

Several alternate methods of providing the required photographic coverage were explored to provide a backup capability in the event of the primary aircraft's unavailability. Such methods included the use of other aircraft such as a Manned Spacecraft Center C-130 or NASA's Ames Research Center U-2. Additionally, planning contacts were made with the Air Force's Aerospace Cartographic and Geodetic Survey and the 58th Weather Reconnaissance Squadron to determine the suitability and availability of other high- or medium-altitude aircraft. Schedule and operational constraints eliminated all but the NASA/USAF RB-57F from consideration.

The RB-57F operation was thus planned as a long-term project, using existing personnel, facilities and operating systems with minimum modifications and with minimum impact to existing programs. A project method was selected (as opposed to the mission plan methods) in order to provide continuity throughout the experiment, with all information for RB-57F operations to be contained in one document, the "Project Plan."

As has been detailed elsewhere in this volume, the project was organized into three phases (1, 2, and 3) based on objectives and imagery required. Phase 1 would consist of acquisition of black-and-white imagery to be used in developing 1:20,000 scale land-use maps. During Phase 2, baseline color infrared imagery suitable for mapping soil conditions prior to the emergence of the corn would be obtained. Phase 3 would be repetitive coverage of the sample areas with color infrared photography for identifications and monitoring of corn blight. This latter phase would be comprised of eight missions of two-week duration, arranged to coincide with the two-week sampling periods. This mission breakdown of phase 3 would be useful from the mission reporting and personnel scheduling standpoints, providing positive starting and ending points for data acquisition and record keeping.

Data Requirements

Specific mission requirements, including all aspects of operations planning and data acquisition, handling, processing, and distribution, were detailed in the NASA Earth Observations Aircraft Program Corn Blight Project Plan for Site 277 - Corn Belt, dated April 1971. The Project Plan reflected the coordinated RB-57F total mission requirements and was issued prior to the start of the Phase 1 operations.

The area of coverage, as agreed to by the participating agencies at the issuance of the Project Plan, was to include 37 flightlines (approximately 3,800 flightline miles - 210 sample segments) for each phase. Thirty of the flightlines covered extensive sections of Ohio, Indiana, Illinois, and Iowa, and portions of Minnesota, Nebraska, and Missouri, with seven additional flightlines covering the intensive study area in Indiana. The flightlines were to be covered on Mission 171, from April 16 through April 30, to obtain Phase 1 black-and-white imagery; then on Mission 166, from May 10 through May 31, to obtain Phase 2 color infrared soil background imagery. Phase 3, Missions 173-180, from June 14 through October 1, would be to obtain biweekly repetitive color infrared coverage of all segments. A general weather constraint for all phases of the project would restrict data acquisition to periods when total cloud coverage was less than 30 percent. This restriction, however, was not clearly defined as to its applications and exceptions.

Sun angle constraints were determined after consideration of both optimal sun angles for color infrared photography and of the characteristics of summertime cumulus cloud formations. Data collection flights were begun as soon as the morning sun reached the minimum angle suitable for photography, early enough to provide sufficient data collection time before typical afternoon cloud accumulations. No maximum sun angle restrictions were imposed.

The flight altitude selected for Phase 1 operations was 50,000 feet above ground level (AGL). This would provide an original photographic scale of 1:000,000--necessary in order to allow production of 1:20,000 paper print enlargements using existing MSC equipment. Phase 2 and 3 operations were planned for 60,000 feet AGL, a near-optimal altitude for RB-57F operations. This altitude would provide a primary camera photographic scale of 1:120,000.

It was decided that if any Phase 3 flightlines were not completed in a planned two-week period, the flightline coverage would not be carried forward to the succeeding mission.

Maintenance Planning

Maintenance responsibilities for the RB-57F operation would be divided between the Air Force (aircraft and aircraft systems) and NASA, through the support contractor (pallet and sensor system). A normal sensor complement (Figure 1.07) was carried in the event that time was available for contingency test sites (sites requested by other investigators but not a part of the Corn Blight Watch).

Periodic inspections and scheduled maintenance for the aircraft were to be carried out in June, prior to the start of Phase 3; from July 26 to 29; and again from September 10 to 16. Scheduled aircraft inspections were planned for a total of ten days during Missions 176 and 179. No reliable estimates of unscheduled aircraft maintenance were possible, however, since this was the first long-term deployment planned for the RB-57F. Since sensor requirements for the Corn Blight Watch allowed for successful mission completion with one primary RC8 camera, no maintenance periods were scheduled for pallet or sensor systems. This was also due in part to extensive flight requirements and critical seasonal data requirements.

Staging Base Requirements

Responsibility for selection of a staging base was to rest primarily with the Air Force once they had been notified by NASA of mission dates and test site locations. Bases would be selected upon considerations which included aircraft hangar and maintenance facilities, runway and taxiway conditions and obstructions, facilities for physiological equipment operations and storage, flight planning and weather forecasting facilities, mess facilities for aircrews, office space, and operations conflicts by tenant organizations. Survey of alternatives and selection of a primary staging base were not complete at the publication of the Project Plan.

Operations Planning-Phase 1

Two Wild-Heerbrugg RC8 metric mapping cameras, which employ six-inch focal length lenses, were planned for simultaneous operation during Phase 1 operations. The 9-1/2-inch-square format cameras were to be loaded with black-and-white Plus-X film (type 2402) and fitted with Wratten 12 filters.

Both rolls of exposed film from each flight were to be shipped from the staging base to the Manned Spacecraft Center(MSC) Photographic Technology Division Laboratory (PTD) on the day the film was exposed. The film was scheduled to be processed upon receipt by PTD, with one of the original processed films to be sent to the MSC Mapping Sciences Branch (MSB) and two duplicate negative transparencies to be processed from the second original film. One of these duplicate transparencies would be sent to ASCS and the other sent to the MSC Research Data Facility (REDAF) for future reference.

The original film sent to the Mapping Sciences Branch would be used to identify the 210 test segments and cut to provide 5-inch by 7-inch negatives, which would be sent to PTD for a 5X enlargement. Three copies of the enlargements would then be duplicated, reproduced on matte paper, and sent to the Statistical Reporting Service for use in test site enumeration. These enlargements were scheduled to be at SRS by May 1.

Operations Planning - Phases 2 and 3

One RC8 camera with infrared film (type 2443) and a Wratten 15 filter would be required for Phases 2 and 3 (see Figure 1.07 for sensor systems details). In order to eliminate variations in the imagery due to differences in camera lenses and filters, one serial-numbered camera and one serial-numbered filter were to be used for all color infrared photography. In order to eliminate differences between film emulsion batches, all color infrared film would be from a single, special-order batch.

Flightlines were planned to provide 60-percent forward overlap (50 percent if film limitations required) for possible stereographic coverage and to allow selection of the test site from the area of best tonal quality. Flightlines in the intensive study area were planned to provide 30 percent side overlap, based on the higher flight altitude flown during Phases 2 and 3.

Exposed film from Phases 2 and 3 was to be returned to MSC each Friday, and to be delivered to PTD not later than 8:30 Monday morning. Three sets of duplicate positive transparencies would be processed by the Tuesday evening following the delivery of the exposed film to PTD. Two of these sets would be shipped to LARS at Purdue University by Wednesday morning. The method of film transportation to Purdue was not originally specified.

The other duplicate transparency set would be sent to MSC for test site identification and indexing. MSC was to provide LARS with a test site index for all film within three days of the receipt of the duplicates. In addition, two sets of color contact prints were to be processed and sent to LARS by the end of work on the Friday following receipt of the exposed film.

Supplementary Personnel Requirements

Personnel requirements were established by the individual MSC supporting organizations based on the requirements presented in the Project Plan and were so planned as to incur the minimum impact on ongoing programs and functions while still providing positive support to the Corn Blight Watch Experiment.

Flight operations for the two-place RB-57F were planned on a seven-day-week basis, including holidays, in order to take advantage of all opportunities for data acquisition. Air Force regulations pertaining to flight hours and crew rest required that three crew members for each position be available for flight.

The limited number of NASA Scientific Equipment Operators available for flight were also engaged in planning and documentation, so the Air Force also provided two navigators to supplement NASA personnel.

In addition, due to the large area of coverage with one sensor configuration, a full-time meteorologist was to be deployed with each mission. The National Oceanic and Atmospheric Administrations' Spaceflight Meteorology Group - MSC filled this requirement by providing one meteorologist per mission throughout the project, with the exception of the Apollo 15 mission period. This meteorologist was responsible for short range forecasting and weather monitoring during flights.

C. Multispectral Scanner

As part of Phases 2 and 3 of the Corn Blight Watch Experiment, multispectral scanner (MSS) data was to be collected over thirty sites in the intensive study area of western Indiana. These missions were scheduled to be conducted by the University of Michigan's Willow Run Laboratories using an instrumented C-47 aircraft under contract to the National Aeronautics and Space Administration/Manned Spacecraft Center. The aircraft was to be based at Willow Run Airport in Ann Arbor, Michigan, with the Purdue Airport at West Lafayette, Indiana, as a secondary base.

The intensive study area was set up in the three westernmost crop reporting districts in Indiana (see Figure 1.05), with the thirty sites selected by SRS (see Section II). They were typically one mile wide by ten miles long (with the shortest 7.2 miles, the longest 14.0 miles) and oriented north-south.

The original analog tapes from fifteen of these sites, five from each of three regions (North, Central, South), were to be delivered to LARS on the day of collection. There they would be analyzed, then returned to WRL for storage.

Data from the other fifteen sites, also representative of the three regions, were to be analyzed by WRL, with the original analog tapes delivered directly to the laboratories as the aircraft returned to base. Care was to be taken on board the aircraft to see that data destined either for LARS or WRL was obtained in discrete blocks. Areas to be analyzed by WRL and LARS were derived by dividing the sites in each of the three crop reporting districts of western Indiana into two groups of four to six segments in such a manner that each laboratory was analyzing comparable data. Bases for the groupings were similar soil type and elevation as determined from topographic and soil maps of the area.

The WRL C-47 aircraft was expected to be available for collection of the Phase 2 MSS data no later than May 17 and possibly as early as May 10. The slated completion date for Phase 2 was May 31. Because of time required for planned modifications to the MSS system, MSS data would not be obtained for the first mission of Phase 3 on June 14, but would begin with the second mission on June 28. The third through eighth missions would begin at two-week intervals after June 28.

Optimal altitude for the MSS data collection (5,000 to 5,500 feet above sea level), was to be maintained as closely as possible with due consideration for flight safety rules and cloud conditions. The preferred heading was 180 degrees (north and south), although exceptions might be made where strict adherence to this requirement would result in an excessive increase in the time required to complete a mission. In any case, a given site would always be overflown with the same aircraft heading.

Since flightline alignment would be dependent upon natural landmarks as observed by the pilot, and since at 5,000 feet altitude visual alignment accuracy is no better than 1/4 mile, the MSS would be turned on approximately 1/4 mile before the beginning of each site and allowed to run 1/4 mile beyond the end site. LARS was to furnish WRL with adequate surface feature maps to aid the pilot in visual flightline alignment.

Panchromatic and color infrared 70mm photographic coverage would be obtained coincident with the MSS data. Two magazines were to be used sequentially on the panchromatic camera in order to obtain two equivalent sets of photography - one for WRL sites and one for LARS sites. The set for LARS would be delivered, unprocessed, each time MSS tapes were delivered. The color infrared film would be delivered initially to WRL where it would be used for reference in processing and analysis of the MSS data. Each facility was to process its own film, and all original transparencies of aerial camera film and scanner film strip reproductions were to be delivered to NASA/MSC for data storage at the end of the Experiment.

The minimum desired sun angle for MSS data collection was 50 degrees, which would permit a maximum time period of data collection ranging from six hours per day in late June to less than one hour by late September.

Willow Run Laboratories estimated that, under ideal conditions, all sites in the intensive study area could be covered in two days. The C-47 would be available for the full two-week mission period if this was necessary to obtain the desired total one-time coverage. Except in the case of repeated coverage to take advantage of improved weather conditions, the minimum span of data collection between mission periods would be four days.

The preferred weather for MSS data collection was defined as clear (less than 10 percent cloud cover) with no haze, with these criteria to be applied whenever there was a choice of regions to be flown or when there was opportunity for repeated coverage of marginal data. However, data would also be considered acceptable whenever the visibility exceeded six miles and less than 30 percent of the data was affected by cloud cover. Solid high overcast would also be considered acceptable. All data would be evaluated as soon as possible after collection to determine that these parameters had been met.

The scanner configurations for Phases 2 and 3 would necessarily be different due to the modification which was expected to result in improved data utility. The scanner was to be modified to provide single line-of-sight registration for all spectral channels - visible through infrared. (See Figure 1.08 for MSS scanner configurations and Table 1.06 for anticipated MSS system parameters.)

Table 1.06 Anticipated MSS Parameters

	Phase 2
FM Center Frequency:	216 kHz, tape containing 15 video bands in 0.4 to 2.6μm wavelength region 108 kHz, tape containing 2 bands in 4.5 to 11,7μm wavelength region
Magnetic Tape Speed:	60 i.p.s.
Spectral Bands (two tapes):	12 bands over 0.4 - 1.0μm range, selected to approximate Phase 3 bands and 1.0-1.4μm 1.5-1.8μm 2.0-2.6μm 4.5-5.5μm 9.3-11.1μm
Sync Channels:	Standard (roll stabilized video synch pulse and a calibration reference synch pulse for each of the two scanners).
	Phase 3
FM Center Frequency:	216kHz, all video channels
Magnetic Tape Speed:	60 i.p.s.
Spectral Bands:	8 bands over 0.4-0.9μm range, to be specified by WRL and LARS before May 15 and 1.0-1.4μm 1.5-1.8μm 2.0-2.6μm 9.3-11.7μm
Sync Channels:	One standard, one special, as requested by WRL (roll stabilized video synch pulse and a calibration reference synch pulse for the one scanner).

D. Auxiliary Data

1. Photographic

In addition to aerial photo coverage by WRL's C-47 and the NASA/USAF RB-57F, LARS was to collect auxiliary photographic data over the intensive study area during each mission period. Since it was not feasible to use the C-47 for this purpose, it was hoped that use of Purdue University's C-45 (Twin Beechcraft) would provide color and color infrared photographic imagery for multispectral analysis teams with a minimum turnaround time. County maps outlining sample segments were to be used as navigation aids.

The aircraft would fly all thirty segments included in the intensive study area during each mission and process acquired data immediately upon return to the Purdue Airport. It was estimated that three to four days would be required for coverage of the entire 30 segments. Imagery was to be acquired on 70mm Kodak 2448 film (using an HF3 filter) and Kodak 2443 film (using a Wratten 16 filter). In addition, the aircraft would also be available to fulfill supplementary or extended coverage needs arising during the Experiment.

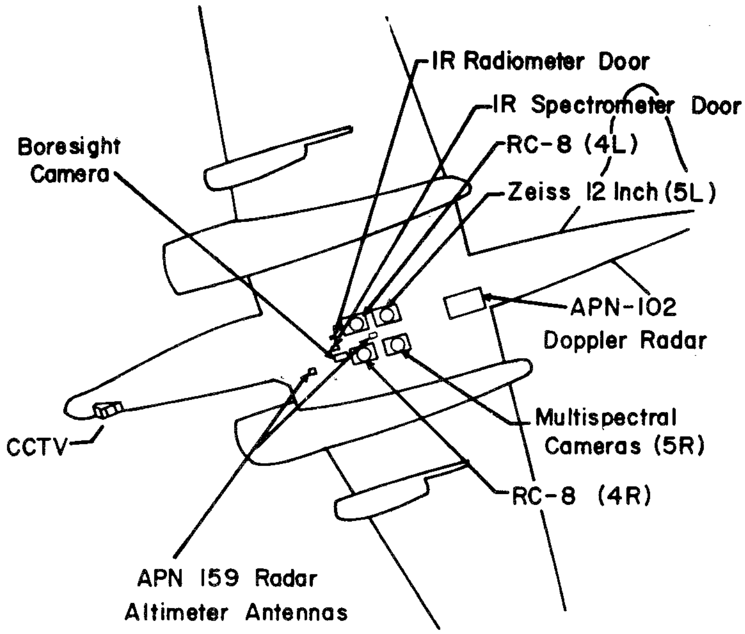
It was determined that the Hasselblad photographic system, which had been previously used, was unsatisfactory for two reasons. First, it had not demonstrated acceptable reliability and second, its lens focal length (80mm) would require a mission altitude of 10,000 feet in order to obtain coverage comparable to the WRL C-47. Within the operational parameters of the Beechcraft, this altitude would have involved the installation and use of oxygen equipment.

It was, therefore, planned to obtain Hulcher 70mm aerial camera systems equipped with 38mm lenses. The combination of shorter focal length (thus wider angle coverage) plus higher film load (four times greater than the Hasselblad) was expected to provide a much more efficient and reliable system which could operate at a more feasible altitude.

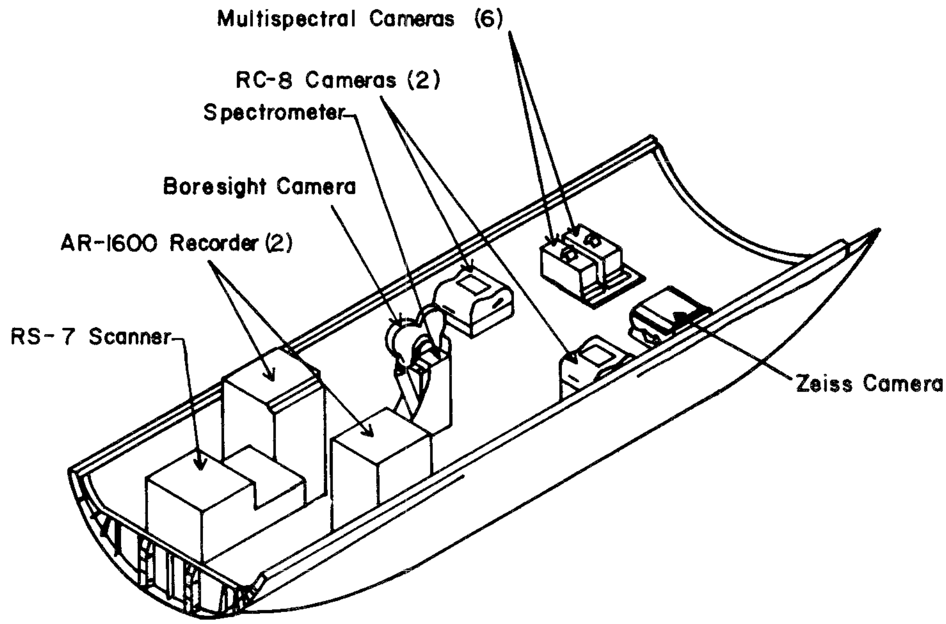
In addition, extensive modifications of the existing darkroom facilities at LARS was expected to enable technicians to process up to 200 feet of film per day, which was seen as adequate. Also, an additional technician would be hired to man the processing laboratory and handle the additional workload resulting from Beechcraft coverage.

2. Ground

In addition to the field observations made by CES and ASCS personnel, a limited amount of ground data would be collected during visits to selected segments in the intensive study area by personnel from WRL and LARS. The information from corn fields would be used to: 1) provide data which could be used to test the accuracy of blight severity classifications and 2) explain why certain fields were improperly classified. In addition, supplementary data would be collected describing the condition of noncorn fields. This data was slated for latcr use in crop identification and classification experiments.



RB-57 Ventral View



Instrument Pallet

Figure 1.07 RB-57F and Instrument Pallet

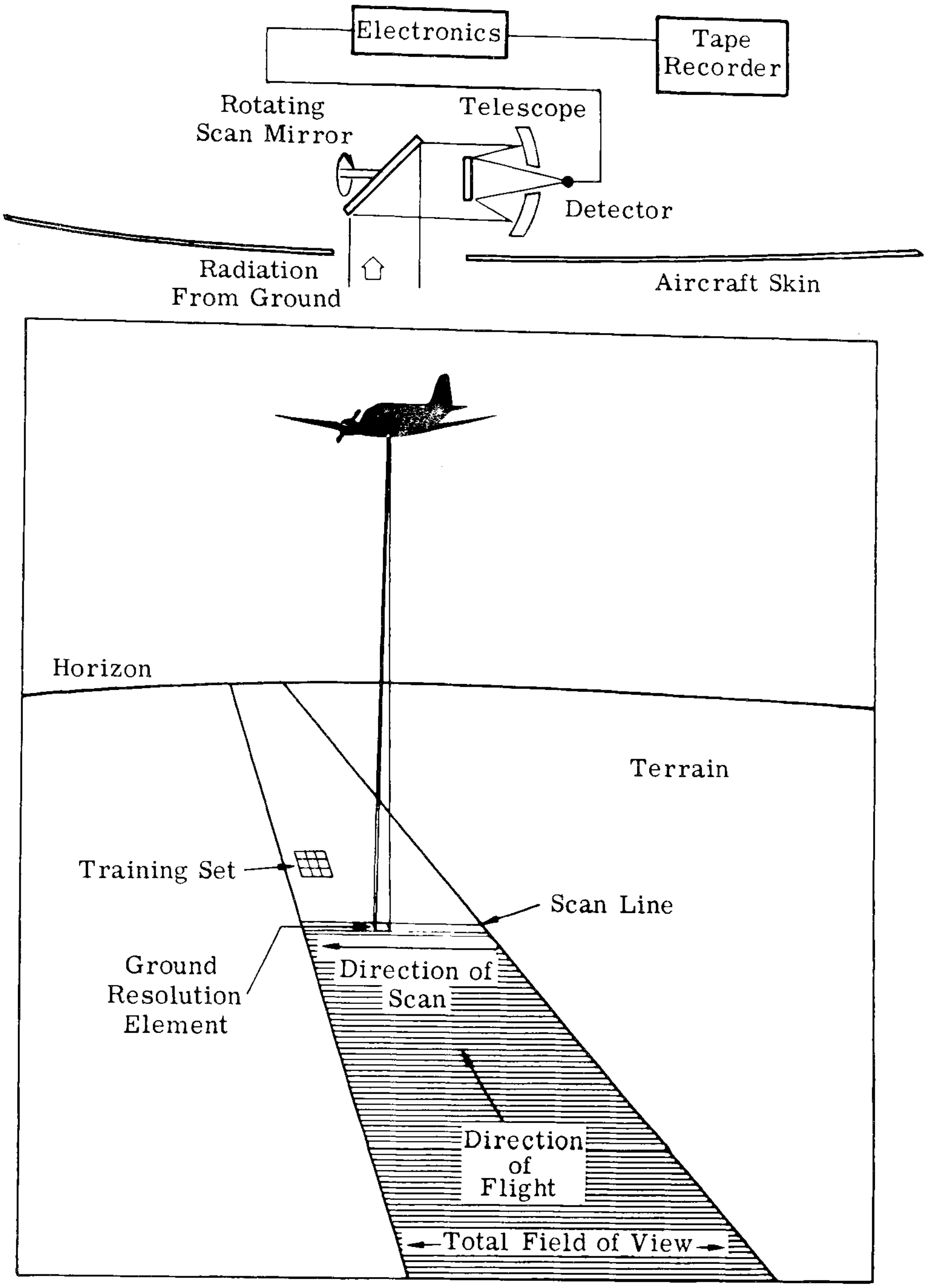


Figure 1.08 Multispectral Scanner Operation

SECTION IV – DATA STORAGE AND RETRIEVAL

SECTION IV - DATA STORAGE AND RETRIEVAL

A. System Considerations

Earlier chapters have described the segments of the Corn Belt where Corn Blight Watch data would be collected and the methods with which that data would be acquired. In addition, the nature of the CBWE and resources available for conducting the Experiment dictated that there be several centers to concentrate this data input.

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's Corn Blight information center in Washington.

The advantage of a central site was that maximum communications between individuals performing separate reduction functions on the data would occur. Also, both the overhead required for transferring data between many data reduction locations and the time required for data transfers would be minimized. However, although the central reduction site concept was considered optimum in terms of achieving the greatest experimental success, the resources available did not permit its implementation. Therefore, an alternate plan, the establishment of a data flow plan between available processing centers, was implemented.

Centers were identified where resources had been 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 (see Subsection B). The principal data acquisition centers were: a base to be selected by the Air Force (eventually Scott Air Force Base, Illinois) for high-altitude imagery, Willow Run Laboratories at the University of Michigan (collection of multispectral data), and the SRS state offices which would compile data from the Agricultural Stabilization and Conservation Service and Cooperative Extension Service county personnel who would serve as ground enumerators.

The principal data processing centers were to include the NASA Manned Spacecraft Center (MSC) which would process high-altitude film and identify frames showing the segments identified in the sampling plan. The Statistical Reporting Service (SRS) of USDA in Washington would assume the responsibility for collecting, editing, and collating all ground observations; draw inferences from them and deliver results to the data reduction center at LARS.

Willow Run Laboratories (WRL) accepted the responsibility to process 15 flightlines of multispectral data per mission and report the results to the LARS data reduction center at Purdue University. LARS would reduce the other 15 flightlines of multispectral data and interpret the 210 segments of aerial photography from the entire test area. LARS was also to collate and analyze all interpreted results and communicate them to SRS and other participants in the Experiment.

Since the principal data reduction center (DRC) was located at LARS and most data products were handled there, a LARS data storage and retrieval system was initiated to provide access to all data collected for the Corn Blight Watch Experiment. Specifically, the system was to fulfill these functions:

- Maintain a record of all Corn Blight Watch data, stored and reduced, in an organized library for future access.
- Report to the photo data and multispectral scanner reduction teams all information required, in a format allowing the simplest access possible by the teams.
- Record data reduction results from photo and multispectral scanner data reduction teams and merge with the data collected.
- Report data reduction results to the Statistical Reporting Service in Washington and other participants in the Experiment.

A description of the data storage and retrieval system thus set up is given in Subsection C.

B. Data Flow

Since the Corn Blight Watch Experiment was to be 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. Both data acquisition and reduction centers are labeled in the diagrams with an abbreviation which is identified in Table 1.07.

Table 1.07 Principal Centers of Data Acquisition and Processing

NASA/MSC	NASA Manned Spacecraft Center, Houston, Texas.
Scott AFB	Scott Air Force Base.
WRL/Aircraft	Willow Run Laboratories, University of Michigan aircraft system.
ASCS Washington	Agricultural Stabilization and Conservation Service of USDA, Washington, D.C.
ASCS State	Agricultural Stabilization and Conservation Service of USDA-State Offices.
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 Services of the seven states.
CES/County	Cooperative Extension Service County Agents.
WRL	Willow Run Laboratories, University of Michigan.
DRC/LARS	Data Reduction Center located at the Laboratory for Applications of Remote Sensing, Purdue University.
USDA Corn Blight Information Center	United States Department of Agriculture: Agricultural Information Center; Washington, D.C.

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In addition, each data transfer is numbered and a table describing each such transfer is included. The coding system used to describe each transfer combines the phase and the transfer number for that phase. For example, P1-4, indicating the fourth transfer in Phase 1, is shown in Figure 1.09. P1-4 (see* in table 1.08) is identified as being flight logs and two sets of exposed 2402 film sent from Scott Air Force Base to NASA/MSC beginning on April 16, and continuing each day film was exposed until phase completion on May 2.

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Table 1.08 Data Flow for Phase 1

P1-1	April 1: Identification of flightlines and segments – from SRS/Washington to DRC/LARS, NASA/MSC, and ASCS Washington.
P1-2	April 15: RB-57F – from NASA/MSC to Scott AFB.
P1-3	April 15: Black-and-white panchromatic film type 2402 and other supplies – from NASA/MSC to Scott AFB.
P1-4*	April 16 and each day film exposed through completion on May 2: Flight logs and two sets of exposed 2402 film – from Scott AFB to NASA/MSC.
P1-5	May 3: Three sets of 1:20,000 scale black-and-white prints (25x40 inches) for each segment – from NASA/MSC to SRS/Washington.
P1-6	May 3: Existing black-and-white contact prints of segments for backup – from ASCS/Washington to SRS/Washington.

P1-7 May 3: Set of 1:100,000 duplicate negatives and flight logs — from NASA/MSC to ASCS/Washington.

P1-8 May 5: One set of black-and-white prints with 1x8 mile segments outlined — from SRS/Washington to ASCS state offices.

P1-9 May 5: Part ID, Form A, and instructions — from SRS/Washington to ASCS enumerators.

P1-10 May 5 — 11: Training schools by ASCS, SRS, and LARS for ASCS enumerators.

P1-11 May 6 — 22: Part ID, Form A, and annotated baseline photographs — from ASCS enumerators to SRS/Washington.

P1-12 June 1: One set of annotated baseline photographs and digital tape with edited Form A data — from SRS/Washington to DRC/LARS.

P1-13 June 1 — 10: One set of annotated baseline photographs and fields selected for biweekly visits — from SRS/Washington to CES agents of each state at extension school.

P1-14 June 15: Photo copies of black-and-white annotated prints of segments in intensive study area — from DRC/LARS to computer analysts at LARS and WRL.

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During Phase 1 (April 1 — May 2), baseline data for the entire Corn Blight Watch Experiment was to be collected. Generally, 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 enlargement 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 DRC at LARS.

Specifically, a duplicate set of the original black-and-white photography was to be delivered to ASCS in Washington, along with three sets of 1:20,000 scale prints of each site. SRS was to mark the segment outlines on one set of baseline photography for each of the 210 sample sites and, in a training school for ASCS enumerators, deliver the photography, Part ID and Form A forms (for identification of tract owners and crops), and instructions for carrying out the initial ground observations.

The ASCS enumerators were to be asked to annotate the baseline photography with tract and field boundaries showing the codes for each tract and field and deliver these with the completed Part ID and Form A forms to SRS in Washington. SRS would then annotate the other two sets of baseline photography, edit and punch on cards the information on the forms, and collate the information on a digital tape.

One set of annotated photography and a digital tape were then to be delivered to the data reduction center at LARS. The second set of annotated photographs would be used by CES agents to locate biweekly sample fields. A third set of annotated photography would be retained by SRS. Photo copies of annotated prints of segments in the intensive study area would then be made and delivered to the multispectral analysts at LARS and WRL.

Information from the digital tape was also expected to be made available to both the multispectral and photo data reduction teams. These major data transfers for Phase 1 of the Experiment are outlined in Table 1.08 and diagrammed in Figure 1.09.

During Phase 2 (May 10 – June 21), spectral characteristics of soils in the 210 sample sites were to be accumulated. Color infrared photography at a scale of 1:120,000 was to be collected by a NASA/USAF RB-57F and multispectral measurements acquired by WRL's C-47.

These photographic and multispectral data were then to be analyzed in order to stratify the corn fields within the segments into different categories on the basis of the spectral characteristics of soils, and the results os the soil analysis recorded by the data storage and retrieval system. A brief description of each data transfer for this phase is included in Table 1.09. Figure 1.10 displays the major transfers of data.

Table 1.09 Data Flow for Phase 2

P2-1	May 10 – June 1: RB-57F staged at Scott AFB – from NASA/MSC.
P2-2	May 10: Frozen color IR (type 2443) film – from NASA/MSC to Scott AFB.
P2-3	May 10 – 31: C-47 flown by WRL aircraft in intensive study area.
P2-4	May 10 – 31: Flight logs, analog tapes, and CRT images – from WRL aircraft to DRC/LARS.
P2-5	May 10 – 31: Flight logs, analog tapes, and CRT images for segments analyzed by WRL – from WRL aircraft to WRL.
P2-6	May 16 and every Sunday evening through May 31: Flight logs and rolls of exposed color IR film – from Scott AFB to NASA/MSC.
P2-7	May 18 and every Tuesday through June 2: Data logs and two sets of duplicate positive transparencies – from NASA/MSC to DRC/LARS.
P2-8	May 12 and every Saturday through June 7: Two sets of color contact prints – from NASA/MSC to DRC/LARS.
P2-9	May 24 – June 9: Color prints of segments – from DRC/LARS to ASCS and CES enumerators.

P2-10 June 21: Analysis results of spectral data of soils in 30 segments of intensive study area — from WRL and DRC/LARS to DRC/LARS.

P2-11 June 21: Analysis results of color IR positive transparencies for 210 segments — from DRC/LARS to DRC/LARS.

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Flight missions were to be conducted during Phase 3 — June 14 to October 13. During this phase, color infrared photography was to be collected every 14 days over all 210 segments and multispectral measurements to be 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 would also be acquired. All of this data was then to be processed and sent to the data reduction center at LARS. Fifteen segments of multispectral data and ground observations over these segments were to be sent to the data reduction center at WRL. Again, the photographic and multispectral data were to be analyzed and results recorded by the data storage and retrieval system. Analysis results were to be reduced and reported to SRS and other participants in the Corn Blight Watch Experiment. The major data transfers for Phase 3 are described in Table 1.10 and diagrammed in Figure 1.11.

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Table 1.10 Data Flow for Phase 3

P3-1 June 1 — 10: Training schools for Extension enumerators by SRS — Plant Pathologist from each state, and LARS.

P3-2 June 1 — 10: One set of annotated baseline photographs, selected fields for biweekly visits, Form B's and instructions — from SRS/Washington to CES agents of each state at extension school.

P3-3 June 14: Frozen color IR (type 2443) film — from NASA/MSC to Scott AFB.

P3-4 June 14 — October 3 (Day 1 — Day 14): RB-57F staged at Scott AFB by NASA/MSC.

P3-5 June 14 — October 3 (Day 1 — Day 14): C-47 flown by WRL in intensive study area.

P3-6 June 14 — October 3 (Day 1 — Day 14): Low altitude color IR data acquisition over 30 segments in intensive study area by LARS as required.

P3-7 June 14 — October 3 (Day 1 — Day 14): Flight logs, analog tapes, and CRT images — from WRL aircraft to DRC/LARS.

P3-8 June 14 — October 3 (Day 1 — Day 14): Flight logs, analog tapes, and CRT images — from WRL aircraft to WRL.

P3-9 June 14 — September 23 (Day 1 — Day 3): Biweekly visit reports — from CES enumerators to SRS state offices.

P3-10 June 18 — September 23 (Day 5): Test and evaluation biweekly reports — from ASCS enumerators to SRS state offices.

P3-11 June 18 – September 24 (Day 5): Biweekly visit reports and punched cards – from SRS state offices to SRS/ Washington.

P3-12 June 18 – October 3 (Day 5 and Day 13 – every Friday): Flight logs and rolls of exposed color IR film – from Scott AFB to NASA/MSC.

P3-13 June 22 – October 6 (Day 9 and Day 16 – every Tuesday): Flight logs and two sets of duplicate positive transparencies – from NASA/ MSC to DRC/LARS.

P3-14 June 22 – September 28 (Day 9): Digital tape with edited biweekly reports – from SRS/Washington to DRC/LARS.

P3-15 June 22 – September 28 (Day 9): Ground data inference of percent corn infected plus severity levels in corn belt test area and intensive study area – from SRS/Washington to DRC/LARS and ASCS/Washington.

P3-16 June 16 – October 6 (Day 3 – Day 17): Ground Observation Summaries – from DRC/LARS to DRC/LARS and WRL.

P3-17 June 26 – October 9 (Day 13 and Day 20 – every Saturday): Two sets of color contact prints – from NASA/MSC to DRC/LARS.

P3-18 June 28 – October 11 (Day 16 and Day 25 – every Monday): Color prints of segments with instructions and questions – from DRC/LARS to ASCS and CES segment enumerators.

P3-19 June 23 – October 10 (Day 10 – Day 21): Analysis results of color-IR positive transparencies for 210 segments from DRC/LARS to DRC/ LARS.

P3-20 July 4 – October 10 (Day 21): Analysis results of spectral data for intensive area – from DRC/LARS and WRL to DRC/LARS.

P3-21 July 6 – October 12 (Day 23): Analysis results – from DRC/ LARS to SRS/Washington.

P3-22 June 22 – October 13 (Day 10 and Day 24): Summarization of Corn Blight Watch Experiment results – from SRS/ Washington to USDA Corn Blight Information Center.

P3-23 July 7 – November 15: Analysis and summarization of results – from DRC/LARS and other participants to all participants in the Corn Blight Watch Experiment.

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During Phase 3, a new mission was to start every 14 days – Monday **June 14, June 28, July 12, July 26, August 9, August 23, September 6, and September 20. Each mission was expected to be completed in 21 days and results were to be punched, checked, collated, and reported 23 days after the mission began. The day of each mission period that a data transfer was scheduled is also listed in Table 1.10.**

As in Phase 2, 1:120,000 color IR photography (film type 2443) would be collected over 36 flightlines. NASA/MSC would again identify the frame numbers to be analyzed and indicate the best frames when reflights were taken. NASA/MSC was to send two duplicate transparencies and two positive contact prints of all color IR photography to the data reduction center at LARS.

The WRL aircraft would collect multispectral data over the 30 segments in the intensive study area with all data to be checked at DRC/LARS, then immediately sent to the analysis center for processing.

When evaluation of data analysis should be required, low-altitude, large-scale photography would be collected over a number of segments within the intensive study area by Purdue (see Section III D). These data would be analyzed in conjunction with ground measurements to establish the exact condition of a number of fields. This information was then to be used either to evaluate the performance of photointerpretation or of machine-processed data results, or to determine the source of difficulty in data reduction.

Ground observations were to be made in a maximum of 12 fields in each segment early in each mission period. Reporting of ground observations would flow from enumerator to state SRS office to SRS in Washington, D.C., to the data reduction center at LARS. These ground observations were to arrive at LARS on day nine of the mission period, the same day the first shipment of processed film from NASA/MSC was to arrive. Ground observations data were expected to be made available to analysis teams the next day.

Color IR prints for each segment would then be edited and sent to the appropriate ASCS or CES enumerators along with instuctions and questions to be answered for each tract. This process was intended to acquaint the enumerators with photography of this type and also to establish a communications link between enumerators and data reduction teams.

In addition, results from photointerpretation and machine processing were to be punched, checked, and collated at the data reduction center at LARS, then be reduced to reports and sent to SRS in Washington and other participants in the Experiment. Also, results would be placed on a digital tape along with other data collected. This digital tape was to be described and made available for further analysis at the end of the Experiment.

Data flow to the public during the Experiment was to be to and through the Corn Blight Information Center at USDA. This procedure is detailed in Section VIII of this Volume.

C. System Description

The Corn Blight Watch Experiment Data Storage and Retrieval System was to be implemented in two subsystems. One, for general usage, would be called the Data Catalog (DC) and the other, specifically intended for CBWE use, was designated the Corn Blight Record (CBR). A specific description of these subsystems, their interaction, and use is the subject of this portion of Section IV.

Data Catalog

The Data Catalog, which would make use of an existing system at LARS, was to include a method of storing film, analog tapes, and digitized tapes for access by the Data Reduction team, combined with an indexing scheme and computer programs for listing information about the storage location of available data.

As data was received, it would be stored in a location specifically suited for the storage of its type of data format. The baseline photographs, for example, would be stored in a map file cabinet sufficiently large to preclude their folding or other damage. The 9×9-inch prints were to be stored in a file cabinet and the roll film kept in storage bins specifically constructed for either 9-inch or 70mm rolls of film. Analog and digital tapes would also be stored in appropriate environments. Finally, each set of data was to be assigned a storage bin number to aid in future retrieval.

At LARS, 15 of the flightlines recorded on analog tapes would be digitized and reformatted for storage on digital tapes. The remaining 15 flightlines of analog data were to be entered into the Data Catalog and sent to Willow Run Laboratories.

The next step in cataloging data was to be recording of the parameters of each segment for the intensive study area and each flightline for the remainder of the test area. The information, to be recorded on a data catalog form, would include the date, time, ground heading, equipment, film type, and type of data. The information from the DC form would then be punched on computer cards and entered into computer data files.

Storage and retrieval software was written that would make use of the data files in apprising analysis teams of identity and storage location of data available.

Both a short and long form of output (see Figure 1.12) were to be implemented, with the short form (table of contents) expected to be adequate in most cases due to the familiarity of the analysis groups with data collection. A number was to be included on the short form referring to a page in the more detailed long form Data Catalog. Data recorded in the long form DC was to include most or all of the parameters describing a flightline or segment. This information was expected to prove useful to interpreters having less familiarity with the data.

Since most data would be analyzed immediately upon arrival at the DRC, it was not expected that the Data Catalog would be greatly needed during CBWE execution. The Catalog was, however, expected to become valuable during post-Experiment analyses. At that time the organized data storage system and indexing schemes, along with the computer-generated reports, were expected to be of self-apparent use in expediting the location of data. It should also be noted that such a system had the potential of becoming the precursor of an on-line retrieval system.

Corn Blight Record

The other aspect of the data storage and retrieval system, developed specifically for the Corn Blight Watch Experiment, was to be centered around a set of computer tapes called the Master Corn Blight Tape. These tapes, which would contain a record of data collected and reduced for the CBWE (see Table 1.11), were to be the responsibility of the LARS Data Reduction Center. The tape was to be defined and created by June 10, using the input from Field Form A. Updating of the Tape was to be performed utilizing information from the most current Field Form B's, flight logs and DRC results.

Outputs required from the Master Corn Blight Tape during the Corn Blight Watch Experiment are detailed in Table 1.12. A ground observation summary was to take the form of a computer listing for both the photo data reduction teams and for the multispectral scanner data reduction teams. A complete computer-listed ground observation record of all data available would also be generated for both teams. Also, results and tabulations of data reduction efforts would be compiled in listings and tapes to be sent to the SRS Data Analysis Center.

A task timetable was to be set up to regulate inputs and outputs of the data storage and retrieval system. For Phase 1, the annotated baseline 1:20,000 scale black-and-white photography would be logged into the system. Also, data collected on the Form A (Initial Interviews) would be recorded on magnetic tapes by SRS, sent to DRC/LARS, and recorded on the Master Corn Blight Tape. During Phase 2, the color infrared photography (1:120,000 scale) and flight logs from NASA would be received and recorded, as would the data from the multispectral scanner flown by WRL's C-47. Soil experiment results would complete the data additions from Phase 2 of the Experiment.

During Phase 3, activities were to occur on a biweekly schedule starting June 14. Figures 1.13 and 1.14 and Table 1.13 detail the projected input and output activities during the eight biweekly periods included in this phase of the Experiment.

Format of Ground Observation Summary

The purpose of the Ground Observation Summary was to briefly list information that would be the most useful to the photo and multispectral analysis teams. The summary format was designed in such a manner that each segment would fit on one computer page in order to avoid confusion in handling several listings. Specifically, the segment and state identification were to be printed across the top of each page (see Figure 1.15). Following this, the flight log information (film roll number, date flown, time flown, frame number and FIPS number) would be given. The next information would consist of a listing of biweekly visited fields with specific data (field identification, number of acres in the segment, percent normal cytoplasm for blend fields, planting date, planting pattern, row direction, row width, subjective blight rating, objective blight rating, maturity, estimated number of plants per acre, plant height, other stress, and data of observation) on each.

This information would be printed one field per line, based on the most recent observation included on the Master Corn Blight Data Tape. Information on all other corn fields would include field identification, acres in segment, percent normal cytoplasm, planting pattern, row direction, row width, and estimated number of plants per acre. In this case data on two fields would be included on each line. Finally, all noncorn fields would be listed and information given on field identification, acres in segment, and land use. Four fields of this category were to be printed on each line.

Figure 1.15 contains a detailed layout of the Ground Observation Summary. X's denote that numerical information is placed in that position, while A's denote the placement of alphabetic information. The field identification code to be used would consist of two letters, a dash, and three numbers, with the letters signifying the tract and the numbers defining the field number.

Any tract defined with the lower case letters would show capital letters overprinted with slashes since lower case letters were not available on the print chain. Planting date and date of observation were to be listed as a two-digit month and a slash followed by a two-digit day number. Estimated number of plants per acre would be listed as a range of acres in thousands of acres. The stress would be represented as follows: by 0 (no stress), the name of the stress if one stress factor were present, or the word "SEVERAL" if several stress factors were evident.

All information listed would be obtained from the Master Corn Blight Data Tape, and, as with other outputs, these listings were to be produced on a biweekly basis as new information was obtained.

A format for the Ground Observation Record, data analysis results, and results analysis were to be designed during the course of the Experiment. This Record would list almost all parameters contained on the Master Corn Blight Data Tape and could serve as a readable listing of that tape. Data reduction results and tabulation outputs would be designed for biweekly reports of the most up-to-date CBWE information to SRS. Furthermore, analysis of data collected and reduced was expected to take place following conclusion of the Experiment, but programs for this purpose would be defined as the CBWE progressed.

Table 1.11 Data Contained on Master Corn Blight Tape

Data	Responsible Organization
Field Form A	SRS/USDA Data Processing
Field Form B	SRS/USDA Data Processing
Photo Data Collection Flight Log	NASA/Houston
Data Reduction Form A	LARS
Data Reduction Form B	LARS, WRL
Multispectral Data Collection Flight Log	LARS, WRL

Table 1.12 Master Corn Blight Tape Outputs

Output	Output Sent To
Ground Observation Summary	Photo analysis teams Scanner analysis teams
Ground Observation Record	Photo analysis teams Scanner analysis teams
Data Reduction Center Results	SRS/USDA Data Analysis Center
Data Reduction Center Tabulations	SRS/USDA Data Analysis Center

Table 1.13 Data Storage and Retrieval Biweekly Tasks

Task		
A. Log in multispectral scanner tapes as available	WRL to LARS	Day 1 to Day 14
B. List information for multispectral scanner data reduction teams	LARS to WRL	Day 3 to Day 14
C. Record initial ground observations as phoned from State office	SRS(IND) to LARS	Day 3 to Day 5
D. Record Form B ground observations sent by SRS	SRS to LARS	Day 9
E. Log in color infrared positive transparencies	NASA to LARS	Day 9 and Day 18
F. Record NASA flight logs	NASA to LARS	Day 9 and Day 18
G. List information for photo reduction teams	LARS to LARS	Day 9 and Day 18
H. Log in Film collected by Michigan	WRL to LARS	Day 10 and Day 18
I. Record data reduction results	LARS/WRL to LARS	Day 10 to Day 21
J. List results of analysis for county personnel	LARS to County	Day 13 and Day 21
K. Tabulate and list data reduction results and record on magnetic tape	LARS to LARS	Day 21
L. Deliver results to SRS	LARS to SRS	Day 23

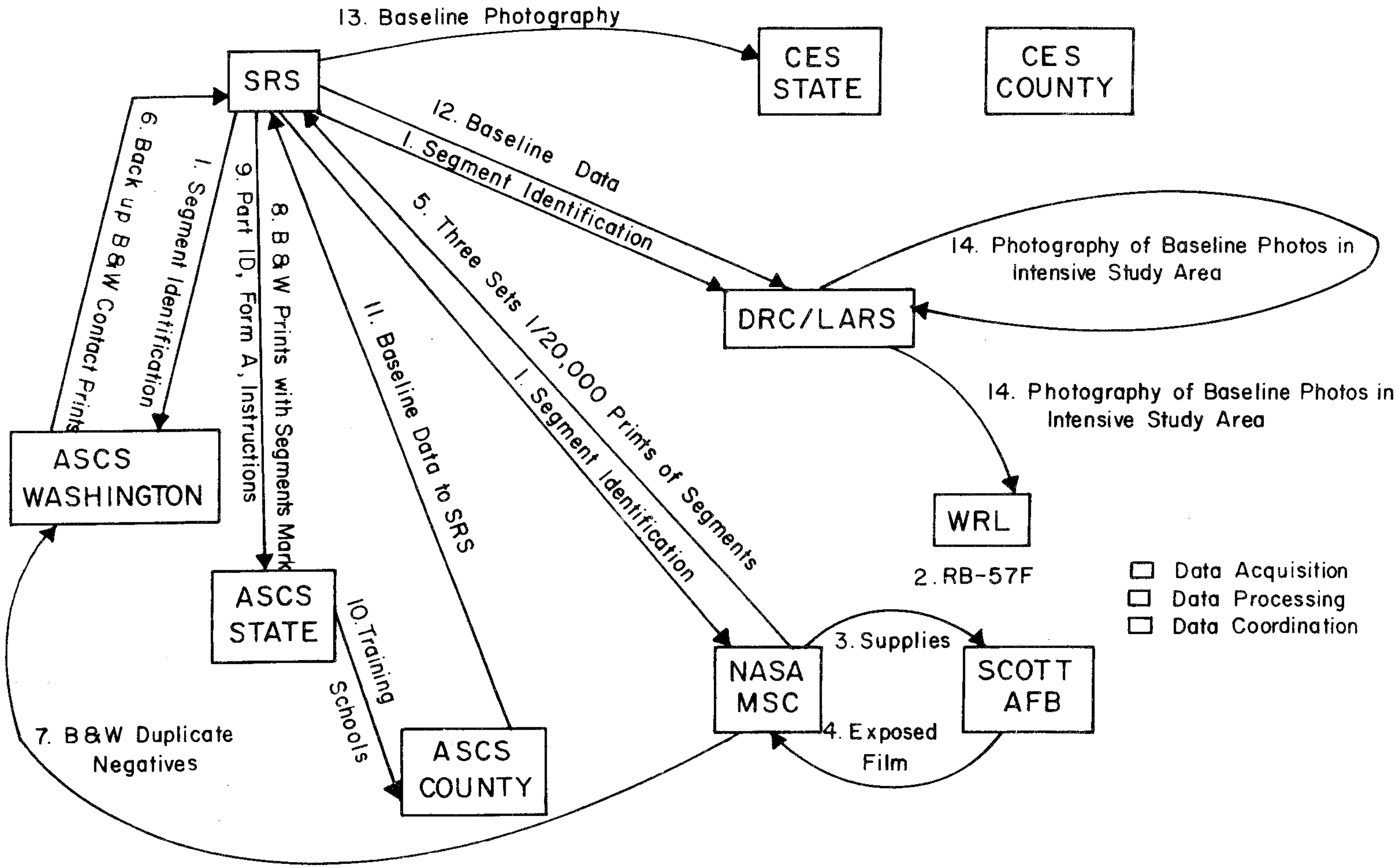

Figure 1.09 Phase 1 Data Flow for Corn Blight Watch Experiment

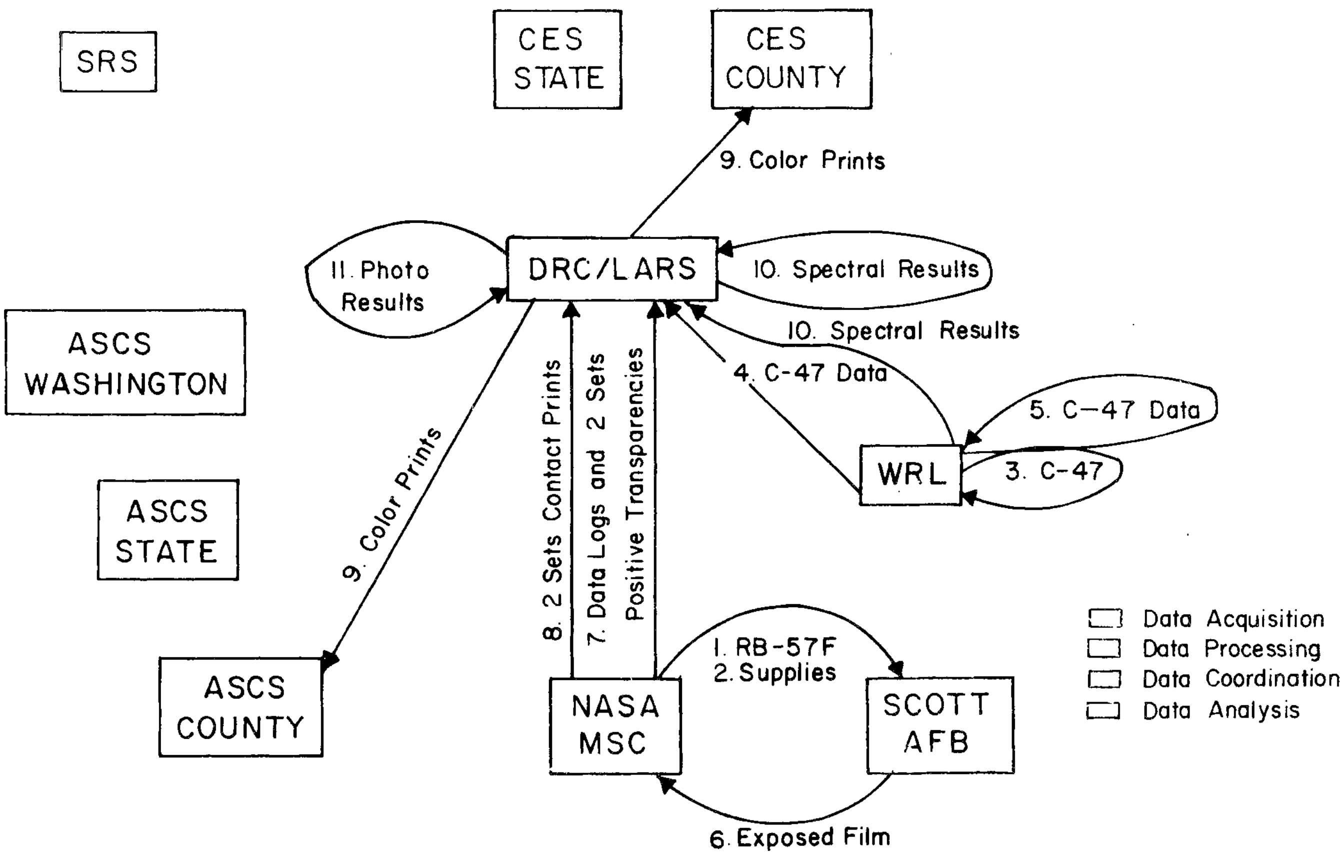

Figure 1.10 Phase 2 Data Flow for Corn Blight Watch Experiment

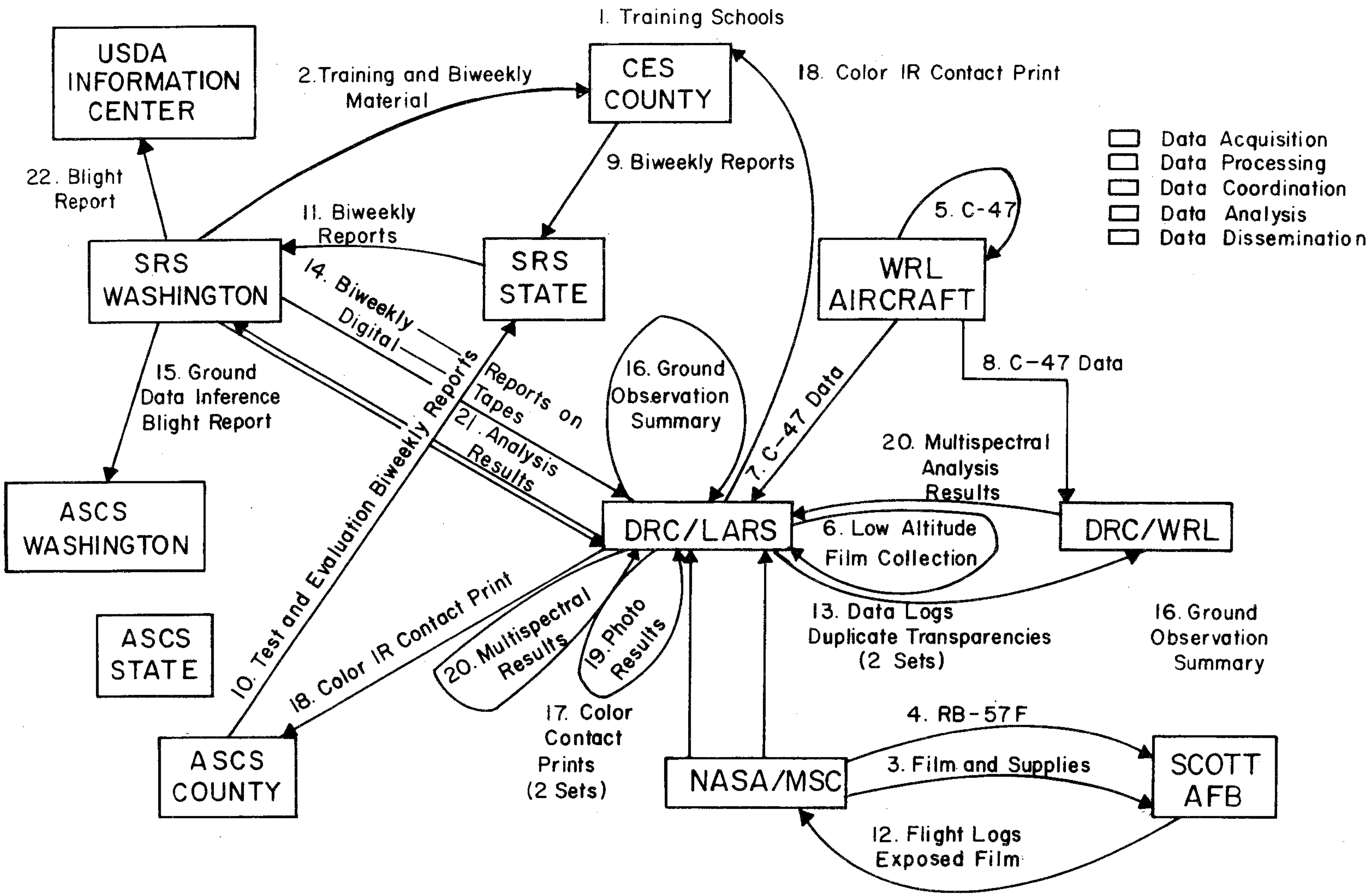

Figure 1.11 Phase 3 Data Flow for Corn Blight Watch Experiment

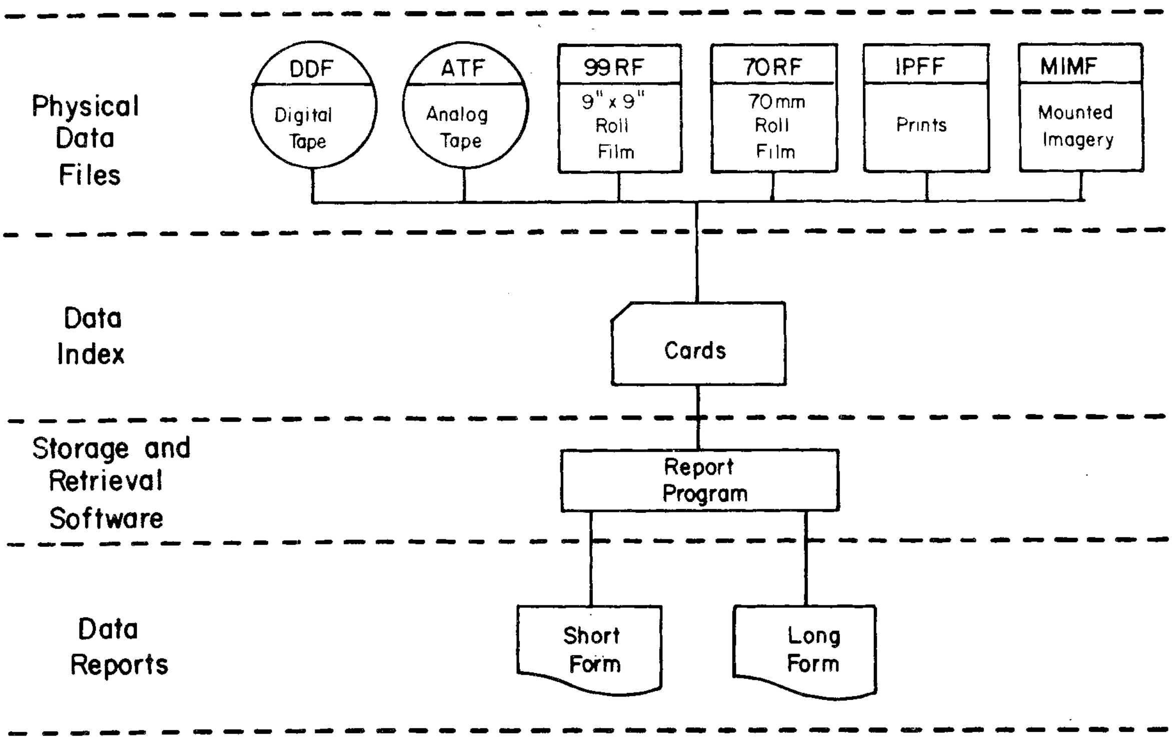

Figure 1.12 Data Catalog Block Diagram

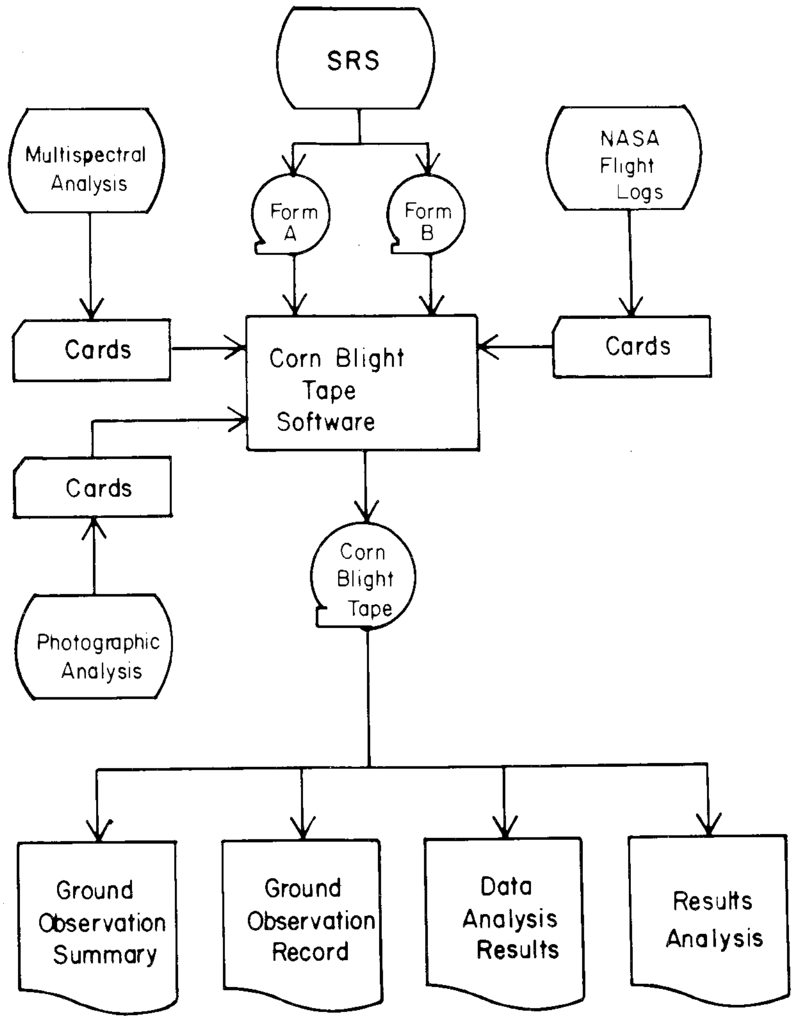

Figure 1.13 Corn Blight Record Data Flow

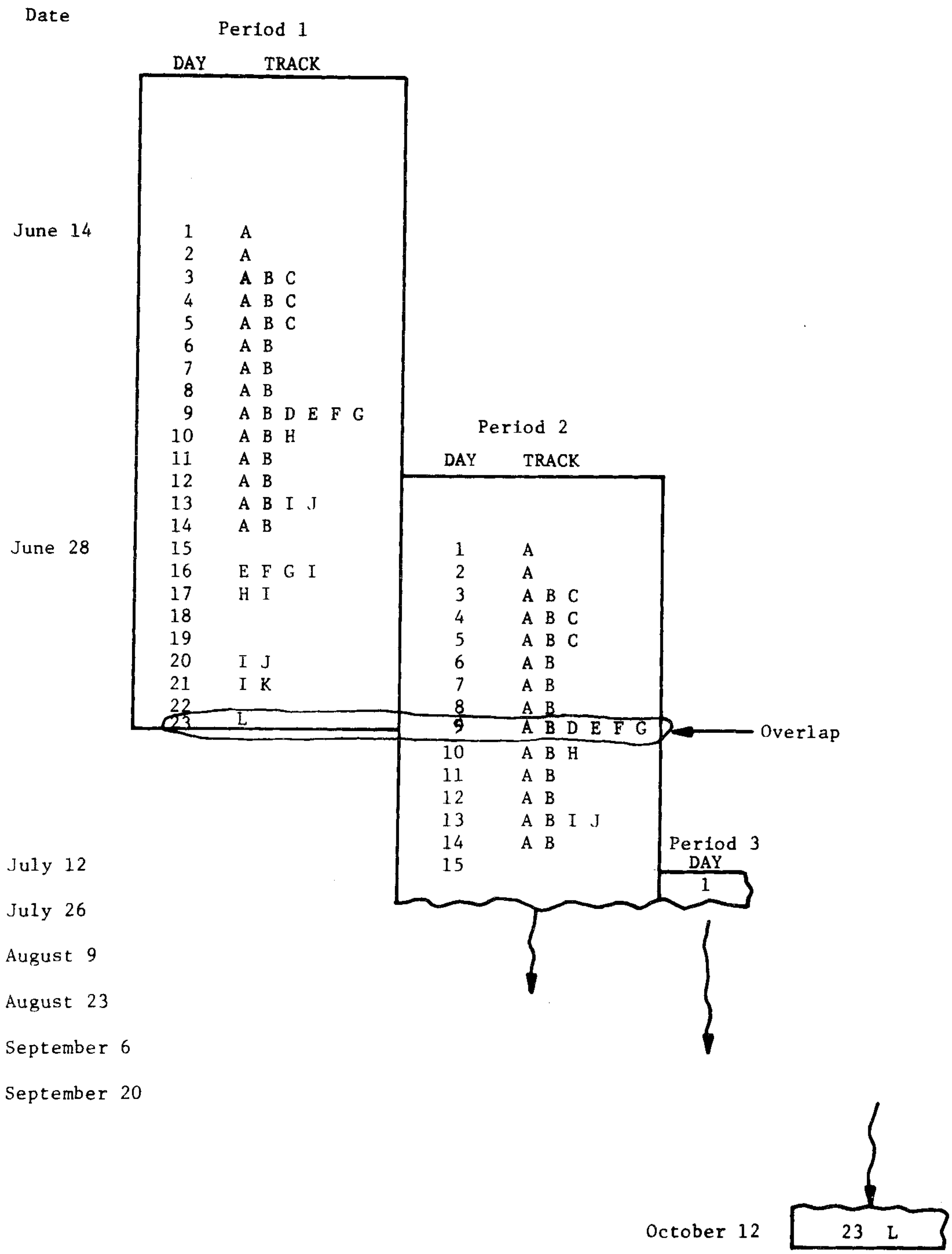

Figure 1.14 Calendar of Data Storage and Retrieval Tasks

LISTING DATE AAAA XX-XXXX

FILM ROLL NUMBER XXXXXX

SEGMENT XXX
DATE FLOWN XX/XX

STATE AAAAAAAA A
TIME FLOWN X XXX

FLIGHTLINE XXX
FRAME NUMBER XXXX

FIPS NO. XXXXXXXXXX

FIELDS VISITED BIWEEKLY

FLD. ID	ACRES IN SEG.	PCT N BLEND	PLANT DATE	PLANT PATTERN	ROW DIR.	ROW WIDTH	SUBJ BLIGHT	OBJ BLIGHT	MATUR	*EST PLANT	PLANT HGT	OTHER STRESS	DATE OF OBSERVATION
AA-XXX	XXXX	XX	XX/XX	AAAAAAA	AAAA	XX	XX	XX	XX	XX/XX	XX	X	XX/XX

OTHER CORN FIELDS

DATE OF COLLECTION XX/XX

FLD. ID	ACRES IN SEG.	PCT N BLEND	PLANT DATE	PLANT PATTERN	ROW DIR.	ROW WIDTH	*EST PLANT	FLD. ID	ACRES IN SEG.	PCT N BLEND	PLANT DATE	PLANT PATTERN	ROW DIR.	ROW WIDTH	*EST PLANT
AA-XXX	XXXX	XX	XX/XX	AAAAAAA	XXXX	XX	XX/XX	AA-XXX	XXXX	XX	XX/XX	AAAAAAA	AAAA	XX	XX-XX

NON-CORN FIELDS

FLD. ID	ACRES IN SEG.	USE	FLD. ID	ACRES IN SEG.	USE	FLD. ID	ACRES IN SEG.	USE	FLD. ID	ACRES IN SEG.	USE
AA-XXX	XXXX	AAAAAAA	AA-XXX	XXXX	AAAAAAAA	AA-XXX	XXXX	AAAAAAAA	AA-XXX	XXXX	AAAAAAAA

* Numbers Represent Thousands of Plants per Acre

Figure 1.15 Layout of 1971 Corn Blight Watch Ground Observation Summary

SECTION V – DATA REDUCTION

V. DATA REDUCTION

A. Ground Data

A large quantity of ground data was to be collected during both the initial interview survey and the biweekly field observations. It therefore became of paramount importance to the Experiment's execution that this large volume of data be reduced efficiently and accurately to useful information.

Ground Observation Field Codes

The field information was to be recorded on magnetic tapes by use of a 13-digit identification system. Every state in the study would be identified by its two-digit Federal Information Processing Standards (FIPS) number. The RB-57F flightlines (those which would be flown to collect color IR photography) would be numbered from 1-30 in the Corn Belt area and from 51-56 in the intensive study area during Phase 1. During Phases 2 and 3, the intensive study area segments would be numbered 41-46. (This numbering change was initiated to indicate that Phase 1 data would be collected from 50,000 feet while Phases 2 and 3 were to be overflown at 60,000 feet).

In addition, each segment in the Corn Belt area was to be numbered from 1-180 and those in the intensive study area from 201-230. Tracts (areas within a segment farmed by one operator), would be numbered in segmental sequences with fields within each tract numbered in a similar manner.

13-Digit Field Designator

State	Fltline	Segment	Tract	Field
44	030	169	022	11

The listing of ground observations for the analysts at LARS and WRL would use the same ID number except that the three-digit tract number would be replaced by a designated letter. This was necessary in order to coordinate the ground observations with the black-and-white baseline photography which used letters for tract identification. The sequence would run through upper case letters (1-26), double upper case letters (27-53), triple upper case letters (54-80), and lower case letters (81-107), etc.

Ground Observation Field Designator

State	Fltline	Segment	Tract	Field
44	030	169	V	11

Initial Interview Survey

The first step in the planned data reduction process would be the mailing of completed Form A interview forms to the Statistical Reporting Service in Washington, D. C. There, the forms would be reviewed and all necessary coding and editing done to prepare them for keypunching. Preparation for keypunching was to be facilitated through appropriate formatting of Form A. Despite this, dates and crop type or land use would have to be coded at this time since they would not be precoded at the time of form completion.

Crop entries were to be based on field *use* rather than field *content*. For example, a field of clover would be coded by its intended use (hay or pasture) rather than as by its content, clover. This emphasis on land *use* would reduce the number of field codes needed to about 40.

Once the Form A's were coded and edited, actual keypunching was to be performed by a commercial contractor because state SRS offices would be working to capacity with other major surveys to be processed during the same period. Card format for the Form A was to be designed in such a manner that all data for one field could be punched on one card.

Upon return from the keypunch contractor, the data cards would be processed through an error-edit program which would identify errors in the data due to improper editing, coding, and keypunching. Fields with errors were to be corrected and repunched.

When all forms for a segment had been processed and errors corrected, a corn field printout would be run off, with the fields categorized by cytoplasm type. This printout would then be used to select the sample corn fields within the segment (see Section II).

Upon final completion of all processing, data for fields enumerated in the initial interview survey would be compiled in a segment printout which, along with a corresponding data tape, would be sent to the Data Reduction Center at LARS (see Section IV-B).

The data from the initial interview survey was to be presented to the analysts at the DRC in a manner that would facilitate the analytical process. Form A codes would be translated and, although all information would be available, only the necessary entries--crop or land use, acreage, planting date, cytoplasm type, row width, plant population, and row direction--would be included for the analyst's information.

Biweekly Field Observation Survey

Unlike the Form A, the Form B (Field Observation) data would be edited and keypunched at the state SRS offices before mailing to the Washington, D. C., office for processing. Performance of the editing and keypunching in individual state SRS offices was expected to both spread out the workload and reduce the time required to transit from field observations to processed data, and to take advantage of the experience and ability of the state SRS offices in handling data quickly.

Most of the editing was to involve the compilation of individual plant observations into unit totals, since only the unit totals would be keypunched. In addition, checks would be made for reasonableness and adjustments made for missing individual plant data since most items would be processed as totals of five plants.

Keypunched cards and Form B's were to be sent from state SRS offices to SRS-Washington on Friday of the scheduled survey week. On Monday, the SRS-Washington office would review the forms and check for valid identification, editing, and completeness. Each error was to be corrected and all field observation information placed on a data tape to be sent to the Data Reduction Center at LARS.

As with the Form A data, the Form B data was to be reduced to information which would facilitate DRC analysis. The most important item was expected to be the description of blight severity. This could be presented as either the unit blight severity rating assigned by the observer, or as a calculated objective blight class, based on the percentage of the lower and upper leaf area infected by SCLB lesions.

Other items which would be important to analysts were the estimate of plant population (calculated from the row width and plant count measurements) and percentage of plants with tassels. In addition, a leaf index (the ratio of leaf area to unit ground area) would be calculated from the plant population, number of leaves, and leaf length and width measurements.

Supplementary information which would be made available to the analysts was to include: stage of maturity, presence of other stress conditions, and representativeness of the sample units when compared with the rest of the field.

Summary Tables showing the frequency of specified stress factors would be presented to the National Corn Blight Information Center and the USDA Crop Reporting Board. Items to be included in this summary were: number of fields reporting each blight severity level, number of fields in which infection exceeded specified percentages in upper and lower leaf areas, and number of fields with ear and/or stalk rot.

Since a stratified sample of fields was selected and the acreage of each stratum (cytoplasm) and the proportion of the total area to the sample acreage was known, statistically valid inferences for the whole experimental area could be made. Therefore, the final part of the data reduction and analysis process would involve the input of the biweekly field observation data into a statistical model which would be used to expand the data from the eight to ten fields in each segment to an estimation of blight severity acreages (or other parameter acreages) for the entire segment, flightline, and region.

B. Photographic

The methodology of aerial photographic coverage and interpretation, combined with statistical sampling techniques, is not a new one in its application to various types of resource surveys. Foresters, geologists, geographers and land-use specialists have used the techniques extensively. Indeed, the increased precision that has come with technological advances in image acquisition systems forecasts an even more extensive use in the future. However, at the inception of the 1971 Corn Blight Watch Experiment, application of these methods to general agricultural surveys had been slight.

In addition a review of university curricula would have discovered that little attention was being paid to photointerpretive training in agriculture. Formal courses in photointerpretation processes were usually found in Forestry, Civil Engineering, Geology, and Geography departments. It was, therefore, to be assumed that there were few trained agricultural photointerpreters (PI's).

The Photographic Data Reduction portion of the 1971 Corn Blight Watch Experiment, therefore, had two unique aspects. First, it applied aerial photography and statistical sampling techniques to the identification and monitoring of an agriculturally important crop disease spread over a large geographical area. Second, the Experiment had to utilize test area personnel who were not trained in photointerpretation to accomplish the analysis of the photography.

Organization

Realizing the need for trained photointerpreters but understanding the unavailability of such personnel, the Corn Blight Watch Executive Committee requested the support of participating federal and state government agencies in recruiting people to be trained as photoanalysts. These personnel would be required to participate in two training sessions and to spend the summer at LARS Photo Data Reduction Center (PDRC).

Photointerpretation personnel were required to have, or be working toward, an agriculture degree in the plant sciences or to be skilled photointerpreters. All personnel would receive training in the fundamentals of both photointerpretation and corn blight identification.

A total of 12 analysts plus four supervisory personnel were requested as staff for the PDRC. ASCS made 10 people available, of whom five would be selected as PI's. Ideally, it was hoped that the remaining seven PI's would come one from each of the participating states. The remainder of the staff would consist of a representative of the Agricultural Research Service and four people on the LARS staff who would have the responsibility of training the PI's and coordinating the analysis procedures. Three of the LARS personnel, designated as Area Coordinators, would be responsible for three geographic areas within the seven-state test area.

Each coordinator would guide the effort of two-man analysis teams, each of which had been assigned specific areas to analyze throughout the Experiment. This responsibility was to include overseeing the analysis and ensuring a steady flow of verified results to the fourth LARS staffer, designated Chief Coordinator, who would be responsible for the overall operation of the Photo Data Reduction Center.

Where possible, individual analysts would be assigned areas within their home states. Also (depending on weather and flights in obtaining the photography), analysts would work with the same test segments throughout the Experiment. Each analyst was to be responsible for interpreting approximately 15 to 18 segments, with the analysis expected to take no longer than two weeks and, ideally, to proceed more rapidly.

Since most of the personnel in the Photo Data Reduction effort would not be fully trained PI's, some deviations from normal photointerpretive processes were necessary. The primary difference was that identification of crop cover types would not be required. This information would be gathered for each test segment prior to the collection of the first set of color infrared photographic data. The problem then would become only one of judging the effect of blight on corn as distinguished by varying hues on color-IR films. It was this procedure, therefore, that is referred to as photointerpretation.

PI Selection

Applicants for summer positions as PI's were required to spend one day at LARS during mid-April in order to be interviewed and tested. The test and interview procedure was originally designed to select PI's from the personnel made available by the cooperating agencies. However, since ASCS was the only agency to make more personnel available than would be needed, only they were thoroughly tested prior to a May 5 training session. Testing included color blindness, stereo perception, PI acuity and agronomic aptitude examinations designed to measure ability and aptitude for photointerpretation and understanding of corn and agronomic problems (see Appendix I-B).

The interview portion of the day would allow LARS personnel to become acquainted with the applicants and determine their attitude toward the Corn Blight Watch Experiment. It was considered desirable that trainees be strong in visual acuity, power of observation, imagination, patience, judgment, and especially learning capacity. Overall, the test and interview procedures were designed to indicate an applicant's potential for training as a photointerpreter and his motivation toward the Experiment.

PI Training

In addition to the testing, a two-day workshop entitled "Fundamentals of Photointerpretation," to be given by personnel from the University of California's Forestry Remote Sensing Laboratory, under the direction of Dr. Gene Thorley and Don Lauer, was scheduled for May 5 and 6 at LARS.

Workshop lecture material and related laboratory exercises (see Table 1.14) were designed to familiarize an untrained individual in the basic uses of aerial photography. It was hoped that motivation would be aroused through practice of actual interpretation procedures during the laboratory portion of the instruction. In addition, as confidence was gained by the individuals, an actual interpretation problem dealing with identifying wheat and barley on 1:120,000 scale color imagery was to be assigned.

During the last part of the two-day workshop, participants would review examples of the 1970 corn blight as it was encountered in western Indiana and be given the opportunity to interpret examples on high-altitude photography. This session was intended to indicate the feasibility of identifying corn and determining the severity of a disease from small scale aerial photos.

An additional training session, designated an "Intensive Study Program" (see Table 1.15) was scheduled from June 7 to June 11 at LARS. This session was designed to familiarize analysis trainees with the photoanalysis portion of the experiment.

In order to provide a background for the crop variation that photoanalysts would be viewing, members of the LARS staff would present slide lectures displaying and describing stages or corn maturity and nutritional, cultural, and pathogenic factors that would alter normal growth appearance. In addition, the Southern Corn Leaf Blight problem of 1970 and the associated analysis performed that year were to be reviewed to acquaint analysts with the scope of the disease. Participants were also to be given an overview of the Experiment including goals, blight predictions, and the role of ground observation data.

The major portion of the Intensive Study Program, however, would be a simulation exercise designed to approximate the actual working procedures of the 1971 Corn Blight Watch Experiment. Analysts would use the same equipment (tube magnifiers, stereoscopes, and rear projection viewers), data input and results forms to be used during the actual experiment as they examined 1970 small scale (1:120,000) black-and-white baseline photography. They were to use the 1:120,000 black-and-white baseline photography in learning to identify test sites on the color infrared transparencies, and ground observations listed on the Ground Observation Summary in training themselves to recognize blight-originated differences in the appearance of corn fields. Finally, they would record their evaluations and comments for all corn fields within the test site on Data Reduction Form A.

Soil Training and Phase 2 Image Analysis

Prior to receipt of the first Phase 3 photographic data, the photoanalysts were also to receive fundamental training in aerial soil

Table 1.14

Fundamentals of Photointerpretation

Workshop Agenda

May 5, 1971

8:30 a.m.	INTRODUCTION Scope and objective of project Definition of terms Historical development Advantages and limitations Brief survey of applications of Remote Sensing
10:15 a.m.	COFFEE BREAK
10:30 a.m.	PROCUREMENT OF AERIAL PHOTOGRAPHY Vehicles Cameras Films Demonstration of various types of photography
	SCALE RELATIONSHIPS
12:00 p.m.	LUNCH
1:00 p.m.	STEREOSCOPY Monocular depth perception Binocular vision Stereo depth perception Accommodation Naked eye stereo
2:30 p.m.	COFFEE BREAK
2:45 p.m.	STEREO VIEWING AND EXERCISES
4:30 p.m.	ADJOURN

May 6, 1971

8:30 a.m.	PHOTOINTERPRETATION PROCESS Detection Delineation - shape, size, tone or color, texture Identification shadow, location, association, etc. Evaluation
9:45 a.m.	CONVERGENCE OF EVIDENCE

(Table 1.14 continued)

10:15 a.m.	COFFEE BREAK
10:30 a.m.	EXERCISE ON PI PROCESS
12:00 p.m.	LUNCH
1:00 p.m.	APPLICATIONS, CASE STUDIES AND EXAMPLES OF PHOTOGRAPHY Raisin lay surveys Fruit and nut crop surveys Livestock surveys Land use mapping Cereal grain surveys
2:30 p.m.	COFFEE BREAK
2:45 p.m.	WORKSHOP (Individuals will study examples of high-altitude photography taken of the Corn Belt. Discussions will center on preparation of PI keys, ground truth, PI process, compilation of results).
4:30 p.m.	ADJOURN

Table 1.15

Intensive Study Program

Agenda

Location: Unit B, Flex Lab II, Purdue University

Monday a.m.	INTRODUCTION Purpose of the intensive training Experimental Objectives Overall program Photoanalysis program Review of facilities Equipment
Monday p.m.	FIELD TRAINING REVIEW ASCS - Field Form A CES - Field Form B
Tuesday a.m.	IDENTIFICATION AND INTERPRETATION Corn Primer Soybean Primer Corn blight review
Tuesday p.m.	INTRODUCTION OF SIMULATION PROCEDURES Analysis Procedure Data Catalog Ground Observation Summary DRC Form A Recording Data Filing
Wednesday a.m. to Friday p.m.	SIMULATION EXERCISE

identification and to perform a basic analysis of the Phase 2 soils data, in preparation for examination of data acquired during Mission 166. Accordingly, Prof. Robert Miles of Purdue's Air-photo Identification Laboratory was asked to present a one-half to one-day course covering this type of identification, with emphasis to be placed on land-forms and soil categories that could be expected to occur within the seven-state test area.

Mission 166, flown in early to mid-May, would acquire 1:120,000 color-infrared photography for soil baseline delineation. The analysis of this imagery would be used to

- Acquaint analysts with those segments they would analyze throughout the Experiment
- Classify subregional characteristics around the segment that might be an influence in future analyses
- Classify the predominant soil tone or tone/pattern relationships in corn fields within the segment boundaries.

Appendices I-C and I-D are samples of forms which would be utilized during Phase-2 analysis. Appendix I-C (Regional Analysis of segments from Phase-2 Imagery) would require analysis (topography, drainage, pattern, tone, and predominant land use) of an entire frame containing a segment.

Analysts would be required to circle the description that best defined the regional characteristics of the frame. Additional space was provided for comments which might be valuable in future analyses. Appendix I-D (Analysis of Phase-2 Imagery) was the form to be used in identification of the predominant soil tone or tone/pattern relationships that existed within corn fields over the test area. The analysts were required to classify the soil tones or tone/patterns into one of the following categories:

L - Predominantly light soils
D - Predominantly dark soils
L/D - Light soils with a dark pattern
D/L - Dark soils with a light pattern
M - Mixed or mottled tone or pattern.

Additionally, the analyst was required to determine if the soils within a field exhibited any signs of erosion.

Information from both forms would be helpful in future analyses since it would allow the analyst to determine if abnormalities detected within corn fields were a function of the soil tone or tone/patterns, or of a stress condition such as blight. Both soil analysis forms were to be retained for ready reference. This analysis of the Phase 2 imagery would continue until receipt of the first Phase 3 imagery.

Phase 3 Analysis

In addition to the handling of photo input, already detailed in the Data Flow subsection of Data Storage and Retrieval (section IVB), one set of duplicate transparencies received at the Photo Data Reduction Center on the 9*th* and 16*th* day of each mission period would be reviewed by the area coordinators for image quality and coverage, then roll and frame numbers for the frame to be used in the segment analysis would be indicated. Manipulation of the roll film (cutting and splicing for continuity of analysis) would be done at this time.

All photoanalysis personnel were to train themselves with current photography and ground observations collected over their area of concentration. Area coordinators would supply additional information when applicable or as necessary. This information might include:

1. Soil conditions or crop status that might be expected during the period of overflight;

2. General review of the corn blight situation for the area of interest; and

3. Review of any analysis aids that might be of use during each analysis period.

In addition, analysts would be trained on imagery collected over the intensive study area and be required to analyze test segments within that area. Large scale (1:20,000 or larger) color-infrared photography was to be collected by Purdue University's Beechcraft (see Sec. IIID) over test segments within that area This photography could be used as an additional observation in lieu of further ground measurements. It would also be used as a standard to evaluate the accuracy of the photoanalysts in interpretation of the small-scale photos from the RB-57.

This evaluation procedure was considered necessary in order to determine the efficiency of the analysts and to correct for human error in the analysis procedure. The assumption made was that analysts would make consistent errors regardless of the area for each mission period. The error, however, might vary between missions, so the evaluation step would be required for each mission.

During analysis of segments within the seven-state and intensive study areas, three techniques were to be used and subjectively evaluated:

1. Monocular vision with 8 to 10X magnification

2. Binocular reinforcement using stereo images obtained with either a Zoom 90 stereoscope or old Delf scanning stereoscope

3. Variscan rear projector viewers

The analysis procedure to be followed would be identical for each analysis system used. Each analyst would:

1. Locate the segment on the current 1:120,000 scale

photography using the 1:20,000 black-and-white baseline photography;

2. Locate the corn fields within the test segment;

3. Train himself to recognize different levels of blight infection on a subsample of the fields that were ground checked (if current ground observations were not available for a segment, analysts would use current data from the nearest segment for training purposes);

4. Formulate, in his mind, the conditions he would expect to find on the remainder of the fields in the test site;

5. Test himself on the remaining fields that had ground data available;

6. Evaluate his results and either continue to complete the segment or ask for help;

7. Fill in the required form and continue on to the next segment.

As an aid in the analysis of the test segments, photo analysts would have available the Ground Observation Summary. Additionally, if needed, color infrared soils photography would be retrievable for sequential analysis of the test segments.

Results of the analysis of the test segments were to be reported on Data Reduction Form A (see Appendix I-E) which, along with the soils analysis forms and a sequential set of photography, would be filed by segment and flightline number.

Facilities

During its operation from early June to mid-October, the Photo Data Reduction Center was to be housed in Unit B of Flexible Laboratory II, at LARS--made available through funds from the Purdue University Agricultural Experiment Station.

Unit B is approximately 3,800 square feet in area, of which 2,000 square feet were to be used for Photo Data Reduction. Interpretation equipment located in the unit was to consist of:

* Six Houston Fearless Variscan rear projection viewers with variable (3, 6, 12 and 36X) magnification capability;

* Two Richards single-channel light tables, each equipped with a Bausch and Lomb Zoom 70 microscope;

** One Bausch and Lomb Zoom 90 stereoscope, modified to adapt to a Richards single-channel light table;

* Two aerial film plotting tables;

* One Houston Fearless motor-driven splicing table;

* One Graphic Arts light table.

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* Indicates equipment made available by ASCS from government surplus.

** Indicates equipment from NASA/MSC.

All support and clerical equipment was made available by LARS.

C. Multispectral Scanner

The multispectral scanner (MSS) coverage of the intensive study area planned as part of the 1971 Corn Blight Watch Experiment would provide an opportunity to assess the usefulness of MSS data and associated automatic data processing techniques in providing timely and objective surveys of crop disease situations. In addition, since ground observations and aerial photography were to be available over the same area covered by the MSS (see Section III), the possibility existed of evaluating the effectiveness and relative costs of each of these data sources alone and in combination.

As with ground observations and aerial photography, the MSS data were to be analyzed to detect the occurrence, spread, and severity of Southern Corn Leaf Blight in the intensive study area. Results were to include mission-by-mission determination of the condition of all corn fields comprising the western Indiana statistical sample defined by SRS.

Specifically, it was intended to discriminate six levels of SCLB severity and provide acreage measurements to indicate the extent of each severity level. From these results, inferences were to be drawn by SRS concerning the overall condition of the crop in the entire intensive study area.

LARS and Willow Run Laboratories were to cooperate in performing the MSS data analysis, each facility processing data from 15 of the 30 segments in the intensive study area (section II).

In order to meet the objectives of the Corn Blight Watch Experiment, it was vital that the Experiment timetable be rigidly observed. In particular, this required that the MSS data analysis results for each mission be available for preparation and transmission to SRS by the end of day 21 of that mission. Although the average time available for analyzing the data from any given site was expected to be greater than 14 days, in case of unfavorable weather it could be as short as seven days.

Collateral Data

The principal data input for this portion of the Experiment was the multispectral scanner data collected by WRL. However, other forms of data were expected to support the MSS data analysis. These included:

- Black-and-white photography (70mm) collected by the MSS aircraft coincident with the scanner data. This would be particularly useful for early evaluation of the collected MSS data. If, for example, cloud cover over a site were found in the photography to exceed acceptable levels, a reflight of the site could be requested immediately.

- Color and color IR photography (70mm) collected by the Purdue Beechcraft. This photography would provide an indication of spectral uniformity within agricultural fields and aid in explaining anomalous situations observed in the MSS data. It would also be valuable in selection of training samples and in postanalysis evaluation of the data reduction results.

- Initial (Form A) surface feature information indicating ground cover types, acreages, etc. This would be the only source of information concerning noncorn surface features.

- Current (Form B) ground observations for corn fields selected by SRS. This information would be the basis for the analysis of each mission, since training samples would be drawn from these corn fields.

- Soil and topographical maps, as available.

Results

The results of the MSS data analysis for each mission were to be reported as follows:

- Number of acres in each segment classified into each blight severity level.

- Estimates of Type 1 and Type 2 error rates. Type 1 was false dismissal, in this case, classification of corn as noncorn. Type 2 was false assignment, classification of noncorn as corn.

- Evaluation of each corn field. This was to include a percentage classification into each blight severity level plus a uniformity rating for each field both of which would be visually estimated from the computer-generated output (see Appendix I-H).

WRL was to be responsible for communicating to LARS the analysis results for their segments. LARS would then forward all tabulated MSS data results to SRS.

Data Analysis Specifications

In order to satisfy the specifications of the statistical design a conscious effort was to be made to limit the analysis to the areas within the specified segment boundaries. Accurate overflights would minimize any problems in this area.

No special preprocessing of the MSS data was expected to be necessary (e.g., to remove view angle/sun angle effects). However, in case preprocessing should prove to be required or desirable, the data processing procedure would be modified appropriately.

In order to produce comparable results, LARS and WRL were to establish analysis procedures as similar as possible. However, a basic difference existed in that LARS' operational classifier was implemented on a digital computer and operated on digitized data, whereas WRL's classifier was an analog processor and operated on analog MSS data. This was not expected to be a major problem, though, since both classifiers were based on the same underlying theory and both implemented decision rules of the same functional form.

Some differences in analysis details would be virtually unavoidable. LARS planned to restrict their analyses to the use of four spectral bands for classification since a substantial penalty in processing time would result from use of more than four bands on the digital system. WRL planned to use six spectral bands which would involve little additional cost on the analog system.

On the other hand, WRL's SPARC processor was limited to recognition of eight classes of ground cover (although some consideration was given to increasing this to 12, if time and funds for minor modifications to the hardware could be found). LARS' setup was limited to about 60 classes, which was expected to be more than ample for the Experiment needs. The net effects of these differences were expected to be offsetting in terms of overall classification accuracy.

LARS' responsibility included selection of the spectral bands to be used by each facility. For each mission, data from representative segment of each of three regions (North, Central, South; see Figure 1.05 following Section III) were to be analyzed to determine the best sets of bands for discriminating corn from everything else and for distinguishing the six levels of Southern Corn Leaf Blight.

Each facility would define ground cover classes corresponding to the blight severity levels for which ground observations were made, plus as many "other" (non-corn) categories as feasible and necessary for accurate classification. It was decided that it probably would be preferable to define classes for each segment based on the ground observations within that segment. However, given the size of the ground observation samples (8-10 fields per segment) it was considered likely that instances would arise in which all blight severity levels present in a given segment would not be represented by ground observations within that segment.

If this situation were encountered (or suspected), the possibility of using data from nearby segments to supplement that from the segment in question would be considered. However, the factors of proximity, in terms of both distance and time of scanner data collection, would also have to be weighed.

SECTION VI – ANALYSIS OF RESULTS

VI. ANALYSIS OF RESULTS

As has been detailed in previous sections of this volume, there were to be three major sources of the data which would be collected and reduced during the span of the Corn Blight Watch Experiment. To review, these were:

1. Ground observations collected for selected corn fields located in the 210 segments in the test area,
2. Color infrared photography over the 210 segments in the seven-state Corn Belt and intensive study areas, and
3. Multispectral scanner data collected over the 30 segments within the intensive study area.

Reduced data from each of these sources would flow into an Analysis Center where they would be summarized and used in statistical models that would elicit information on levels of corn blight infection. Through the expansion of ground observation data and remote sensing classifications (see next subsection) these models would also provide estimates of the number of acres of each blight level present in the nonintensive and the intensive study areas. Intermediate steps would provide estimates for individual segments and flightlines.

Another major function of the Analysis Center would be to fully analyze, evaluate, and interpret the experimental results. Most of these analyses, however, would not be carried out until the conclusion of the Experiment when all the ground data had been collected and all multispectral scanner data and aerial photography had been classified or interpreted. Such <u>final</u> statistical analyses would thus be more detailed and complete than those which would be implemented during the <u>operation</u> of the CBWE.

The major analyses to be carried out would include evaluations of the reliability and consistency of the remote sensing classifications, comparison of ground and remote sensing estimates of blight infection and the variances of these estimates, and comparison of PI and MSS results. Other important analyses to be conducted after the Experiment would include comparisons of the sampling models used in the intensive and nonintensive study areas and determination of optimal combinations of ground and remote sensing data.

A. Expansion of Results

The sampling design and information collected during the Initial Interview Survey and Field Observation Survey were to be used in expanding the raw ground observation results to separate estimates of the corn blight situation for the intensive and nonintensive study areas. Combining of these results would give an estimate for the entire test area. The MSS and PI results would be expanded similarly to the ground data, but separately from it and from each other.

Individual steps in the expansion model were to provide separate estimates of the acreage (by cytoplasm type) of each blight level in individual segments and flightlines. Cytoplasm figures would then be combined to provide estimates for the whole segment, flightline, or area.

Basically, the expansion would work as follows: in each segment, the proportion of each cytoplasm type with a particular blight level (as observed in the field) would be assigned to all fields of that cytoplasm type. For example, suppose four units in fields with TMS cytoplasm were rated and one of them had blight level 3. The total number of TMS acres present in the segment would then be multiplied by 1/4 and the result would be an estimate of the total number of blight-level-3-infected acres of TMS corn in the segment. The same procedure would be repeated for each cytoplasm/blight level combination in that segment and for each segment in the flightlines.

The next step would then be to combine the level 3-TMS estimates from all segments in the flightline and expand (multiply) that total by an expansion factor to achieve an estimate for the whole flightline. The expansion factor used would depend on the proportion of the total flightline included in the segments. Finally, flightline estimates would be multiplied by the proper expansion factors to obtain estimates for the entire test area.

The same expansion procedures would be followed for MSS and PI results except that, instead of units, the proportion of acres with each blight level would be used. Before this procedure, both MSS and PI results would have been converted to acres of each blight level present in each field (see next subsection).

At the same time the expansion was accomplished, variances would be calculated for each stage (field, segment, flightline, test area) in the multistage sampling model. Knowledge of such variances would be necessary in order to construct confidence limits and make valid inferences about acreage estimates, since it would be the variance which determined the precision and reliability of the acreage estimates.

B. Summarization of PI and MSS Results

A first step in the analysis of the remote sensing results would be the conversion of the photointerpretation and multispectral scanner classification results to acreage figures. This would then put these two sources of information on a common basis with the expanded ground observations, and make direct comparision of results possible.

For both PI and MSS data sources the acre conversion to be used as a preliminary to the expansion process would be:

$$\hat{X}_{jb} = A_j P_{jb}$$

where $\hat{X}_{jb}$ was the number of acres of field j with blight level b, Aj the number of acres in field j and Pjb the proportion of field j classified or interpreted as blight level b. The latter proportion (pjb) of each field classified into each blight level would come from Data Reduction Forms A and B, for PI and MSS data respectively; and the acreage figures (Aj) would be obtained from the Master Corn Blight Tape.

For both PI and MSS results an adjustment would have to be made for fields or portions of fields neither interpreted nor classified as corn. However, since PI's would be interpreting only fields known to be corn, the adjustment was expected to be significant in only rare cases. The only decrease from the number of acres indicated by the Initial Interview Survey would be a result of drowned out areas in fields, fields hidden by cloud cover, changes in crop planted, or failure to locate fields in the photography.

For the MSS analysis, where the more difficult task of classifying the entire segment (including noncorn fields) would be attempted, the problem would be more complex since some corn might be classified as noncorn and some noncorn areas as corn. In this case, a different procedure, outlined below, would be followed to arrive at the number of acres of each blight level.

To determine the number of acres of each individual blight level (A_b) present in a segment, the equation:

$$\hat{A}_b = \frac{\hat{N}_b A}{N}$$

would be used; where A was the number of acres known to be in the segment and $\hat{N}_b$ the number of points classified as blight level b. $\hat{N}_b$ would be determined for each blight severity level.

To evaluate the accuracy and reliability of corn vs noncorn classifications, a different approach would be used. In this case two kinds of error rates would be calculated. A type 1 error was defined as corn classified as noncorn; while a Type 2 error was noncorn classified as corn. The Type 1 and Type 2 error rates, E_1 and E_2, were not independent and each could be written as a function of either N corn/noncorn or N noncorn/corn--where N equals the number of points of corn or noncorn. $\hat{N}$ equals the number of points classified as corn or noncorn; nc equals noncorn, and c equals corn.

$$E_1 = \frac{\hat{N}_{nc/c}}{N_c}$$

$$E_2 = 1 - \frac{\hat{N}_{nc} - \hat{N}_{nc/c}}{N_{nc}}$$

or

$$E_1 = \frac{\hat{N}_{nc} - N_{nc} + \hat{N}_{c/nc}}{N_c}$$

$$E_2 = \frac{\hat{N}_{c/nc}}{N_{nc}}$$

The expression used is determined by whether it is easier to estimate $\hat{N}$ corn/noncorn or $\hat{N}$ noncorn/corn from the data. In either case, classification of a representative portion or portions of the data (at least 20 percent) in each segment would be made and evaluated in obtaining the estimate.

In addition, there was established a "no decision" case in the event that the computer classifier found the likelihood associated with a classification so low that it chose to make no decision (at LARS, this was called "thresholding"). The "no decision" threshold was recommended to be set at 0.05 (1/2 of 1 percent) for each class. Any "no decision" report was to be counted with the "other" category for reporting purposes.

C. Ground vs Remote Sensing Blight Severity Estimates

Several analyses would be used to evaluate the success of remotely sensing Southern Corn Leaf Blight. The method most commonly employed at LARS in the past had been the use of comparison test fields. In this type of analysis, blight levels of many fields were checked on the ground and the remote sensing classifications compared to the ground ratings. Using this method, the accuracy of the MSS or PI classification could be evaluated. An example of this kind of comparison is shown below.

Table 1.16 Ground vs Remote Sensing Estimates

Class	No. of Samples	Number of Samples Classified As: Blight Level 1	Blight Level 2	Blight Level 3	Noncorn	Percent Correct
Blight Level 1	603	546	25	19	13	90.5
Blight Level 2	866	54	703	67	42	81.2
Blight Level 3	1348	201	75	1004	68	74.5
Noncorn	1743	37	223	56	1426	79.9
TOTAL	4559					

$$\text{Overall Performance} = \frac{546 + 703 + 1004 + 1426}{4559} = 80.0 \text{ percent}$$

This kind of evaluation would be quantitative and quite easy to carry out if sufficient ground observation data were available. Its greatest limitation would be the assumption that a whole field would be the same blight level and that discrete classes would be present whereas, in reality, blight infection is a continuum.

This latter problem could in part be overcome by grouping together certain classes. Although, logically, a higher percent of correct recognition is expected when grouping is used, the method also makes better allowance for error since it assumes that both the field observation and the remote sensing classification may be subject to small errors. The nongrouped method, on the other hand, assumes few or no errors in field observations.

However, given the projected ground observation plan, there would be insufficient ground data available to test the classification accuracy with respect to blight severity levels. Should this situation change, such a test would be incorporated into the data analysis procedures.

Since sufficient resources would not be available to collect enough ground information to adequately evaluate the remote sensing classifications using the test field method, other methods of evaluation would have to be used. These methods would be statistical in nature and make use of estimates of blight severity for larger areas than the test fields.

One technique available would be correlation of ground and remote sensing estimates of the same parameter. The parameter of interest could be either the acres of each blight class or the segment average blight level. Both of these would be obtained from the "expanded" data.

The correlation coefficient (r) would be computed as follows: Let X equal the ground estimate of the average blight severity for a segment and Y equal the *remote sensing* estimate of the average blight level. The number of segments or values to be correlated is n. The correlation coefficient may then be defined as:

$$r = \frac{\sum_{i=1}^{n} (X_i - \bar{X})\ (Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n} (X_i - X)^2\ (Y_i - \bar{Y})^2}}$$

The correlation coefficient (r) is a measure of the degree of linear association between the X values and the Y values. It is a dimensionless quantity that may take any value between -1 and 1, inclusive. A large positive value would indicate a high degree of linear association.

It should be pointed out, however, that correlation does not always measure the degree of agreement between two variables. For example the data set of (X,Y) variables of (1,2), (2,4), (3,6) and (4,8) would be highly correlated but the values of X and Y do not agree very well.

Another analysis technique which could be used was analysis of variance. Analysis of variance may be used to determine if there is a statistically significant difference between two or more "treatments." In this case treatments might be N, T, and B cytoplasms and the hypothesis that blight severity would be greater in T cytoplasm fields than in N or B cytoplasm fields could be tested.

It was, in fact, expected that MSS and photoanalysis would indicate higher blight severity levels in fields of T-cytoplasm corn (on the average), than in fields of N or B cytoplasm corn. Therefore, analysis of variance tests would be performed to determine whether mean blight levels estimated by PI and MSS analyses were indeed significantly higher in T fields than in N or B fields. Additionally, this test would amount to an indirect test of the success of remote sensing since not all the N, T, and B corn fields would actually undergo ground observation.

D. Photo-MSS Comparisons

Since fields in the intensive study area would have blight levels assessed by both photo and MSS analysts, a study was to be undertaken to determine how well the biweekly results of the two methods agreed, (See Appendix I-G). Ratings would be grouped in three levels for comparison purposes:

1.0-1.9 light infection
2.0-3.4 moderate infection
3.5-5.0 heavy infection

Both the average ratings per field and total number of fields in each of the three comparison levels could be computed from Data Reduction Forms A and B for western Indiana segments.

Finally, a chart could be drawn expressing PI classifications in terms of MSS results, and MSS classifications in terms of PI results. This diagram could provide a clue if, for instance, MSS analysts results indicated consistently higher blight levels than PI results.

In addition, correlation coefficients between PI and MSS results would be computed. This would provide another method of quantifying and summarizing the agreement between the two methods, but would not, of itself, provide a positive test of the degree of success attained by either method. That is, PI and MSS results could agree with each other but disagree with ground observations. In that event, accurate evaluation could not be made without further information.

SECTION VII —
ORGANIZATION AND MANAGEMENT

VII. ORGANIZATION AND MANAGEMENT

A. Executive Committee Composition and Agency Responsibilities

As was mentioned in the Introduction to this volume, the 1971 Corn Blight Watch was an experiment not only in technological organization and expertise but also in institutional and multidisciplinary cooperation and coordination.

Overall program direction for the Experiment was to be provided by the United States Department of Agriculture with Dr. John M. Barnes, previously designated as Director of the National Federal-State Information Center for Corn Blight, assigned as Coordinator for USDA activities. Dr. John DeNoyer, National Aeronautics and Space Administration was to serve as Project Manager for NASA activities.

As chairman of an ad hoc working group designated the Corn Blight Watch Executive Committee (CBWEC), R. B. MacDonald of NASA's Manned Spacecraft Center was to serve as Overall Program Coordinator with authority to represent all participants in carrying out program objectives. The CBEWC, which would consist of members representing each of the participating organizations, was to conduct regular meetings and maintain a continuing overview of the Experiment. Original participating organizations and their representatives were:

Organization	Member	Alternate
Corn Blight Center (Information)	A. Broughton	
Agricultural Research Service (ARS)	R. Miller	
Economic Research Service (ERS)	J. Sharples	
Extension Service (ES)	B. Lanpher	C. Beer
Cooperative State Research Service (CSRS)	J. Barnes	
Statistical Reporting Service (SRS)	R. Allen	E. Lippert
Agricultural Stabilization and Conservation Service (ASCS)	J. Clifton H. Jamison	
National Aeronautics and Space Administration (NASA)		
Headquarters (HDQ)	A. Park	B. Nolan
Manned Spacecraft Center (MSC)	A. Watkins	O. Smistad
Ames Research Center (ARC)	M. Knutson	

Willow Run Laboratories (WRL) University of Michigan	P. Hasell	R. LeGault
Laboratory for Applications of Remote Sensing (LARS), Purdue University	M. Bauer R. MacDonald** J. Peterson	
Cooperative Extension Service (CES)	H. Diesslin*	
Agricultural Experiment Station (AES)	H. Kramer*	

*Represented by J. B. Peterson
**Moved to NASA/MSC in June, 1971 as Project Scientist - ERTS

USDA Support

Each of the major and subsidiary organizations which were to play a part in the CBWE would have specific responsibilities directly related to their mission and capabilities. USDA, for instance, would participate through the involvement of its Statistical Reporting Service, Agricultural Stabilization and Conservation Service, Extension Service, Cooperative State Research Service, Economic Research Service and Agricultural Research Service.

Responsibilities of SRS were to include preparation of a statistical sampling design and survey materials, enumerator training, data analysis, evaluation of extent of infection, and periodic public release of information.

ASCS would aid in ground data acquisition, training of enumerators, and provide photographic support and photo analysts.

Extension Service and Cooperative State Research Service were to provide coordination of their respective State activities in support of CBWE, and the Economic Research Service would aid in compiling an economic evaluation of the Experiment. Agricultural Research Service was to provide photoanalytical support.

NASA Support

NASA participating organizations would include the Earth Observations Aircraft Program Office, the Earth Observations Division, and the Photographic Technology Division at the Manned Spacecraft Center, Houston, Texas, which would provide an RB-57F aircraft and data processing facilities; Ames Research Center, Mountain View, California, which was to provide a U-2 backup aircraft; and Purdue University's Laboratory for Applications of Remote Sensing, Lafayette, Indiana, which was to be responsible for providing multispectral data analysis personnel and facilities.

Also participating under NASA funds would be the Willow Run Laboratories of the University of

Michigan, Ann Arbor, Michigan, which were to provide a C-47 aircraft, multispectral scanner system and data reduction facilities.

Purdue University Support

In addition to the technological support under NASA's portion of the Experiment, the Laboratory for Applications of Remote Sensing was to develop and supervise a center for the analysis of aerial photography acquired by the NASA-USAF RB-57F. LARS would also serve as a coordination center for all contributions to the Experiment, particularly those of the Agricultural Experiment Station Directors, Cooperative Extension Service Directors, and Corn Blight Watch State Coordinators. Working space for the photo reduction, data library and a portion of the multispectral analysis was to be provided by Purdue University's Agricultural Experiment Station.

University of California Support

The Forestry Remote Sensing Laboratory of the U. of California was to be responsible for the organization and presentation of a training school to instruct Experiment photoanalysts in the fundamentals of photointerpretation.

Agricultural Experiment Stations and Cooperative Extension Services Support

Units from the participating states (Ohio, Indiana, Illinois, Iowa, Minnesota, Missouri, and Nebraska) were to be responsible for collection of ground data within sample sites, the training of site enumerators, and laboratory identification and confirmation of disease and other stress conditions. State AES and CES organizations would also serve as a source of photoanalysis trainees.

University of Michigan and Michigan State University Parallel Activities

In addition to Willow Run Laboratories' support of the Corn Blight Watch Experiment, the U. of Michigan and Michigan State would be conducting independent research on the incidence of Southern Corn Leaf Blight in Michigan. Study results, which would come from the same type of ground data acquisition as the CBWE and follow the same format, were to be made available to CBWE data analysts at the Statistical Reporting Service in Washington, D. C.

B. Rationale for Participation

In addition to providing its own particular expertise to the Experiment's armory of technological and managerial talents, each Participant expected to reap benefits which would facilitate the accomplishment of its primary responsibilities in the future. These ranged from the Cooperative Extension Services and Agricultural Experiment Stations, which hoped to aid the development of a more, speedy and accurate method of crop inventories, to the Agricultural Stabilization and

Conservation Service, which was interested in a more efficient way of evaluating the economic potential of yearly crops.

Those agencies with primary responsibilities to the Experiment prepared statements of rationale detailing the payoffs they, in particular, hoped would result when final data from the Experiment was analyzed. The Statistical Reporting Service, National Aeronautics and Space Administration, Agricultural Stabilization and Conservation Service, Laboratory for Applications of Remote Sensing, Cooperative Extension Service and Agricultural Experiment Stations were asked to answer the following questions:

1. Why are you and your agency interested in remote sensing? What potential payoff do you think there is for the use of remote sensing to collect information?
2. What do you think will be the important contributions of the Corn Blight Watch Experiment? (See Appendix I-H.)

C. Organization and Management Personnel

Although equipment, analysis, technology and techniques were critical elements to the success of the Experiment, the most critical element would be human resources. Over 1,000 professional personnel were to participate in the Corn Blight Watch Experiment, contributing not only to the operation of the study, but also comprising a reservoir of trained personnel which could be tapped in future efforts of this type.

The purpose of this subsection is to recognize those professionals whose help would be vital to the progress of the Experiment and to provide a listing of those upon whom the future of remote sensing will be built. Space, unfortunately, does not permit the listing of a huge supporting cast of clerks, typists, lab technicians and others who were equally vital to CBWE.

Participants are listed both by employing institution and by the research function they performed, thus leading to a partial cross-indexing under which some participants are listed several times. (See Appendix I-I.)

SECTION VIII — INFORMATION DISTRIBUTION

VIII. INFORMATION DISTRIBUTION

A. Public

During initial planning for internal and external release of information generated by the 1971 Corn Blight Watch Experiment, a weekly summary of both ground and remote data was decided upon as the preliminary source material. This information would be discussed by designated Corn Blight Watch Executive Committee members, then prepared in draft form and merged with data from other projects early on Wednesday, the intended day of release.

A draft of the release was to be ready for review by the entire Committee no later than 11 a.m., with final revision and clearance at 1 p.m. Press release by the Federal State Corn Blight Information Center was slated for 3 p.m.

Additionally, an information tape would be recorded prior to 3 p.m. each Wednesday by the Information Center for location at public telephone call stations in each of the participating states. Any interested persons would be able to dial an announced number within their state to receive this taped information. This service would also make the official release rapidly available to county agents and other Experiment participants.

The initial information to come from the Experiment would be locations where blight had been reported by field observations. This information would be emphasized as "field observation *reports*." Only when blight had been verified by a pathologist would confirmation appear in the releases.

It was hoped that remote sensing results would make it possible to report the overall levels of blight infection more definitely, and that reports such as "50 percent of the fields observed in southwest Indiana were classified as having moderate blight damage," might result. This type of statement would, however, need specific Crop Reporting Board approval before release.

B. Internal

It was tentatively agreed that the results of remote sensing data analysis for each site would particularly be made available to the Extension and ASCS personnel involved in collecting ground data for that site. In addition, the analysis results for all sites within a state were to be made available to the Experiment Station and Extension Service Directors of that state and to the ASCS State Executive Director.

All these Experiment participants were to be cautioned that remotely derived data was of an experimental nature, subject to considerable error at times, and that the validity of Experiment data would be determined at a later date. In addition, participants were to be warned that the sampling density was only sufficient to make large area blight inferences that were not necessarily valid on a local basis.

Experimenters themselves were also cautioned that in their contacts with the public concerning blight situations outside the Experiment, they should be careful not to speak as a representative of the Corn Blight Watch or in any way infer that there would be free access to all data being generated by the Experiment.

C. USDA and Related Agencies Information Activities

1. USDA - The USDA Interagency Task Force on Corn Blight was developed in the Fall of 1970 in response to USDA recognition of the need for some mechanism to evaluate the corn blight problem and provide policy guidance to the Department.

The task force consisted of representatives from the Agricultural Research Service, Statistical Reporting Service, Economic Research Service, Agricultural Stabilization and Conservation Service, Extension Service, and the Cooperative State Research Service. This group, relying largely on the resources of an Extension Service Task Force on Corn Blight, prepared two Departmental publications. In addition, the Task Force worked with SRS and the American Seed Trade Association in obtaining inventories of hybrid seed corn supplied for 1971.

Coordinator: Dr. Buel Lanpher, Extension Service, USDA.

2. National Federal-State Information Center on Corn Blight for 1971 - The major responsibility of the Information Center was to assemble, evaluate, and distribute summarized information concerning all aspects of the corn blight situation during the 1971 crop season. The Center was to depend on a cooperative relationship involving information exchange with USDA agencies, State Research, Extension, regulatory and other groups, and various commercial and private organizations. It would not, however, serve in an advisory or other policy-oriented capacity.

Weekly (or as needed) press releases would be cleared through the Statistical Reporting Service, Interagency Task Force on Corn Blight, and other appropriate USDA agencies. In addition, periodic reports would be made available to research groups, State Extension Service personnel, representatives of other Federal agencies, and to all other interested groups requesting the information.

Members of the Information Center staff were to include an Extension Agronomist from the Extension Research Service; a Plant Pathologist from the Cooperative State Research Service; an Experiment Station Committee on Organization and Policy (ESCOP) representative; the Extension Committee on Organization and Policy (ECOP) representative to the Center; and an Information Specialist from the Agricultural Stabilization and Conservation Service.

Coordinator: Dr. J. M. Barnes, Cooperative State Research Service, USDA.

3. Dixie Early Warning Line (DEW) Line - The Dixie Early Warning

Line was a communications network developed by Extension Plant Pathologists in Southern corn-producing states to facilitate the regular exchange of corn blight information throughout the growing season. The network, which included a telephone conference capability among all Southern Extension Plant Pathologists and certain Extension Plant Pathologists in Corn Belt States, was to include regular weekly communication to provide a joint assessment of the corn blight situation. Cooperating plant pathologists were also to prepare reports on the condition of selected corn fields for exchange within the network and for mailing to other key persons. In addition, the reports would be forwarded to Dr. Luther Farrar, Extension Plant Pathologist, Auburn University, Auburn, Alabama, who had agreed to forward them to the Federal-State Information Center on Corn Blight.

Liaison: Dr. Harlan Smith, Plant Pathologist, Extension Service, USDA.

4. Southern Corn Leaf Blight Reporting Service - The Southern Corn Leaf Blight Reporting Service was a Federal-State cooperative project involving plant pathologists of the Agricultural Experiment Stations in virtually all of the Corn Belt States and most of the southern and northwestern states where corn is produced. Cooperating State Plant Pathologists had agreed to set up spore collection traps at strategic locations in their states, and report information on collection of the corn blight fungus, *Helminthosporium mydis*, Race T, to the project coordinator.

This experimental effort was designed to develop information which would be used to test the future feasibility of this type of disease monitoring system in forecasting Southern Corn Leaf Blight.

Climatological information for this cooperative project was to be made available by the Agricultural Climatology group in the Department of Commerce.

Coordinator: Dr. Paul Fitzgerald, CCRB, ARS, Plant Industry Station, Beltsville, Maryland.

5. Uniform Regional Corn Planting Program - Cooperative USDA-Regional Corn Conference uniform variety planting programs had been in progress for many years. In response to the corn blight epidemic of 1970, representatives of the Cereal Crops Research Branch, ARS-USDA, and the Corn Improvement Conferences of the Northeast, Northcentral and Southern Regions had developed coordinated plans to plant nurseries of inbred and hybrid dent corn in selected sites in these regions.

In addition to the uniform plantings, state cooperators would also make limited plantings of their own selections for evaluation of resistance to Southern Corn Leaf Blight and other diseases. These plantings would also, through use of a "trap" plant method, serve as indicators of first blight infections in a given area.

Coordinator: Dr. G. F. Sprague, CCRB, ARS, Plant Industry Station, Beltsville, Maryland.

VOLUME I — APPENDICES

UNITED STATES DEPARTMENT OF AGRICULTURE
Statistical Reporting Service
and
Agricultural Stabilization and Conservation Service

Appendix I-A

PART I.D.

State ______________________

County ______________________

Flight Line. . . . . ______________

Segment Number. . . . . ______________

1971 CORN BLIGHT WATCH EXPERIMENT

Pre-Interview Listing of Tract Operators

______ of ______

PRE-LISTING OF PART I.D.			VISITS TO SEGMENT		
Date	Time Started	Time Ended	Date	Time Started	Time Ended
Number lines checked "YES" in Col. (4) – Part I.D. .... ______			Form A questionnaires completed............................ ______		

____
Enumerator's Name

Tract Code (1)	I. D. Number (2)	Name of Tract Operator, Street or Route No. City, State, Zip Code (Phone No.) (3)	Check YES and complete Form A if crop-land or pasture is in tract. (4)	If NO in Column (4)-- Describe land use (Woods, wastelands, residential, etc.) (5)
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	

Tract Code (1)	I. D. Number (2)	Name of Tract Operator, Street or Route No. City, State, Zip Code (Phone No.) (3)	Check YES and complete Form A if crop-land or pasture is in tract. (4)	If NO in Column (4)--- Describe land use (Woods, wastelands, residential, etc.) (5)
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	

Tract Code (1)	I. D. Number (2)	Name of Tract Operator, Street or Route No. City, State, Zip Code (Phone No.) (3)	Check YES and complete Form A if cropland or pasture is in tract. (4)	If NO in Column (4)-- Describe land use (Woods, wastelands, residential, etc.) (5)
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	
			Yes No	

Appendix I-B

1964-GA-1 **Exam No.** ☐

Simulated Photographic Images Test

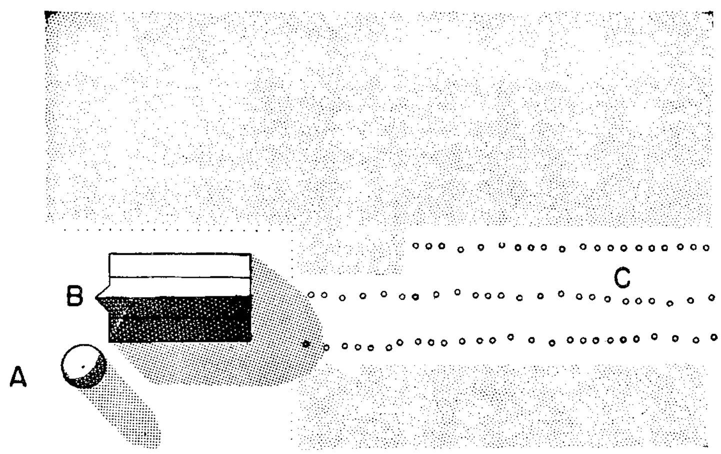
Time Limit: 40 minutes

This is one of a series of tests designed to evaluate the potential ability of persons to be trained in the interpretation of aerial photographs. There are 24 numbered drawings included, each having one to five answers. A total of 39 identifications are required. The sketches are designed to represent overhead views or shadows of common urban, rural, or physiographic features.

DO NOT WRITE ON THIS BOOKLET - USE ANSWER SHEET PROVIDED
DO NOT TURN PAGE UNTIL TOLD TO DO SO

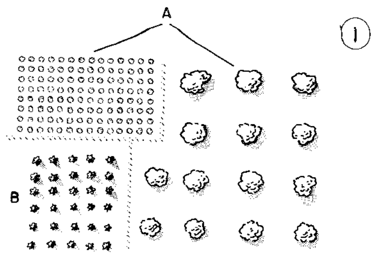
In the example below, an agricultural area is indicated, with a silo at (A), a barn at (B), and shocks or bales of grain at (C). A secondary interpretation of (C) is an orchard or vineyard, though the rows are somewhat irregular. The stippled area (not labeled) is presented to convey an impression of plowed fields or pasture lands.

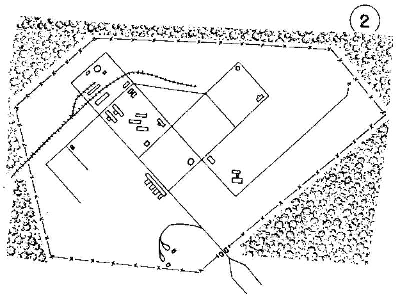
EXAMPLE



Scoring norms for university students are being complied; these are expected to be available sometime after July, 1965. Further information on this test and other examinations being devised may be obtained from the address below:

Test designed by Dr. T. Eugene Avery, School of Forestry, University of Georgia, Athens. Published by the University of Georgia Printing Department, October, 1964.


A
B
1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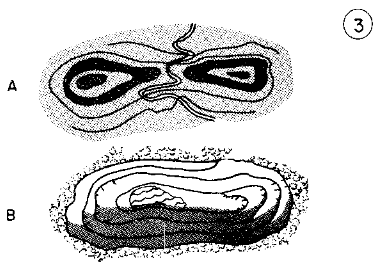
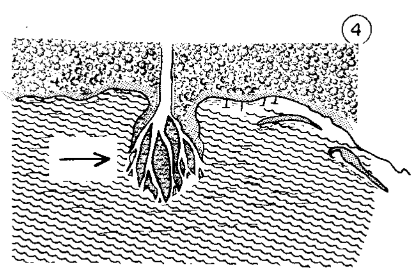

3
A
B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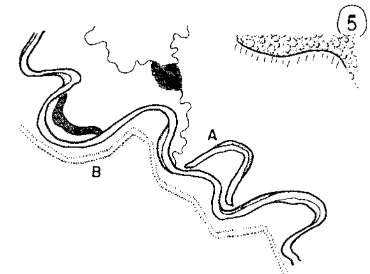
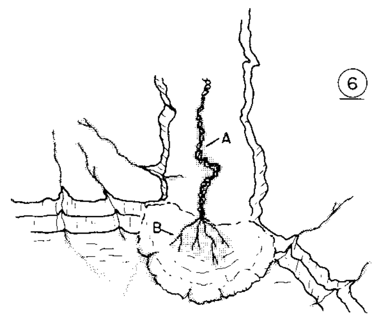
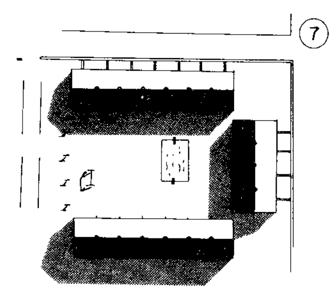

5
A
B


6
A
B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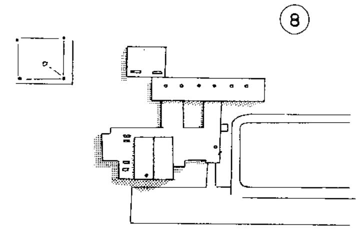
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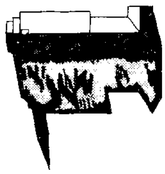

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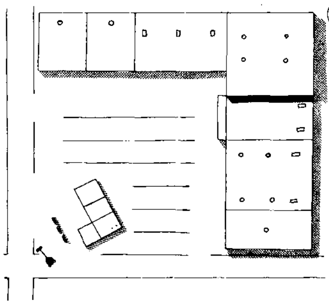

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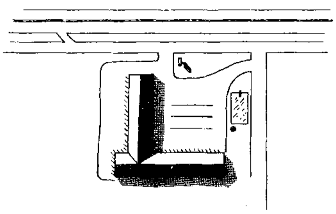

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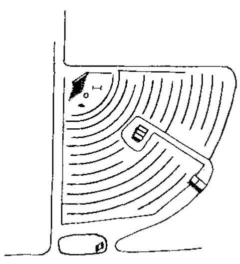

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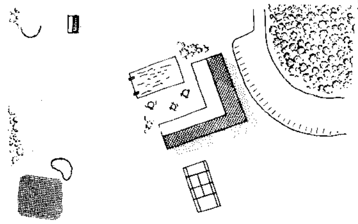

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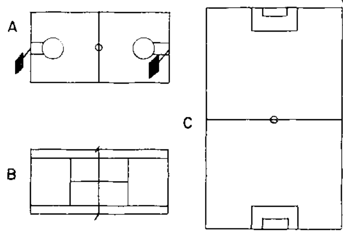

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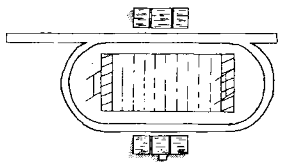

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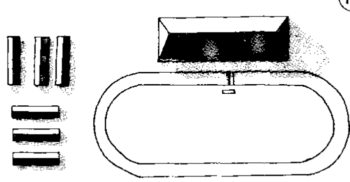

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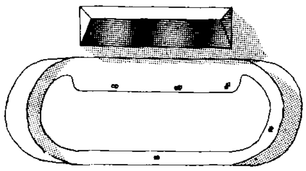

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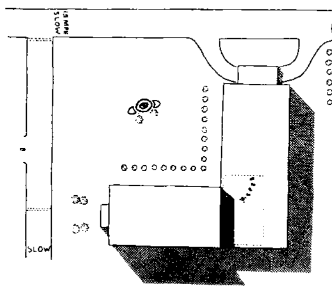

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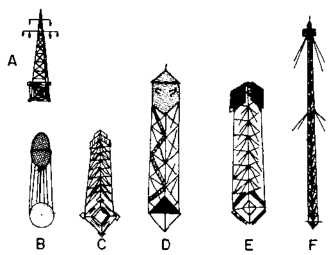

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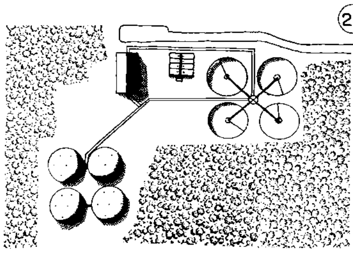
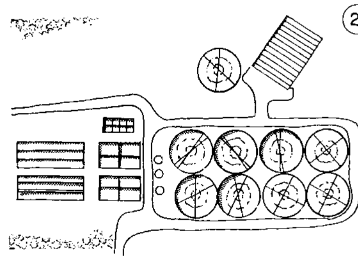


(21)



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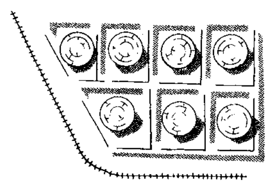

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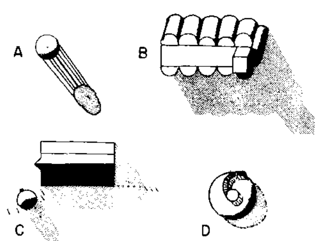

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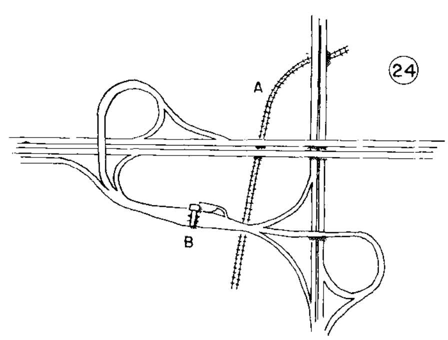


1964-GA-1 Exam. No. ______

Answer Form

Simulated Photographic Images Test

Name ______________ Class: 1-2-3-4–Graduate Raw score ______

Age ______ Sex: M - F Major field ______________ Percent ______

Credit hours in physical geography & geology ______________ Ranking ______

Previous experience in aerial photo interpretation:

College courses ______ credits Military or civilian training ______ months

1-A	______	15	______
1-B	______	16	______
2	______	17	______
3-A	______	18	______
3-B	______	19-A	______
4	______	19-B	______
5-A	______	19-C	______
5-B	______	19-D	______
6-A	______	19-E	______
6-B	______	19-F	______
7	______	20	______
8	______	21	______
9	______	22	______
10	______	23-A	______
11	______	23-B	______
12	______	23-C	______
13	______	23-D	______
14-A	______	24-A	______
14-B	______	24-B	______
14-C	______		

A-10

1964-GA-2 **Exam No.** ______

Aerial Photo Identification Test

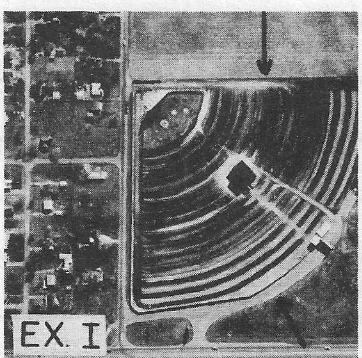
Time Limit: 20 minutes

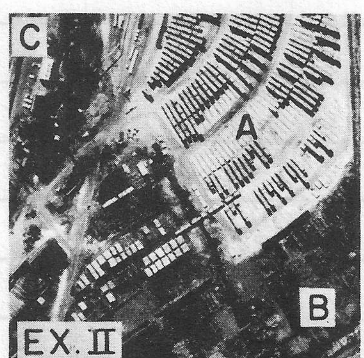
This is the second in a series of tests designed to evaluate the potential ability of persons to be trained in the interpretation of aerial photographs. There are 24 photographic illustrations included, each requiring one principal identification. All photographs are overhead or near-vertical views of familiar urban and rural features in midwestern United States. Photographic scales range from 330 to 660 feet per inch.

DO NOT WRITE ON THIS BOOKLET - USE ANSWER SHEET PROVIDED

DO NOT TURN PAGE UNTIL TOLD TO DO SO

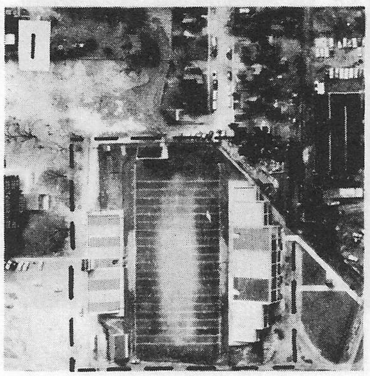
The two examples below indicate the specific nature of answers required and the range of difficulty covered by the examination. Example I (easy) pictures a drive-in theatre. Example II (difficult) shows a wood preserving or creosoting plant, with untreated wood at (A), treated material at (B), and pressure tanks at (C). The identification of Example II as simply a lumber yard or sawmill would be only partially correct, because an explanation is needed to explain why some stacks of wood are much darker than others.





Specific answers are required in all cases. Thus "athletic field" will not suffice for a baseball diamond, nor will "buildings" correctly describe a hospital, shopping center, or industrial complex. The examinee should scan the entire test quickly to dispose of easy identifications first. Then more time will be available for items requiring study and deductive reasoning.

Test designed by Dr. T. Eugene Avery, School of Forestry, University of Georgia, Athens. Published by the University of Georgia Printing Department, December, 1964.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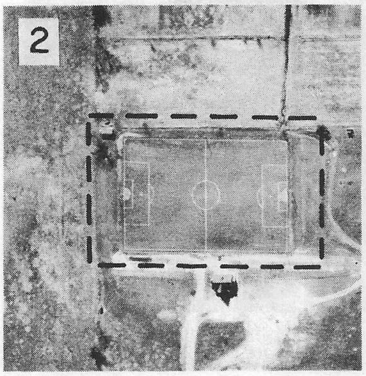
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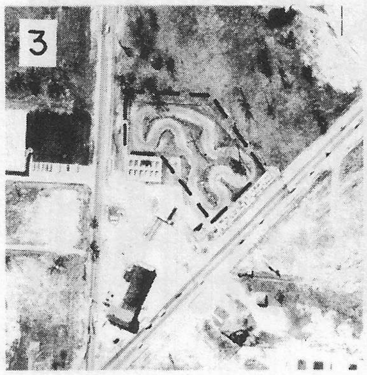
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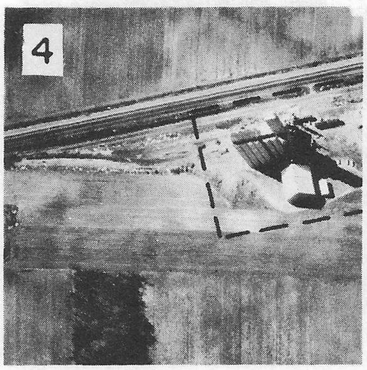
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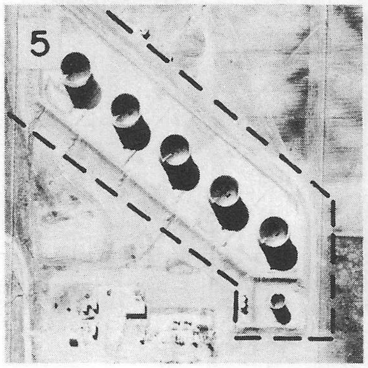
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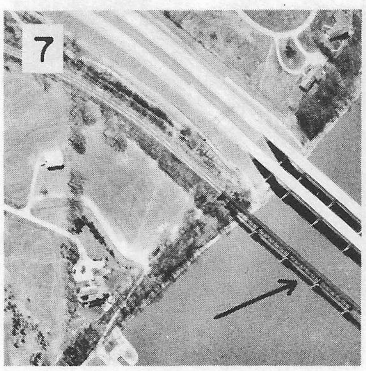
6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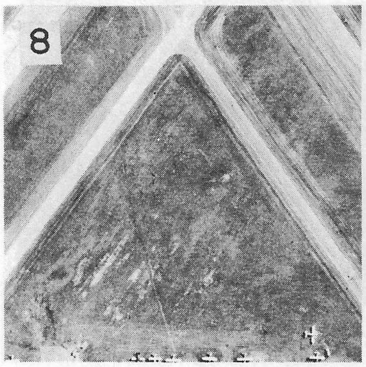
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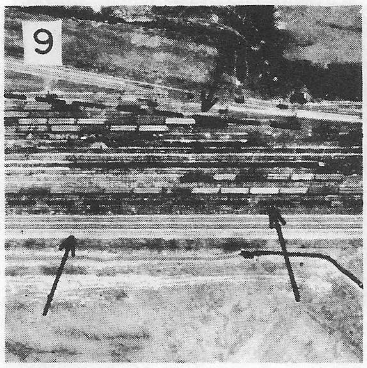
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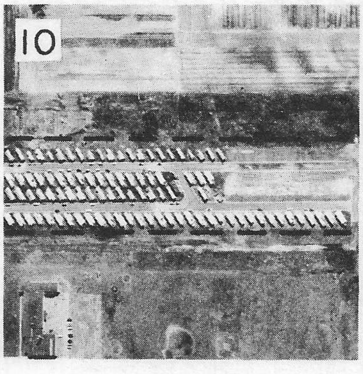
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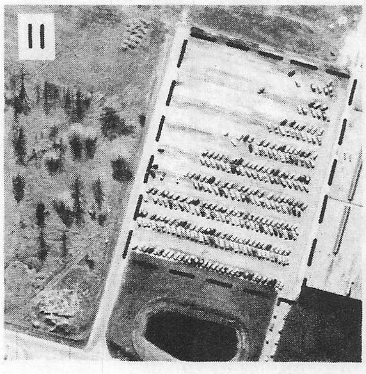
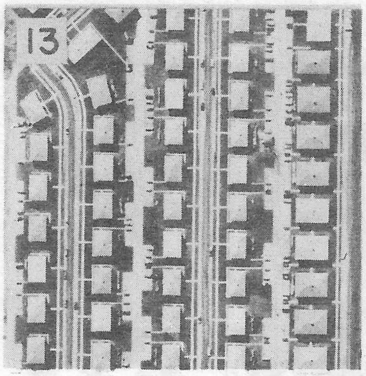

11


12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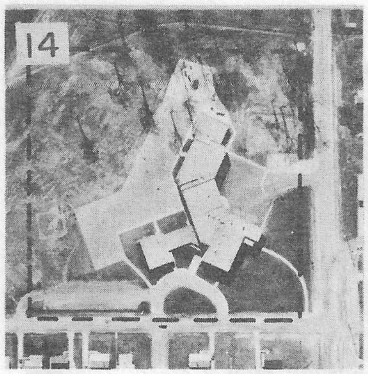
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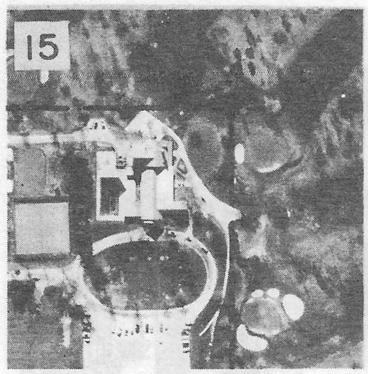
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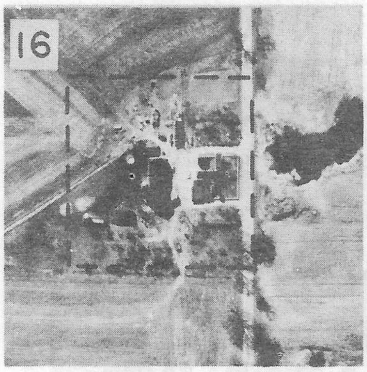
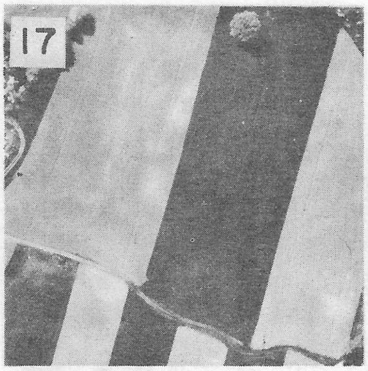

16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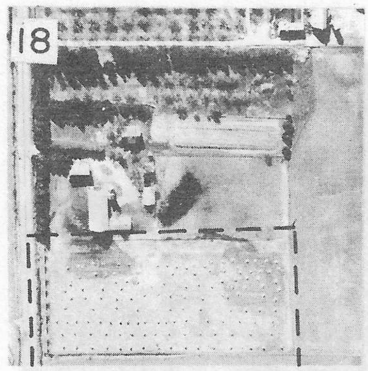
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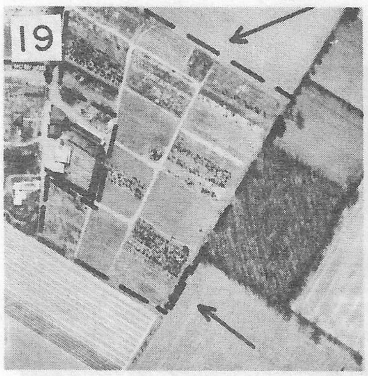
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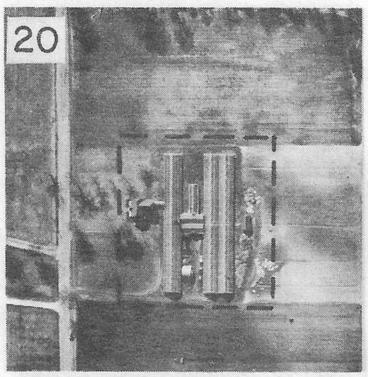
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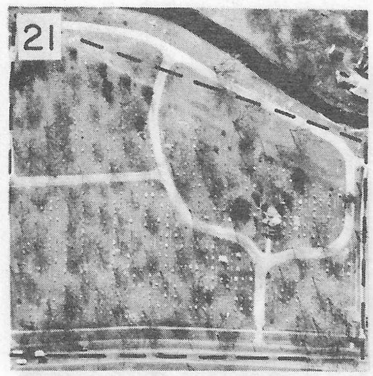
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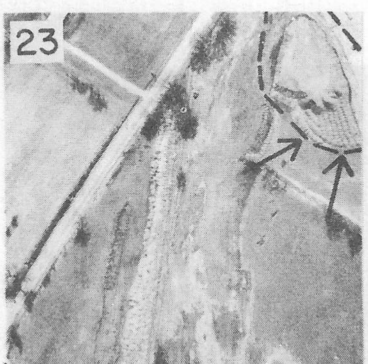
22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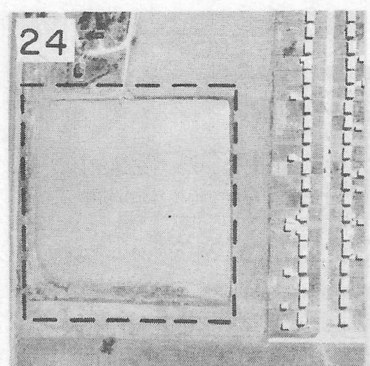
24

1964-GA-2 **Exam No.** ______

Answer Form

Aerial Photo Identification Test

Name________________ Class: 1-2-3-4—Graduate Raw score________

Age________ Sex: M - F Major field________________ Percent________

Credit hours in physical geography & geology________________ Ranking________

Previous experience in aerial photo interpretation:

College courses________ credits________ Military or civilian training________ months

1 ____________________
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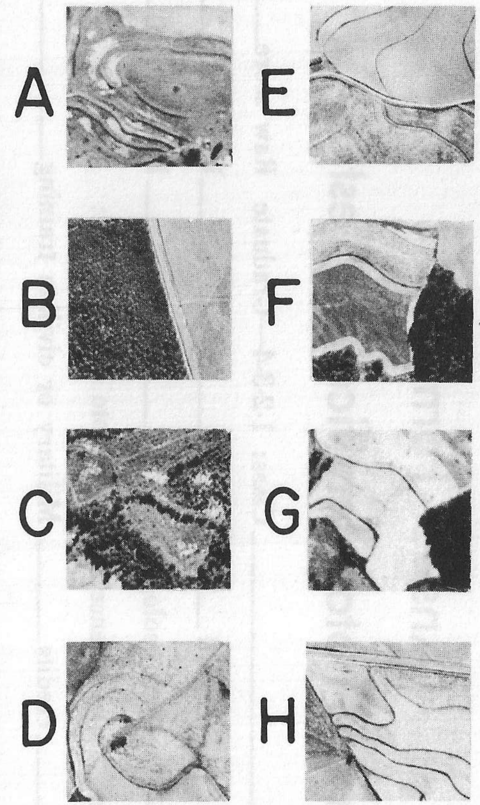
24 ____________________

1965-GA-3

Visual Search Test

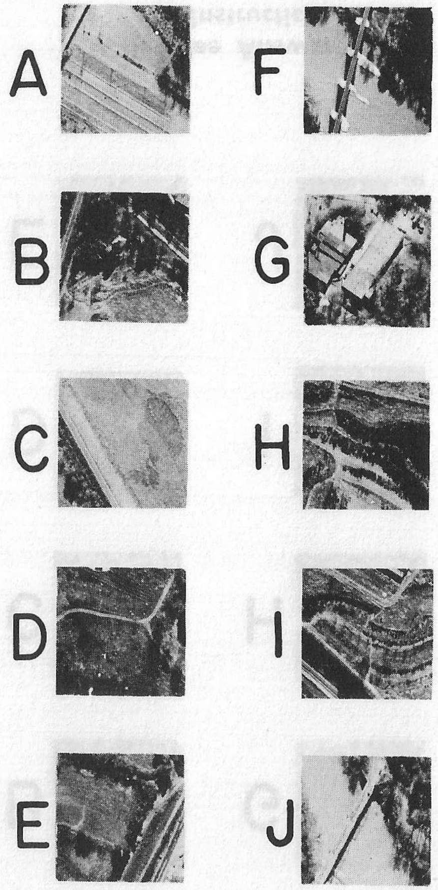
Exam No.

A-14



Part I.—See Answer Form For Instructions

Test designed by Dr. T. Eugene Avery, School of Forestry, University of Georgia, Athens. Published by the University of Georgia Printing Department, March, 1965.



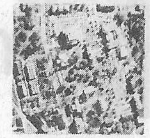
Part II.—See Answer Form For Instructions

A

F

B

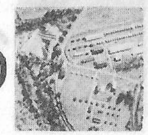
G



C

H

D

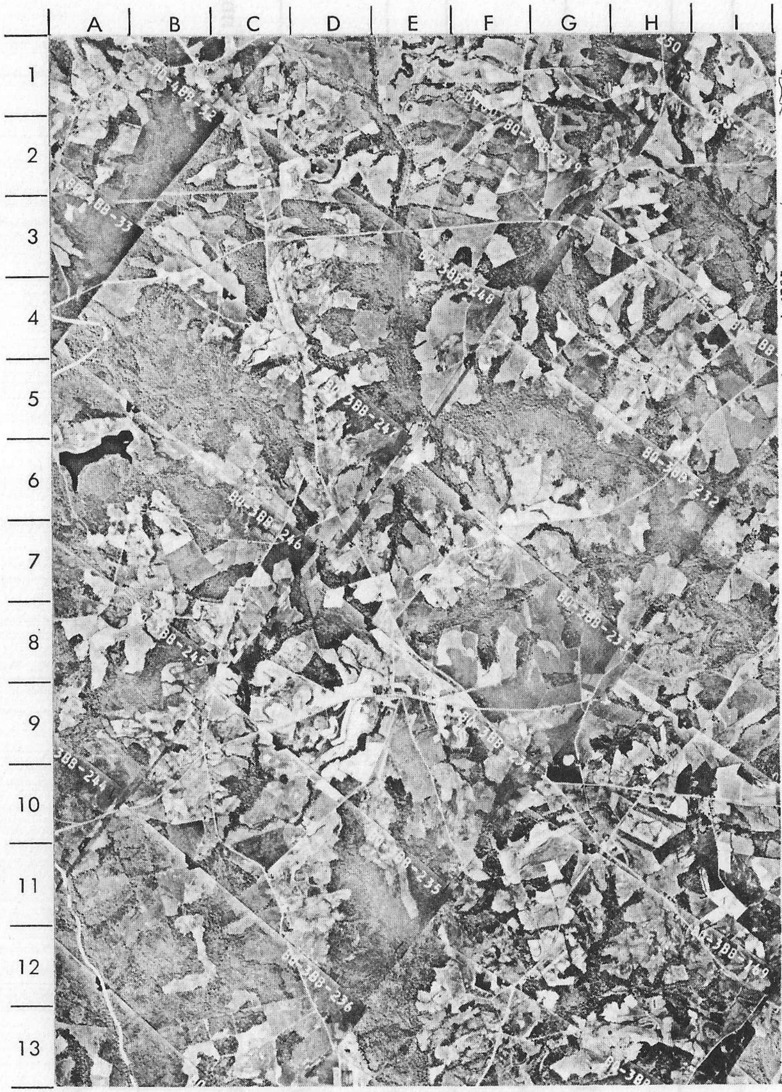


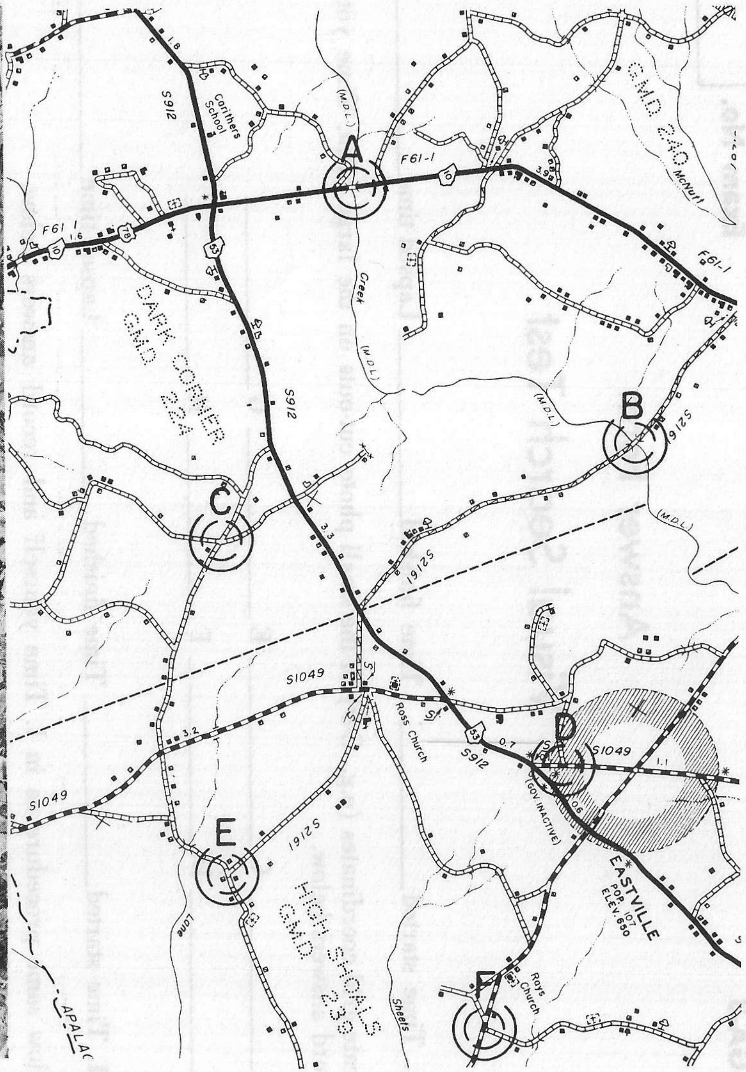
I

E

J

Part III.—See Answer Form For Instructions





Part IV.—See Answer Form For Instructions

1965-GA-3 **Exam No.** [ ]

Answer Form

Visual Search Test

Part I. Time started__________ Time finished__________ Lapsed time__________

Locate grid coordinates (e.g., G-9) of the small photo cut-outs on the large print. Time yourself and record answers below.

A __________ C __________ E __________ G __________

B __________ D __________ F __________ H __________

Part II. Time started__________ Time finished__________ Lapsed time__________

Follow same procedure as in I. Time yourself and record answers below.

A __________ C __________ E __________ G __________ I __________

B __________ D __________ F __________ H __________ J __________

Part III. Time started__________ Time finished__________ Lapsed time__________

Follow same procedure as in I & II. Time yourself and record answers below.

A __________ C __________ E __________ G __________ I __________

B __________ D __________ F __________ H __________ J __________

Part IV. Time started__________ Time finished__________ Lapsed time__________

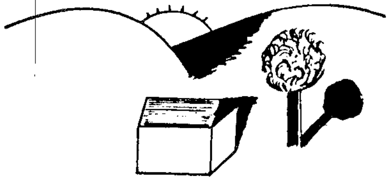
Locate grid coordinates of the 6 lettered map positions on the photo index sheet at the left. Time yourself and record answers below.

A __________ C __________ E __________

B __________ D __________ F __________

No. Incorrect [ ] Total lapsed time [ ] Score [ ]

1



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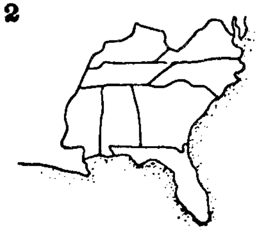

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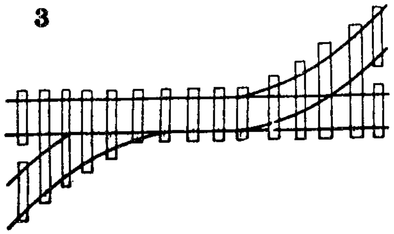

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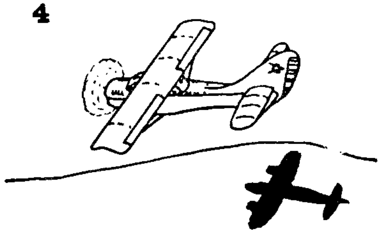

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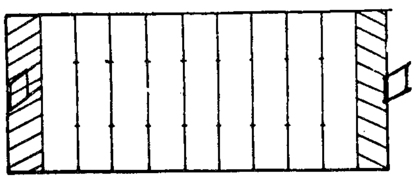

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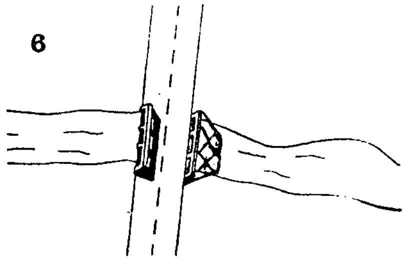
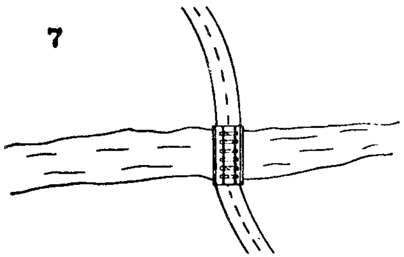
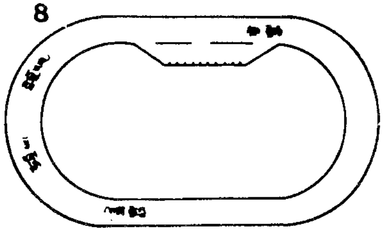


7



8



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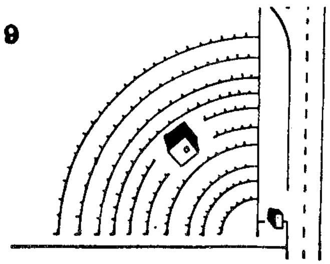
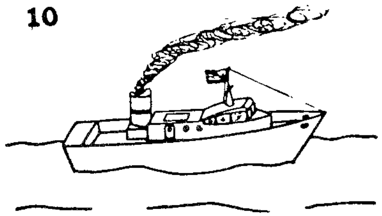


10



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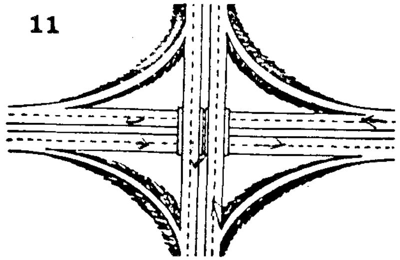

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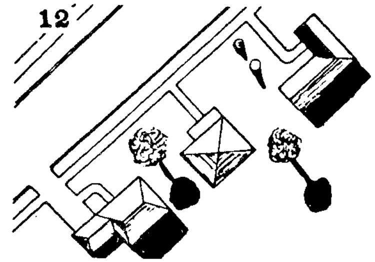

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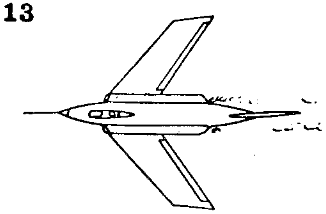

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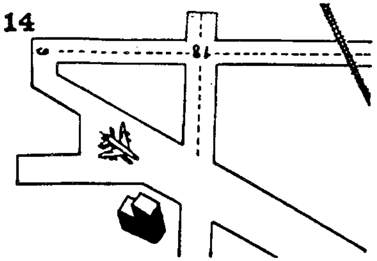

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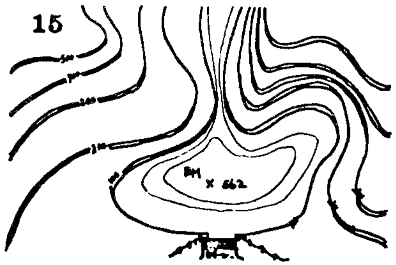

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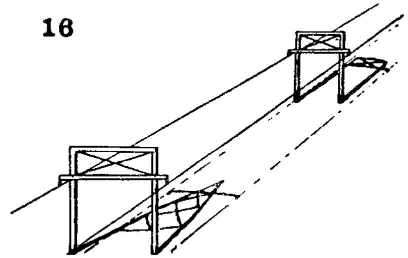

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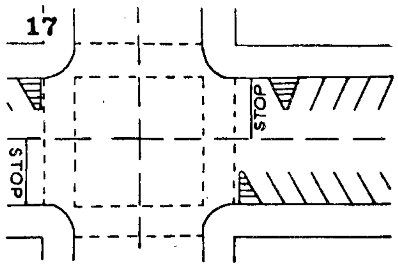

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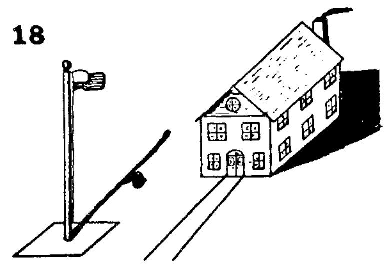

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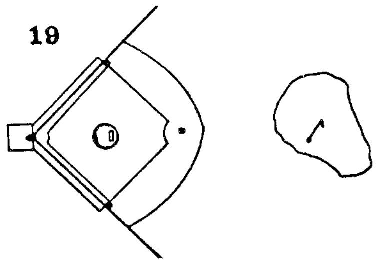

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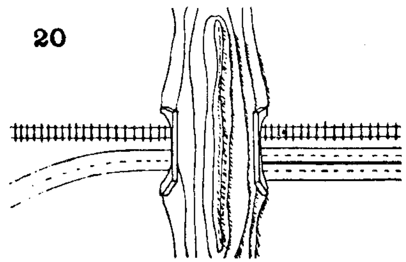

A-20

1964-GA-2

Exam No. ______

Answer Form

Incorrect Images Test

Name________________ Class: 1-2-3-4—Graduate Raw score________

Age______ Sex: M - F Major field________________ Percent________

Credit hours in physical geography & geology________________ Ranking________

Previous experience in aerial photo interpretation:

College courses________ credits______ Military or civilian training________ months

1 ______
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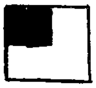
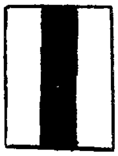
23 ______
24 ______

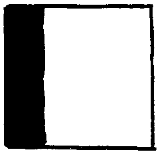
Exam No

A-21

Area Perception Test

1 

2 

3 

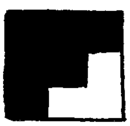
4 

5 

6 

7 

8 

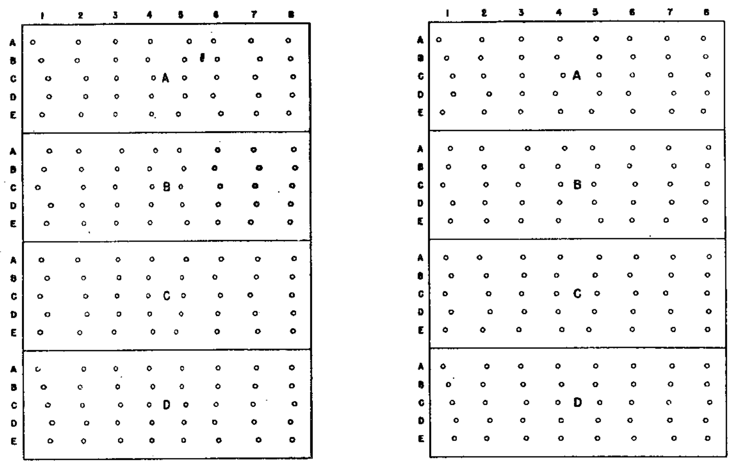
9 

10 

FLOATING-CIRCLES STEREOGRAM TEST SHEET

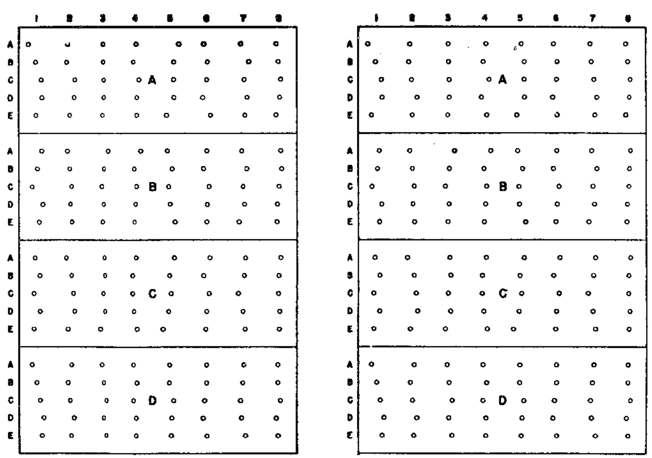
Stereogram I

(Lens separation - 2.25 inches)



Stereogram II

(Lens separation - 1.9 inches)



Name ______________________________

Date ______________________________

____

____

Mark the number of each circle in each row and block that appears to float above the datum plane formed by the paper.

A	1	2	3	4	5	6	7	8	
B	1	2	3	4	5	6	7	8	
C	1	2	3	4	5	6	7	8	Block A
D	1	2	3	4	5	6	7	8	
E	1	2	3	4	5	6	7	8	
A	1	2	3	4	5	6	7	8	
B	1	2	3	4	5	6	7	8	
C	1	2	3	4	5	6	7	8	Block B
D	1	2	3	4	5	6	7	8	
E	1	2	3	4	5	6	7	8	
A	1	2	3	4	5	6	7	8	
B	1	2	3	4	5	6	7	8	
C	1	2	3	4	5	6	7	8	Block C
D	1	2	3	4	5	6	7	8	
E	1	2	3	4	5	6	7	8	
A	1	2	3	4	5	6	7	8	
B	1	2	3	4	5	6	7	8	
C	1	2	3	4	5	6	7	8	Block D
D	1	2	3	4	5	6	7	8	
E	1	2	3	4	5	6	7	8	

AGRONOMIC APTITUDE

List all the possible factors or variables which you think might cause corn fields to look different from one another if you walked through the corn fields.

Which of the factors you listed above do you think might also cause differences in the appearance of corn fields on color aerial photography?

For the Corn Belt, what percent of the corn is planted in 40 inch rows?__________ Is this more or less than was planted in 1968?

What population would you as a corn grower plant if you had a farm in central Illinois with Muscatine silt loam soil which has been tile drained and is well fertilized to maximize your yield?

What date would you plant your corn under the above conditions?

Would you adjust your planting rate if you grew corn in southern Illinois? If so to what? ____________

How about if you were farming in western Iowa?

What steps would you as a corn grower take to minimize your losses to SCLB in 1971 assuming you could get only enough N-cytoplasm seed for planting half of your normal acreage?

Appendix I-C

1971 Corn Blight Watch Experiment
Data Reduction Form C

Regional Analysis of Segments from
Phase II Imagery

710005

Segment No.	081-7775	Interpreter	Team 4
Date of Flight	5-13-71	Method	
Date Interpreted	6-16-71	Start Time	0900
Image Quality	6	Finish Time	0905

Circle the descirptions that best qualify the regional characteristics of the frame.

1. Pattern (Course or Fine)
   a. mottled
   b. pitted
   c. eroded
2. Tone (Predominate)
   d. light
   e. dark
3. Topography
   f. uneven
   g. level
4. Surface drainage
   h. abundant streams
   i. few streams
   j. abundant ditches
   k. few ditches
   l. internal none apparent
5. Predominant land use
   m. crop 50%
   n. non-crop

1971 Corn Blight Watch Experiment
Data Reduction Form D
A-26

NO mistakes checked

Appendix I-D

Analysis of Phase II Imagery

Segment No.(1-3) 081 Interpreter TEAM 4

Date of Flight(4-6) 13 MAY 71 133 Method 1

Date Interpreted(7-9) 22 JUN 71 173 Start Time 1530

Image Quality 6 Finish Time 1606 36 min

Corn Field ID Tract (10-12)		Field (13-14)	Predominant Soil Tone or Pattern (15) L	D	L/D	D/L	M	Erosion (16) Yes	No
N	014	02		2	✓				1 ✓
R	018	03		2	✓				1 ✓
S	019	12	✓	0					1 ✓
F	006	01	✓	0					1 ✓
	006	02	✓	0					1 ✓
J	010	02	✓	0					1 ✓
	010	03	✓	0					1 ✓
O	015	02	✓	0					1 ✓
	015	04	✓	0					1 ✓
S	019	01	✓	0					1 ✓
	019	14	✓	0					1 ✓
W	023	01		2	✓				1 ✓
	023	02		2	✓				1 ✓
	023	05		2	✓				1 ✓
	023	06		3		✓			1 ✓
	023	09	✓	0					1 ✓
	023	12		2	✓				1 ✓
B	002	01	✓	0					1 ✓
	002	02	✓	0					1 ✓
	002	03	✓ off	0					1 ✓

1971 Corn Blight Watch Experiment
Data Reduction Form D

6)< checked

Analysis of Phase II Imagery

Segment No.(1-3) 081 Interpreter team 4

Date of Flight(4-6) 5-13-71 133 Method 1

Date Interpreted(7-9) 6-22-71 173 Start Time 1540

Image Quality 6 Finish Time 1606

Corn Field ID Tract (10-12)		Field (13-14)	Predominant Soil Tone or Pattern (15) L	D	L/D	D/L	M	Erosion (16) Yes	No
E	005	01	[illegible]	2	✓				1 ✓
	005	02		2	✓				1 ✓
	005	03	✓	0				✓	0
J	010	01	✓	0					1 ✓
K	011	01	✓	0					1 ✓
M	013	01	✓	0					1 ✓
	013	02	✓	0					1 ✓
N	014	01	✓	0					1 ✓
	014	03	✓	0					1 ✓
	014	04	✓	0					1 ✓
	014	05	✓	0					1 ✓
	014	06	✓	0					1 ✓
O	015	01	✓	0					1 ✓
	015	05	✓	0					1 ✓
P	016	01	✓	0					1 ✓
	016	02	✓	0					1 ✓
Q	017	02		3		✓			1 ✓
	017	03	✓	0					1 ✓
	017	04		2	✓				1 ✓
R	018	01	✓	0		—			1 ✓

1971 Corn Blight Watch Experiment
Data Reduction Form D
A-28

Analysis of Phase II Imagery

Segment No.(1-3) 081 Interpreter team 4

Date of Flight(4-6) 5-13-71 133 Method 1

Date Interpreted(7-9) 6-22-71 173 Start Time 1540

Image Quality 6 Finish Time 1606

Corn Field ID Tract (10-12)		Field (13-14)	Predominant Soil Tone or Pattern (15) L	D	L/D	D/L	M	Erosion (16) Yes	No
R	018	02		2	✓				1 ✓
	018	04	✓	0					1 ✓
S	019	03	✓	0					1 ✓
	019	09	✓	0					1 ✓
V	022	01		3		✓			1 ✓
Y	025	01	✓	0					1 ✓
	025	03		3		✓			1 ✓
O	015	03	✓	0					1 ✓
U	021	08		3		✓		✓	0

Data Reduction Center, Form A: PI Blight Results

State . . . . ________________

County. . . . . . . ________________

Flightline No. . . ________________

Test Site No. . . ________________

Date Ground Obs. . ________________

Date of Flight. . . ________________

Date Interpreted . ________________

Interpreter . . . . ________________

Beginning Time. . . ________________

Time Finished . . . ________________

Corn Field ID	Appearance		Blight		Blight Severity Rating					Infection		Percent of field infected with blight severity level					
	Normal	Abnormal	Yes	No	1	2	3	4	5	Uniform	Non-Uniform	0	1	2	3	4	5

Appendix I– E

Appendix I – F

DRC Form B. Results of MS scanner analysis estimates of Southern Corn Leaf Blight infection.

State ____________
County ____________
Flightline No. ____________
Test Site No. ____________

Date Ground Obs. Taken ____________
Date of Flight ____________
Date Analysis Begun ____________
Persons Analyzing Data ____________

Blight Severity Rating						Spectral Appearance of Field*			Percent of Field Infected by Each Blight Severity Rating					
0	1	2	3	4	5	Uniform	NU-1	NU-2	0	1	2	3	4	5
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ %	☐ %	☐ %	☐ %	☐ %	☐ %

*Uniform = mainly one blight class indicated on printout for this field (more than 90%).

NU-1 = more than one class indicated for field, but symbols in one part of the field are all the same (like soil patterns observed in 1970 study of corn blight)

NU-2 = more than one class indicated for field and various symbols are more or less uniformly (or randomly) distributed over the field.

Appendix I-G

Flightline 31 Date August 23, 1971

PI Blight Levels

Segment No.	0	1	2	3	4	5
1 201	...					
2 202	acres	...	...	...	...	...
3 203	...					
4 204	...					
5 205	...					
6 206	...					
Total						

Scanner Blight Levels

	0	1	2	3	4	5
1				...		
2				...		
3				...		
4	...	...	...	acres	...	...
5				...		
6				...		
Total						

Dual Listing of Phointerpretive and MSS Results

Appendix I—H

CORN BLIGHT WATCH EXPERIMENT

RATIONALES OF PARTICIPANTS

LARS Rationale

A blend of a number of engineering, agricultural, and scientific fields, Purdue University's Laboratory for Applications of Remote Sensing (LARS) was formally organized in 1966 to conduct research, develop technology, and train people in the field of remotely determining the state of the earth's resources and our environment. From its inception, support of this effort came from the National Aeronautics and Space Administration (NASA), in conjunction with the United States Department of Agriculture (USDA).

Research over six years included studies in pattern recognition; the development of instrumentation for ground and airborne data collection platforms; biophysical aspects of vegetative, soil, and hydrologic features; and the development of computer techniques to more rapidly and efficiently process remotely-derived multispectral data. By 1971, research into a considerable number of individual aspects of the overall problem had been successfully concluded, and the next scientifically logical step was a realistic test integrating these individual procedures under real-world conditions. The 1971 Corn Blight Watch Experiment (CBWE) appeared to be an excellent project for this purpose.

Researchers for LARS had performed initial investigations on Southern Corn Leaf Blight in 1970 and discovered that SCLB could be remotely detected and classified during later stages of corn maturity. During the winter months of 1970, NASA and several USDA agencies were contacted about using multispectral scanning and aerial photography in a large coordinated experiment during the 1971 growing season. The CBWE grew out of these contacts.

LARS' rationale for CBWE participation was, therefore, that the Experiment provided the overall comprehensive and coordinated test we had been seeking. The CBWE would orient a spectrum of remote-sensing techniques toward one goal, and would enable us to devise and test a remote-sensing system in which the entire procedural gamut--from data acquisition; through data storage, retrieval, processing, and analysis; to data dissemination--would be in operation. The CBWE would, in brief, provide both a basis and a future. It would provide a test of the integration of past results and identify additional areas in need of new work.

Dr. David A. Landgrebe
Director,
Laboratory for Applications
of Remote Sensing

CES-AES RATIONALE

for CBWE Participation

For people who work with the land as a producer of crops, any efficient, accurate, and speedy method by which to inventory the crop population of large areas can be extremely valuable. The value of these inventories is enhanced still further if they can be graphically or photographically displayed in a two-dimensional format.

Land data, such as the level of organic matter in surface soil and the amount of soil erosion, are important to land planner, conservationist, and farmer alike. The more of these factors that can be expressed in an inventory display, the more varied become the potential uses of that information.

In addition, differences in plant appearance reflect the presence of soil nutrient deficiencies, stresses due to drought, diseases, or insects. The recording and interpreting of these appearance "clues" are of critical importance. If they can be rapidly and easily tracked and reported, managerial decisions will be made early enough to alleviate the effects of crop stresses.

The Cooperative State Extension Services and Agricultural Experiment Stations of the seven states involved in the 1971 Corn Blight Watch Experiment believe that remote sensing has the potential to provide us these vitally-needed types of information.

Our purpose for participation in the CBWE was therefore three-fold: (1) we expected to obtain much valuable information about crop status in the seven-state region; (2) our efforts would help in the attempt to refine a methodology that should be of vital importance to our needs in the future; and (3) many of our people would receive specialized training and experience that should facilitate our future use of remote sensing.

Dr. J. B. Peterson/LARS
for the Cooperative Extension
Services and Agricultural
Experiment Stations

ASCS RATIONALE

for CBWE Participation

The Agricultural Stabilization and Conservation Service (ASCS) is administratively responsible for a number of U.S. Department of Agriculture programs which require over three and one-half million determinations annually. In addition to production adjustment, conservation, and price support programs, the Agency is concerned with the environment (through the Rural Environmental Assistance Program), and is the executive arm of the Commodity Credit Corporation, which is involved in domestic and international commodity operations. To fulfill these multifaceted responsibilities effectively, it is necessary to compile comprehensive data about crop status rapidly and accurately. An effective remote-sensing system is the most promising vehicle for collecting this data.

Such a system can provide current information to aid in establishing program and production goals, and in administering the farmer compliance aspects of the production adjustment programs. This necessitates the refinement of remote-sensing techniques that identify crop and land use and relate acreages to such use. Such a system can also aid in our national disaster and defense responsibilities by providing a tool with which to obtain comprehensive damage assessments.

Specifically, the Corn Blight Watch Experiment should assist us in approaching these goals. Significant advances in interpretation and analysis techniques are basic to the future of remote sensing. This study of a one-crop situation in a specific area lays the groundwork, in terms of mechanics and procedures, for the structuring and implementing of similar programs, including participation in NASA's Earth Resources Technology Satellite project. Additionally, because of participation in the Experiment, ASCS will have developed a nucleus of employees with a greater appreciation of the concepts and potential of remote sensing, which should facilitate the acceptance and future utilization of remote-sensing techniques.

Joe Clifton
Agricultural Stabilization
and Conservation Service

SRS RATIONALE

for CBWE Participation

The Statistical Reporting Service (SRS) of the Department of Agriculture is always interested in improving its estimating program. Improvement, although normally measured in terms of increased estimate precision, can also refer to lowering the cost of present precision levels.

In accordance with this interest, SRS has been involved for the past several years in some type of remote-sensing research. Involvement has included studies of the remote-sensing potentials in the areas of livestock inventories, and the use of aerial remote-sensing techniques in crop identification and crop yield experiments.

Great claims have appeared in the literature and at symposiums regarding the potential of remote sensing for worldwide crop identification and yield determinations. The goal of SRS's efforts is to keep abreast of the developing remote-sensing technology in order to evaluate its true potentials and capabilities.

Additionally, the Agency is examining alternative uses of remote-sensing technology. Remote-sensing data, for instance, might be used to classify fields into potential yield strata for more efficient ground sampling, thus allowing a "double sampling" approach to yield estimations. Also, satellite imagery may be extremely useful in preparing and maintaining area sampling frames which are now used for many surveys.

The payoff might not be as spectacular as the efficient and comprehensive estimation of large-scale crop acreages and yields. Aerial photography is already being used to obtain citrus tree inventories in Florida and Arizona.

The SRS does not estimate the amounts of damage due to insects, weather, and disease as part of its regular estimating program. The agency does, however, consider all available information in order to arrive at accurate crop production forecasts and estimates. Thus, the Agency was interested in the Southern Corn Leaf Blight information generated by the Corn Blight Watch Experiment.

The SRS has considerable experience and expertise in designing and conducting interview parties in the preparation of new surveys; this would have been available to the Corn Blight Watch even if the Agency had not been so heavily involved in the Experiment operations.

In view of the goals and of the structure of SRS, the Agency's overall goal in participating in the 1971 Corn Blight Watch Experiment was to examine the state of the art of remote sensing. How far had remote sensing techniques progressed? What were the limitations imposed on the use of remote sensing in an operational context? What research was still needed and how should it be structured? These are the types of questions the SRS hoped the 1971 Corn Blight Watch Experiment would answer.

Richard Allen
Statistical Reporting Service

NASA RATIONALE

for CBWE Participation

The use of remote sensing to provide data for management of earth resources makes it one of the most important modern scientific techniques. If the quality of human life is not to diminish generation by generation, we must find a way to live in harmony with the physical world we inhabit, balancing our growing needs for resources against the long-term ability of the earth to satisfy them. But we still lack information fundamental to making responsible decisions on how to exploit, modify, and conserve the resources of the earth. Aerospace technology and interdisciplinary science employing remote-sensing techniques offer the best opportunity to unlock this information and so make possible rational resources management.

NASA recognized the possibility of using remote sensors to survey earth resources from orbital altitudes in the early days of the space program. This recognition was based on observations from meteorological satellites, as well as photography from Mercury and Gemini missions. Several feasibility studies were conducted from 1964 to 1966, and these culminated in the publication of a concept for the Earth Resources Technology Satellite (ERTS) in 1967. In July 1968, an interagency committee was established to coordinate the NASA Earth Resources Survey Program (ERSP) on the Federal level. In 1967-1968 the National Academy of Sciences/National Research Council conducted a comprehensive evaluation of space applications, which gave strong endorsement to the accelerated research on earth resources surveys from space.

The goal of the NASA ERSP in its experimental phase is to develop the information necessary for national decisions on the advisability of developing operational earth survey systems for the direct social and economic benefits they can provide. NASA, therefore, was interested in participating in the Corn Blight Watch Experiment (CBWE) as a test of remote-sensing data acquisition and analysis methodology on a regional basis.

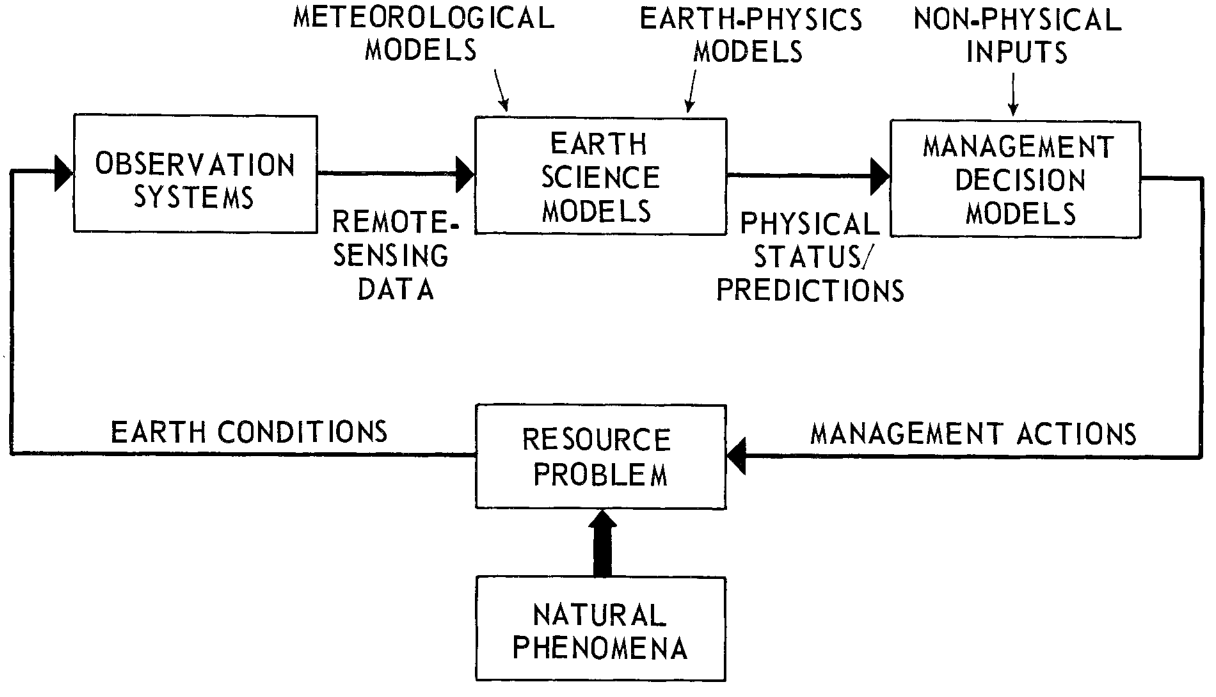
Substantial applications for remote sensing are being developed in the fields of agriculture, environmental quality, forestry, geography, geology, hydrology, oceanography, public health, regional ecology, and urban studies.

Remote sensing can now give an integrated overview of environmental and resource situations previously difficult, if not impossible, to obtain. We are learning to extract from remote-sensor data a new class of information about the earth – the information necessary for making decisions in what might be termed "planetary engineering." We foresee the development of interrelated physical models of the earth and its environment that will predict both the natural course of resource and environmental conditions, as well as the effects of human actions.

In the National Academy of Sciences study "Useful Applications of Earth-oriented Satellites," the Central Review Committee Conclusions and Recommendations stated:

> "The benefits from space application are expected to be large – larger than most of the Study participants had originally believed, and certainly larger than the costs of achieving them."

In addition, immediate and significant intensification and acceleration of these programs were specifically recommended. NASA and the user agencies have been responding to the recommendations by increased efforts.



Operational Earth Resources Model

Those familiar with the Corn Blight Watch will recognize the similarity of the flow diagram above to the plan for conducting the CBWE. In fact, one of the outstanding accomplishments of the CBWE was expected to be the experience gained by testing this methodology in a quasi-operational atmosphere involving statistical modeling, rigid scheduling, and coordination of many organizational elements.

Another important contribution of the CBWE was expected to be further refinement of the analysis of multispectral scanner (MSS) data by electronic processing. Significant progress has already been made in automatic classification of terrestrial features using digitized MSS data. Much of this work is being carried out under NASA sponsorship by the Laboratory for Applications of Remote Sensing (LARS) at Purdue University using the MSS and aircraft of the University of Michigan. The CBWE provided rigorous tests for these systems.

The Purdue/LARS automatic digital classification techniques are being adapted for use in other disciplines. The capabilities for automatic classification of data gathered by aircraft remote sensing are being extended to spacecraft remotely sensed data. The extent of the ability of a spacecraft to gather remote sensor data is being tested in the analysis of the ERTS-A and ERTS-B data.

In summary, NASA was motivated to join the CBWE to accomplish the following:

- Develop remote-sensing techniques applicable to the detection of crop stress in agriculture.
- Refine multispectral scanner data analysis procedures.
- Test the ability of a large-scale remote sensing operation to accurately extrapolate small-scale remote-sensor data using the statistical concepts of multistage sampling.

Appendix I-I

CORN BLIGHT WATCH EXPERIMENT

Organization and Management Personnel

U.S. DEPARTMENT OF AGRICULTURE

Agricultural Research Service

Robert Miller*; Washington, D.C.
Alvin Gerbermann; Weslaco, Texas

Cooperative State Research Service

John Barnes*, Washington, D.C.

Extension Service — Washington, D.C.

Gene Lear
Raymond Scott
George Enfield
Buel Lanpher*
Charles Beer*

Economic Research Service

Jerry Sharples*; Lafayette, Indiana
Douglas Trunnell; Purdue University

Statistical Reporting Service — Washington, D.C.

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James Kendall
William Kibler
Don VonSteen
Dick Knight
William Arends
George Roney
Nina Carroll
Carol Claggett
Al Potter
Doug Fenley
Ray Halley
Bruce Graham
Larry Snipes
Richard Max
Ethel Copeland
Eugenia Heisserman
Don Jump

Statistical Reporting Service — State Statistical Offices

Ohio:	Dan Tucker, Tom Charles, and Kent Hoddick
Indiana:	Earl Park, Lewis (Bud) Beaver, Kurt Braunwart, and Ed Burgess
Illinois:	Robert Moats, Ken Zelazny, Douglas Murfield, and Richard Sims
Iowa:	R. Sutherland and Lloyd Stuber
Minnesota:	Doug Darling and Cecil Foss

*CBW Executive Committee

Nebraska: John Ridgely and Dewayne Hamilton

Missouri: Eddie Brickner and Tom Keedy

Agricultural Stabilization and Conservation Service

Joe Clifton*, Harold Jamison*, Seth Huisman, and A. Broughton; Washington, D.C.

Photointerpreters:

Ken Anderson, Wisconsin
Bill Bower, Indiana
Tom Pieper, Iowa
Harrison Ray Hicks, Ohio
Bill Knowles, Indiana
Dan Whaley, Indiana

Below is the list of names of ASCS personnel who played a major role in carrying out the farmer survey and field verification. Several of those listed also made biweekly ground observations.

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- William D. Hay
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Nola A. Parman

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- Janice E. Cradick

Thayer County
- Ernest H. Peithman
- Haroldine W. Grueber

York County
- Sam A. Gibbs, Jr.
- Roger D. Keil
- Florence O. Heinz

Cooperative Extension Service and Experiment Stations

The state Cooperative Extension Services and some Agricultural Experiment Stations provided the manpower for the biweekly field surveys.

Ohio

State Staff

- Lansing Williams**, plant pathologist
- Austin Ezzell
- Allen Troxel and Jim Starr, photointerpreters

Local Staffs

Auglaize County
- R. Dale Wilson

Belmont County
- Dale T. Bonnett

Butler County
- M. Edward Haagen
- Roy L. Titkemeyer

**State Coordinator

Carroll County
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L. Z. "Pete" Newsome

Cuyahoga County
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Darke County
Dennis K. Baker
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