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THE CORN BLIGHT WATCH EXPERIMENT: Economic Implications for Use of Remote Sensing for Collecting Data on Major Crops*

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The 1971 Corn Blight Watch (CBW) Experiment was the result of two major developments. One was the Southern corn leaf blight epidemic of 1970 and the concern about its return in 1971. The other was the need to test and evaluate the technological breakthroughs that had recently been made in remote sensing. In this paper I use the Corn Blight Watch experience to draw some implications for using remote sensing to collect data on major crops.

Why the interest in remote sensing?

Billions of dollars are spent for public and private collection of data that will aid in market and policy decisions. The market system needs accurate and timely information in order to provide an orderly flow of goods and services from producer to consumer. Poor information or the lack of information leads to a disorderly and inefficient economic system.

The cost of obtaining data by conventional collection methods increases each year. The cost of labor-intensive methods of data collection, whether by personal interview, telephone interview, or by visits to sample plots, will continue to increase as the price of labor increases.

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It is within this background of data needs and rising costs that interest has centered on the development of remote sensing. Sensors mounted on airplanes or satellites have the potential of scanning the earth's surface and obtaining large quantities of certain kinds of data very rapidly. Remote sensing promises much to the future development of improved agricultural information systems. But as with any new technology, many questions need to be answered before remote sensing becomes a part of an operational data collection system.

My purpose in this paper is (a) to describe the Corn Blight Watch Experiment, (b) to describe the two types of remote sensing technology used, and (c) to summarize some economic implications for using remote sensing in the near future to collect data on major crops.

The Corn Blight Watch

The Corn Blight Watch was an experiment in data collection but it also was a real-time source of information about the spread of the Southern corn leaf blight. In this paper, just the experimental use of remote sensing is discussed.[1/]

[1/] The Corn Blight Watch was also an experiment in institutional organization and coordination. Never before had so many different government agencies at the Federal, State, and local level brought themselves together in an agricultural remote sensing application effort of this magnitude. The Statistical Reporting Service (SRS/USDA), The Agricultural Stabilization and Conservation Service (ASCS/USDA), The Federal Extension Service (FES/USDA), The Economic Research Service (ERS/USDA), The Cooperative State Research Service (CSRS/USDA), The Cooperative Extension Service (CES), and The State Agricultural Experiment Stations (SAES) of the participating States, The National Aeronautics and Space Administration (NASA), Purdue University and its Laboratory for Applications of Remote Sensing (LARS), The Institute of Science and Technology (IST) at the University of Michigan, and others combined efforts in the experiment.

The experiment was initiated in early 1971. Ground and aerial observations of 210 sample sites were monitored from May to September over a seven-State area within the Corn Belt. 180 sites were located in Ohio, Indiana, Illinois, Iowa, Eastern Nebraska, Southern Minnesota and Northern and Eastern Missouri. An additional 30 sites were located in an intensive study area in Western Indiana. The sample sites were each about one mile wide and eight miles long, and were uniformly spaced along flightlines. The flightlines are shown in figure 1.

Data were collected on the ground and with remote sensing devices for each site once every two weeks. "Ground" data--data obtained by enumerators visiting sample fields--were needed in order to interpret the remote sensing data. Field observations consisted of (1) an interview in May of all farm operators who had land in the sites (conducted by ASCS personnel), and (2) biweekly visits to approximately eight selected corn fields in each site by county extension personnel. ASCS interviewers obtained the expected acreage and land use of all fields within the 1 mile x 8 mile site. For corn fields they also collected data on acreage, type of cytoplasm, plant population, row direction, planting date, width of rows, and whether or not corn was planted in the field last year.

After attending a training school, a county agent in late June laid out two observation plots in each of the selected corn fields. Every two weeks the first five plants in each plot were observed for stage of maturity, height, evidence of blight lesions, ear rot, drought, and other stresses. The observer also made a subjective evaluation of the overall field compared with the 5 plants.

About 8,000 farmers were interviewed by ASCS people. They collected information on 56,000 fields of which 16,000 were corn fields. Biweekly ground observations were made by extension people of 1,600 sample corn fields and detailed measurements are taken from 16,000 corn plants.

The remote sensing phase of the experiment consisted of two parts: color infrared photography collected for all flightlines at 60,000 feet by an Air Force RB-57F contracted by NASA; and multispectral scanner sensing of the 30 intensive study sites in Western Indiana collected with a C-47 by the Institute of Science and Technology (University of Michigan), also under NASA contract. The output from the former were 9" x 9" color infrared transparencies to be analyzed by photo interpreters and the output from the latter was a magnetic tape to be processed on a computer. The flights were scheduled for every two weeks to coincide as much as possible with the collection of ground information. The total area photographed every two weeks approximated the combined area of Ohio and Indiana. The total area analyzed (the 1 mile x 8 mile sites) was about 1,680 square miles.

A word about remote sensing as used in the experiment: The color infrared photography measured the energy reflected between .67 and .90 microns which is part visible and mostly reflective infrared. The use of this film is a proven tool in the detection of diseases. The multispectral scanner measured energy from seven wavelength bands in the visible spectrum, four bands in the reflective infrared, and one in the thermal infrared. The responses from these twelve bands were recorded simultaneously on magnetic tape. Each type of vegetation has its own unique "signature" when one or more of the channels are compared. Several levels of corn blight can be differentiated using this process. One of the difficulties is that signatures change as the plant matures, after a rain, in weedy fields, on dark soils, etc. All these variables need to be neutralized to improve accuracy.

Data collected in the field and by airplane were sent to the Laboratory for Applications of Remote Sensing (LARS) at Purdue. At the time this paper was written the results of the experiment were being summarized by engineers, agricultural scientists and other scientists connected with the experiment. Their research focuses on the accuracy of identification of various levels of Southern corn leaf blight, the accuracy of identification of corn and other crops, comparison of the accuracy obtained by the two types of remote sensing technology employed, optimum sampling, factors related to the spread of blight, and so on.[1/]

Costs and Benefits

My comments will focus on the cost of data collection in the Corn Blight Watch Experiment with some attention also given to what was obtained for the cost. In this discussion I will examine the cost of the infrared photography portion of the experiment and the corresponding data collected on the ground. The experiment was designed so that the data on corn blight collected on the ground could in a statistical sense stand alone. The remote sensing data was used to augment the ground data.

The cost of collecting the ground information was $393,000[2/] and the cost of

[1/] Further information can be obtained from the Laboratory for the Application of Remote Sensing, Purdue University, Lafayette, Indiana 47907.

[2/] The cost of collecting the ground information is in line with what the Statistical Reporting Service, USDA, spends to estimate corn acreage and yield. They estimate corn acreage from information obtained in the June Enumerative Survey and they estimate the corn crop condition four times during the growing season with their Objective Yield Survey. For the 7 states included in the CBW Experiment, SRS estimated that the Objective Yield Survey cost about $160,000 for the four visits. If this cost were doubled to be comparable with the 8 sampling periods of the CBW and if the cost of the corn portion of the June Enumerative Survey were added in, the total cost would be near the $393,000 spent to collect ground information in the CBW.

collecting the color infrared photography was $588,000 giving a combined cost of $981,000.[1/]

The ground survey yielded timely information about corn blight during the summer of 1971. So what additional was obtained for the additional expenditure of $588,000? Basically two things: (a) corn blight readings on over 14,000 additional corn fields, and (b) documentation and storage of sample data. Ground observations were obtained on only 1500 corn fields so the use of infrared photography greatly increased the sample size at a much lower cost per corn field. With accurate analysis of the photography, the expanded sample would greatly increase the reliability of the estimates of blight infection. Continuing research on the results indicate that although early detection of blight was difficult, as the blight got more severe, infrared photography could accurately detect it.

Documenting the sample on a photograph has considerable potential as an aid in data interpretation. A questionnaire includes very specific information. If an error is detected several days later, it is expensive to revisit field plots and the sample may have changed considerably during the intervening period. A photograph, on the other hand, can be reexamined many times by different people. Changes in the condition of a field can be readily observed by comparing photographs over time. Work can easily be checked by several interpreters.

[1/] All costs of the experiment are explained in the appendix.

The above types of benefits are difficult to measure quantitatively. What is the value of reduced variance or of photographic documentation of the sample? Little is known but some initial work in this area was done by Hayami and Peterson (March 1972 Amer. Econ. Rev.) and by Eisgruber ("Potential Benefits of Remote Sensing," Information Note 030872, LARS, Purdue University).

The other remote sensing technique used in the Corn Blight Watch, multispectral sensing, is still an infant technology. Consequently, the cost of collecting data on crops is currently very high. The performance in the CBW experiment in the area of crop acreage and crop condition identification was encouraging. Multispectral sensing has the potential of being highly automated so that the data flows from the sensor through the computer to a final output form with very little human interruption. In the Corn Blight Watch, one-third of the cost of data collection using multispectral scanner sensing was for computing expenses and 38 percent was for aerial data collection. Changes in computer hardware and software are on the horizon that could greatly reduce computer costs. Comparable efficiencies in data collection are also quite likely. The remaining costs--primarily labor--could be greatly reduced as the system becomes automated. Thus multispectral sensing could provide breakthroughs in efficient data collection during the latter 1970's.

From the CBW experiment several conclusions can be drawn about the use of remote sensing for estimating the acreage and periodic condition of major crops.

In the foreseeable future, remote sensing should not be expected to substitute for the more conventional methods of crop data collection. The role of remote sensing as a data collection technique appears to be one of augmenting the enumerator in the field rather than replacing him.

Given the 1971 level of technology, color infrared photography or multispectral scanner sensing will not lower the cost of collecting acreage and crop condition data under most conditions. But where surface travel is very difficult due to a hostile environment on the ground--e.g., in Viet Nam or in rough terrain--then remote sensing may be the only feasible means of data collection.

The storage of basic data on the photograph or the scanner data tape is a unique feature of remote sensing. But in addition the tape or photograph stores information about any other feature within the geographical area covered by the scanner. Data on corn, soybeans, wheat, oats, or even on such things as quality characteristics of water in lakes and rivers could be obtained from the one data source. The cost per user could be greatly reduced if the total cost of data collection could be divided among the several users. One of the challenges in the future of remote sensing will be to coordinate the needs of the many potential users so that a set of photographs or scanner data tapes can be more fully utilized and the costs shared.

APPENDIX

In order to analyze costs, two decision rules were followed. First, all contract work was valued at the face value of the contract. Contract work included all flights of the RB-57 (Air Force contract), all flights of the C-47 (University of Michigan contract), and some of the keypunching of computer cards.

Second, no charge was made for overhead costs such as office or lab space, or depreciation of durable equipment.

A value was assigned to all the labor, computer time, aircraft flying time, film, processing, and so on, used in the experiment. The grand total of all expenditures was $1.9 million. Table 1 shows the cost summary.

Item I in Table 1, preparation for the experiment, primarily consisted of two parts: (a) experimental design and selection of sample segments, and (b) acquisition of initial photography of the sample areas.

Item II, ground information, includes all activities associated with collecting, editing and processing data obtained from farmer interviews and field observations.

Item III includes the cost of data collection with the RB-57, processing the film, photo interpretation, and summarizing the results.

Item IV includes the cost of the C-47 for data collection, and the cost of analyzing and summarizing the data.

Item V, planning, guidance and administration of the experiment, includes the time and travel expenses of the Executive Committee, the State Extension and Experiment Station Coordinators, and the technical coordinators.

Table 1. Summary of costs, Corn Blight Watch Experiment.

I.	Preparation for experiment		$ 105,000
II.	Ground information:		393,000
	A. Initial interview	$ 128,000	
	B. Biweekly field survey	215,000	
	C. Other	50,000	
III.	Color IR photography and analysis		588,000
IV.	Multispectral sensing		606,000
V.	Planning, guidance and administration		195,000
	TOTAL		$ 1,887,000

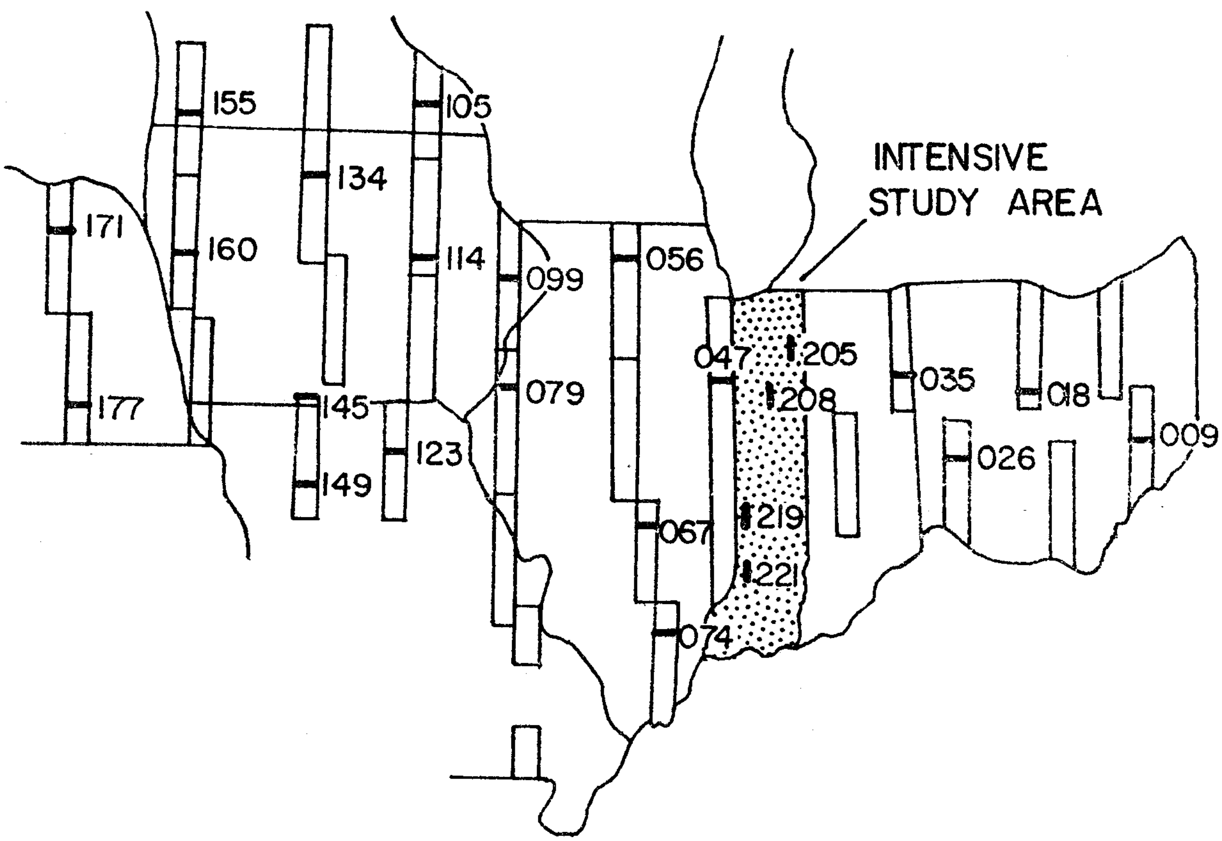

Figure 1. Flightlines of the Corn Blight Watch Experiment.