LARS INFORMATION NOTE 091170

Purdue University

September 11, 1970

SOUTHERN CORN LEAF BLIGHT

Status Report No. 2

by

Staff of the Laboratory for Applications of Remote Sensing

I. Introduction

Study is continuing of the detectability by remote sensing techniques of the Southern Corn Leaf Blight, a fungal disease of corn which has been observed this year throughout the central Corn Belt and the South. For further background information concerning the disease see LARS Information Note 083170 and its Appendix.

The specific goals of this study are to evaluate the feasibility of detecting the Southern Corn Leaf Blight by each of several remote sensing techniques and further to determine the detectability of various degrees of blight infection. The remote sensing techniques under consideration are:

1. standard photo-interpretive techniques applied to various forms of aerial photography;
2. automatic pattern recognition techniques applied to digitized multiband aerial photography; and
3. automatic pattern recognition techniques applied to multispectral scanner data.

II. Data Collection

Table 1 is a complete listing of the data collection missions in conjunction with this study.

Table 1. 1970 CORN BLIGHT STUDY MISSIONS - AERIAL

DATE	ORGANIZATION/PLANE	AREA COVERED	DATA TYPE
8/19	Purdue Univ. Beechcraft	S. River Road	Photography: 35mm color & color IR
8/21	Purdue Univ. Beechcraft	S. River Road; study areas south of Lafayette	Photography: 70mm color; 35mm color and color IR
8/24	Purdue Univ. Beechcraft	S. River Road; study areas north of Lafayette	Photography: 70mm color; 35mm color and color IR
	University of Michigan	N/S flight line study areas, 2 passes (3000')	Multispectral scanner; Photography: black and white; color, color IR
8/26	NASA RB57F	N/S flight line, 2 passes (60,000')	Photography (RC-8): Color and color IR Photography (Zeiss): Color IR Photography (Hasselblads): Various film/filter combs.
8/27	Air Force C-131	N/S flight line (20,000')	Photography: 9 lenses, 70mm format
8/28	Bendix Corporation	N/S flight line study areas	Multispectral scanner
9/5	University of Michigan	N/S flight line study areas (3000', 5000'); flight lines 21,23,24 (3000')	Multispectral scanner; Photography: black and white
9/9	NASA RB57F	N/S flight line, 2 passes (50,000')	Same as above (8/26) except longer lens on Hasselblads
9/10	Air Force C-131	N/S flight line	Same as above (8/27)

Table 1. 1970 CORN BLIGHT STUDY MISSIONS - AERIAL (con't.)

DATE	ORGANIZATION/PLANE	AREA COVERED	DATA TYPE
9/11	Purdue Univ. Beechcraft	N/S flight line study areas	Photography: 70mm color and color IR
	University of Michigan	N/S flight line study areas (3000', high alt. up to 10,000')	Multispectral scanner; Photography: black and white

1970 CORN BLIGHT STUDY MISSIONS - GROUND TRUTH

DATE	ORGANIZATION	AREA COVERED
8/26-8/27	Purdue University	N/S flight line study areas
9/3-9/4	Purdue University	Study areas D, E, and F
9/8-9/9	Purdue University	Study Areas A, B, and C; flight lines 21,23,24 in Tippecanoe County

The test site establisehd specifically for this study (Figure 1) has been described in an earlier status report, LARS Information Note 083170. Briefly, it consists of a north-south (N/S) flight line running the length of Indiana, with six intensive study areas in which ground truth is being collected. The intensive study areas are referred to as areas A, B, C, D, E, and F. Area A is the northernmost, F the southernmost. Photographic data has also been collected from an area southwest of West Lafayette, Indiana (South River Road) which has fields exhibiting several stages of the blight and which is particularly convenient to LARS by automobile. Finally, the areas designated as Purdue Flight Lines 21, 23, and 24 have been added to the study. These are flight lines which have already received considerable attention as the result of other LARS data analysis projects. The accessibility of these areas and the ready availability of ground truth for these areas should prove of considerable value to the corn leaf blight study.

Ground Truth Data. Ground truth information has been collected by Purdue staff members and area crop extension agents at approximately 7 - 10 day intervals in conjunction with the aerial data collection. Initially, each corn field was rated for the degree of Southern Corn Leaf Blight infection, including leaf damage, ear and stalk lesions, and ear and stalk rot. The plant maturity stage was also recorded. Additional items have now been added, including information on the crops (or use of field) other than corn and on factors other than Southern Corn Leaf Blight and normal maturity which may be causing corn plants to turn brown (fertility deficiency, drought, etc.).

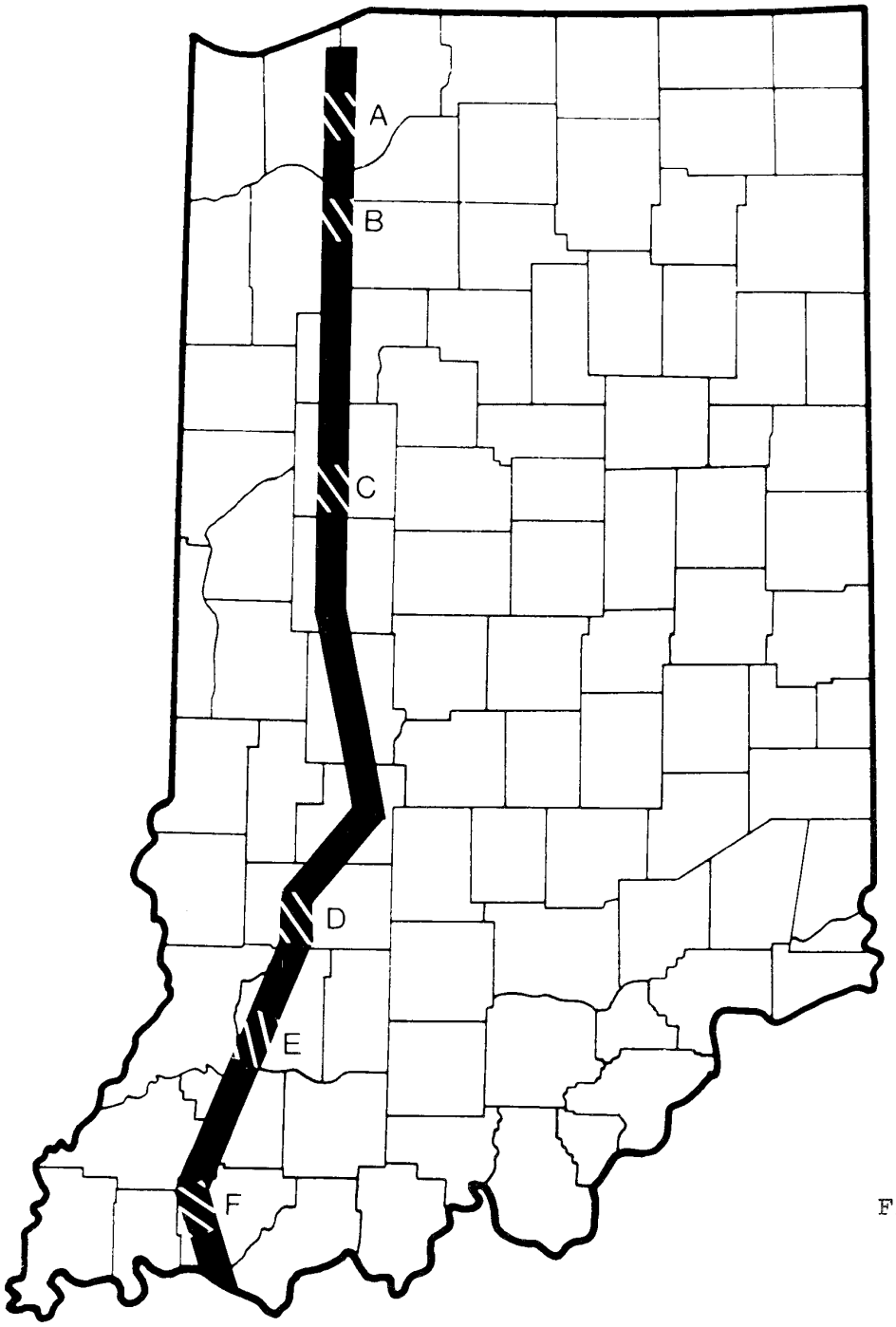

Figure 1

Southern Corn Leaf Blight Flightline in Indiana flown in August, 1970 for the Laboratory for Applications of Remote Sensing (LARS) at Purdue University. Cross-hatched regions are intensive study areas.

Multispectral Scanner Data. LARS is most appreciative of the cooperation given them by the various organizations who have participated in the corn blight study. The University of Michigan's Institute of Science and Technology (Willow Run) is one such organization. In spite of a tight schedule, they managed to fly the north-south test site on August 24 and had duplicate analog tapes and nine inch black and white contact prints available to be picked up at Willow Run by R. B. MacDonald by 6:00 p.m. August 25. LARS was able to begin processing the data less than two days after the data was obtained.

The pressures of the U. of M. plane schedule have had some unfortunate consequences with respect to the August 24 flight. The equipment operators apparently did not have time to reconfigure the scanner recording system to the "standard" setup used for LARS. As a result, an additional overlay has been necessary to register the visible and infrared channels. In addition, the onboard prints of two data channels, usually obtained, were not obtained for this mission. These were relatively minor inconveniences, however. A far greater problem arose from the weather conditions, which were marginal. By the time the plane was over the flight line (10:30 a.m.) there had been considerable cloud buildup which persisted until late afternoon. On landing at Evansville, Indiana (at the southern end of the flight line) the flight personnel notified the principal investigator at LARS that the data was of questionable value due to cloud cover. The principal investigator suggested that the aircraft remain in Evansville overnight and refly the test site the following morning, August 25. This was ruled out because of a prior commitment to a

mission in Maine. The principal investigator then suggested that the test site be reflown that same afternoon. A portion of the resulting data has been found to be usable.

Bendix Corporation (Aerospace Systems Division) volunteered to fly the test site with their multispectral scanner. As this provided an opportunity to acquire backup for the data from the August 24 U. of M. mission, LARS agreed to process the Bendix data, which, after some delay due to weather, was collected on August 28. However, Bendix' analog recording equipment is not compatible with the LARS reproducing equipment making it necessary to demodulate and re-record the data on the recorder at LARS. Various commitments of the Bendix equipment delayed this procedure somewhat and on September 4 the LARS reproducing equipment became inoperable due to a serious malfunction, thereby postponing the conversion indefinitely.

The failure of the LARS reproducing equipment will also delay processing of all U. of M. data collected subsequent to the August 24 mission.

Photographic Data. The color and color IR photography collected by LARS was generally of good quality and served to indicate the degree to which the corn blight could be detected visually. Cross-referenced to the black and white photography taken during the August 24 mission by the U. of M. aircraft, the LARS photography also provided a useful extension of the available ground truth data.

The 9" x 9" black and white prints from film taken aboard the U. of M. plane were of good quality and could be used both for ground truth collection purposes and for selection of the limited areas in

the scanner data which were relatively unaffected by the weather conditions and thus most amenable to analysis. The color and color IR taken concurrently with the scanner data collection have been only very recently received at LARS and although appearing to be relatively good quality have not yet been used for analysis purposes.

The photography from the first NASA RB57F overflight was picked up by R. B. MacDonald in Indianapolis on August 28, 1970, having been shipped there from Houston via commercial airline. The quality of the photography was generally good, although one roll of 70 mm color IR subsequently received on September 2, 1970 was of much poorer quality. Apparently the 9" x 9" Zeiss photography will be best for the photo-interpretive analysis because of its scale.

Unfortunately, the imagery collected by the U. S. Air Force C-131 out of Rome, New York and picked up there by a LARS courier was not usable. Only the black and white photography was interpretable. The color was apparently underexposed and the color IR was oversaturated in the blue; in both cases it was very difficult to distinguish ground features.

Further Data Collection Efforts. On September 5, 1970 the U. of M. plane flew the six study areas along the north-south flight line plus three additional flight lines over Tippecanoe County. According to the flight crew, weather was ideal. The data is expected to arrive at LARS shortly, although the difficulties with the LARS analog reproduction equipment will delay processing and analysis of the scanner data by as much as several weeks. The U. of M. plane made a final flight for blight study purposes on September 11, 1970.

The NASA RB57F and Air Force C-131 have also made additional flights. The photography from these flights has yet to be received at LARS.

The weather over the test site has been quite variable during the period of time over which the aerial data has been collected. The availability of photographic and multispectral scanner systems dedicated, as it were, to such a study project has permitted advantage to be taken of the breaks in the weather which have occurred and thus assured that the study could be successfully conducted.

III. Data Analysis

Ground Truth. Virtually all fields initially checked in conjunction with this study August 26 and 27 were found to have some degree of the Southern Corn Leaf Blight infection. The three study areas in the northern half of the state were generally rated from 1 to 3 on a scale of 0 to 5 (no infection to very severe infection) while fields in the three southern segments tended to be rated 3 to 5. Ear and stalk rots were found in more fields in the southern half of the state. Predicted yield loss due to the leaf blight was estimated at less than 5% for the northern three segments and from 5% to 40% in the three southern segments. With the exception of study area C, most fields had reached the dough and dent stages of maturity.

A second set of ground truth has ben collected from the same areas as well as from Flight Lines 21, 23, and 24 in Tippecanoe County for use in conjunction with the later aerial missions.

Although this set of ground truth has not yet been given detailed attention, it is clear that the general severity of the infection has increased noticeably, as expected.

Photo-interpretation. It was determined early in this study that black and white photography is not a good medium for detecting the Southern Corn Leaf Blight. Emphasis was therefore concentrated on color imagery (regular color and color IR).

The 35 mm and 70 mm color and color IR taken by LARS/Purdue has proven useful for distinguishing three categories of corn: healthy corn with little or no infection; mildly infected corn or corn turning brown due to other influences; blight-killed corn or early maturing corn. Apparently, what is seen in this imagery is green corn fields or fields with various levels of brownness or dryness. It is not possible to distinguish in such photographs brownness due to the corn blight from brownness due to other causes (including natural senescence).

The 9 inch Zeiss imagery (color and color IR) from the RB57F flight is the subject of intensive photo-interpretive efforts. Study area D, south of Worthington, Indiana, was selected for concentrated attention because of the degree of diversity of the corn fields in the area and also in order to coincide with the portion of the scanner data receiving attention (see below). An overlay was made for frame no. 37 (each frame covers an area about 10 miles square). Thirty nine fields for which ground truth was available were located and coded according to field number, leaf damage, maturity stage, and estimated yield loss. It was discerned that fields in three severity categories

could be distinguished within the frame of photography. Again these categories corresponded to the brownness of the vegetation; it was impossible to distinguish brownness due to blight from brownness due to various other factors including natural maturation.

Ongoing work in the photo-interpretation area includes additional effort to develop an interpretive key for the Zeiss photography and evaluation of the Hasselblad photography from the RB57F flight.

Automatic Analysis of Photography. A frame of the Zeiss photography from the RB57F flight has been selected and delivered to IBM/Houston for digitization. IBM will make color separation prints which will then be digitized for computer analysis.

Scanner Data Analysis. Initial efforts were directed at analyzing a portion of study area A, northbound pass (A2), which was free of clouds, contained a good sampling of fields with various degrees of infection, and for which ground truth was available (ground truth for areas A, B, and C was available a day or so earlier than for areas D, E, and F). These efforts were terminated, however, when the Divergence Processor ($DIVERG) of LARSYS/A showed that the corn blight classes (levels of severity) were not distinguishable. Even the severest stage of the blight present in this area (severe, level 4) could not be distinguished reliably from only very mild (level 1) infection.

The data for area D, northbound pass (D2), was next considered, as it was the only other segment which was relatively cloud-free and contained a representative sample of several levels of the infection.

In this case the results were encouraging, suggesting that the extremely low illumination level of A2 was responsible for the indistinguishability of the blight severity levels in that data. The corn fields for which ground truth was available represented five blight severity levels (level 1 or very mild through level 5 or very severe). Based on the histograms of the scanner data, the fields were divided into 15 obviously distinguishable subclasses (attempts to relate the subclasses within each severity level to natural factors have been inconclusive). It was then found, based on the Divergence Processor results, that the samples for each severity level were relatively separable from those in other severity levels. Only one exception to this was found: a set of very mature corn fields rated as level 1 blight severity was inseparable from the more severely infected classes. This was true even when all twelve visible wavebands were used for the analysis (study of the IR bands has been somewhat delayed due to the overlay processing required to register them with the visual bands). This suggests that, at least for the "visible" data, it may be difficult to discriminate blight effects from natural maturity of the corn.

A classification of a segment of study area D was performed using all twelve "visual" channels (Figure 2). The fourteen discriminable classes of blighted corn were used plus six rather arbitrarily chosen classes of "other" ground cover. In the figure, numerals represent corn of the given level of infection; "other" ground cover is represented by dashes. Blanks are points which have been thresholded, i.e., points which are spectrally unlike any of the corn or "other"

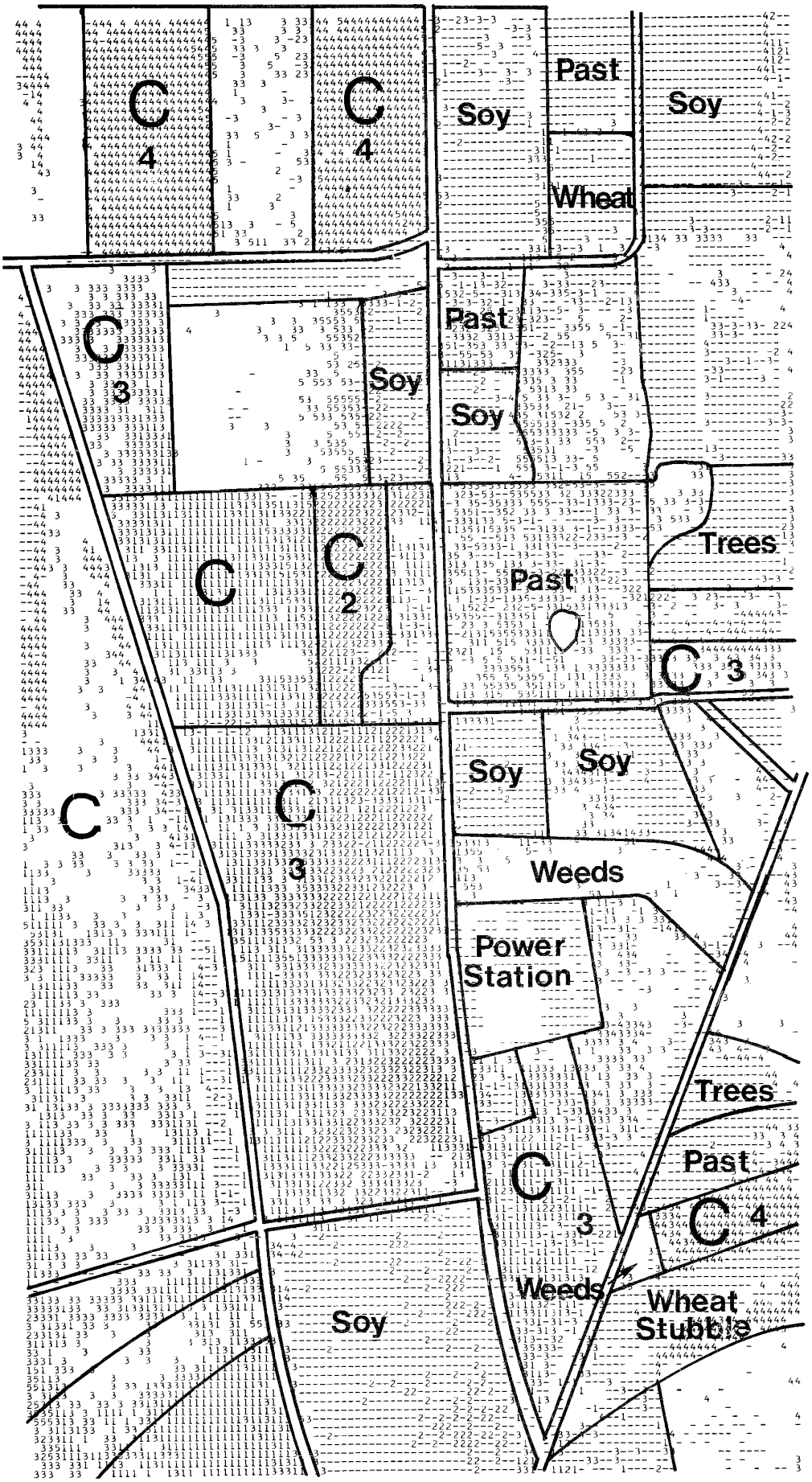

Figure 2

Automatic Identification of Corn Leaf Blight

classes. The two fields labelled "C" (for corn) without a blight severity label have been determined to be corn by means of photo-interpretation. In these cases, no blight severity label has been included because ground truth is not available. The correlation between ground truth and the classification results is good.

IV. Summary

Photography collected over the north-south flight line has revealed the wide-spread and variable effects of the Southern Corn Leaf Blight in Indiana. Three levels of severity of the infection can be discerned from good quality color and color IR photography. As many as five severity levels can apparently be detected and classified from multi-spectral scanner imagery. The latter conclusions are only preliminary, however, having been obtained from a limited amount of good quality scanner data collected over a small geographical area. The degree to which these results can be generalized to more significant areas remains to be seen. It is already clear, however, that some natural effects such as normal maturity will complicate the task of detecting the Southern Corn Leaf Blight.