Reprinted from

Eighth International Symposium

Machine Processing of

Remotely Sensed Data

with special emphasis on

Crop Inventory and Monitoring

July 7-9, 1982

Proceedings

Purdue University
The Laboratory for Applications of Remote Sensing
West Lafayette, Indiana 47907 USA

REMOTE SENSING OF SUNFLOWERS IN MINNESOTA'S RED RIVER VALLEY REGION: A SUMMARY OF INTERIM RESULTS

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I. ABSTRACT

Supervised and unsupervised analyses of 1980 and 1981 Landsat data covering Minnesota's Red River Valley have been undertaken to determine the extent to which sunflowers are spectrally separable from other crops grown in the region. Preliminary data analysis suggests that under conditions of extreme drought (1980), severely stressed sunflowers and potatoes are differentiable from those not severely stressed, but a stressed sunflower vs. stressed potato separation is not possible. Under "normal" moisture conditions (1981) sunflowers are separable from potatoes, wheat, barley, alfalfa, and pinto beans. Single-date separation from sugarbeets appears questionable. Multitemporal analysis of the 1981 data is continuing.

II. INTRODUCTION

The objective of this continuing study is to assess the spectral separability of sunflowers from other crops located in the Red River Valley of Minnesota using Landsat (MSS) data in conjunction with 70mm color infrared aerial photography and ground reference data. Spectral variation associated with the condition of sunflower fields will also be studied in an attempt to determine Landsat's role in the early warning crop assessment process. Figure 1 depicts the general geographical area under study.

To assist us with our analysis, an integrated approach has been used to tie the ground locations and conditions of the crops under study to the corresponding Landsat data. Ground reference data for the 1981 growing season were provided from several sources, yielding locations of nearly 400 fields including: sunflowers, potatoes, small grains, sugar beets, pinto beans, and several miscellaneous crops of lesser acreage. The University of Minnesota Extension Service Crop Pest Management program (CPM) provided detailed information on the condition of approximately 150 fields of sunflowers, potatoes, and small grains. Centrol, a farm management cooperative, provided us with the location of a number of fields of sugarbeets, pinto beans, and other miscellaneous crops.

The information on crop condition monitored by the CPM program is included in a computerized data base maintained at the University of Minnesota and includes weekly information on the condition of each field including the presence and degree of infestation of various pests, such as insects, weeds, etc. Crop history and management practice information for each field is also included in the data base. To facilitate season-to-season comparison of spectral response the locations of approximately 50 potato and 50 sunflower fields during 1980 were extracted from the data base. The 1980 and 1981 growing seasons were characterized by quite different meteorological conditions, with 1980 being a "drought" year and 1981 being a "normal" year. To assist in analyzing the Landsat data, large scale (1:10,000) 70mm color and color IR photographs of a subset (60) of the fields in the study have been acquired. These photographs have provided substantiation and an understanding of anomalous conditions noticed on the ground and in the Landsat data.

The Landsat data samples being used in the study are 240 X 240 pixel segments of full scenes which are displayed on an interactive image analysis system. This allows the analyst to view the Landsat data in contrast enhanced color, electronically magnify the image to observe the full detail in the data, and to outline ground areas over which reference data have been collected. Forty image segments or "windows" have been analyzed over three Landsat scenes in 1980, at three times during the growing season, and some 25 windows have been analyzed for a single date in 1981. (The oral presentation of this paper included the results of analyzing a second date of 1981 data. These were not available at the time of this writing).

III. SUPERVISED ANALYSIS PROCEDURE

The 1980 Landsat scenes were analyzed using only a supervised training technique, while both supervised and unsupervised training were employed to analyze the 1981 data. The University of Minnesota Image Processing Software (UMIPS) system was used to carry out both analyses. In the supervised approach, the operator used ground determined field locations and ½-inch to the mile county highway maps to carefully outline polygons on the interactive display corresponding as closely as possible to the ground derived information. Since the images were geometrically corrected, a grid overlay showing mile square segments (Public Land Survey sections) was very useful in locating a desired field in relation to easily identifiable features on the base map and display. In delineating the polygon to represent the ground conditions in a given field the operator used his judgement as to the exact boundaries of the field and avoided edge pixels to the extent possible. If anomalous conditions existed within a field as viewed on the interactive system, the operator would create a polygon both with and without the anomaly. If aerial photographs were available for a field in question they were used to help decide the shape and position of the polygon to best represent the ground observation. The aerial photographs were found to be extremely useful in this regard.

Using the vertices that defined each polygon, the spectral data for each field were extracted from the appropriate Landsat tape. To "clean" the data base before further analysis, a histogram/range plot was compared for all polygons representing the same crop type. Those polygons that were noticably different from the rest within their respective groups were investigated in an attempt to create representative crop groupings. Samples with fewer than 30 pixels were deleted due to their lack of statistical reliability. Fields which exhibited high variability, or multimodality in one or several bands were also deleted if reference information confirmed that they were indeed atypical fields. Once the file editing process was completed, fields were grouped and named as to their crop type, condition, time of year, etc., and a new set of statistics was then created. Two-dimensional scatter plots of each Landsat band vs. all others were then prepared and the pairwise transformed divergence values among all fields were computed.

IV. UNSUPERVISED ANALYSIS PROCEDURE

In order to more fully explore the spectral characteristics of the test areas and simulate an operational crop inventory system, an unsupervised classification was performed on a subset of the Landsat windows for 1981. A UMIPS algorithm which is a variation of the SEARCH program developed by the NASA Earth Resources Laboratory was used for this purpose. This algorithm passes a 3X3 pixel moving window over the data set. Any window falling below a user defined maximum variance threshold is analyzed. (This operation reduces the occurrence of "edge effect" spectral classes). These sets are accumulated and combined down to a user defined maximum number of spectral classes, with 18 classes being found to be an appropriate number with which to work. Once these spectral classes were defined the various windows were classified using a scaled distance algorithm. (A scaled distance measure is used because covariance data are not generated for the spectral classes in the algorithm). Ground reference data were then used to identify and combine spectral classes into information classes on the interactive display. With the aid of the UMIPS software, colors were assigned to each spectral class on the display using the previous supervised training information as well as the 70mm CIR aerial photography, county highway maps, and information acquired directly from farmers in the area.

V. 1980 DATA ANALYSIS

The locations of the three 1980 Landsat scenes analyzed using supervised training are shown in Figure 1. The dates analyzed included June 26, July 23, and Sept. 6. The June 26 image was not available for the northern scene. Again, extremely dry conditions prevailed during 1980, causing crops to vary widely in their condition. For the midsummer scene analysis it was therefore necessary to stratify each of the sunflower and potato fields into two sub-classes based on their infrared reflectance. The sub-groups were created using two major criteria. The first was their appearance on the interactive display. Highly infrared reflective fields appeared red or pink, while those of low infrared reflectance appeared cyan. Subsequent analysis of the variance, range of the digital numbers, transformed divergence values, and bispectral plots of each field demonstrated the validity of the separate grouping. Due to the extremely dry conditions represented in the data set it is entirely possible that the "sunflower" or "potato" fields in the low infrared reflectance groups were fields under severe stress and/or were simply bare. With this in mind, we adopted the same field grouping for the spring and fall scene analyses. Although we can show separability between types of fields (stressed/bare vs. productive) within both potatoes and sunflowers, there was no differentiability between these classes by crop type, even on a multitemporal basis.

VI. 1981 DATA ANALYSIS TO DATE

The supervised and unsupervised analysis of the 1981 crop has been completed for only one date (July 9) at the time of this writing, and for only the two most northerly Landsat scenes shown in Figure 1. Due to the extremely cloudy conditions realized in 1981, these images were the only midsummer scenes available for analysis. September 19 images for the same two scenes have recently become available and the comparative analysis of these will be reported orally at the symposium. It goes without saying that many of the comparisons we were expecting to make were not obtainable due to the poor Landsat coverage during the 1981 growing season - i.e., one date of mid-season imagery over only two thirds of our study area.

We have found for the July 9 image that, in general, sunflowers are separable from potatoes, wheat, barley, alfalfa, and pinto beans. However, the separability of sunflowers from sugarbeets on this single date is questionable. It should be noted that the number of fields of alfalfa and pinto beans was limited in this study due to inadequate information and the low percentage of these crops grown in the study area. Therefore, our comparisons of sunflowers with these crops are based on a small number of samples which were often located in a limited geographic area.

In addition to showing separability from several other crops, sunflowers also showed some interesting spectral subclasses. Sunflower fields were grouped into geographic regions and growth stages in an attempt to account for this spectral separability among subclasses of sunflowers. Since each of the windows extracted from the Landsat tapes were approximately 8.5 square miles in dimension and were chosen from all major sunflower growing areas contained within the Landsat scenes, the windows were used as strata to compare sunflowers among various geographic areas. Using these groupings, sunflowers within a specific window were indeed separable from sunflowers in many other geographic areas. As expected, a north to south gradient was found to exist within a single scene. Possible causes for these gradients include a range of soil types, precipitation variations, etc. For a limited number of fields the CPM program provided the growth stages for sunflowers on or within a few days of July 9. When fields that had the same growth stage were grouped together it was found that several of the different growth stage groups were separable from one another. Whereas July 9 is fairly early in the growing season for sunflowers and there was not complete ground cover by the plants at this date, it is suspected that soil reflectance could be influencing our spectral analysis. In short, combining the sunflower fields in the above two manners did not create completely homogeneous groupings. In either grouping there was general, not complete, separability of subgroups. Insufficient data at this time was contained within the CPM data base to try to check the condition of the crops within the growth stages studied. It is hoped that when this information is entered into the data base that this will help explain some of the within-group stage variability.

We have shown in this preliminary study that under "normal" growing conditions sunflowers seem to be separable from small grains, alfalfa, potatoes, and pinto beans, but may be confused with sugarbeets. There is, however, a need for further study to verify these results and to examine sunflowers at several times during the growing season so that their spectral reflectance properties can be known in relation to other crops at various stages of growth.

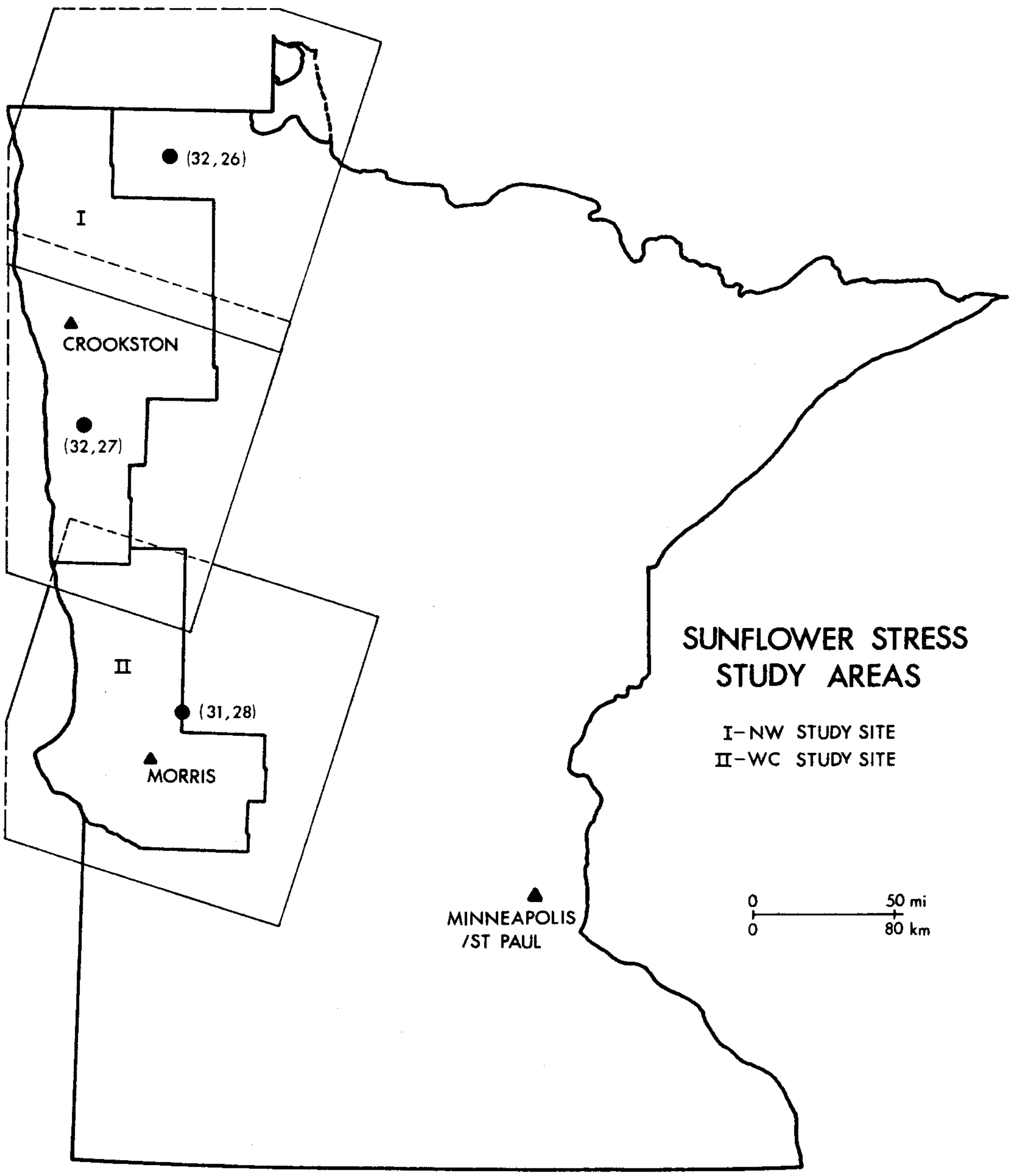
(32,26)
I
CROOKSTON
(32,27)
II
(31,28)
MORRIS
SUNFLOWER STRESS
STUDY AREAS
I-NW STUDY SITE
II-WC STUDY SITE
MINNEAPOLIS
/ST PAUL
0 50 mi
0 80 km

Figure 1.

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Thomas M. Lillesand is Director of the University of Minnesota Remote Sensing Laboratory. He is a Professor in the Departments of Forest Resources, and, Civil and Mineral Engineering. Prior to joining the faculty at Minnesota in 1978, he taught remote sensing for five years at the SUNY College of Environmental Science and Forestry at Syracuse, New York. He received his formal education in Civil and Environmental Engineering from the University of Wisconsin-Madison. He is a Past-Director of the Remote Sensing Applications Division of the American Society of Photogrammetry (ASP). In addition to teaching remote sensing, he currently directs a range of remote sensing research projects in agriculture, forestry, and water quality assessment. He is senior author of the textbook Remote Sensing and Image Interpretation (Wiley, 1979).

Marty Goldblatt is a Graduate Research Assistant in the University of Minnesota Remote Sensing Laboratory. He received a B.S. degree in Biology from the State University of New York College at Brockport. He will receive a M.S. degree in Forest Resources in June, 1982. He will be pursuing a career in remote sensing applications in natural resource management.