Reprinted from

Ninth International Symposium

Machine Processing of

Remotely Sensed Data

with special emphasis on

Natural Resources Evaluation

June 21-23, 1983

Proceedings

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

APPLICATION OF A U.S.-BASED ANALYSIS APPROACH TO ARGENTINA CROP IDENTIFICATION

J.B. ODENWELLER, C.M. HAY, B.L. WOOD

University of California/Space Sciences Laboratory
Berkeley, California

ABSTRACT

A generic, U.S.-based analysis approach was evaluated with respect to corn and soybean identification in Argentina. Using crop separability expectations derived from the analysis of Argentina ancillary data and U.S. spectral data, the approach was applied to Argentina spectral data by an expert analyst. Eight classes were detected and labeled independent of ground data. A high correspondence between the labels and limited ground data was achieved. It was concluded that an approach of this type could be applied to Argentina without major difficulty.

I. INTRODUCTION

Accurate and timely estimates of crop production in foreign areas are of vital importance to the Foreign Agricultural Service of the United States Department of Agriculture. To address this requirement, the AgRISTARS Inventory Technology Development Project (ITD) focused on the development of Landsat-based techniques for crop inventory that do not depend on ground data. Approaches to the analysis of Landsat multispectral scanner (MSS) data have been developed and refined within ITD using data from the Corn Belt and Great Plains regions of the United States. This study examines the application of a generic analysis approach, which is employed by several ITD procedures, to the detection and identification of corn and soybeans in Argentina.

Expectations with regard to Argentina crop separability were developed from: (1) assumptions used in the analysis of spectral data from the U.S. Corn Belt, (2) an analysis of ancillary data from the Argentina study area, and (3) a study of the spectral-temporal characteristics of corn and soybean confusion crops conducted with U.S. data. The expectations were applied to Argentina spectral data by an expert analyst, who had no prior exposure to either ground data or spectral data from the study area. The analyst followed a standard approach frequently used in the analysis of U.S. spectral data. The results of the analysis were compared to ground data to assess the feasibility of the approach and the validity of the crop separability assumptions.

II. FORMULATION OF ANALYST EXPECTATIONS

A. ASSUMPTIONS FROM THE U.S. CORN BELT

Analysis techniques developed for application in the U.S. Corn Belt rely on three basic assumptions:

1. Corn and soybeans are separable from non-summer-crop classes on the basis of temporal pattern. That is, the corn/soybean growing period occurs at a different time and/or is of a different duration than those of the small grains, pasture, trees, alfalfa and other land use classes.

2. Corn and soybeans are separable from one another on the basis of spectral value. That is, the maximum value of a spectral vegetation indicator (e.g. Tasselled Cap greenness) is generally greater for soybeans than for corn.

3. Summer crops other than corn and soybeans do not occupy a significant proportion of the agricultural acreage in this region.

B. ARGENTINA ANCILLARY DATA ANALYSIS

Assumptions from the U.S. Corn Belt experience were calibrated to Argentina using ancillary data from the Argentina study area (i.e., the provinces of Buenos Aires, Cordoba, Entre Rios and Santa Fe). These data included province-level crop calendars as well as planting statistics

at both the province and partido (county) levels. They were obtained as part of an Argentina ground data collection effort that was conducted jointly with the Environmental Research Institute of Michigan (ERIM) in 1981.[1] A determination of the crop mix in Argentina was made from the planting statistics. Potential similarities in crop temporal patterns were identified based on the timing of crop development stages. Due to the unavailability of Argentina spectral data at this state of the investigation, the potential for spectrally-based crop confusion could not be evaluated.

Through this exercise, a revised set of expectations was established for Argentina:

1. As in the United States, corn and soybeans would be separable from non-summer-crop categories such as wheat and pasture on the basis of temporal pattern.

2. Unlike the U.S. situation, corn and soybeans would additionally be separable from one another on the basis of temporal pattern.

3. Other summer crops, particularly sorghum (both grain and forage) and sunflowers, would be found in proportions frequently greater than or equal to those of corn and soybeans.

4. Due to similarities in temporal pattern, other summer crops would potentially be confused with corn and soybeans.

C. CONFUSION CROP SPECTRAL CHARACTERISTICS

To gain some insight into the spectral reflectance characteristics of sunflowers and grain sorghum, U.S. spectral data were examined in lieu of Argentina data. AgRISTARS sample segments were selected for study from a number of Great Plains states, including North Dakota, Minnesota, and Kansas. These states, located on the western edge of the Corn Belt, contain higher densities of sunflowers and sorghum than are found in the central Corn Belt.

Scatterplots of Tasselled Cap greenness versus brightness and profiles of greenness versus time were examined for separability among the crops of interest. The following observations were made:

1. Sorghum greenness values tended to be similar to those of corn and lower than those of soybeans.

2. Sunflower greenness values tended to be similar to those of soybeans and higher than those of corn, although this was not consistently the case.

3. At certain times in the growing season, sunflower brightness values were slightly higher than those of corn and soybeans at a given greenness value.

III. ANALYSIS OF ARGENTINA SPECTRAL DATA

A. TEST SITE

When Argentina spectral data became available at Berkeley, time and resources did not permit an extensive evaluation. Instead, an AgRISTARS sample segment in northern Buenos Aires province was selected for intensive study. This segment (511, Bragado) was chosen on the basis of data quality and Landsat acquisition history. Seven registered acquisitions from crop year 1980-81 were available: August 6, January 5, February 28 and March 1 (a sequential-day pair), March 19, April 5, and April 24. Planting statistics and a province-level crop calendar (Figure 1) were also available to support the analysis.

B. ANALYSIS APPROACH

The analysis followed a general sequence of steps common to a number of ITD procedures (the precise configuration of each step varies from procedure to procedure).

1. Data Normalization. The MSS data were calibrated to LACIE Processor standards, and a cosine sun-angle correction was applied.[2,3]

2. Feature Extraction. Physically-relevant features were extracted through the application of the Tasselled Cap transformation.[3]

3. Labeling Target Definition. The Tasselled Cap greenness and brightness channels from six dates (omitting one of the sequential-day pair) were clustered using a minicomputer-based version of the iterative ISOCLAS algorithm.[4]

4. Labeling. Using the expectations derived from the analysis of U.S. spectral data and Argentina ancillary data, an expert analyst labeled the clusters without referring to ground data. Labeling proceeded from the general to the specific. Based on the overall shape of the mean greenness versus time profile and the spatial relationships of the clusters within the segment, the clusters were grouped into three strata: (a) agricultural crops, (b) permanent vegetation (e.g., range, riparian), and (c) non-vegetated classes (e.g., water, roads). Data within the

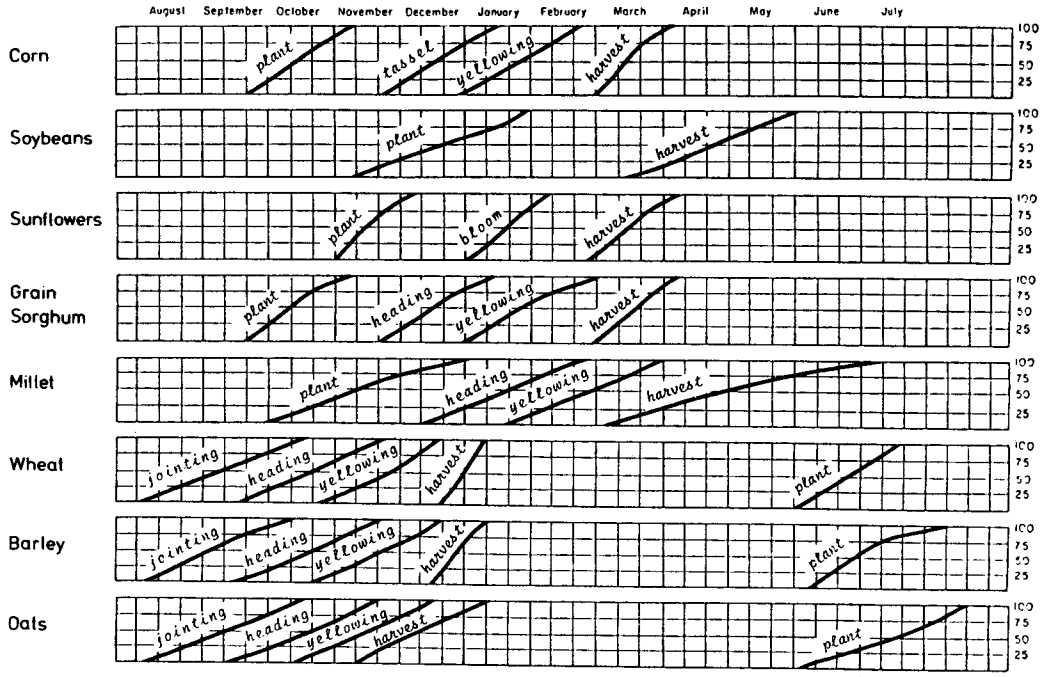


Figure 1. Buenos Aires North Crop Calendar. The biostage curves are based on estimates by agronomic experts in Argentina.

agricultural stratum were clustered a second time in order to obtain clusters that were as pure as possible with respect to crop type. These clusters were labeled based on: (a) the overall shape of the greenness profile, (b) the maximum observed greenness value, and (c) the date of the observed maximum.

IV. RESULTS AND CONCLUSIONS

Eight classes were detected and labeled: (1) permanent vegetation, (2) non-vegetated, (3) intensive pasture/alfalfa, (4) sunflowers, (5) soybeans, (6) corn/grain sorghum, (7) millet, and (8) miscellaneous unassignable clusters. Representative profiles from five of the classes are shown in Figure 2.

Due to the limited extent of the 1981 ground data (fields along two major roads only), accuracy statistics were not computed. A qualitative comparison of the classification map to available ground data was made (Figure 3). Based on this assessment, it was concluded that the labels in the first five categories are largely correct. The clusters in the sixth category are probably all corn, since grain sorghum was not reported in the ground data and the full range of variation observed among clusters in this category is represented by fields identified as corn by the ground data. The millet category could not be verified. The single millet cluster for which ground data existed was identified as pasture; there is evidence to indicate that the ground data is incorrect in this instance.

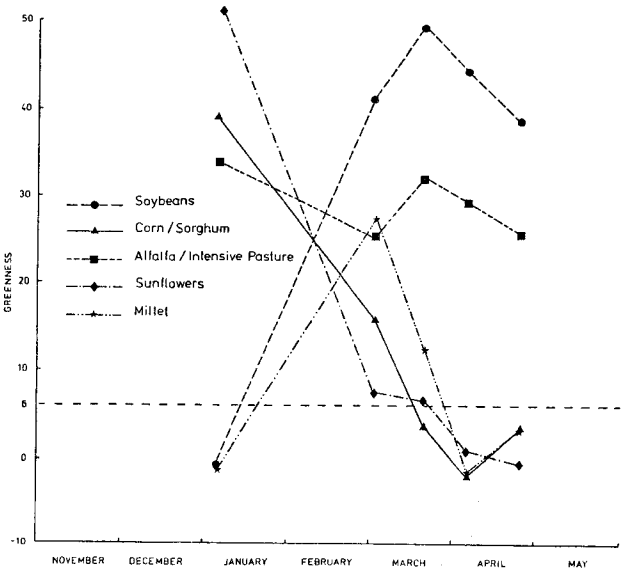
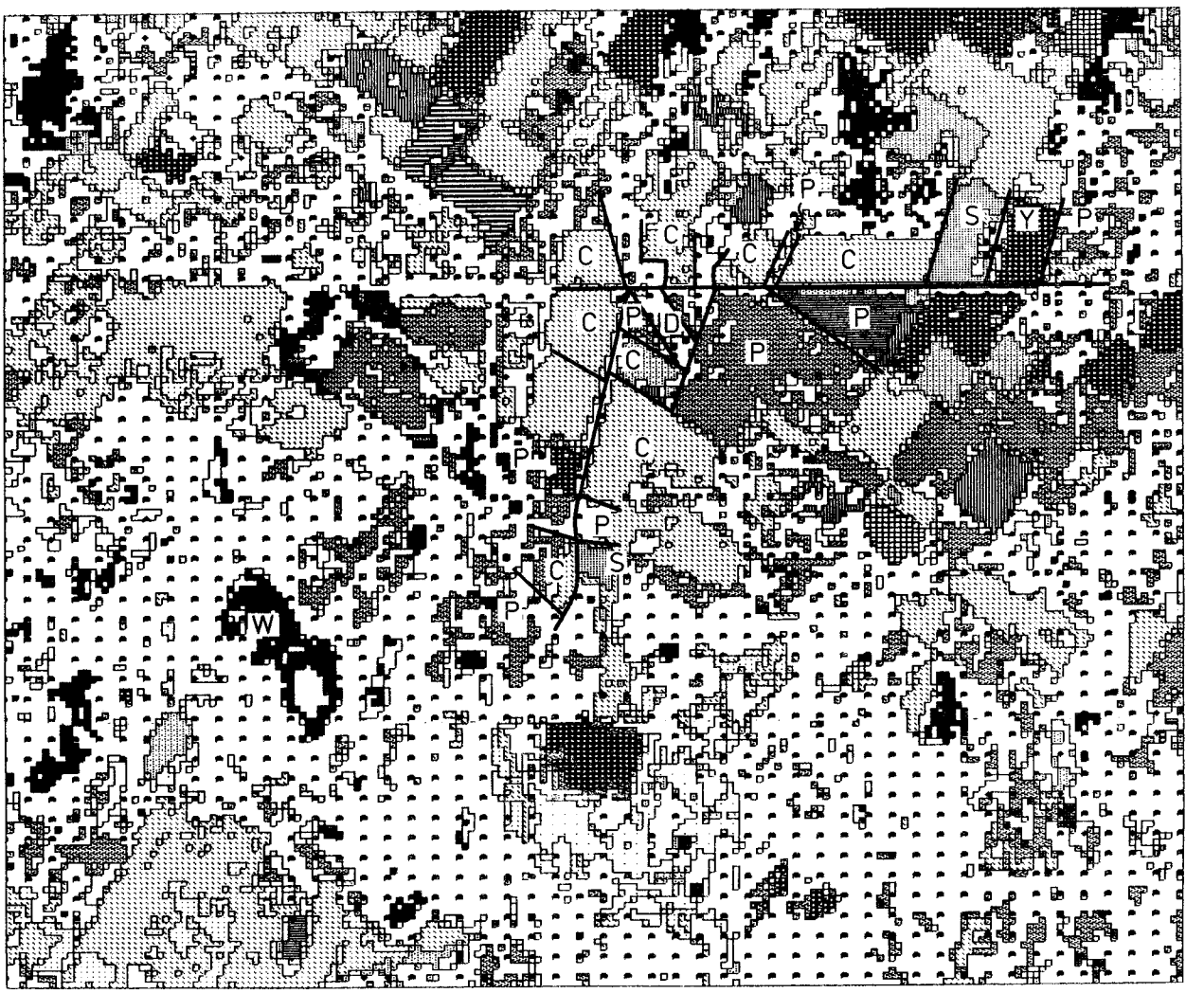


Figure 2. Cluster Mean Profiles, Segment 511, Bragado. Features of these profiles were the basis for cluster labeling.



KEY TO THE CLASSIFICATION

PERMANENT VEGETATION	NON-VEGETATED	PERMANENT VEGETATION	SOYBEANS	CORN, SORGHUM	SUNFLOWERS	CORN, SORGHUM	UNASSIGNED
UNASSIGNED	MILLET	MILLET	UNASSIGNED	INTENSIVE PASTURE, ALFALFA	UNASSIGNED	UNASSIGNED	UNASSIGNED

Figure 3. Segment 511 Classification Map. The 1981 ground data labels[1] are superimposed on the classification. Key to the ground data: C = Corn, D = Drainage Way, P = Pasture, S = Sunflowers, Y = Soybeans.

As expected, summer crops could be separated from other categories based on temporal pattern. This was also the primary method used to separate corn from soybeans. Sunflowers were distinguished from soybeans based on temporal pattern and from corn based on spectral amplitude. The analyst had to shift the province-level crop calendar by approximately four weeks in order to obtain a match with the temporal patterns observed in the segment.

No major obstacles were encountered that would stand in the way of adapting the U.S.-based crop identification techniques used in the study to an Argentina agricultural environment of this type. However, it is recommended that an area in Argentina with grain and forage sorghum fields be examined in order to assess the confusion potential introduced by these crops.

V. ACKNOWLEDGEMENTS

This work was performed under NASA contracts NAS9-14565 and NAS9-16413 from the Johnson Space Center, Houston, Texas.

VI. REFERENCES

1. Hicks, D., B. Sellman, E. Sheffner, G. Thomas, and B. Wood, 1981. 1981 Argentina ground data collection, AgRISTARS technical report SR-E1-04174, Environmental Research Institute of Michigan, Ann Arbor, Michigan, and University of California, Berkeley, California.

2. Wacker, A.G., 1981. Empirically determined calibration differences between MDP-LIVES and LACIE processed data, AgRISTARS report SR-J1-04133, NASA/Johnson Space Center, Houston, Texas.

3. Kauth, R., P. Lambeck, W. Richardson, G. Thomas, and A. Pentland, 1979. Feature extraction applied to agricultural crops as seen by Landsat, in The LACIE Symposium, JSC-16015, NASA/Johnson Space Center, Houston, Texas, pp. 705-721.

4. Ritter, P., and A. Kaugers, 1978. Cluster users guide, version 1.0, Remote Sensing Research Program, University of California, Berkeley, California.

Julie B. Odenweller. Ms. Odenweller holds A.B. and M.A. degrees in Geography from the University of California, Berkeley (UCB). She has been associated with UCB's Remote Sensing Research Program since 1975. Within the LACIE and AgRISTARS projects, she has conducted research in the areas of crop signature characterization and crop identification techniques development, with emphasis on corn, soybeans, and associated confusion crops. She recently served as project manager for the AgRISTARS Inventory Technology Development Project contract at UCB. Ms. Odenweller is a member of the American Society of Photogrammetry and the California Remote Sensing Council.

Claire M. Hay. Ms. Hay has been engaged in remote sensing research with the Remote Sensing Research Program of the University of California, Berkeley (UCB), for 14 years. She has worked with Apollo, Skylab, Landsat, and high altitude aircraft data with regard to geological, agricultural, and wildland vegetation resource information extraction. In recent years Ms. Hay has concentrated on the utilization of Landsat data in crop inventory systems and has served as project manager for LACIE and AgRISTARS contracts at UCB. She holds an A.B. in Geography from UCB and has completed all coursework toward the M.A. in Geology.

Byron L. Wood. Mr. Wood is a Ph.D. candidate in the Department of Geography at the University of California, Berkeley (UCB). His areas of specialization are biogeography, environmental planning and remote sensing. Currently he is with Technicolor Government Services (TGS), NASA - Ames Research Center, on leave from UCB's Remote Sensing Research Program where he worked in the areas of foreign and domestic agricultural crop identification, water quality analysis and the development of Landsat-based geographic information systems. At TGS his primary responsibilities are in the areas of agricultural remote sensing and geographic information system development. He has taught remote sensing in the Department of Geography at UCB and is a member of the Association of American Geographers, the American Society of Photogrammetry and the California Remote Sensing Council.