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Below: Figure I — This "false color" composite image was taken by a NASA satellite orbiting 580 miles above the earth. It covers the approximate area of eastern South Dakota shown in Figure II on the next page. The photo was taken on August 25, 1979.

The dark red areas are areas of high intensity crop cultivation, mainly sunflower and corn. Grayish areas are fields which have already been harvested or else spots with little natural vegetation. Dark blue, almost black, areas are bodies of water.

The use of the satellite data can help improve the accuracy of USDA crop acreage estimates.

SATELLITE PROVIDES ASSIST IN IMPROVING USDA ACREAGE ESTIMATES

By Paul W. Cook[1]

Throughout recorded history, man has developed many imaginative and innovative ways of accomplishing a given task. Reported on here is a method by which sunflower acreage estimates were generated for a six-county area in South Dakota by means of matching data from a satellite launched by the National Aeronautics and Space Administration (NASA) with a sample of ground observations. This was done in an effort to improve the precision of crop acreage estimates by researchers with the USDA's Economics, Statistics and Cooperatives Service (ESCS).

Obtaining the data needed for analysis of a given area is not always easily achieved. Clouds may render the optimal dates for crop discrimination unusable. For example, studies done by ESCS for three midwestern states for which total state coverage was desired have been made incomplete by from two to 17 counties due to clouds obscuring those areas.

Another important consideration is the timely and full availability of NASA's LANDSAT satellite digital data. For agricultural crops, this means that data should be produced within two weeks of the satellite's overpass. This would allow for a rapid data analysis and increase the satellite's usefulness.

Since the crop must be at a stage of growth that allows it to be easily observed by the satellite, early season estimates using satellite data are not possible. Consequently, early season acreage estimates will always need to be made by ground survey, as the ESCS Crop Reporting Board presently does. However, late-season precision may be improved by use of the satellite data.

SATELLITE IMAGERY PROCEDURE

ESCS's scientists have been examining the utility of making crop acreages with NASA's LANDSAT satellite series since its inception. Originally known as the Earth Resources Technology Satellite (ERTS), LANDSAT I was launched in July, 1972, LANDSAT II in March, 1975 and LANDSAT III in March, 1978. Although at various times two satellites have been operating, there have also been times when only one satellite has provided data.

The 580-mile-high polar orbit of each satellite allows it to pass over a given region of the earth's surface every 18 days while providing data on a swath 185 kilometers (115 miles) wide. Photoelectric sensors measure the amount of reflected energy from the earth's surface for four portions of the electromagnetic spectrum. Two bands are in the visible light range, with the other two bands in the near-infrared wavelengths.

Each set of four readings made by the sensors on board the satellite is known as a picture element, or pixel, and has an areal extent of 59 meters by 80 meters (approximately 1.14 acres). These data are beamed to earth receiving stations where they are recorded on digital computer tapes for further processing. NASA then cuts the long swaths of data into more manageable 115-mile-square (185-km-square) scenes (see Figure I). Tapes containing many such scenes are sent to the U.S. Department of Interior's EROS Data Center at Sioux Falls, S.D. There the tapes are processed to produce both digital and photographic products with resampled pixel sizes of 57 meters by 57 meters (188 feet by 188 feet) for the user community.

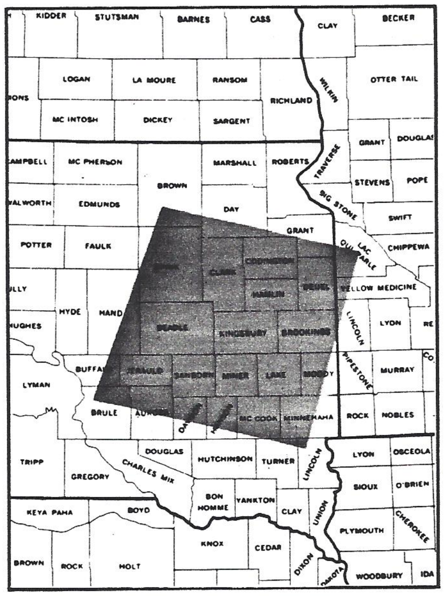

Figure II: Outlined here are the boundaries of the Landsat scene and those eastern South Dakota counties included in the study.

The photographs may be produced for each band individually in black and white, or three bands may be combined using colored filters to produce a false-color composite as shown in Figure I. For the crop estimation research, ESCS uses the photo products primarily as a means of determining where the LANDSAT scene is located in respect to the U.S. Geological Survey (USGS) map base. Another possible use of the photos is to locate the boundaries of different types of land uses, such as agricultural land, cities, forests, etc., to develop land use strata maps.

ESCS regularly collects information on approximately 16,000 randomly selected sample areas (or segments) throughout the United States on a yearly basis. This data collection effort is known as the June Enumerative Survey (JES). Enumerators interview each operator of land within each segment to determine what crops are being grown as well as the location and size of each field. This survey is a major input into the official June Acreage Report of the Crop Reporting Board. Other information collected from the JES on livestock numbers, farm labor, utilization of planted crops, etc., is used for other reports by the Crop Reporting Board.

Use of the LANDSAT data to make year-end state and sub-state estimates of greater precision for the Annual Crop Summary requires the ground information from the JES. ESCS's methodology for using the LANDSAT data involves matching the LANDSAT digital pixel values with known fields of crops from the randomly located segments throughout the area or state of interest. In the Midwest, sample segments are typically one square mile in size (300-400 per state).

Once all the segments are located accurately within a LANDSAT scene (usually up to 60 segments are available), the matched LANDSAT pixel data are used to develop crop signatures for each crop-type present in the sample segments (such as corn, soybeans, sunflower). A large computer in California (the ILLIAC IV) then does the calculations necessary to assign or classify each of the 10 million pixels within the scene to one of the appropriate crop types or land uses.

The relationship between the classified LANDSAT pixels within the sample segments and the reported acreage in the same segment is used to correct inaccuracies in the classification process. Thus, the final statistical acreage estimates can have a statement of precision made about them — a statistical way of measuring the amount of variability that the estimate might have if different ground samples were used.

SOUTH DAKOTA STUDY

During the summer of 1979, the Remote Sensing Institute (RSI) of South Dakota State University and ESCS engaged in a study to determine the importance soils may have for distinguishing crops using LANDSAT data. To implement this study, a random sample of 252 one-quarter-square-mile segments was drawn within a six-county area of South Dakota (see Figure II). This intensive sample was drawn by ESCS and enumerated by RSI in order to study 10 different soil strata. Coincidentally, this area included Spink County, which had a considerable acreage of sunflower. Since much of the winter wheat crop was lost during the 1979 growing season, additional acreage of sunflower was planted in this county. The soil study segments were available for examining the possibility of estimating the sunflower acreage.

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Six contiguous counties (Beadle, Clarke, Codington, Hamlin, Kingsbury and Spink counties) in South Dakota made up the study area, which was virtually all contained on LANDSAT scene 21676-16321 taken on August 25, 1979 (see Figure I). The dark red areas in the image are areas of high intensity crop cultivation. Primarily, these are fields of corn and sunflower. The light or dark grayish-appearing areas are fields that have been harvested or where there is little natural vegetation. The dark blue areas are bodies of water.

The majority of the sunflower fields were in Spink County. Therefore, the best relationship between the classified LANDSAT pixels and the reported acreage was found for that county. This statistical relationship (known as r^2) calculated from the data was found to be in excess of 0.92 (on a scale of 0 to +1), which shows there to be a very high positive correlation between the ground data and the classified pixel information. This meant that the LANDSAT data with ground data could be used to make a more precise estimate of the sunflower acreage within the county than by use of ground data alone.

To examine the value of using LANDSAT data to improve the precision of our acreage estimate, we'll use the statistical measure known as the coefficient of variation (CV). By definition, it is the ratio of the standard deviation (a measure of statistical variability or spread) to the estimate's mean calculated from the sample data and expressed as a percentage.

Using ground data alone, we found the CV to be 22.8 per cent for the sunflower estimate, whereas the estimate made using the LANDSAT data in conjunction with the ground data reduced this to 13.2 per cent. Consequently, the LANDSAT-aided estimate of 147,000 acres for the six-county area was remarkably more precise than was that obtained from the ground data only.

To have obtained this same increase in precision by use of ground data alone, 3.7 times as many segments would have been required. However, cost of such a data collection effort would have been much greater than the costs associated with the LANDSAT data analysis effort.

Future research plans include further testing of new methods for making more effective use of the LANDSAT data. Also, new satellite systems are under design work by NASA now. The combination of these improvements should allow better results in the near future. Indeed, ESCS will continue to seek out ways to implement new advances in technology to help improve the precision of crop acreage estimates.