LANDSAT Image Availability for Crop Area Estimation *

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ABSTRACT

This report describes an analysis of the National Aeronautics and Space Administration's (NASA) LANDSAT data series on The U.S. Department of Interior's (USDI) EROS data base for completeness concerning the needs of the Statistical Reporting Service (SRS) of the U.S. Department of Agriculture (USDA). A temporal window of mid-July to mid-August was used to study the effects of clouds and missing LANDSAT scenes on crop area estimation of corn and soybeans. This study shows that for reasonable coverage of the corn belt two satellites are the minimum operational configuration for USDA/SRS needs.

I. GENERAL

The purpose of this study was to format LANDSAT I, II, and III National Aeronautics and Space Administration's earth resource satellites acquisition information, existing in the U.S. Department of Interior's EROS data base, into a form useful for management decisions in the U.S. Department of Agriculture's Statistical Reporting Service. A five week temporal window centered on August 1 was used for the study. This window is optimum for most of the corn belt for satellite discrimination of corn and soybeans. Optimum temporal windows for particular crops in localized regions may differ from this window. Thus, crop calendar information should be consulted to select the window for a particular crop and region. The optimum acquisition window also varies from year to year due to such factors as late planting dates, or plant growth conditions (drought, or excessively wet weather). Imagery obtained prior to the optimum temporal window is degraded for crop identification by reflectance from soil background because of incomplete crop canopy closure. Imagery obtained on dates after the optimum window deteriorates for crop discrimination due to maturation of the crop. Individual fields have a much longer window than five weeks, but, the estimation window is determined by the latest fields planted and the earliest fields maturing.

With one satellite in operation a five week window allows only 2 passes or occasionally 3 per year. Two satellites gives 4 or occasionally 5 passes to this same window. Unfortunately imagery suitable for crop estimation is not obtained on every pass. Operational considerations prevent acquisition of some images. Orbital adjustment and enhancement of adjacent scenes are two examples of operational factors precluding 100% coverage. Equipment or software malfunction in orbit or ground systems also occur. From a crop reporter's point of view the earth's atmosphere can be a very cloudy place. Adequate soil moisture and high humidity often create excellent conditions for crop growth and the resulting high yields. Rainfall and cloudy weather often accompany these growth factors. In irrigated areas with frequent sunshine extra water must be provided for the transpiration loss caused by the low humidity of these areas. Irrigated crops supply considerably less than one half the production of major crops in the U.S. For example, over one-third of the U.S. rice crop is grown on the Texas Louisiana gulf coast where clear days during the crop window are very rare.

II. USDA/SRS MANAGEMENT CONSIDERATIONS

USDA/SRS management considerations in choosing a particular crop-region (region being a part of a state, a state, or a group of states) for inclusion in the AgRISTARS DCLC project include: crop importance to U.S. or region; percentage of U.S. production; the amount of work needed to prepare SRS area frame for use in LANDSAT-based estimation; the number of LANDSAT scenes necessary to image the region; the number of SRS June Enumerative Survey (JES) sample segments in region; the amount, the degree, and the number of confusion crops present (for example wheat and barley); local and national interest in the project; and the probability of obtaining cloud free imagery. If timely estimation is to be made, expenditures for ground truth and frame construction must be made well ahead of the LANDSAT passes. Ideally a crop region would have the following attributes. The crop selected would be a major crop in terms of value of U.S. production. A large proportion of the crop would

be grown in a relatively small area. The area frame would already be prepared for estimation. The confusion crop problem would be negligible. Local interest in the crop and its estimation by remote sensing would be high. There would be at least 5 but not more than 40 JES segments in each land use stratum in each LANDSAT analysis district. The region would be relatively cloud free during the optimum window for the selected crop.

III. SAMPLE

Although occasionally a 20 percent cloud cover scene is used by SRS for estimation some 10 percent cloud cover scenes are unusable because of the type of cloud cover (10 percent popcorn clouds over entire scene). Therefore for this study, a usable scene was defined to be one with 10 percent or less cloud cover and obtained between July 14 and August 19. The EROS data base was searched to obtain the cloud cover information. A systematic sample taking every fourth path and every other row was obtained. A total of 59 sample scenes located in 11 paths and 8 rows were selected. Information from 14 extra scenes along the coasts were used to refine the iso-maps.

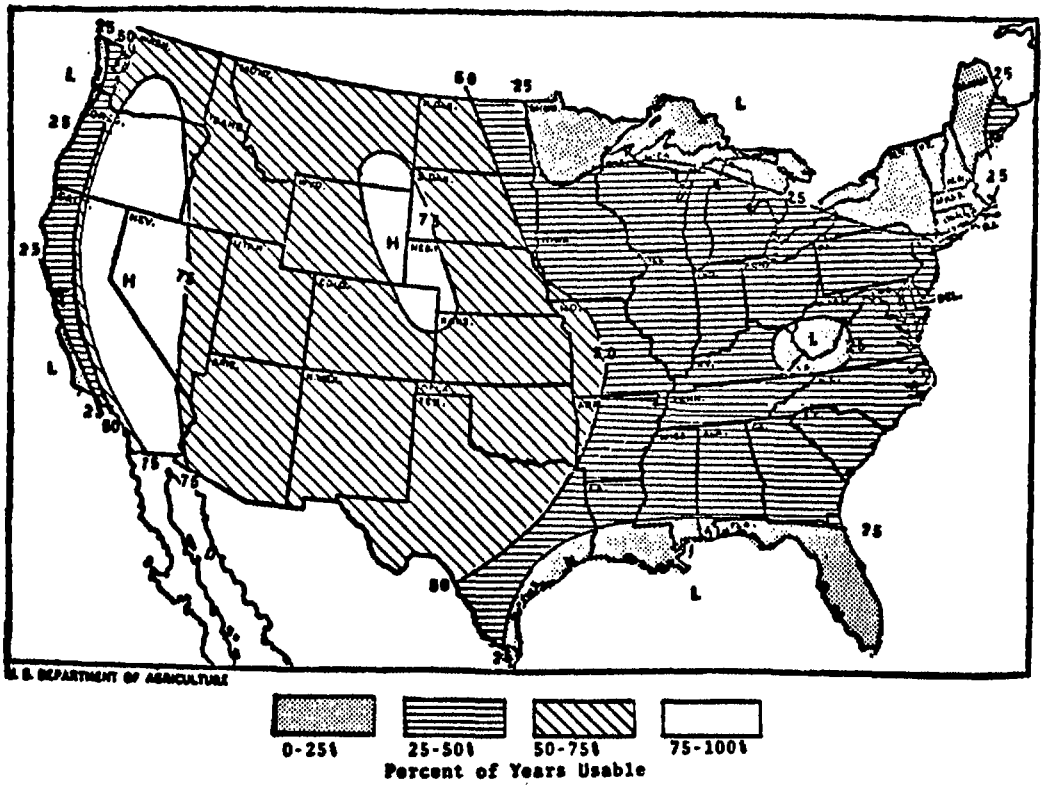
IV. METHODS

Total passes were calculated by projecting available EROS acquisitions along the same path for each year. By adding or subtracting increments of 18 days to a scene present in the data base, passes for which no scenes were acquired could be counted. Also a pass along the same path occurs on the same date. If for example a LANDSAT II scene was acquired on July 14, 1979 for path 32, row 26, passes also occurred on August 1, 1979 and August 19, 1979 for this scene. Passes occurred on these dates not only for this scene but for every scene in path 32. Total acquisitions were the number of scenes with MSS coverage and 90 percent cloud cover or less between July 14 and August 19. Scenes not acquired were either 100 percent clouds or imagery was not transmitted to EROS.

V. RESULTS

Isoline maps were prepared comparing one satellite and two satellite coverage (see Figures 1-2). The percentage was calculated by dividing the number of windows for which 10 percent or less cloud

FIGURE 1. 10 Years of LANDSAT 1972-1981 Images With Less Than 10% Clouds: Simulation of 16 Years of One Satellite Coverage: Temporal Window (July 15 - August 20)



cover imagery was obtained by the total number of windows. Isolines (lines connecting points of equal value) were drawn on the maps at the 25, 50 and 75 percentage points. An interior "H" designates a point on the map where the percentage decreases in all directions. Conversly an interior "L" designates a point on the map where the percentage increases in every direction. Exterior "H" 's and "L" 's indicate that the percentage was increasing or decreasing respectively in directions towards this point as the border of the United States was approached. There were 6 years of two satellite data or 6 windows per point. Four more years of single satellite data was added to the 12 windows (one for each satellite per year) for the years in which two satellites were operational. Thus, 16 windows per point were available for the single satellite percentages. Since LANDSAT III was not fully operational during the window for 1981, only LANDSAT II data was used for this year.

VI. IMPLICATIONS

By comparing the one satellite configuration to the two satellite configuration, it becomes obvious that the minimum operational configuration for USDA/SRS needs would be two satellites. To assure reasonable coverage for the corn belt two satellites are the minimum. A similar study will be conducted for an April-May window to study the acquisition history as it pertains to winter wheat.

VII. ACKNOWLEDGEMENT

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FIGURE 2. Six Years of LANDSAT 1975-1980 Images With Less Than 10% Clouds: Two Satellite Coverage: Temporal Window (July 15 - August 20)