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Technical Report

CLASSIFICATION AND AREA ESTIMATION OF LAND COVERS IN KANSAS USING GROUND-GATHERED AND LANDSAT DIGITAL DATA

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16. ABSTRACT

Ground-gathered data and Landsat multispectral scanner (MSS) digital data from 1981 were analyzed to produce a classification of Kansas land areas into specific types called land covers. The land covers included rangeland, cropland, forest, residential, commercial/industrial, and various types of water. The analysis produced two outputs: acreage estimates with measures of precision, and map-type or photo products of the classification which can be overlaid on maps at specific scales. State-level acreage estimates were obtained and substate-level land cover classification overlays and estimates were generated for selected geographical areas. These products were found to be of potential use in managing land and water resources. This land cover information was obtained by utilizing an operational program within the U. S. Department of Agriculture. Statistical methodology is not discussed in detail, but is highly referenced for the interested reader.

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Introduction

The Statistical Reporting Service (SRS) of the U.S. Department of Agriculture is responsible for providing national and state estimates of crop acreages and other items of U.S. agriculture. To obtain these data, SRS uses an "area sampling frame" that has been developed within all states except Alaska. An area sampling frame is a subdivision of land area within a state into units of size and location that are appropriate for statistical sampling(3). These samples are enumerated by field personnel and the data collected are expanded to provide statistically based crop area estimates at state and national levels(1). The combining of Landsat Multispectral Scanner (MSS) data with the SRS ground-gathered data has significantly improved the precision of these estimates(4, 7).

The objectives of this study were to: 1) expand the SRS methodology of crop area estimation to include such noncrop cover types as forest, residential, rangeland, and water; and 2) determine if land cover information obtained from this expansion could be useful to State and Federal agencies that have responsibilities for managing land and water resources.

Procedure

The statistical basis for obtaining land cover area estimates and classification products was the SRS area sampling frame for Kansas. The first step in frame development is to stratify the entire state according to land use and cultivation intensities as defined in Table 1. Total land area within each stratum is then divided into blocks called segments. From this population of segments, a stratified random sample is selected. The stratum sample sizes are shown in Table 1 along with the average segment size. During June 1981,

Table 1. Definition, Population Numbers, and Segments Selected for Each Kansas Stratum

Stratum	Brief Description	Population Size	Sample Size	Average Segment Size (mi^2)
11	Greater than 80% cultivated	25,028	170	1.00
12	50 to 80% cultivated	21,704	120	1.00
20	15 to 49% cultivated	21,286	100	1.00
31	Agri-urban	2,774	12	0.25
32	City	2,941	12	0.10
33	Resort area	247	2	0.25
40	Rangeland	3,147	15	4.00
50	Nonagricultural	294	2	1.00
61	Potential water	29	2	0.50
62	Water	231	0	1.00
	TOTAL	77,681	435	

personnel enumerated all land within each of the 435 segments and provided field boundary, acreage, crop, and land cover data. This information was collected as part of SRS's annual June Enumerative Survey (JES), using a specially modified version of the JES questionnaire. Field boundaries were recorded on aerial photography and then digitized into computer-readable format. These data were used to obtain acreage estimates, establish training fields for computer classification of Landsat digital data, and determine land cover classification accuracy.

The 1981 Landsat data analyzed in this study are given in Figure 1. For each scene the Landsat row-column coordinates were registered to USGS map latitude-longitude coordinates by means of a polynomial equation[2] , and then segment field boundaries were matched to patterns in the Landsat data.

Segment digitization, ground and Landsat MSS registration, Landsat MSS analysis, and acreage estimation were accomplished using the methodology currently employed by SRS to obtain crop area estimates in seven Midwestern States[6, 8]. All map-type products were generated using software developed by NASA, Earth Resources Laboratory, located at the National Space Technology Laboratories, Mississippi[5].

Estimation and Mapping

SRS ground data were used to classify each Landsat scene depicted in Figure 1 to obtain a land cover classification for the entire state. Regression relationships were obtained by regressing ground data (dependent variable) within each of the 435 segments with classified Landsat data (independent variable) for each segment. These regression relationships were applied to the entire land cover classification to produce the area estimates given in

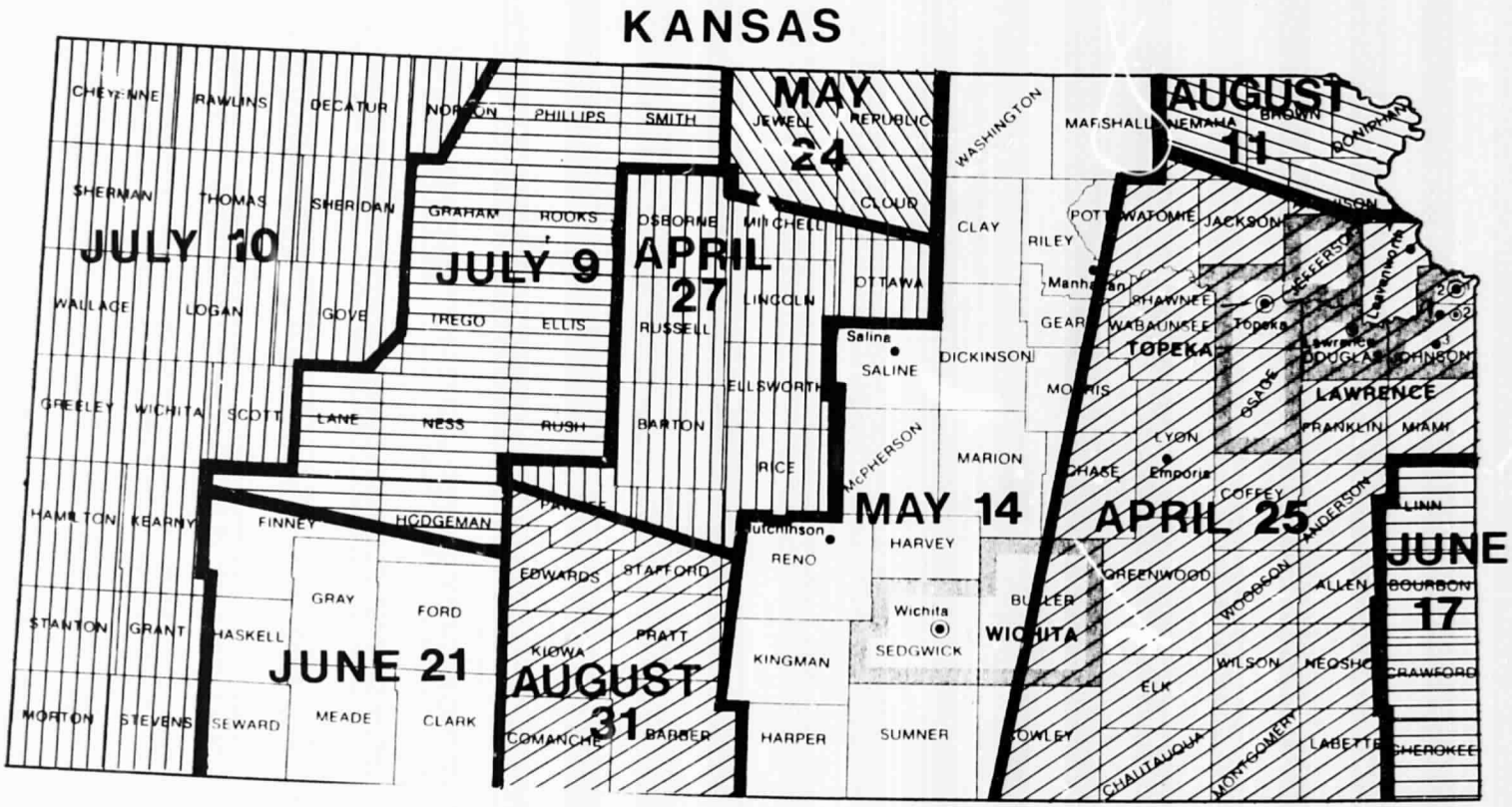

Figure 1. 1981 Dates of Landsat MSS Digital Data Analyzed for the Kansas Land Cover Study

Table 2. The coefficient of variation, which is a measurement of precision for the acreage estimates, is relatively high for several noncrop cover types. These coefficients of variation are high because the JES sample design is for an agricultural statistics survey. As indicated in Table 1, most of the 435 sample segments fall in agricultural strata(11, 12, 20) , while very few fall in the remaining nonagricultural strata. One method for lowering the coefficient of variation of noncrop covers is to select more segments from strata in which they are contained. For example, precision of the estimates for commercial/industrial and other urban categories can be improved by selecting additional samples in strata 31, 32, and 33 and enumerating these segments during the JES. This can be accomplished with minimal effort, because as shown in Table 1, the population for each stratum has been defined.

As mentioned above a state-level land cover classification must be produced in order to derive regression estimates. Therefore, this classification can be used to obtain land cover map-type products and associated acreage counts for any land area within the state (such as a county or watershed) whose boundaries are recorded in a computer-readable format. A four-county area comprised of Harper, Sumner, Sedgwick, and Harvey was used to demonstrate this capability. Figure 2 is a cathode ray tube (CRT) display of the land cover classification. Colored prints, slides, or view-graphs can be produced from this display. For field and office work this classification is obtained in a map-type product from an electrostatic plotter. This plot is produced at a scale specified by the user, and then overlaid onto a base map, such as a county highway map or USGS topographic map.

Table 3 lists the cover types displayed in Figure 2 along with regression estimates derived using the 22 SRS segments contained within the four

Table 2. State-level Area Estimates for Land Covers Analyzed in Kansas

Land Cover Categories	Regression Estimate (Acres)	Coefficient of Variation (%)
Cropland	28,009,000	1.3
Permanent pasture	2,971,000	16.3
Range	15,929,000	2.9
Farmstead	417,000	4.7
Forest (not grazed)	1,010,000	7.0
Forest (grazed)	744,000	13.2
Wooded strips	481,000	10.1
Residential	451,000	7.5
Commercial/industrial	90,000	20.2
Transportation, communication, and utilities	507,000	24.4
Other urban	146,000	18.7
Stripmines, quarries, gravel pits	110,000	26.5
Sand dunes	5,000	38.0
Ponds (<40 acres)	183,000	10.3
Lakes (>40 acres)	184,000	9.8
Rivers	132,000	50.0
Transitional	79,000	52.4

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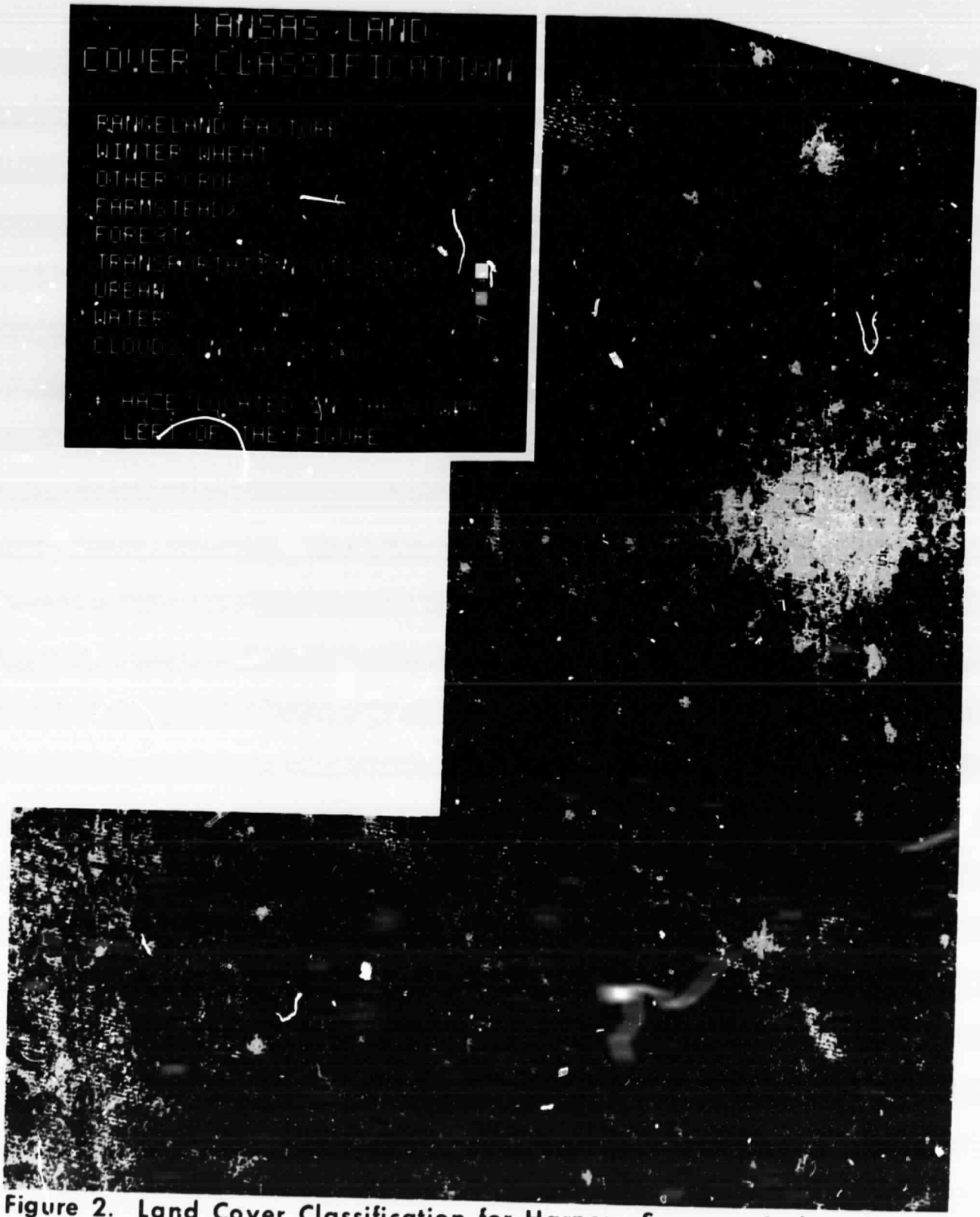

Figure 2. Land Cover Classification for Harper, Sumner, Sedgwick, and Harvey Counties

Table 3. Area Estimates for Land Covers Analyzed in Harper, Sumner, Sedgwick, and Harvey Counties

Land Cover Category	Regression Estimate (Acres)	Coefficient of Variation (%)
Rangeland/permanent pasture	748,300	8.1
Winter wheat	1,243,800	3.7
Other crops	441,300	8.5
Farmsteads	18,500	24.1
Forests	65,900	15.6
Pavement	37,300	7.2
Urban	98,600	11.4
Water	7,100	18.8

counties. Some land covers estimated at the state level could not be estimated for this area because sufficient ground data for certain covers were not contained within these segments.

Summary and Applications

The feasibility of using USDA SRS crop area estimation methodology to obtain land cover classification products and area estimates was demonstrated over the entire state of Kansas. Results of this study were presented to representatives of 15 Federal, State, and county agencies at a meeting in Topeka, Kansas. Several agencies requested additional land cover products appropriate as tools in their particular work.

Currently, SRS is utilizing ground and Landsat data to estimate major crops in Oklahoma, Kansas, Colorado, Missouri, Illinois, Iowa, and Arkansas. Thus, the vehicle for obtaining the type of land cover information discussed in this report exists in these seven states.

The experiences gained from this study will be applied in Missouri during 1983. In that work 23 noncrop covers will be classified and estimated along with winter wheat, corn, soybeans, and rice. For that analysis, 67 additional segments from nonagricultural strata, mainly forestland, will be added to the regular SRS sample size of 450 segments. Multitemporal Landsat analysis (imagery from two dates—e.g., spring and fall) will be analyzed over the state instead of unitemporal analysis (single date imagery), which was used in Kansas.

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