A Continuing Development of An Application For Landsat Data: 1983 DCLC Winter Wheat Acreage Estimates For Four States*

Paul W. Cook
George May, and Richard A. Kestle

U.S. Department of Agriculture (USDA)
Statistical Reporting Service (SRS)
Statistical Research Division (SRD)
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ABSTRACT

The Statistical Reporting Service (SRS) continued to produce crop acreage estimates using satellite data as part of the 1983 Agriculture and Resource Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) Program in a seven state area within the Midwest. Landsat data combined with ground gathered data provide timely and more precise estimates for corn, soybeans, rice, cotton, and winter wheat than can be made using only ground data. Results for winter wheat in Colorado, Kansas, Missouri, and Oklahoma will be presented in this paper.

Significant improvements in the EROS Data Center's processing of Landsat data made possible this year's early completion of planted and harvested winter wheat estimates. The Remote Sensing Branch (RSB) presented the winter wheat estimates for the four states by November 16, 1983 to the SRS Crops Branch and the State Statistical Offices (SSO's) for use in setting the final year-end crop acreage estimates in the Crop Reporting Board's Annual Crop Summary.

Optimal dates during late April, early May and mid May were available for a number of scenes covering the four state areas. However, a large area of Colorado had only late June coverage and the central portion of Kansas, where a great deal of winter wheat is grown, had no coverage. These varying coverages provided a variety of results from poor to very good.

The major difficulty during analysis was the USDA Payment-in-Kind (PIK) Program which encouraged farmers to reduce overall crop production. Many fields of winter wheat were destroyed by the farmer during the time period for which imagery was received. This caused difficulties in correlating the computer categorized pixel information with that of the collected ground data. Overall efficiency gains were reduced from those obtained during 1982.

NOAA provided satellite imagery in a more timely manner during 1983. This improved data delivery could not overcome, however, the major problems caused by the PIK program and the presence of only one satellite (Landsat 4) to provide data. Frequent coverage during the critical crop window time frames is necessary to provide sufficient Landsat data for cost effective crop acreage estimates.

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I. INTRODUCTION

The 1983 AgRISTARS Domestic Crops and Land Cover (DCLC) Project is the continuation of the SRS remote sensing program which started in 1972, continued on a small scale until 1979, and then split in 1980 into an applications project involving two states and a separate research program. The applications project has continued to grow in size each year as chronicled in yearly reports (1, 2, 3). This year's project involved analysis work in seven states.

The major focus of this project is the development of an operational remote sensing program which combines Landsat acquired data with ground-gathered data to provide more precise year-end crop acreage estimates in a timely manner.

SRS has reported yearly on progress in using Landsat data for crop acreage estimation. New methods and procedures designed to faciliate the overall efficiency and effectiveness of SRS's methodology are an important part of those reports. It is therefore necessary to address many of the same issues found during earlier projects. Important topics for this report will be the delivery times of the Landsat computer compatible tapes (CCT's) to SRS, ground data collection and evaluation, and overall project costs. These are basic considerations involved in SRS's decision of when to implement these procedures in a fully operational manner.

II. METHODOLOGY

The operational crop acreage estimation program of SRS relies very heavily on a survey of approximately 16,000 random sample units (called segments) across the U.S. This survey, which is called the June Enumerative Survey (JES), provides the basic data set used in setting crop acreage estimates for major crops in the states. RSB carefully edits this basic data set on a field by field basis and verifies field boundary information on eight inch to a mile aerial photos to provide the ground data for the AgRISTARS research.

The segment locations in the Landsat scenes are determined by a careful two-step operation in which the Landsat scene is first registered to a U.S. Geological Survey (USGS) map base at 1:250,000 scale and the segment photos are calibrated to USGS maps at 1:24,000 scale. The second step consists of a computer and manual shift of the segment boundaries within the Landsat data. This process produces correct segment locations to within $\pm$ 30 meters ($\pm$ ½ pixel). This is done to ensure that only pure Landsat pixels are used in training the Gaussian maximum likelihood classifier.

After clustering the sample segment data within crop type with CLASSY (4), RSB classifies the entire Landsat CCT(s) which contain(s) the segments found within the Landsat path. The correlation relationship between the classified segment pixels and the SRS ground gathered data, as measured by the coefficient of determination r^2, determines the degree of acceptability of the overall classification. A regression estimator as established by Cochran (5) uses this relationship to produce an estimate of the total crop grown as well as a standard deviation as a measure of precision.

Improvements in this overall methodology are necessary in order to provide the estimates at lower cost and with greater efficiency. This year, RSB tested two new methods of doing the segment digitization procedure. This stage of the work provides computer compatible outlines of the segments on a field by field basis and allows the later match up of the ground data with the Landsat pixels.

The two methods included the use of a microcomputer in one case and in the other a video camera for video digitization. Use of the microcomputer proved to be beneficial, but it did not provide significantly faster digitization times because files still had to be transferred to RSB's main computer system and many manual operations had to be performed. Video digitization, however, gave improved digitization speed and the promise of greater future data handling capability. In fact, video digitization provided 18 segments per day while the microcomputer based digitization system produced approximately 9 segments per day.

III. GROUND DATA

Data collection for the JES begins in late May and finishes during early June. During this time period, data for as many as 435 segments in Kansas was gathered directly from farmers operating the land within the segment boundaries. Trained enumerators were responsible for approximately ten segments each during this time. Their instructions were to determine the correct acreage, location and crop type for every field within the segment.

The enumerators sent their completed aerial photos and questionnaires to the State Statistical Office (SSO) in their state. There, agricultural statisticians with many years of experience in gathering crop information edited the questionnaires. Their objective was to insure the accuracy of the data.

RSB has added a post-JES field level check of the data. Each field's acreage is checked on the aerial photograph to agree with that provided in the questionnaire. Field boundaries are also checked with color infrared photography flown during the current crop year. Fields with acreage or boundary discrepancies are not used for training purposes.

RSB must give special recognition to the Colorado, Kansas, Missouri and Oklahoma SSO office personnel for their strong support of the DCLC Applications Project. Their efforts are appreciated since they provided quality ground data in a form that RSB could easily use.

IV. LANDSAT DATA DELIVERY TIMES

The 1983 ERIM corn and soybeans report emphatically stated that SRS needs rapid delivery of Landsat data for an operational program. Data delivery times (as measured from the satellite overpass date) in the range of 20-30 days would be appropriate.

Last year's paper broke down the delivery cycle into five steps because the overall times far exceeded the optimum range. This breakdown is not necessary this year, because the median delivery time to RSB for Kansas scenes approached 34 days; far superior to the median delivery time of 49 days observed in 1982 for corn and soybeans data. The other three states also showed significant gains in timeliness.

EROS Data Center and Goddard Space Flight Center significantly reduced the Landsat overpass-to-data acquisition time. All 15 Landsat scenes in Kansas were acquired by EROS within 21 days; most within 15 days. This component of the delivery time showed great improvement over last year's minimum time of 30 days with a median of 44 days. Seven of the 15 scenes were available within ten days. This ten day overpass-to-acquisition time period more closely follows the time table needed to meet RSB's operational requirements.

Photographic products required from 7 to 13 days for EROS to process for Kansas with similar times for the other 3 states. These times included two day delivery by UPS Blue Label service. Processing times within this range would be acceptable provided the overpass-to-acquisition times could be kept within the 7-10 day range.

Digital tapes required even less time to process than did photographic products. All computer compatible tapes required no more than seven days for delivery, including two days for mail delivery. This service time would be quite acceptable for RSB in an operational program.

The preceeding discussion indicates that RSB's requirement for a 20-30 day overpass-to-data delivery schedule can be achieved. The major problem remains the overpass-to-data acquisition and availability at EROS. If this could be maintained at ten days, then RSB's requirements for winter wheat states would be fully met by EROS's new NOAA management.

Comparison of delivery times is also necessary with this year's corn and soybeans states. Most of this data becomes available at the end of the U.S. government's fiscal year. Consequently, a larger volume of orders occurs during the fall than during the spring. To meet SRS's operational needs, EROS must also supply the data for corn and soybeans analysis on a similar schedule.

V. LANDSAT DATA ANALYSIS

The 1982 corn and soybeans report provided an overall list of pre-analysis and analysis phases. These procedures continue to be used with only minor variations.

A change in selecting training data was made this year because of USDA's PIK program. Only fields of winter wheat which would be harvested for grain were chosen to train the classifier. This was necessary because of the large farmer participation in the PIK program. Otherwise, overall crop acreages would have been inflated by pixels incorrectly classified to winter wheat.

PIK caused problems in the use of the regression estimator. Many fields were classified as winter wheat in early spring imagery because they had not yet been destroyed due to PIK at that time. This meant that many segments had large numbers of classified wheat pixels, but relatively little or no reported harvested winter wheat acreages. Some planted fields had already been diverted to PIK and were thereby classified as non-winter wheat. Because these observations did not correspond to the usual relationship between classified pixels and reported acreages (a linear trend), the coefficients of determination (r^2) between reported and classified acreages for both planted and harvested winter wheat were not as high as in previous years. Consequently, this poor relationship reduced the overall relative efficiency; that is, the ratio of the JES state level direct expansion variance to that of the Landsat regression variance. Even when Landsat data acquisition occured for optimum dates, the effect of PIK was to reduce the overall relative efficiencies.

VI. WINTER WHEAT ACREAGE ESTIMATES

The following ten tables present the winter wheat acreage results for Colorado, Kansas, Missouri, Oklahoma, and the Four State Region. Both direct expansion estimates from SRS ground gathered data and Landsat regression estimates are shown by analysis district as well as by state and regional totals. Standard errors, coefficients of variations (CV) and relative efficiencies for each analysis district estimate, state total and regional total are also presented.

The best winter wheat results occured in Colorado where the relative efficiencies for planted and harvested winter wheat were 2.1 and 2.0, respectively. Some of this improvement, however, may be due to the fact that the Colorado area sampling frame is 20 years old. During this period a considerable amount of range land has been converted to crop land. This frame has been updated for 1984 and results from the 1984 DCLC project will help evaluate this assumption.

Relative efficiencies for Kansas were much lower than previous years primarily because the central portion of the state, which contains significant wheat acreage had no Landsat data. Nevertheless, the overall Coefficient of Variation (CV) was reduced for both planted and harvested estimates.

This was the first year a winter wheat estimate was made for Missouri. Both forests and pasture showed much confusion with winter wheat. However, the Landsat analysis did reduce overall CV's.

Results for Oklahoma showed the least gain in the four state region. Because of problems caused by PIK, March and early May data for this crop year were far from optimal and thereby yielded a very low relative efficiency for both planted and harvested estimates.

VII. PROJECT COSTS

Last year's corn and soybeans paper (3) promised a further update on costs and overall efficiency of using SRS's Landsat and JES method to produce estimates. A careful analysis of costs for this year has located some additional project costs not fully accounted for during previous calculations. Consequently, the RSB cost estimate excluding JES data collection costs for this year is $146,000 per state, of which approximately $13,000 were for costs not previously included. The additional $8,000 increase over the corrected 1982 per state costs ($138,000) comes from increases in Landsat data purchase costs, computer time, and additional salary costs.

A large part of the per state costs is overhead for salaries, preliminary processing and field level editing of the JES ground data. Should no Landsat data be available, these preliminary costs are not recoverable.

Previous Remote Sensing Branch papers have discussed what a breakeven relative efficiency would be above which the Landsat plus JES method would be a cost effective improvement over actually increasing the JES sample to achieve comparable results. The relationship between increasing the JES sample size and the corresponding improvement in the precision of the JES expansions is not necessarily linear. As the costs of SRS's remote sensing procedures have come down, this breakeven point has also begun to decrease. The current Remote Sensing Branch calculations indicate that a relative efficiency of between 2.0 and 2.5 is still the breakeven point. It is anticipated that a more precise calculation can be made following the 1984 project, since more care will be taken to capture actual project costs.

Sufficient sample size increases in the JES to produce relative efficiency gains comparable with that achieved with Landsat data would be quite difficult to obtain because of budget restrictions on staff and operations as well as government restrictions on respondent burden. Consequently, remote sensing continues to remain a viable alternative and likely will remain so as long as data and monies are available to continue this work.

VIII. SUMMARY

The winter wheat analysis for 1983 has shown the deleterious effects of both the PIK program and the presence of clouds. Since PIK was a one time program that was quite popular with farmers, it should not impact the project to the same extent this year. Clouds will be a perenial problem, however, and only additional satellites would aid in overcoming this problem. Because two satellites will be available during the 1984 season, clouds should not be as great a problem this year. These changes from last year provide hope for significantly better results for the 1984 project.

The success of the video digitization procedure during this project has made possible even greater reliance on this procedure for the upcoming 1984 project. Future developments of this type should aid in greater expansion of RSB's work into additional states in the years to come.

IX. ACKNOWLEDGEMENTS

As it was for 1982's corn and soybeans work, this year's work with winter wheat required the cooperation of numerous people from RSB, the SSO's, Sampling Frame Development Section, Methods Staff, Enumerative Survey Section, Crops Branch and Systems Branch of SRS. The personnel at NASA-Ames, EROS Data Center, NOAA and BBN also gave us much assistance.

The authors would like to thank Martin Ozga of RSB for his fine programming on BBN and the Cray, Sherman Winings and Van Johnson for updating the field level edit program, Jim Mergerson for analysis in Oklahoma, and George Hanuschak for his excellent leadership. Our thanks also go to the SSO's for their assistance: Kansas, Phil Doctor, who headed the data collection, and Jeannette Ulm, who digitized the segments; Oklahoma, Dave Ranek and Judy King; Colorado, Ken Neubauer and Mary Gilbner; Missouri, Peggy Stringer, Barry Bloyd and Joyce Nichols. Many thanks go as well to Patsy Nelson for her excellent typing of this manuscript and tables.

Paul Severson of EROS Data Center along with Howard Warriner of NOAA at EROS made every effort to provide the Landsat data in a timely and operational manner. Their efforts resulted in much improved delivery times that indicate the possibility of SRS's developing an operational program for winter wheat acreage estimation.

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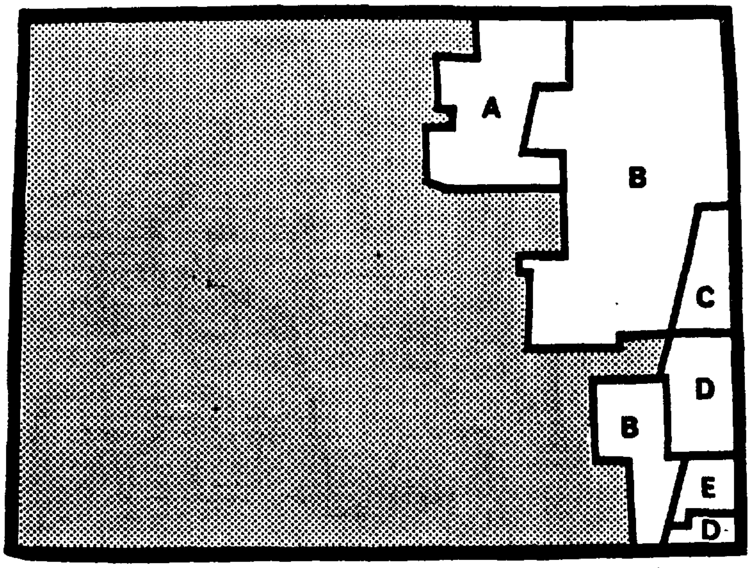
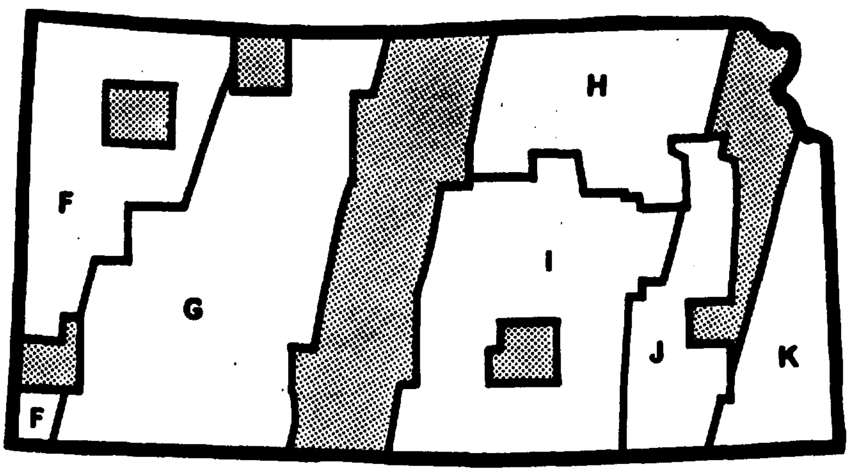
Figure 1. Colorado Analysis Districts



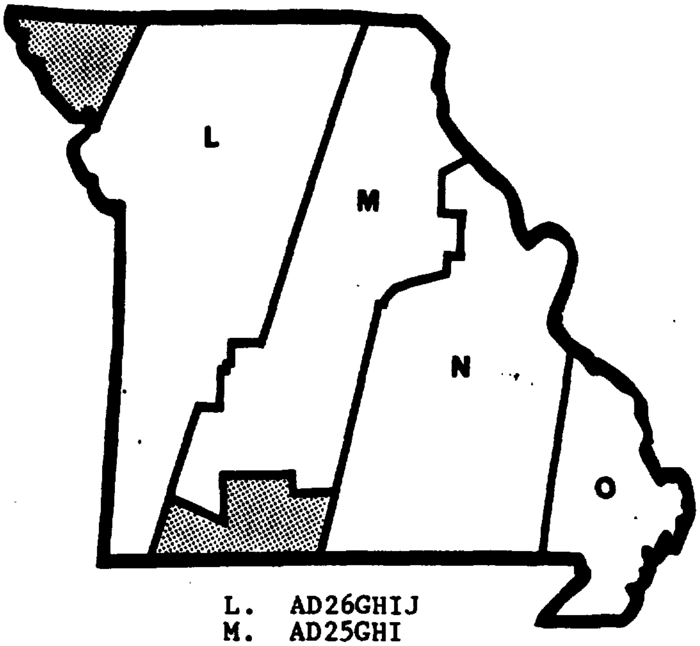
A. AD33G
B. AD32GHI
C. AD31H
D. AD31HI
E. AD31I

Figure 2. Kansas Analysis Districts



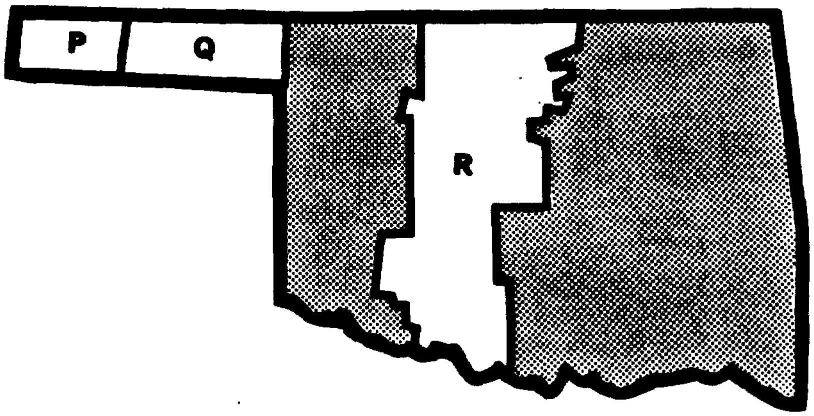
F. AD31GHI
G. AD30GHI
H. AD28GH
I. AD28HI
J. AD27HI
K. AD26HI

Figure 3. Missouri Analysis Districts



L. AD26GHIJ
M. AD25GHI
N. AD24HIJ
O. AD23IJ

Figure 4. Oklahoma Analysis Districts



P. AD31IJ
Q. AD30IJ
R. AD28IJK

Shaded areas indicate where only JES (ground-gathered) data was used. This was due to cloudy conditions during the optimum data collection time or because too little winter wheat was grown in that area to justify Landsat analysis.

TABLE I. 1983 AgRISTARS DCLC
Winter Wheat Planted Hectares Estimates for Colorado

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD31H	6/14	201	33	16.4	209	27	13.0	1.5
AD31I	6/14	64	15	24.4	74	14	18.5	1.3
AD31HI	3/10	113	28	24.2	90	18	19.7	2.4
AD32GHI	6/21	691	77	11.1	703	71	10.1	1.2
AD33G	5/27	238	42	17.9	218	36	16.5	1.4
ADDEW5/	----	223	68	30.5	223	68	30.5	1.0
ADDEE5/	----	6	3	51.3	6	3	51.3	1.0
STATE2/		1,607	166	10.3	1,523	119	7.8	
STATE3/		1,639	172	10.5				2.1

TABLE II. 1983 AgRISTARS DCLC
Winter Wheat Harvested Hectares Estimates for Colorado

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD31H	6/14	119	29	24.4	127	21	16.3	1.9
AD31I	6/14	34	11	32.0	44	7	16.3	2.3
AD31HI	3/10	70	22	32.0	47	7	15.8	8.9
AD32GHI	6/21	533	48	9.0	546	35	6.4	1.9
AD33G	5/27	154	30	19.1	136	12	8.9	6.0
ADDEW5/	----	206	68	32.9	206	68	32.9	1.0
ADDEE5/	----	4	2	54.9	4	2	54.9	1.0
STATE2/		1,135	115	10.1	1,110	81	7.3	
STATE3/		1,193	115	9.7				2.0

1/ Analysis district direct expansions (estimates, standard errors and coefficients of variation (CV)) are Remote Sensing Branch (RSB) direct expansions after a field level edit. These do not add to the state totals.

2/ State level (RSB) direct expansion estimate, standard error and CV are from RSB direct expansion after field level edit ignoring analysis districts.

3/ State level direct expansion, standard error and CV are from the operational JES survey before field level edit.

4/ R.E. is the relative efficiency of the estimate.

5/ Either no Landsat data was available or too little winter wheat was grown to justify Landsat analysis.

TABLE III. 1983 AgRISTARS DCLC
Winter Wheat Planted Hectares Estimates for Kansas

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD26HI	4/24	233	42	17.9	246	23	9.5	3.2
AD27HI	5/1	146	26	18.1	129	22	16.9	1.5
AD28GH	5/24	457	48	10.5	382	30	7.9	2.5
AD28HI	5/8	1,116	67	6.0	1,104	40	3.7	2.8
AD30GHI	5/6	1,356	71	5.3	1,270	45	3.5	2.6
AD31GHI	5/29	777	69	8.9	793	54	6.8	1.6
ADDE5/	----	1,418	104	7.4	1,418	104	7.4	1.0
STATE2/		5,486	180	3.3	5,342	143	2.7	
STATE3/		5,475	162	3.0				1.3

TABLE IV. 1983 AgRISTARS DCLC
Winter Wheat Harvested Hectares Estimates for Kansas

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD26HI	4/24	217	40	18.7	229	22	9.6	3.4
AD27HI	5/1	116	22	18.8	101	16	16.1	1.8
AD28GH	5/24	434	48	11.0	360	31	8.5	2.4
AD28HI	5/8	947	59	6.3	933	25	3.6	3.2
AD30GHI	5/6	1,076	70	6.5	994	47	4.7	2.3
AD31GHI	5/29	685	56	8.2	701	43	6.2	1.7
ADDE5/	----	1,158	87	7.5	1,158	87	7.5	1.0
STATE2/		4,635	163	3.5	4,476	124	2.8	
STATE3/		4,652	153	3.3				1.5

1/ Analysis district direct expansions (estimates, standard errors and coefficients of variation (CV)) are Remote Sensing Branch (RSB) direct expansions after a field level edit. These do not add to the state totals.

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3/ State level direct expansion, standard error and CV are from the operational JES survey before field level edit.

4/ R.E. is the relative efficiency of the estimate.

5/ Either no Landsat data was available or too little winter wheat was grown to justify Landsat analysis.

TABLE V. 1983 AgRISTARS DCLC
Winter Wheat Planted Hectares Estimates for Missouri

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD23IJ	5/5	302	39	12.8	274	32	11.7	1.5
AD24HIJ	4/26	88	20	23.1	61	15	24.9	1.8
AD25GHI	6/4	172	23	13.4	136	15	10.7	2.5
AD26GHIJ	4/24	333	45	13.4	458	32	7.1	1.9
ADDE5/	----	7	3	42.4	7	3	42.4	1.0
STATE2/		902	70	7.8	936	53	5.7	
STATE3/		906	70	7.8				1.8

TABLE VI. 1983 AgRISTARS DCLC
Winter Wheat Harvested Hectares Estimates for Missouri

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD23IJ	5/5	275	36	13.0	249	29	11.7	1.5
AD24HIJ	4/26	81	19	23.9	55	15	27.0	1.7
AD25GHI	6/4	159	22	13.8	125	14	11.1	2.5
AD26GHIJ	4/24	306	42	13.6	430	29	6.7	2.1
ADDE5/	----	5	2	46.8	5	2	46.8	1.0
STATE2/		826	66	8.0	864	49	5.6	
STATE3/		830	66	7.9				1.9

1/ Analysis district direct expansions (estimates, standard errors and coefficients of variation (CV)) are Remote Sensing Branch (RSB) direct expansions after a field level edit. These do not add to the state totals.

2/ State level (RSB) direct expansion estimate, standard error and CV are from RSB direct expansion ignoring analysis districts.

3/ State level direct expansion, standard error and CV are from the operational JES survey before field level edit.

4/ R.E. is the relative efficiency of the estimate.

5/ Either no Landsat data was available or too little winter wheat was grown to justify Landsat analysis.

TABLE VII. 1983 AgRISTARS DCLC
Winter Wheat Planted Hectares Estimates for Oklahoma

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD28IJK	5/8	1,350	70	5.2	1,314	53	4.0	1.7
AD30IJ	5/6	244	28	11.3	226	22	9.9	1.5
AD31IJ	3/10	136	26	19.3	175	25	14.1	1.1
ADDE5/	----	420	53	12.5	420	53	12.5	1.0
ADDW5/	----	1,035	58	5.6	1,035	58	5.6	1.0
STATE2/		3,207	134	4.2	3,170	105	3.3	
STATE3/		3,213	121	3.8				1.3

TABLE VIII. 1983 AgRISTARS DCLC
Winter Wheat Harvested Hectares Estimates for Oklahoma

Analysis District	Imagery Date	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
		1,000 Hectares			1,000 Hectares			
AD28IJK	5/8	711	51	7.1	645	35	5.5	2.1
AD30IJ	5/6	147	16	11.0	147	12	8.3	1.8
AD31IJ	3/10	53	18	33.8	93	13	13.9	1.9
ADDE5/	----	268	38	14.1	268	38	14.1	1.0
ADDW5/	----	536	45	8.4	536	45	8.4	1.0
STATE2/		1,725	89	5.2	1,689	74	4.4	
STATE3/		1,725	85	4.9				1.3

1/ Analysis district direct expansions (estimates, standard errors and coefficients of variation (CV)) are Remote Sensing Branch (RSB) direct expansions after a field level edit. These do not add to the state totals.

2/ State level (RSB) direct expansion estimate, standard error and CV are from RSB direct expansion after field level edit ignoring analysis districts.

3/ State level direct expansion, standard error and CV are from the operational JES survey before field level edit.

4/ R.E. is the relative efficiency of the estimate.

5/ Either no Landsat data was available or too little winter wheat was grown to justify Landsat analysis.

TABLE IX. 1983 AgRISTARS DCLC
Winter Wheat Planted Hectares Estimates for the Four State Region5/

State	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
	1,000 Hectares			1,000 Hectares			
Colorado	1,607	166	10.3	1,524	119	7.8	2.1
Kansas	5,486	180	3.3	5,342	143	2.7	1.3
Missouri	902	70	7.8	936	53	5.7	1.8
Oklahoma	3,207	134	4.2	3,170	105	3.3	1.3
REGION	11,2022/	2892/	2.62/	10,972	220	2.0	
REGION3/	11,232	274	2.4				1.6

TABLE X. 1983 AgRISTARS DCLC
Winter Wheat Harvested Hectares Estimates for the Four State Region5/

State	DIRECT EXPANSION 1/ Estimate	Standard Error	CV(%)	LANDSAT REGRESSION Estimate	Standard Error	CV(%)	R.E.4/
	1,000 Hectares			1,000 Hectares			
Colorado	1,135	115	10.3	1,110	81	7.3	2.0
Kansas	4,635	163	3.5	4,477	124	2.8	1.5
Missouri	826	66	8.0	866	49	5.6	1.9
Oklahoma	1,725	89	5.2	1,688	74	4.4	1.3
REGION	8,3212/	2282/	2.72/	8,141	172	2.1	
REGION3/	8,401	220	2.6				1.6

1/ State level direct expansions (estimates, standard errors and coefficients of variation (CV)) are Remote Sensing Branch (RSB) direct expansions after the field level edit.

2/ Four state regional level (RSB) direct expansion estimate, standard error and CV are from RSB direct expansion after the field level edit.

3/ Four state regional (methods) level direct expansion, standard error and CV are obtained from adding the JES state level direct expansions.

4/ R.E. is the relative efficiency of the estimate.

5/ Four state regional totals are obtained from rounding of the totals and standard errors obtained from using exact state level values.