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AgRISTARS DCLC APPLICATIONS PROJECT

1982 CORN AND SOYBEANS AREA ESTIMATES FOR IOWA AND ILLINOIS

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AgRISTARS DCLC APPLICATIONS PROJECT:
1982 CORN AND SOYBEANS AREA ESTIMATES FOR IOWA AND ILLINOIS*

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ABSTRACT

The Domestic Crops and Land Cover (DCLC) Applications Project within the Agriculture and Resource Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) Program has expanded to a five state area within the Midwest. The project goal is to refine procedures used to make timely and more precise crop area estimates with both Landsat and SRS ground-gathered data. The focus of this paper is the presentation of the 1982 corn and soybeans planted area estimates for Illinois and Iowa. Work on winter wheat area estimates for Colorado, Kansas and Oklahoma will be described in another paper.

Estimates of corn and soybeans acreage using Landsat data and ground-gathered data were provided for both Illinois and Iowa on a timely basis. The precision of the crop area estimates was minimally improved as compared to estimates derived from ground data alone. The SRS Crops Branch and the Illinois and Iowa State Statistical Offices (SSO's) received the estimates by December 16, 1982. The SSO's were able to use the information in setting final year-end crop acreage estimates for the Crop Reporting Board's Annual Crop Summary.

Previous SRS studies in Illinois and Iowa showed that the optimum time period for separating corn and soybeans by using unitemporal Landsat MSS data is early to mid-August. Because of cloud cover, atmospheric haze, poor sensor performance, or problems in the processing pipeline, data was available only for early July, late August or early September for both states. With coverage limited to non-optimal times or else unavailable, the gain in statistical precision was not cost effective for this project.

SRS considered 1982 as a transition year for Landsat data distribution. The loss of Landsat 2, some technical problems with Landsat 3, and the "shakedown" period for Landsat 4 all had a negative impact on this project. However, 1983 will be the first year of U.S. Government commitment for providing operational throughput of MSS data as responsibility is transferred to the National Oceanic and Atmospheric Administration (NOAA). Thus, SRS will view 1983 and 1984 as critical years in determining the operational feasibility of using Landsat and SRS ground-gathered data in combination for crop area estimation.

I. INTRODUCTION

Since the AgRISTARS DCLC program has evolved from work done by SRS from 1972-1979, a considerable amount of the planning and preparation for each year's analysis of project states is based upon previous experience. A ten-year historical paper (1) and last year's DCLC Four State Project report (2) present the major achievements of the AgRISTARS DCLC project. The contributions of this paper will be primarily the comparison of current results to those from prior projects, an update of current methodology, and a description of the efforts required to develop operational procedures for a combined remote sensing and ground-gathered data acreage estimation program.

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A yearly build up in the size of the DCLC Applications Project has resulted in five states (Colorado, Illinois, Iowa, Kansas, and Oklahoma) now being included. The original states, Kansas and Iowa, were added in 1980. Missouri and Oklahoma entered the project during 1981. In 1982, Missouri was converted to a multitemporal land cover and crop inventory research project state. The two newest states, Colorado and Illinois, were added for 1982.

II. METHODOLOGY

SRS uses a regression estimator that regresses ground reported crop acreage on crop pixel classification counts. This estimator is described in Cochran (3) and its application by SRS is found in numerous previous reports. The estimator has a bias term of order 1/n and its variance formula is a large scale approximation. Thus, the estimator theoretically should perform better as the sample size increases.

Those areas for which Landsat coverage is unavailable or too cloudy are estimated by means of direct expansion of SRS ground-gathered data. Consequently, no area of land within a state is excluded from the estimate determined for that state.

Although constantly striving to streamline and improve each step within the estimation procedure using Landsat data, SRS has established an overall quasi-operational set of procedures to meet timeliness and precision standards set by SRS's official Crop Reporting Board. Each component of the overall plan is subject to review and new procedures are added whenever research and testing have shown them to be more effective. This means that each year will bring some changes in methodology as new procedures are adopted.

An example of this philosophy for change during 1982 was the introduction of the use of microcomputers to digitize field boundaries for the segments in both Iowa and Missouri. During 1981, a problem with connecting to the BBN (Bolt, Beranek and Newman) computer system in Boston, Massachusetts and system restrictions had resulted in slower digitizing times for the segments and increased telecommunications costs. After developing software for the microcomputers, Remote Sensing Branch (RSB) and NASA-Ames contract personnel installed the computers in the Iowa and Missouri state offices. Favorable results in reduced digitization time and reduced BBN system time for the Missouri system has persuaded RSB to expand this method for the 1983 study. Also, RSB Research Section personnel are currrently implementating a video digitization system to digitize segments for Arkansas, Colorado and Illinois in 1983.

III. LANDSAT CCT DELIVERY TIMES

Numerous changes in the data delivery system have occurred since the 1978 Iowa project report (4) detailed delivery times to SRS for Landsat CCT's. During that study NASA's Goddard Space Flight Center in Maryland provided tapes directly to SRS. The median delivery time was 49 days at that time (4, p.9). The minimum time required was 32 days and the maximum was 93 days.

Now, SRS's source of Landsat data is EROS Data Center in Sioux Falls, South Dakota. NASA's Goddard Space Flight Center still did the initial processing at the time of this project while EROS did the final P-tape generation along with production of the 1:1,000,000 scale transparency and the 1:250,000 scale paper product which is used in registration of the Landsat data to a USGS map base.

The delivery of Landsat data to SRS consists of five steps. The first two steps are the combined Goddard and EROS Data Center data processing and image preparation time which begins at satellite overpass and ends at customer availability at EROS. The remaining three steps are the delivery of the 1:1,000,000 scale transparency to SRS from EROS, the selection and ordering of cloud-free Landsat scenes, and the delivery of 1:250,000 scale paper products and CCTs to SRS for use in the project.

An examination of 15 Landsat scenes used for the states of Illinois and Iowa showed that the introduction of EROS into the data delivery pipeline increased the overall time needed for SRS to obtain Landsat CCT's despite some very special processing efforts by EROS, NOAA, and NASA Goddard which enabled SRS to obtain the maximum amount of Landsats 3 and 4 coverage available for the Illinois and Iowa projects. Indeed, overall elapsed time from Landsat overpass to receipt of the CCT's has increased to a minimum of 48 days with a maximum of 115 days and a median of 86 days. This increase in time has occurred even though RSB has had tapes mailed overnight to reduce overall delivery times.

When these overall elapsed times are broken down into their component parts and analyzed, it is found that the time from Landsat 3 overpass to customer availability at EROS ranged from a minimum of 30 days to a maximum of 78 days with 44 days being the median. Although this is less than the total 1978 data delivery times, it still remains a major component in the overall elapsed time for CCT delivery.

Processing time at EROS of the CCT's and photographic products is most clearly shown by the time required for delivery from EROS to SRS of the tapes and photos. Although most of the data tapes and photos were shipped by Federal Express in only one day, the minimum time from order to delivery was 7 days, the maximum was 24, and the median was 14 days for the 15 Illinois and Iowa scenes.

Processing of the Landsat scenes was completed on time primarily because sufficient overtime work was done to compensate for data delivery times. It is also evident that had more Landsat data been available, the goal of project completion in mid-December would have been even more difficult to meet. The SRS need is to have more rapid data delivery to reduce overtime work and to make expansion of the project to include more states, feasible. Data delivery times within 20 - 30 days of Landsat acquisition would significantly improve our capabilities to meet SRS timeliness criteria while expanding the AgRISTARS DCLC program to additional states.

Fortunately, the SRS need seems to be consistent with the responsibility of NOAA for operational throughput of Landsat 4 MSS data starting in 1983. The performance of the NOAA Landsat 4 MSS data distribution system in 1983 and 1984 will be critical to SRS planning activities at the end of the AgRISTARS program.

IV. PRELIMINARY DATA ANALYSIS TECHNIQUES

Standardized data analysis methods required by the expansion of the AgRISTARS DCLC project have made possible reductions in the time necessary to analyze Landsat data for each state. A description of these methods is necessary to provide an overview of the progress which has been made in achieving a quasi-operational system. The following is a capsule summary of the pre-analysis steps needed to prepare data for the analysis purpose. These pre-analysis steps include geographic location of the Landsat scene, location of digitized counties and segments within each Landsat scene, refinement of segment locations, and extraction of the Landsat pixels corresponding to the areas within which each segment is located.

Registration (geographic location) of the Landsat scene to United States

Geological Survey (USGS) maps requires the selection of approximately twenty-five to fifty matching points within the Landsat 1:250,000 scale photo and the USGS 1:250,000 scale maps (5). A full-term third-order linear polynomial is calculated using the Landsat line, column coordinates and the USGS latitude, longitude coordinates. The resulting coefficients provide immediate access to every Landsat picture element (pixel) on the computer compatible tape (CCT) since the photo is a direct representation of the CCT.

Digitization of crop field boundaries in the sampled SRS area frame segments follows a careful review and examination of the collected ground data and aerial photographs. The segments are also calibrated to USGS maps, thereby allowing use of the previously calculated coefficients to predict their locations. Similarily, it is possible to digitize the land use strata of each county from the SRS area sampling frame and locate them within the Landsat data as well.

Although most registrations meet an overall 60 meter accuracy standard for each Landsat scene, actual segment locations are usually within one to three pixels in both line and column. To ensure that each pixel chosen is actually within the field specified, it is necessary to shift each segment's location until it properly fits within the Landsat data. Two methods are used to accomplish this movement: one is a manual method and the other is a computer algorithm. The computer algorithm -Automatic Segment Movement Algorithm (ASMA) - was developed by NASA's Earth Resources Laboratory (6). It matches the digital data to the digitized segment overlay stored in digital form. The manual method uses a computer - drawn segment overlay which is manually moved to match lightness - darkness patterns within computer printed grey-scales. This manual method is used as a check and for those cases where ASMA fails to make a match.

After locating the segment data accurately, it is necessary to extract the Landsat pixels for each field within the segments. A computer masking operation makes this extraction process possible. Each segment is converted to a mask format and files of data are generated by selecting pixels by desired specifications such as crop type and field size (7). The same method is also used for county strata files.

The available Landsat images also determine analysis districts for the regression estimator. Analysis districts are generally the entire land area for one Landsat pass obtained on the same date. Thus, depending on cloud cover and Landsat data availability, analysis districts can vary considerably in size.

V. LANDSAT DATA ANALYSIS

After the pre-analysis phase has been completed, Landsat data analysis can begin. Six major steps must be performed for each Landsat analysis district as follows: 1) separation of the Landsat data by crop type, then supervised clustering of each crop type; 2) preparation of statistics files containing means and variances for all crop types; 3) classification of the sample segment pixels and tabulation of results by segment; 4) preparation of sample segment regressions by crop type; 5) classification and aggregation of all pixels within the Landsat CCT; and 6) preparation of Landsat regression estimates for each land use stratum. If Landsat data should be unavailable, ground-gathered data is summarized by a direct expansion estimate. The final step in analysis is the aggregation of analysis district crop area estimates and any direct expansion district estimates to state totals. The resulting state level estimate, which is the sum of the analysis district estimates, is referred to as the state level Landsat regression estimate. State level direct expansion estimates are then calculated to compare with the Landsat state regression estimates.

The ratio of the state level direct expansion estimate variance to the Landsat state level regression estimate variance is the relative efficiency (R.E.) of the Landsat regression estimator. The R.E. gives an estimate of the number of times the segment sample size would need to be increased to give an equivalent improvement in the crop acreage estimate precision using ground data only. It can also provide a measure of the level at which the Remote Sensing methodology can become cost effective.

VI. CROP ACREAGE ESTIMATION RESULTS

Results of the regression estimates for corn and soybeans in Illinois and Iowa are presented in Tables I - IV. The tables give the Landsat imagery overpass date; the June Enumerative Survey (JES) direct expansion estimate and its standard error; the regression estimate and its standard error; and the overall relative efficiency of the regression estimate in relation to the direct expansion.

A closer examination of the tables and Landsat coverage maps (Figures 1 and 2) will help in understanding why results for this year's project had considerably lower relative efficiencies compared to past years. In 1981 (2), estimates for Iowa had overall relative efficiencies of 1.63 for soybeans and 1.56 for corn, while in 1975 (8) estimates for Illinois analysis districts had relative efficiencies for corn ranging from 1.0 to 6.1 and for soybeans from 1.3 to 3.0 (the relative efficiencies were not calculated for the state level). This year's estimates for Iowa corn had an overall relative efficiency of 1.09 while soybeans had a relative efficiency of 1.24. These results compare with relative efficiencies for corn of 2.43 and 2.38 for soybeans in 1978 (4), and relative efficiencies of 1.85 for corn and 1.51 for soybeans for 1980 (9) when very poor Landsat data quality was evident. State level relative efficiencies for 1982 in Illinois were 1.22 for corn and 1.16 for soybeans.

Results for Iowa were much worse this year because of two major reasons. Landsat acquisition dates of either July or early September were not optimum . Another factor was that only one-half the state had cloud-free imagery available and of that one-half nearly two-thirds was during early September.

Results for Illinois were not as good as 1975 because this year's imagery was primarily either in late July or late August instead of mid-August. Another factor was that two of the Landsat 3 scenes in Illinois had some of the rows of data shifted out of position ("sawtooth") within the scene. This caused reduced classifier precision.

From Tables I and II, it can be found that Landsat analysis district level relative efficiencies for corn estimates in Iowa ranged from 1.00 to 3.29 while in Illinois the relative efficiencies for corn estimates ranged from 1.68 to 3.99. These relative efficiencies indicate that the dates available for the Landsat imagery are quite important for good corn discrimination.

For soybeans estimates in Iowa, Landsat analysis district level relative efficiencies (as found in Tables III and IV) ranged from 1.57 to 6.70 while Illinois had 1.38 to 8.75 relative efficiencies for soybeans estimates. These results indicate that the Landsat overpass dates are not as critical for soybeans acreage estimation as they are for corn acreage estimation. Although the best soybeans acreage estimation precision is clearly found for the mid-August date in Illinois, the late August and early July dates did provide better soybeans acreage estimation results than they did for corn.

VII. PROJECT COSTS

The purpose of the AgRISTARS DCLC Applications Project is the development of an operational crop acreage estimation program which utilizes both Landsat data and the SRS ground information.

Since SRS's first state project in Illinois during 1975, the acreage estimation program has expanded to five states. Each year has seen a reduction in the cost associated with producing estimates on a per state basis. This year required approximately $700,000 in total expenditures for the five Applications states. The total was somewhat lower than expected, partially due to reduced data coverage which resulted in lower Landsat CCT costs and processing costs. Consequently, an estimate of $125,000 per state would more accurately express the costs on a per state basis. This is a considerable improvement compared to last year's project (2).

A large part of this cost is for field level edit and preparations prior to analysis of the Landsat data. Should no Landsat data be available, these preliminary costs would not be recoverable.

The other cost associated with doing crop acreage estimation is that of obtaining the SRS ground data (June Enumerative Survey) within the operational system. This cost is generally on the order of $64,000 per state and therefore, when we consider the overall costs of the project, we find the average state cost to be $189,000.

The JES cost per state is not a linear function of increased sample size. As sample size increases, calculations indicate that it would cost about $187,000 to fund a sample collection effort that would produce a relative efficiency of 2.5. That is, a relative efficiency ratio of 2.5 would produce a breakeven point. A relative efficiency above 2.5 would indicate that the Landsat plus JES method is a cost effective improvement.

Although relative efficiencies of 2.5 were achieved for some analysis districts in Illinois and Iowa this year, the overall results did not approach this value. However, 1982 was not a typical year since so little of the available data were acquired at the optimal times, a new satellite was being phased in and data problems were evident with Landsat 3. Future results using the operational NOAA Landsat 4 and D' MSS data should establish more precisely what cost benefit ratios can be obtained and thereby if this procedure is cost effective. Also, in general, the Landsat program reduction from 9 day coverage available from Landsats 2 and 3, to 16 day coverage for Landsat 4 will decrease the probability of cloud free coverage for the AgRISTARS DCLC project as previously determined by Winings (10).

The preceding cost considerations have not included the very real difficulties involved in increasing the sample size of segments sufficiently to produce a relative efficiency of 2.5. Significant budget restrictions on staff and operations would quite probably cause such a proposal to be abandoned. Government restrictions on respondent burden would also reduce the possibility of the sample size being expanded. It would therefore be unlikely for other area sampling methods besides remote sensing data to be useful in obtaining improved precision of crop acreage estimates. In 1983, the cost benefit comparisons will also be extended to examine multiple frame options in Arkansas.

VIII. SUMMARY

SRS considers 1982 to be a transition year for Landsat data distribution. The loss of Landsat 2, some technical problems with Landsat 3, and the "shakedown" period for Landsat 4 all had a negative impact on this project.

The first commitment for operational throughput of Landsat MSS data as responsibility is transferred to the National Oceanic and Atmospheric Administration (NOAA) will be during 1983. SRS will therefore regard years 1983 and 1984 as crucial in determining the operational feasibility of using Landsat and SRS ground-gathered data in combination for crop area estimation. During this time, NOAA must demonstrate the existence of a reliable operational Landsat processing system that will ensure prompt delivery of data to SRS for prime agricultural windows before SRS can make a decision to make this technology an integral part of its operational program.

The procedures needed to implement this project have been described with some detail. The primary means of crop area estimation is that of a regression estimator. SRS ground-gathered data were collected by the Illinois and Iowa SSO's for a random sample of about 350 one square mile segments of land in each state. The Iowa SSO also digitized segments, did field level edits and checked digitizations using plots. The Illinois SSO did the field level editing and prepared segment tracings for later segment digitization. These ground data were used to develop crop signatures from MSS data. Finally, the ground data made possible the adjustment of both the corn and soybean estimates from the Landsat classification.

Relative efficiencies for Iowa were 1.09 for corn and 1.24 for soybeans while Illinois had relative efficiencies of 1.22 for corn and 1.16 for soybeans. These results are considerably less precise than previous years because heavy clouds and Landsat data processing problems during the growth season in Illinois and Iowa severely reduced the availability of Landsat data for the optimal early to mid-August time period. Another factor reducing precision was that only one-half of Iowa and about three-quarters of Illinois had any Landsat data available.

IX. ACKNOWLEDGEMENTS

A project of this size and scope requires the contributions of numerous people both within and outside SRS. The major groups inside SRS included the Remote Sensing Branch (RSB), State Statistical Offices, Sampling Frame Development Section, Methods Staff, Enumerative Survey Section, Crops Branch and Systems Branch. Groups outside SRS included NASA-Ames, EROS data center, NOAA, and Bolt, Beranek and Newman (BBN).

Although it is not possible to name each individual who was involved in this project, the authors want to thank individually those who have made quite significant contributions. Sandra Stutson, Tjuana Fisher, George Harrell, Eric Hendry, Lillian Schwartz, Archie Nesbitt and Pearl Jackson of the RSB Support Staff have digitized strata and field boundaries, registered Landsat scenes, maintained maps and photos, and provided general assistance in meeting project deadlines. Rick Kestle did the full Landsat scene data processing on the CRAY 1-S, while Van Johnson prepared the analysis district maps. Marty Holko, RSB, and Walt Donovan, of Informatics, set up the experiment with off-line segment digitization. Bernie Jansen and Carol Cooper did the segment digitization and editing in the Iowa SSO; Dean Hasenmeyer and Jim Sitek supervised segment tracings and editing in the Illinois SSO. Many thanks to Yvonne Zamer for her outstanding word processing and Pat Joyce for preparing the tables.

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Table I. 1982 AgRISTARS DCLC Corn Planted Acreage Estimates For Illinois

Analysis District	Imagery Date	JES DIRECT EXPANSION Estimate (Acres)	JES DIRECT EXPANSION Standard Error	LANDSAT REGRESSION Estimate (Acres)	LANDSAT REGRESSION Standard Error	Relative Efficiency
AD24G	7/5	204,000	19,000	214,000	13,000	2.44
AD24GH	8/28	1,263,000	90,000	1,169,000	45,000	3.99
AD25FG	7/24	2,177,000	66,000	2,068,000	46,000	2.07
AD25FGX	7/24	511,000	46,000	473,000	30,000	2.49
AD25G	8/11	710,000	45,000	756,000	27,000	2.96
AD25H	7/24	1,181,000	110,000	1,106,000	72,000	2.36
AD26EF	7/25	1,735,000	101,000	1,676,000	78,000	1.68
AD26F	7/7	490,000	48,000	478,000	34,000	1.99
ADDE-S	----	619,000	81,000	619,000	81,000	1.00
ADDE-N	----	1,366,000	110,000	1,366,000	110,000	1.00
ADDE-W	----	1,633,000	131,000	1,633,000	131,000	1.00
State		11,804,000 2/	288,000 2/	11,558,000	261,000	1.22

Table II. 1982 AgRISTARS DCLC Corn Planted Acreage Estimates For Iowa

Analysis District	Imagery Date	JES DIRECT EXPANSION Estimate (Acres)	JES DIRECT EXPANSION Standard Error	LANDSAT REGRESSION Estimate (Acres)	LANDSAT REGRESSION Standard Error	Relative Efficiency
AD26EF	7/26	160,000	26,000	160,000 1/	26,000	1.00
AD27E4	9/3	1,580,000	52,000	1,570,000	42,000	1.54
AD27F4	9/3	2,166,000	132,000	2,184,000	96,000	1.89
AD27G4	9/3	674,000	81,000	671,000	69,000	1.36
AD30E	9/3	1,850,000	63,000	1,766,000	35,000	3.29
AD30F	7/11	523,000	60,000	512,000	62,000	1.00
AD31E	7/11	876,000	57,000	856,000	52,000	1.20
ADDE	---	6,042,000	229,000	6,042,000	229,000	1.00
State		13,757,000 2/	291,000 2/	13,761,000	278,000	1.09

1/ Direct expansion estimate, no Landsat data used.

2/ State estimate and standard error are from the direct expansion (after field level edit and planting intentions follow-up survey). State level direct expansion estimate is not the sum of the analysis district direct expansions. State level direct expansion uses original area frame land use stratification.

Table III. 1982 AgRISTARS DCLC Soybeans Planted Acreage Estimates For Illinois

Analysis District	Imagery Date	JES DIRECT EXPANSION		LANDSAT REGRESSION		Relative Efficiency
		Estimate (Acres)	Standard Error	Estimate (Acres)	Standard Error	
AD24G	7/5	232,000	8,000	203,000	5,000	2.29
AD24GH	8/28	1,163,000	87,000	1,116,000	58,000	2.22
AD25FG	7/24	1,532,000	67,000	1,574,000	42,000	2.49
AD25FGX	7/24	348,000	46,000	329,000	21,000	5.06
AD25G	8/11	739,000	57,000	630,000	19,000	8.75
AD25H	7/24	1,544,000	103,000	1,426,000	82,000	1.57
AD26EF	7/25	494,000	87,000	503,000	55,000	2.54
AD26F	7/7	213,000	41,000	214,000	32,000	1.62
ADDE-S	----	1,016,000	146,000	1,016,000	146,000	1.00
ADDE-N	----	721,000	93,000	721,000	93,000	1.00
ADDE-W	----	1,577,000	121,000	1,577,000	121,000	1.00
State		9,547,000 1/	289,000 1/	9,309,000	268,000	1.16

Table IV. 1982 AgRISTARS DCLC Soybeans Planted Acreage Estimates For Iowa

Analysis District	Imagery Date	JES DIRECT EXPANSION		LANDSAT REGRESSION		Relative Efficiency
		Estimate (Acres)	Standard Error	Estimate (Acres)	Standard Error	
AD26EF	7/26	36,000	13,000	57,000	7,000	4.21
AD27E4	9/3	1,327,000	65,000	1,156,000	40,000	2.66
AD27F4	9/3	1,530,000	113,000	1,456,000	44,000	6.70
AD27G4	9/3	685,000	89,000	637,000	71,000	1.59
AD30E	9/3	1,634,000	96,000	1,465,000	41,000	5.45
AD30F	7/11	418,000	75,000	393,000	34,000	5.02
AD31E	7/11	425,000	52,000	431,000	44,000	1.38
ADDE	----	2,888,000	206,000	2,888,000	206,000	1.00
State		8,843,000 1/	271,000 1/	8,483,000	244,000	1.24

1/ State estimate and standard error are from the direct expansion (after field level edit and planting intentions follow-up survey). State level direct expansion estimate is not the sum of the analysis district direct expansions. State level direct expansion uses original area frame land use stratification.

IOWA

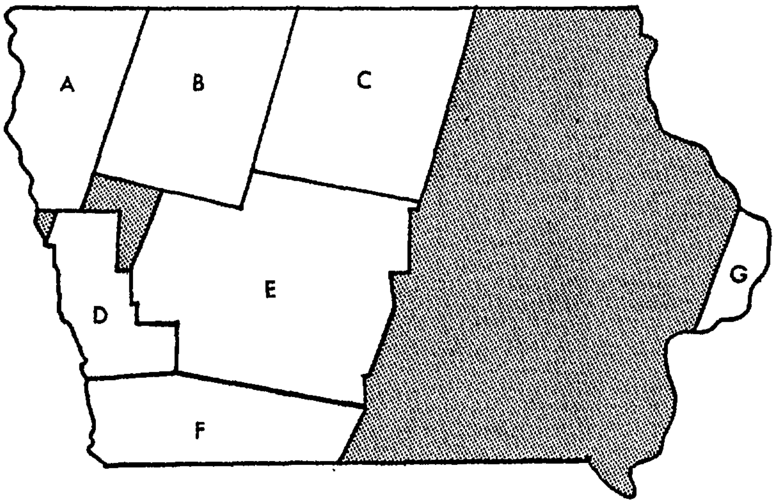

Figure I

ILLINOIS

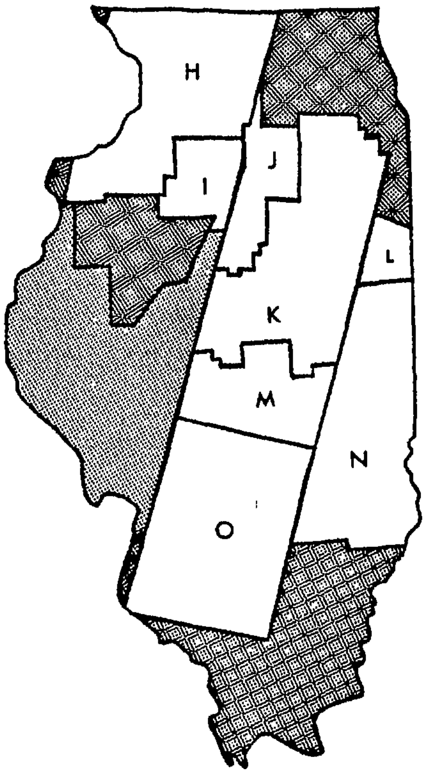

Figure II

IOWA	ILLINOIS
A-AD31E	H-AD26EF
B-AD30E	I-AD26F
C-AD27E4	J-AD25FGX
D-AD30F	K-AD25FG
E-AD27F4	L-AD24G
F-AD27GX	M-AD25G
G-AD26EF	N-AD24GH
	O-AD25H

Shaded areas indicate where direct expansion using ground data alone was employed.