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Stratification and Sample Selection for Multicrop Experiments

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16. Abstract

The purpose of this effort was to identify the locations of the sample segments for the 1978-79 Multicrop experiments to support:

-Development and evaluation of procedures for using LACIE and other technologies for the classification of corn and soybeans.

-Identification of factors likely to affect classification performance.

-Evaluation of problems encountered and techniques which are applicable to the crop estimation problem in foreign countries as well.

In order to meet these requirements, two types of samples were selected. Low density segments were distributed throughout corn and soybean producing areas to sample all variations of conditions which could affect classification accuracy and to more completely represent conditions which might be found in other countries. High density segments were selected in smaller areas to support the investigation of training, classification, and area estimation procedures on a smaller scale for possible use in future Multicrop experiments.

In this report, the data set and methods employed in the stratification are discussed. Rationale, methods, and results for both the low and high density segments are discussed.

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STRATIFICATION AND SAMPLE SELECTION FOR MULTICROP EXPERIMENTS

1. Introduction

In February 1978, LARS was asked to participate in the stratification and sampling tasks for the transition year experiments. The project was supported by personnel and funds from two tasks of NASA Contract NAS9-15466: "Application of Statistical Pattern Recognition to Image Interpretation" and "Application and Evaluation of Landsat Training, Classification, and Area Estimation Procedures for Crop Inventory."

The purpose of this effort was to identify the locations of the sample segments for the 1978-79 Multicrop experiments to support:

- Development and evaluation of procedures for using LACIE and other technologies for the classification of corn and soybeans.
- Identification of factors likely to affect classification performance.
- Evaluation of problems encountered and techniques which are applicable to the crop estimation problem in foreign countries as well.

In order to meet these requirements, two types of samples were selected. Low density segments were distributed throughout corn and soybean producing areas to sample all variations of conditions which could affect classification accuracy and to more completely represent conditions which might be found in other countries. High density segments were selected in smaller areas to support the investigation of training, classification, and area estimation procedures on a smaller scale for possible use in future Multicrop experiments.

In this report, the data set and methods employed in the stratification are discussed. Rationale, methods, and results for both the low and high density segments are discussed.

2. Objectives

In order to support the corn and soybean experiments, two types of segments were selected: low density segments and high density segments. Different issues can be addressed using each type of segment.

The low density segments were selected to cover a wide range of conditions under which areas will have to be classified in larger Multicrop efforts to allow possible problems to be examined (e.g., in algorithms, systems, data acquisition). The low density samples were located in 14 states in the U.S. corn and soybean producing areas. This region was divided into eight strata according to the level of county production of corn and soybeans and average farm size. Twenty segments per stratum were selected. The distribution of these segments permits the calculation of variability within a stratum to predict the variability of aggregated estimates of corn and soybeans in the U.S. and to determine the optimum allocation of samples for making such estimates. The allocation of these samples was not designed for, and thus does not support, making aggregated estimates.

The high density samples are located in four test sites in high production areas of the U.S. Corn Belt. Twenty segments were selected from each test site which is approximately ten counties in size. The increased density of samples permits estimation of the local variability in high production areas. These samples support the investigation of training, classification, and area estimation procedures on a smaller scale for possible use in future Multicrop experiments. Other area estimation procedures such as regression estimation can be evaluated and county level estimates can be assessed.

3. Data Set Description

The data used in this study were acquired by the Statistical Reporting Service of the U.S. Department of Agriculture (USDA/SRS). Two types of data were available: the USDA/SRS county estimates for 1972-76 and the 1974 agriculture census data. The data were supplied by NASA/Johnson Space Center (NASA/JSC).

The SRS dual county estimates program data for 1972-76 were available. Under the Federal program, county estimates are prepared for specified crops, states, and counties. These estimates include the major crops produced in most states. Some of the state statistical offices prepare county estimates for a few crops not required under the Federal program in cooperation with their respective state governments, but these estimates were not available on tape.

Variables which were included in the county estimates data set were: state, crop reporting district, county, year data was punched, crop year, commodity code, acres planted, acres harvested, yield per harvested acre, and production(Figure 1). Counties from the entire U.S. were represented. The commodities for which information was available are listed in Table 1. Some problems encountered with this data set are discussed in the appendix.

The 1974 agriculture census data were supplied for 14 states in the U.S. corn and soybean producing regions. These data included: number of acres in each county, average farm size by county, and the land in farms for each county.

4. Stratification

The first step in selection of sample segments was the stratification of the area to be studied. The variables used in the stratification, the rationale and methods employed, and the results of the stratification will be discussed in this section.

Variables Used in Stratification.

The variables available were those contained in the USDA/SRS county estimates program (Figure 1) and the selected variables from the 1974 agriculture census which were supplied by NASA/JSC. The variables which were considered for use were: acres planted, acres harvested, yield, and production for the crops listed in Table 1; acres in a county; percent agricultural area (land in farms) in a county; and average farm size by county. From these variables, the

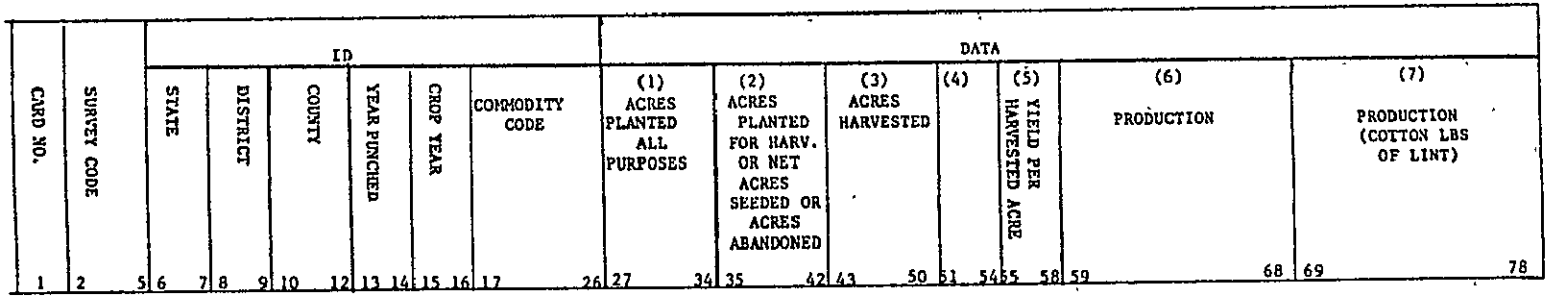

Figure 1. Record layout of county estimates data.

Table 1. Crops included in the USDA/SRS county estimates program.

Winter Wheat
Durum Wheat
Other Spring Wheat
Wheat, All
Rye, All
Rice, All
Corn for Grain
Corn For Silage
Oats, All
Barley, All
Sorghum, All
Cotton, All
Cotton, Upland
Cotton, American Pima
Tobacco
Flaxseed
Peanuts
Soybeans
Dry Edible Beans - Pea (Navy)
- Great Northern
- Flat Small White
- Pinto
- Red Kidney
- Pink
- Small Red
Dry Beans (All Mich.)
Dry Peas - Smooth Green Kinds, All
- Yellow and White Kinds, All
Wrinkled Peas for Seed
Lentils, All
Austrian Winter Peas
Green Peas for Processing, All
Tomatoes for Processing, All
Bush Garden Seed Beans (Idaho)

number of agricultural acres in a county was computed by multiplying the percent agricultural area by the county acreage. Normalized production of a crop for a county was computed by dividing the five-year average production of that crop by the agricultural acres in the county.

In order to fulfill the objectives, the stratification was performed using three variables: normalized production of corn, normalized production of soybeans, and average farm size. The first two variables were selected to make strata which are homogeneous with respect to the relative importance of corn and soybeans in the agricultural scene. The average farm size was selected to represent problems which might be encountered in Landsat data classifications with different field sizes.

Methods of Stratification.

The rationale for the stratification method was based upon the objective of creating eight strata in the United States corn and soybean producing regions which were relatively homogeneous with respect to the relative importance of corn and soybeans in the agricultural scene and the average farm (or field) size. These strata, then, represent several conditions under which Landsat data will have to be classified in Multicrop studies. Samples selected from these strata will be representative of conditions found throughout the corn and soybean producing regions.

The first step in the stratification was a reduction of the data set size. Only the 14 states for which the agriculture census data were supplied were considered. Counties with neither corn nor soybeans were omitted.

The joint distributions of normalized corn and soybean productions and average farm size were examined. The average farm size was represented in two groups: small farms (average size less than or equal to 190 acres) and large farms (size greater than 190 acres).

About one-third of the counties were in the small farms category and about two-thirds were in the large farms category. The division into these two groups was somewhat arbitrary although there was a break in the continuum of data at about 190 acres.

For each farm size, the normalized corn and soybean productions were displayed in deciles to look for broad clusters of data. The strata were determined by examining tables of the distributions of these variables. Three strata of small farm counties and five strata of large farm counties were selected to represent the two farm sizes approximately proportionally to the number of counties in them.

Counties which fell in the lower 10% of all counties in both corn and soybean production were omitted from consideration. Counties which fell outside the broad clusters of data were not included in any stratum. Thirteen counties satisfying all other selection criteria were outliers from the clusters and were not included. A schematic diagram (Figure 2) shows the methodology employed in the stratification. Table 2 gives the definitions of stratum boundaries.

Results of Stratification.

Eight strata covering 14 states in the U.S. corn and soybean producing region were determined. The counties in each of these strata are shown in Figures 3 to 10 and are listed in Tables 3 to 10.

The large farm, highest production stratum (stratum 8) is geographically located at the center of the Corn Belt. Strata 7, 6, and 4 are located around its perimeter outward according to decreased production. In these strata of large farms, corn and soybeans are of approximately equal importance.

Stratum 5 is located geographically apart from the other strata with large farms. This stratum, in which soybeans have a greater

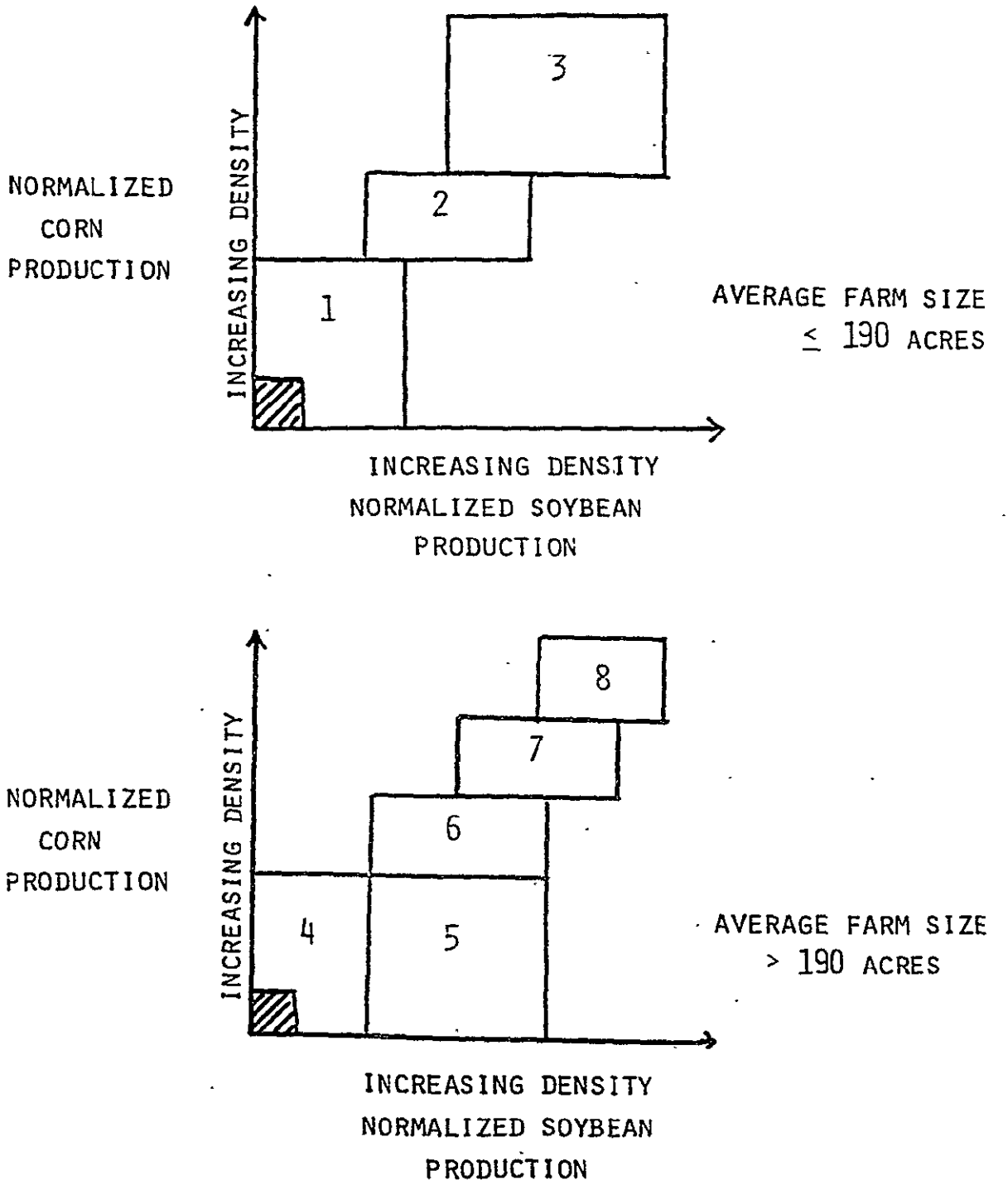

Figure 2. Schematic diagram illustrating the determination of strata for Multicrop experiments based on normalized production of corn and soybeans and average farm size.

Table 2. Determination of strata according to the normalized production of corn and soybeans and average farm size.

Stratum Number	Average Farm Size	Normalized Production		No. of Counties
		Corn	Soybeans	
	(acres)	(deciles)	(deciles)	
1	≤190	0-40	0-40	149
2	≤190	40-60	30-70	109
3	≤190	60-100	50-100	126
4	>190	0-40	0-30	192
5	>190	0-40	30-70	102
6	>190	40-60	30-70	126
7	>190	60-80	50-90	147
8	>190	80-100	70-100	213

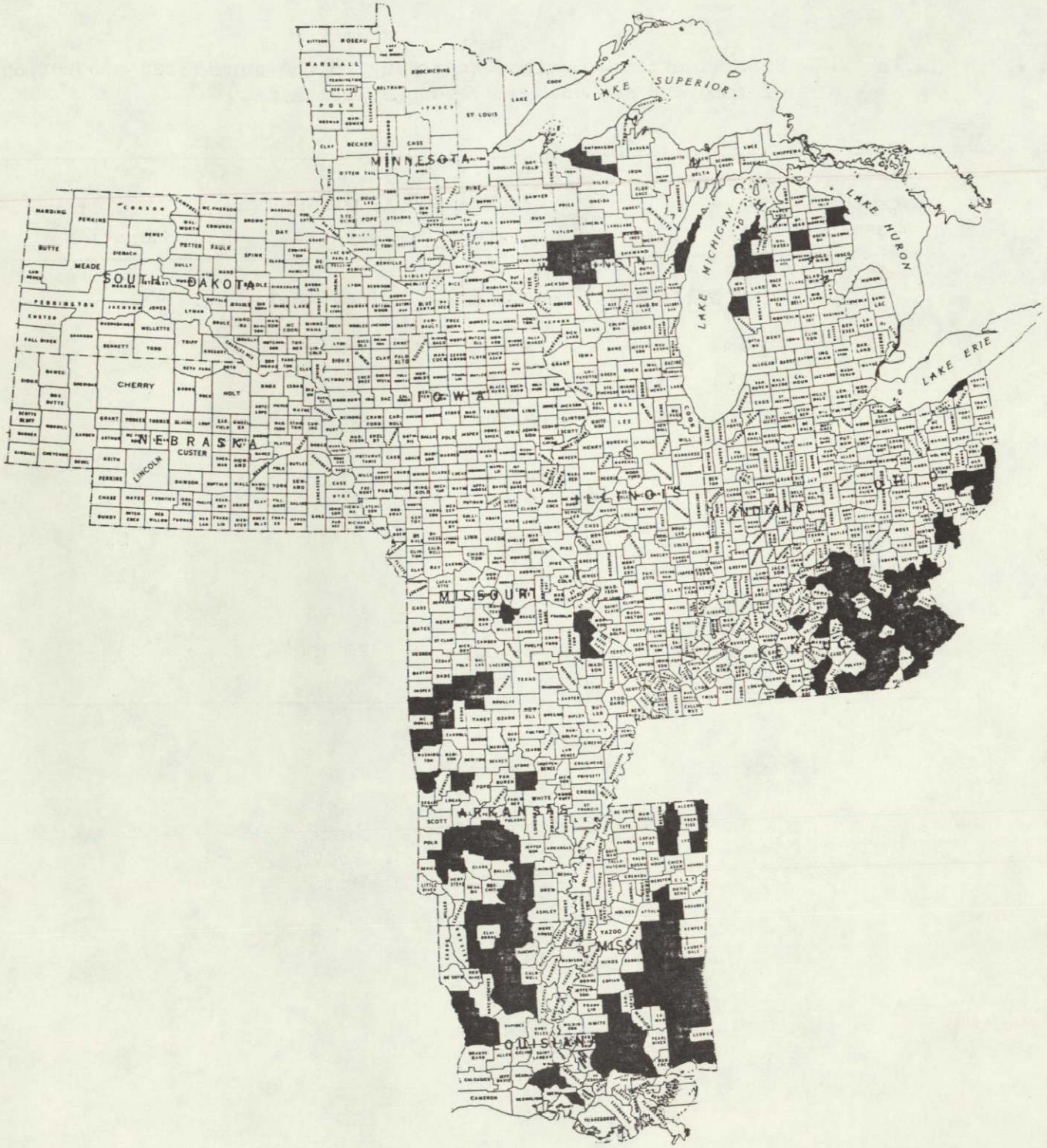

Figure 3. Locations of counties assigned to Stratum 1, small farms, low production of corn and soybeans.

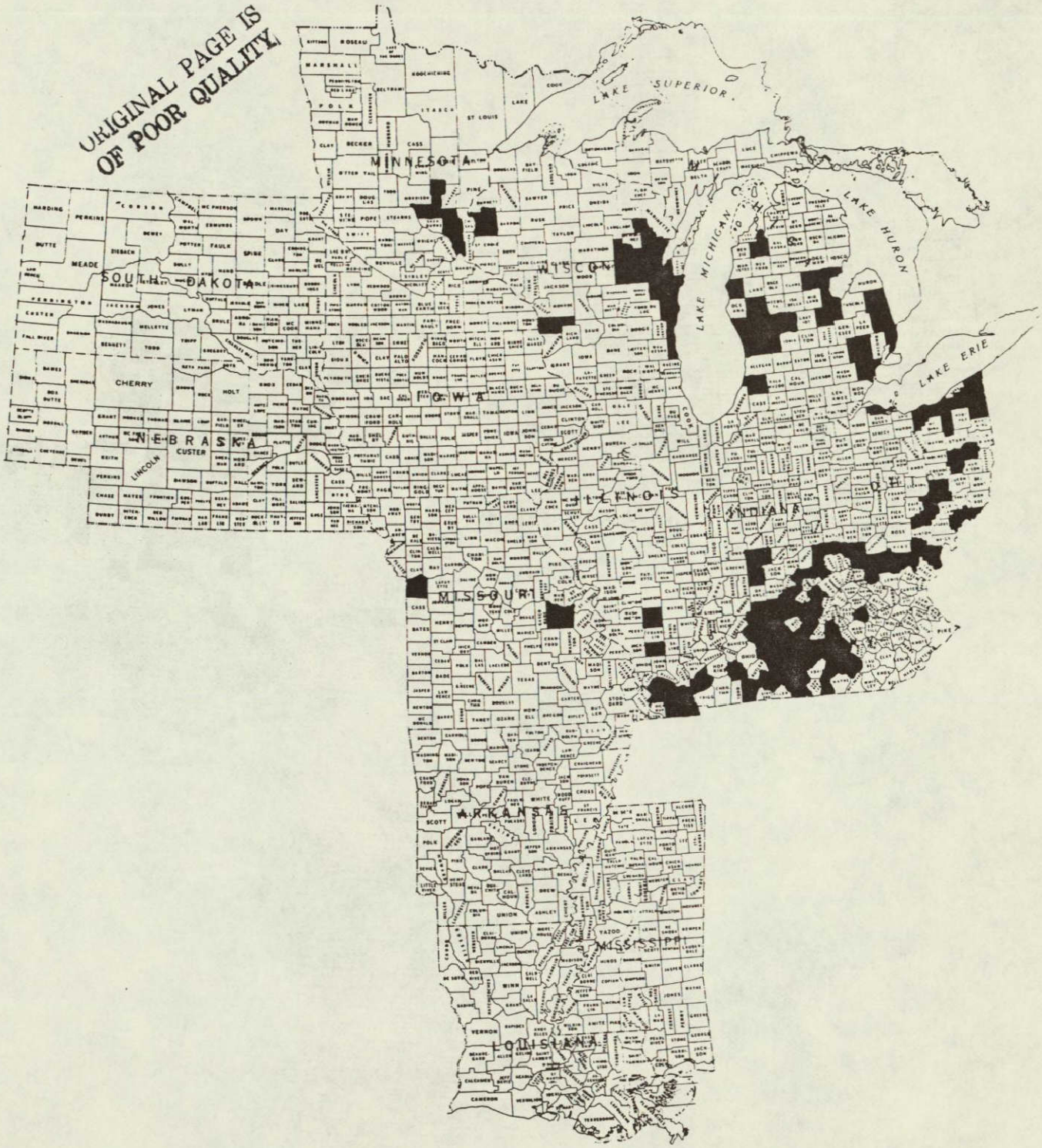

Figure 4. Locations of counties assigned to Stratum 2, small farms, medium production of corn and soybeans.

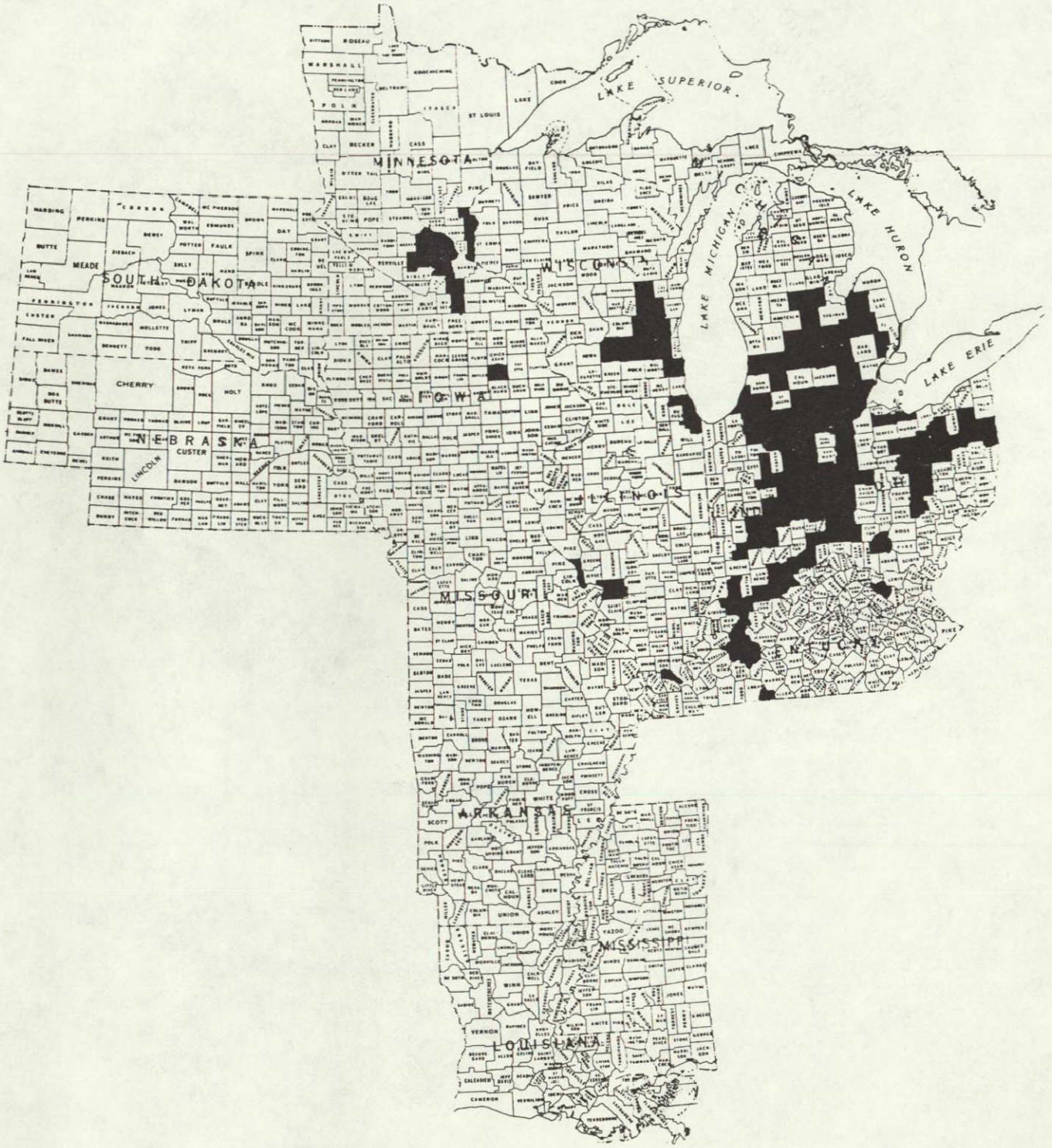

Figure 5. Locations of counties assigned to Stratum 3, small farms, high production of corn and soybeans.

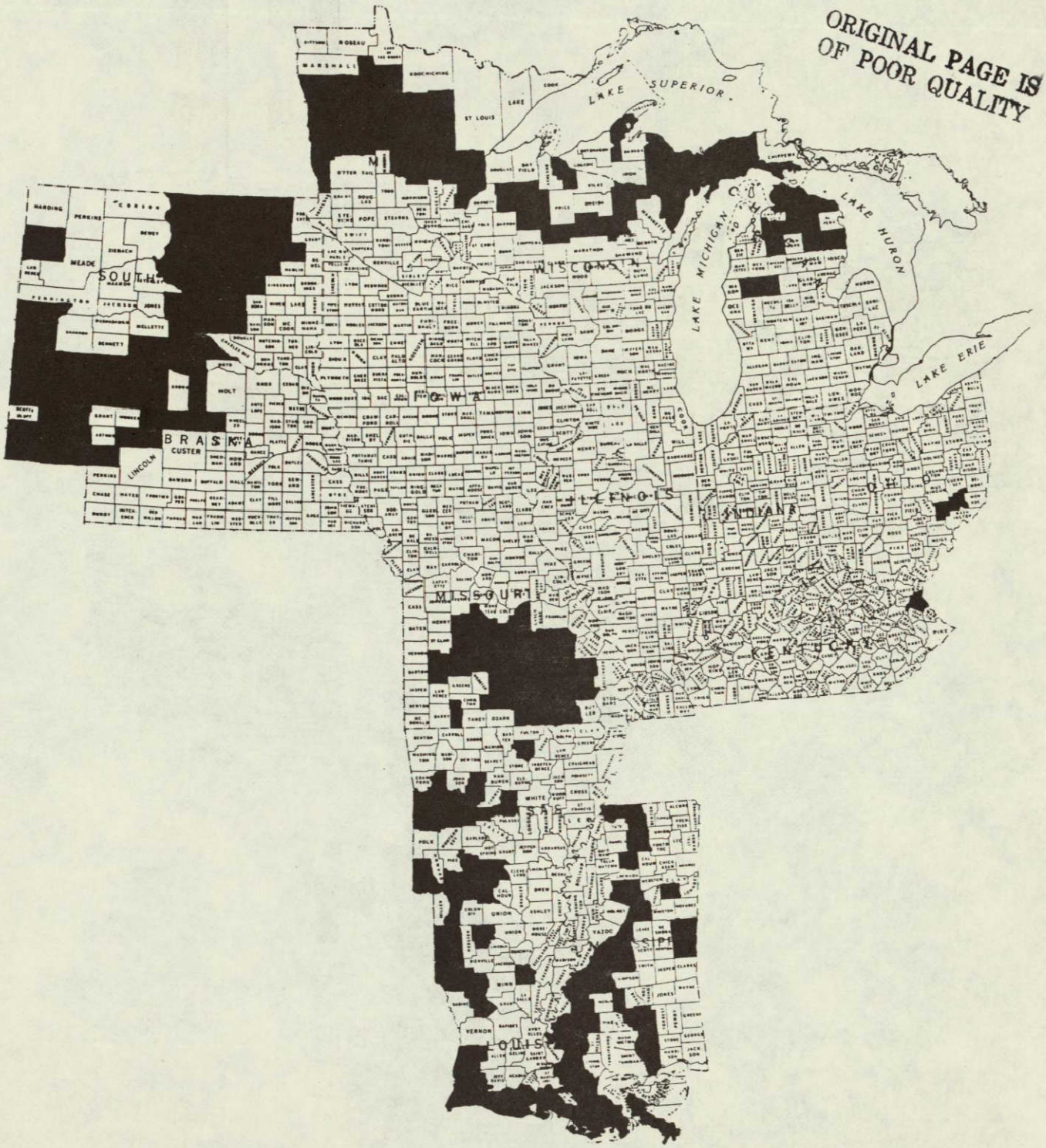

Figure 6. Locations of counties assigned to Stratum 4, large farms, low production of corn and soybeans.

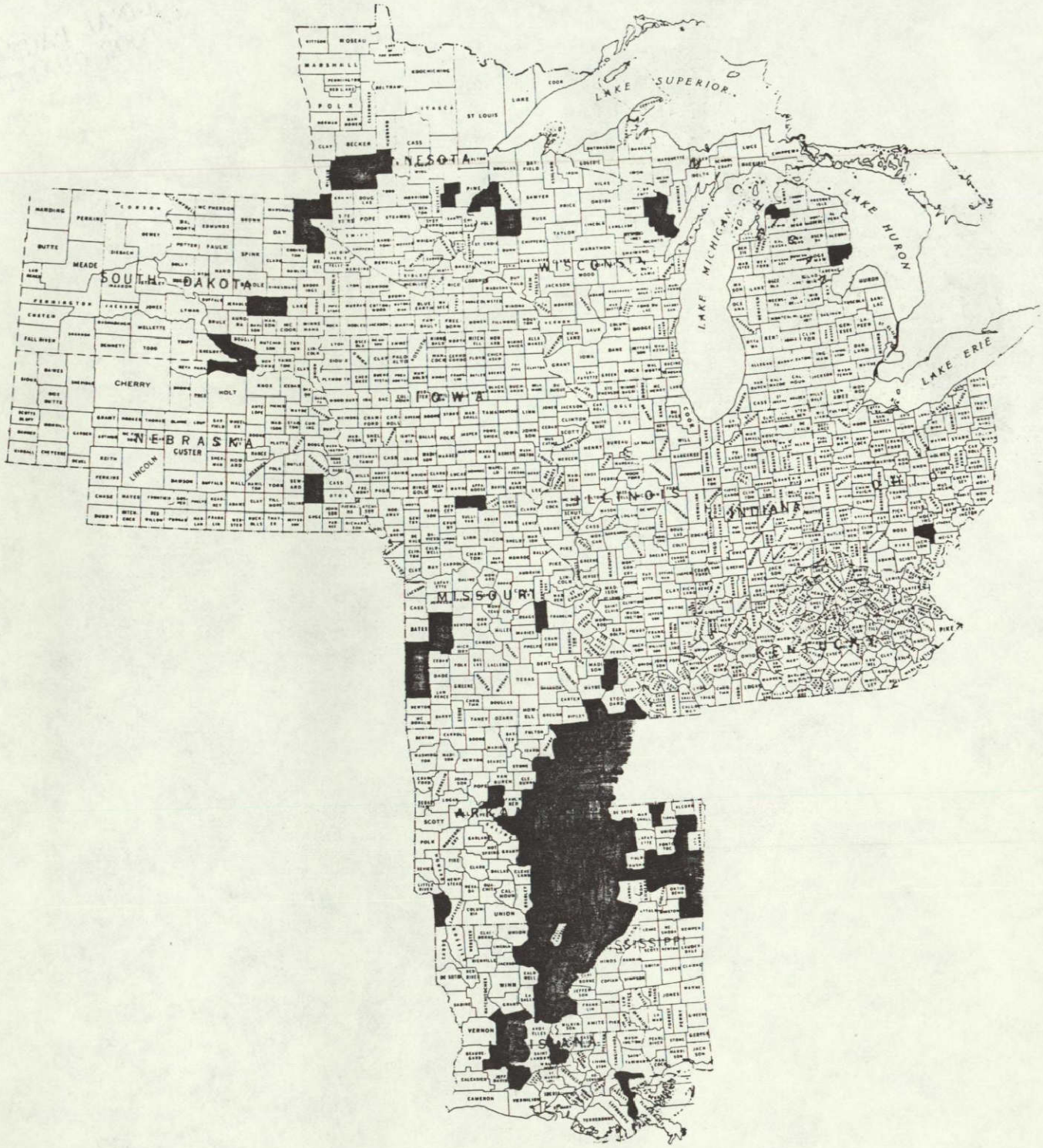

Figure 7. Locations of counties assigned to Stratum 5, large farms, low production of corn, medium production of soybeans.

Figure 8. Locations of counties assigned to Stratum 6, large farms, medium production of corn and soybeans.

Figure 9. Locations of counties assigned to Stratum 7, large farms, high production of corn and soybeans.

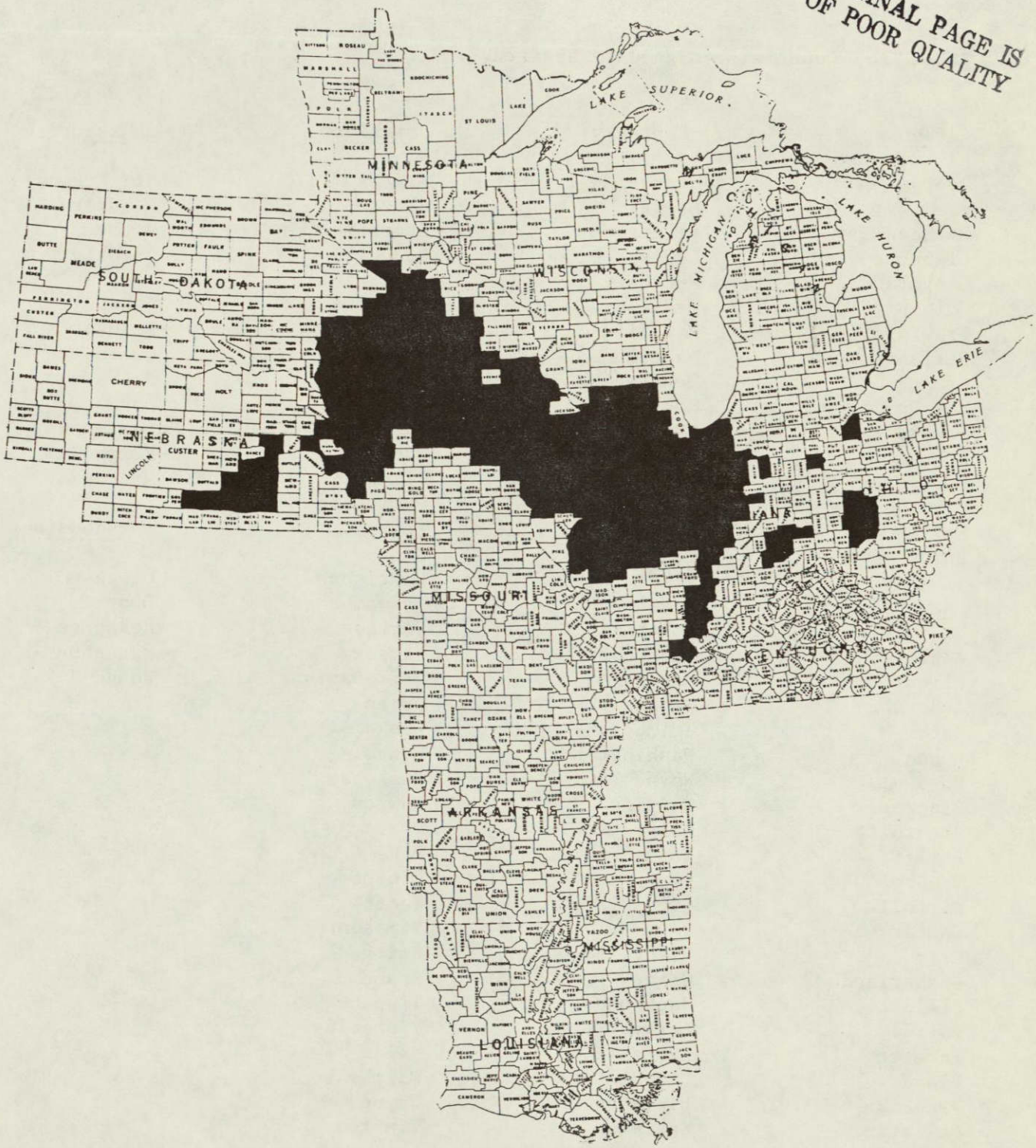

Figure 10. Locations of counties assigned to Stratum 8, large farms, highest production of corn and soybeans.

Table 3. Counties assigned to Stratum 1.

Arkansas

Benton
Bradley
Calhoun
Cleburne
Cleveland
Columbia
Crawford
Garland
Grant
Hot Springs
Howard
Johnson
Montgomery
Pike
Saline
Union

Kentucky

Adair
Allen
Anderson
Bath
Boone
Boyd
Bracken
Breathitt
Bullitt
Campbell
Carroll
Carter
Clay
Cumberland
Elliott
Estill
Fayette
Floyd
Franklin
Gallatin
Garrard
Grant
Greenup
Harlan
Harrison
Jackson
Jessamine
Johnson
Kenton
Knott
Knox
Laurel
Letcher
Lewis
McCreary
Madison
Magoffin
Martin
Menifee
Montgomery
Morgan
Nicholas
Owen
Owsley
Pendleton
Perry
Pike
Powell
Robertson
Rockcastle
Rowan
Scott
Trimble
Washington
Wayne
Whitley
Wolfe
Woodford

Louisiana

Bienville
Grant
Jackson
Lafayette
La Salle
Lincoln
Livingston
Sabine
St. Helena
St. Martin
St. Tammany
Tangipahoa
Union
Vernon
Washington
Webster
Winn

Michigan

Alpena
Benzie
Crawford
Gogebic
Leelanau
Manistee
Oceana
Wexford

Mississippi

Choctaw
Clarke
Covington
Forrest
Greene
Harrison
Itawamba
Jackson
Jasper
Jeff Davis
Jones
Leake
Lincoln
Neshoba
Newton
Perry
Pike
Pontotoc
Scott
Simpson
Smith
Stone
Tippah
Tishomingo
Union
Walthall
Wayne
Winston

Missouri

Barry
Christian
Cole
Greene
Jefferson
Lawrence
Newton
St. Francois
Webster

Ohio

Athens
Belmont
Guernsey
Jefferson
Lake
Lawrence
Meigs
Monroe

Wisconsin

Clark
Door
Kewaunee
Marathon
Wood

Table 4. Counties assigned to Stratum 2.

Illinois

Jefferson
Williams

Indiana

Brown
Clark
Crawford
Dearborn
Floyd
Harrison
Jefferson
Lawrence
Monroe
Ohio
Perry
Switzerland

Kentucky

Ballard
Barren
Boyle
Breckinridge
Caldwell
Calloway
Carlisle
Casey
Clark
Clinton
Edmonson
Graves
Grayson
Green
Hancock
Hardin
Hart
Henry
Jefferson
Larue
Lincoln
Logan
Lyon
McCracken
Marion
Marshall
Mason
Meade
Mercer
Metcalfe
Monroe
Muhlenberg
Nelson
Pulaski
Russell
Shelby
Spencer
Taylor
Warren

Michigan

Arenac
Bay
Gladwin
Grand Traverse
Kent
Mason
Montcalm
Muskegon
Newaygo
Oakland
Ottawa
Saginaw
St. Clair
Sanilac
Van Buren
Wayne

Minnesota

Anoka
Benton
Isanti
Mille Lacs
Ramsey

Missouri

Franklin
Jackson
St. Louis

Ohio

Adams
Ashtabula
Brown
Carroll
Clermont
Cuyahoga
Gallia
Geauga
Hamilton
Hocking
Jackson
Lorain
Muskingum
Ottawa
Perry
Scioto
Summit
Trumbull
Tuscarawas
Washington

Wisconsin

Brown
Calumet
Manitowoc
Milwaukee
Oconto
Outagami
Ozaukee
Polk
Shawano
Sheboyga
Vernon
Waupaca

Table 5. Counties assigned to Stratum 3.

Indiana	Kentucky	Ohio
Calhoun	Davies	Burler
Cook	Fleming	Columbiana
Madison	McLean	Crawford
Massac	Ohio	Darke
Adams	Simpson	Defiance
Allen		Erie
Blackford	Michigan	Fairfield
Daviess		Fulton
De Kalb	Allegan	Henry
Delaware	Barry	Highland
Dubois	Berrien	Holmes
Elkhart	Branch	Knox
Franklin	Cass	Licking
Grant	Clinton	Logan
Hamilton	Eaton	Lucas
Hancock	Genesee	Mahoning
Hendricks	Gratiot	
Henry	Hillsdale	Mercer
Howard	Ingham	Miami
Huntington	Ionia	Montgomery
Jackson	Isabella	Morrow
Jay	Kalamazoo	Portage
Jennings	Lapeer	Preble
Johnson	Lenawee	Putnam
Kosciusko	Livingston	Richland
Lagrange	Macomb	Sandusky
Madison	Midland	Shelby
Marion	Monroe	Stark
Marshall	Shiawassee	Warren
Miami	Tuscola	Wayne
Morgan	Washtenaw	Williams
Noble		
Orange	Minnesota	
Owen		
Pike	Carver	
Randolph	Chisago	
Ripley	Hennepin	
St. Joseph	McLeod	
Scott	Rice	
Spencer	Scott	
Steuben	Steele	
Washington	Washington	
Wayne	Wright	
Wells		
Whitley	Ohio	
Iowa	Allen	
	Ashland	
Bremer	Auglaize	

Table 6. Counties assigned to Stratum 4.

Arkansas

Clark
Dallas
Faulkner
Franklin
Hempstead
Izard
Lafayette
Little Rock
Logan
Nevada
Ouachita
Perry
Pope
Scott
Sebastian
Sevier
Yell

Kentucky

Lawrence

Louisiana

Ascension
Assumption
Beauregard
Bossier
Caddo
Calcasieu
Caldwell
Cameron
Claiborne
De Soto
East Baton Rouge
East Feliciana
Iberia
Iberville
LaFourche
Natchitoches
Plaquemines
Red River
St. James
St. Mary
Terrebon
Vermilion
West Baton Rouge
West Feioana

Michigan

Alcona
Alger
Antrim
Cheboygan
Delta
Dickinson
Emmet
Houghton
Kalkaska
Lake
Luce
Mackinac
Marquette
Menominee
Montmorenci
Osceola
Oscoda
Otsego
Presque
Schoolcraft

Minnesota

Aitkin
Becker
Beltrami
Carlton
Cass
Clay
Clearwater
Crow Wing
Hubbard
Itasca
Mahnomen
Norman
Pennington
Pine
Polk
Red Lake
Wilkin

Mississippi

Amite
Attala
Carroll
Claiborne
Copiah
De Soto
Franklin

Mississippi

Hancock
Hinds
Jefferson
Kemper
Lafayette
Lamar
Lauderdale
Lawrence
Madison
Marion
Marshall
Montgomery
Oktibbeha
Pearl River
Rankin
Wilkinson
Yalobush

Missouri

Benton
Camden
Carter
Cedar
Crawford
Dade
Dallas
Dent
Douglas
Hickory
Howell
Iron
LaClede
Madison
Maries
Miller
Morgan
Oregon
Osage
Phelps
Polk
Pulaski
Reynolds
Ripley
Shannon
Stone
Texas
Washington
Wayne
Wright

Table 6. (con't.)

Nebraska

Banner
Blaine
Box Butte
Cherry
Cheyenne
Dawes
Deuel
Garden
Garfield
Keith
Keya Paha
Kimball
Logan
Loup
McPherson
Morrill
Rock
Sheridan
Sioux
Thomas

Ohio

Morgan
Noble

South Dakota

Aurora
Beadle
Brown
Brule
Buffalo
Butte
Campbell
Clark
Codington
Custer
Day
Edmunds
Fall River
Faulk
Gregory
Hand
Hughes
Hyde
Jerauld
Lyman
McPherson
Marshall

South Dakota

Potter
Spink
Sully
Todd
Tripp
Walworth

Wisconsin

Florence
Forest
Iron
Langlade
Lincoln
Rusk
Sawyer
Taylor
Washburn

Table 7. Counties assigned to Stratum 5.

Arkansas

Arkansas
Ashley
Chicot
Clay
Conway
Craighead
Crittenden
Cross
Desha
Drew
Greene
Independence
Jackson
Jefferson
Lawrence
Lee
Lincoln
Lonoke
Miller
Mississippi
Monroe
Phillips
Poinsett
Prairie
Pulaski
Randolph
St. Francis
White
Woodruff

Louisiana

Adadia
Allen
Catahoula
Concordia
East Carroll
Evangeline
Franklin
Jefferson
Madison
Morehouse
Ouachita
Pointe Coupee
Rapides
Richland
St. John
Tensas

Michigan

Charlevoir
Iosco

Minnesota

Kanabec
Otter
Traverse
Wadena

Mississippi

Adams
Benton
Bolivar
Calhoun
Chickasaw
Clay
Coahoma
Grenada
Holmes
Humphrey
Issaquen
Lee
Leflore
Lowndes
Monroe
Noxubee
Panola
Prentiss
Quitman
Sharkey
Sunflower
Tallahatchie
Tate
Tunica
Warren
Washington
Webster
Yazoo

Missouri

Barton
Bollinger
Butler
Dunklin
Gasconade
Henry
Jasper

Missouri

New Madrid
Pemiscot
Putnam
St. Clair
Vernon

Nebraska

Boyd
Lancaster

Ohio

Vinton

South Dakota

Charles Mix
Grant
Miner
Roberts
Sanborn

Wisconsin

Barron
Burnett
Marinette

Table 8. Counties assigned to Stratum 6.

Illinois	Missouri	Nebraska	Wisconsin
Alexander	Bates	Frontier	Pierce
Franklin	Boone	Furnas	Portage
Hardin	Caldwell	Hitchcock	Richland
Jackson	Callaway	Holt	St. Croix
Johnson	Cape Girardeau	Jefferson	Trempealeau
Monroe	Carroll	Johnson	Waushara
Perry	Cass	Knox	
Pope	Chariton	Lincoln	
Pulaski	Clay	Nuckolls	
Randolph	Clinton	Pawnee	
Union	Cooper	Perkins	
	Daviess	Red Willow	
Iowa	De Kalb	Sherman	
	Gentry	Webster	
Clarke	Grundy	Wheeler	
Decatur	Harrison		
	Howard	Ohio	
Kentucky	Johnson		
	Knox	Harrison	
Bourbon	Lewis	Pike	
Butler	Linn		
Christian	Livingston	South Dakota	
Crittenden	Macon		
Livingston	Marion	Bon Homme	
Oldham	Mercer	Brookings	
Trigg	Moniteau	Davison	
	Monroe	Deuel	
Michigan	Montgomery	Douglas	
	Perry	Hamlin	
Clarey	Pettis	Hanson	
Mecosta	Pike	Hutchins	
Missaukee	Platte	Kingsburg	
Ogemaw	Ralls	Lake	
	Randolph	McCook	
Minnesota	Ray		
	Ste. Genevieve	Wisconsin	
Big Stone	Schuyler		
Douglas	Scotland	Adams	
Grant	Scott	Buffalo	
Morrison	Shelby	Chippewa	
Pope	Stoddard	Crawford	
Sherburne	Sullivan	Dunn	
Stearns	Warren	Eau Clair	
Todd	Worth	Jackson	
		Juneau	
Missouri	Nebraska	La Crosse	
		Marquette	
Adair	Brown	Monroe	
Audrain	Custer	Pepin	

Table 9. Counties assigned to Stratum 7.

Illinois

Adams
Bond
Brown
Clark
Clay
Clinton
Crawford
Cumberland
Edwards
Effingham
Fayette
Hamilton
Jasper
Jersey
Jo Daviess
Lake
Marion
Pike
Richland
St. Clair
Saline
Schuyler
Washington
Wayne
White

Indiana

Greene
Martin
Warrich

Iowa

Adair
Adams
Allamake
Appanoose
Davis
Guthrie
Howard
Jackson
Lucas
Madison
Marion
Monroe
Page
Ringgold
Taylor
Union
Van Buren
Wapello
Warren
Wayne
Winneshiek

Kentucky

Henderson
Hickman
Hopkins
Todd
Webster

Michigan

Calhoun
Huron
Jackson
St. Joseph

Minnesota

Chippewa
Dakota
Fillmore
Goodhue
Houston
Kandiyohi
Lac Qui
Lincoln
Lyon
Meeker
Murray
Olmsted
Pipestone
Redwood
Stevens
Swift
Wabasha
Winona
Yellow Medicine

Missouri

Andrew
Atchison
Buchanan
Clark
Holt
Lafayette
Lincoln
Nodaway
St. Charles
Saline

Nebraska

Antelope
Boone
Buffalo
Butler
Cass
Cedar
Chase
Colfax
Cuming
Dakota
Dawson
Dixon
Franklin
Gosper
Greeley
Harlan
Howard
Madison
Nance
Nemaha
Otoe
Pierce
Richards
Saline
Saunders
Seward
Stanton
Thayer
Thurston
Valley
Washington
Wayne

Ohio

Coshocton
Delaware
Franklin
Hancock
Hardin
Huron
Marion
Paulding
Pickaway
Ross
Seneca
Union
Wyandot

South Dakota

Clay
Lincoln
Minnehaha
Moody
Turner
Union
Yankton

Wisconsin

Columbia
Grant
Green
Green Lake
Iowa
Lafayette
Sauk
Walworth

Table 10. Counties assigned to Stratum 8.

Illinois	Illinois	Iowa
Boone	Stark	Audubon
Bureau	Stephens	Benton
Carroll	Tazewell	Black Hawk
Cass	Vermilion	Boone
Champaign	Wabash	Buchanan
Christian	Whiteside	Buena Vista
Coles	Will	Butler
De Kalb	Winnebago	Calhoun
De Witt	Woodford	Carroll
Douglas		Cass
Du Page	Indiana	Cedar
Edgar		Cerro Gordo
Ford	Bartholomew	Cherokee
Fulton	Benton	Chickasaw
Gallatin	Boone	Clay
Greene	Carroll	Clayton
Grundy	Cass	Clinton
Hancock	Clay	Crawford
Henderson	Clinton	Dallas
Henry	Decatur	Delaware
Iroquois	Fayette	Dès Moines
Kane	Fountain	Dickinson
Kankakee	Fulton	Dubuque
Kendall	Gibson	Emmet
Knox	Jasper	Fayette
La Salle	Knox	Floyd
Lawrence	Lake	Franklin
Lee	La Porte	Fremont
Livingston	Montgomery	Greene
Logan	Newton	Grundy
McDonough	Parke	Hamilton
McHenry	Porter	Hancock
McLean	Posey	Hardin
Macon	Pulaski	Harrison
Macoupin	Putnam	Henry
Marshall	Rush	Humboldt
Mason	Shelby	Ida
Menard	Starke	Iowa
Mercer	Sullivan	Jasper
Montgomery	Tippecanoe	Jefferson
Morgan	Tipton	Johnson
Moultrie	Union	Jones
Ogle	Vanderburg	Keokuk
Peoria	Vermillion	Kossuth
Piatt	Vigo	Lee
Putnam	Wabash	Linn
Rock Island	Warren	Louisa
Sangamon	White	Lyon
Scott		Mahaska
Shelby		Marshall

Table 10. (con't.)

Iowa

Mills
Mitchell
Monona
Montgomery
Muscatine
O'Brien
Osceola
Palo Alto
Plymouth
Pocahontas
Polk
Pottawattamie
Poseshiek
Sac
Scott
Shelby
Sioux
Story
Tama
Washington
Webster
Winnebago
Woodbury
Worth
Wright

Kentucky

Union

Minnesota

Blue Earth
Brown
Cottonwood
Dodge
Faribault
Freeborn
Jackson
Le Sueur
Martin
Mower
Nicollet
Nobles
Renville
Rock
Sibley
Waseca
Watonwan

Nebraska

Adams
Burt
Clay
Dodge
Douglas
Fillmore
Hall
Hamilton
Kearney
Merrick
Phelps
Platte
Polk
Sarpy
York

Ohio

Champaign
Clark
Clinton
Fayette
Greene
Madison
Van Wert
Wood

Wisconsin

Rock

importance than corn, is located in the Mississippi River Valley where the climate and soils are more suited to soybeans than to corn.

Stratum 3, the small farm stratum with the greatest production of corn and soybeans, is located primarily in eastern Indiana and western Ohio where the cropland is productive, but the terrain is rolling. The lesser production small farm strata (strata 1 and 2) are centered about this area on the outskirts of stratum 3.

In summary, looking at the geographic location of the strata, the system appears to be logical and the various strata seem to represent different conditions. This result is supportive not only of the variables and the methodology employed in the stratification, but also of the validity of the data sets employed.

5. Low Density Segments

Sample Allocation.

The low density segments were selected to sample the variability present in corn and soybean producing regions of the United States. The sample was designed to represent differences in climate, topography, field size, variety, and management practices. In order to achieve as diverse a representation as possible, an equal number of segments were allocated to each of the strata. This allocation scheme emphasizes representation of variability rather than sampling in a manner suitable for aggregation purposes.

Twenty 5 x 6 nautical mile segments were allocated to each stratum. The counties to receive sample segments were determined using a random selection procedure without replacement. Thus, all counties in a stratum had an equal probability of receiving a sample and no county could contain more than one segment. Locations of counties receiving sample segments are illustrated in Figure 11. Latitude and longtitude coordinates of the sample segment centers can be found in Table 11.

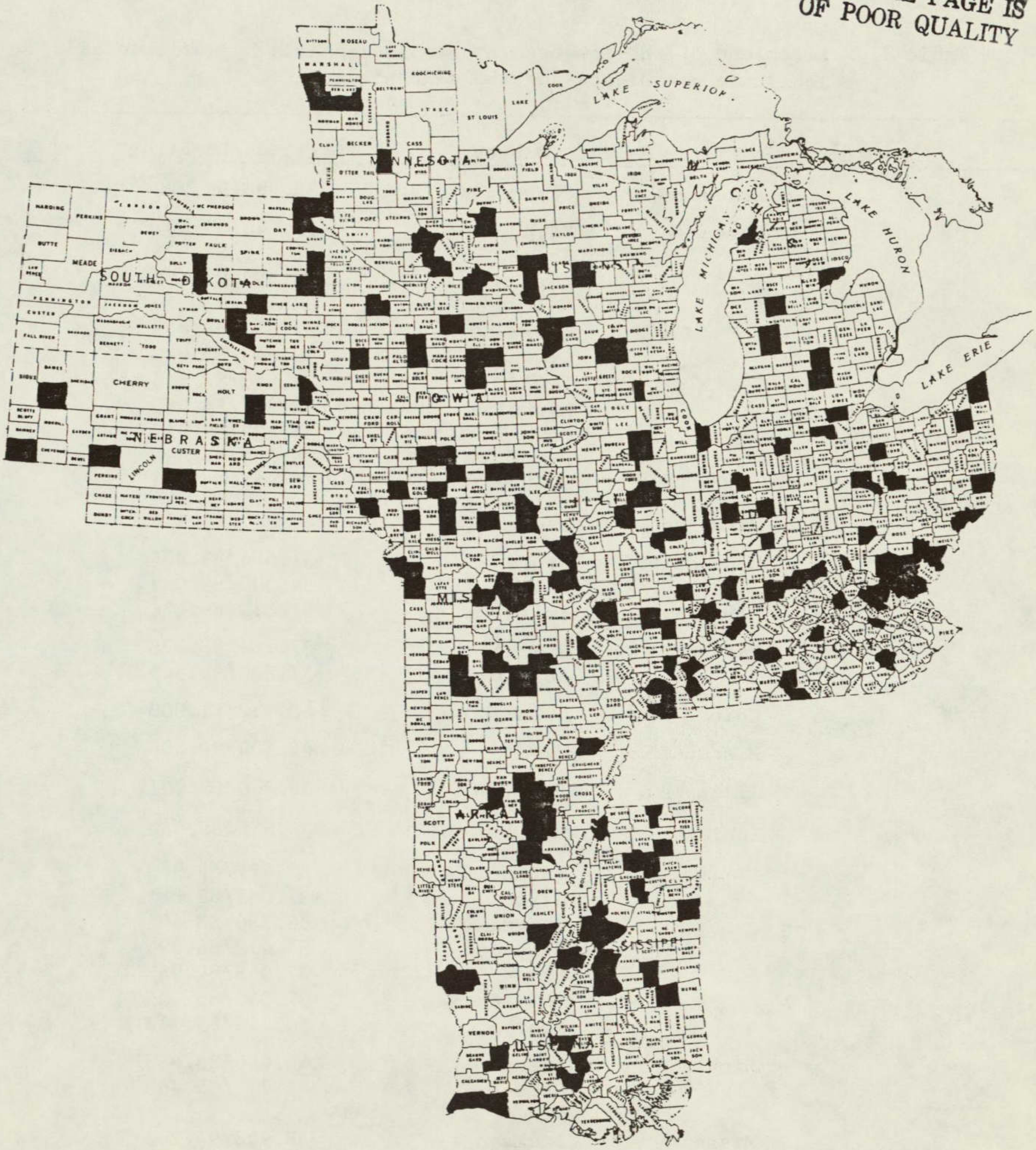

Figure 11. Locations of counties in all eight strata receiving low density sample segments.

Table 11. Locations of the low density sample segments by latitude and longitude coordinates of the segment centers.

Stratum	State	County	Latitude/Longitude
1	Arkansas	Clebuine	35.480/91.970
	Kentucky	Bath	38.240/83.807
		Boone	38.815/84.675
		Boyd	38.385/82.658
		Carter	38.312/83.170
		Clay	37.237/83.833
		Greenup	38.643/82.933
		Lewis	38.570/83.545
		Nicholas	38.327/84.060
		Powell	37.823/83.817
		Scott	38.223/84.636
		Washington	37.677/85.081
	Michigan	Leelanau	44.800/85.916
	Mississippi	Jones	31.594/89.204
		Pontotoc	34.300/89.082
		Smith	32.012/89.436
	Missouri	Greene	37.164/93.470
		St. Francis	37.880/90.540
	Ohio	Belmont	40.112/81.000
	Wisconsin	Wood	44.500/90.000
2	Illinois	Jefferson	38.340/89.101
	Indiana	Switzerland	38.858/85.033
	Kentucky	Ballard	37.117/88.963
		Barren	37.065/85.885
		Graves	36.706/88.695
		Grayson	37.413/86.590
		Lyon	37.058/87.960
		McCracken	37.030/88.735
		Monroe	36.715/85.710
	Michigan	Arenac	44.086/83.685
		Kent	43.271/85.763
	Missouri	Jackson	38.908/94.263
	Ohio	Adams	38.960/83.470
		Ashtabula	41.696/80.818
		Gallia	38.876/82.317
		Jackson	38.930/82.573
		Sciota	38.795/82.829
		Washington	39.456/81.665

Table 11. (con't)

Stratum	State	County	Latitude/Longitude
	Wisconsin	Polk	45.283/92.283
		Vernon	43.617/90.900
3	Illinois	Calhoun	38.920/90.575
	Indiana	Daviess	38.791/87.102
		Hamilton	40.127/86.070
		Jennings	39.040/85.563
		Johnson	39.415/86.245
		Scott	38.693/85.725
		Spencer	37.975/87.145
		Washington	38.624/86.080
		Whitley	41.127/85.667
	Kentucky	Fleming	38.423/83.750
		Daviess	37.660/87.125
	Michigan	Ingham	42.665/84.278
	Minnesota	Carver	44.766/93.800
		Scott	44.633/93.383
		Wright	45.150/93.900
	Ohio	Defiance	41.372/84.550
		Fulton	41.541/84.288
		Logan	40.463/83.612
		Portage	41.284/81.230
	Wisconsin	Dane	42.922/89.385
4	Louisiana	Cameron	29.950/93.080
		De Soto	32.110/93.790
		East Baton Rouge	30.670/91.095
		Iberville	30.141/91.155
		Red River	32.173/93.360
		West Feliciana	30.805/91.315
	Minnesota	Polk	47.816/96.683
	Mississippi	Carroll	33.345/89.813
		Copiah	31.761/90.611
		Hinds	32.348/90.615
		Yalobusha	34.140/89.635
	Missouri	Dent	37.628/91.600
		Laclede	37.669/92.595
		Polk	37.667/93.351
		Texas	37.283/92.000
	Nebraska	Box Butte	42.166/103.233
		Keith	41.168/101.866
		Kimball	41.307/103.650

Table 11. (con't)

Stratum	State	County	Latitude/Longitude
	South Dakota	Aurora	43.750/98.483
		Hyde	44.466/99.450
5	Arkansas	Conway	35.190/92.790
		Greene	36.192/90.710
		Jefferson	34.354/91.882
		Lonoke	34.772/92.003
		Prairie	34.762/91.615
		White	35.208/91.580
	Louisiana	Allen	30.490/92.815
		Madison	32.282/91.501
		Morehouse	32.910/91.630
	Minnesota	Traverse	45.819/96.451
		Wadena	46.439/94.897
	Mississippi	Benton	34.937/89.295
		Calhoun	33.932/89.183
		Humphreys	33.305/90.365
		Noxobe	33.191/88.543
		Sharkey	32.750/90.880
		Tunica	34.570/90.305
		Yazoo	32.765/90.143
	South Dakota	Roberts	45.725/96.950
		Sanborn	43.996/97.878
6	Illinois	Pope	37.335/88.605
	Iowa	Decatur	40.631/94.014
	Kentucky	Crittendon	37.245/88.150
	Michigan	Mecosta	43.681/85.206
	Missouri	Adair	40.250/92.500
		Boone	39.215/92.183
		Callaway	38.962/92.035
		Clay	39.410/94.276
		Cooper	38.745/92.870
		Gentry	40.325/94.430
		Grundy	40.171/93.381
		Lewis	40.005/91.670
		Mercer	40.338/93.383
		Platte	39.484/94.795
	South Dakota	Brookings	44.304/96.890
		Deuel	44.963/96.570
		Douglas	43.333/98.179

Table 11. (con't)

Stratum	State	County	Latitude/Longitude
	Wisconsin	Crawford	43.127/91.034
		Eau Claire	44.735/91.255
		Trempeal	44.387/91.360
7	Illinois	Hamilton	38.035/88.495
		Pike	39.665/91.210
		Richland	38.695/88.135
		St. Claire	38.589/89.865
	Iowa	Lucas	41.050/93.489
		Madison	41.466/94.021
		Taylor	40.792/94.806
		Wapello	40.959/92.300
		Warren	41.384/93.489
	Kentucky	Hickman	36.698/88.944
	Michigan	Jackson	42.336/84.425
	Minnesota	Goodhue	44.453/92.875
	Missouri	Atchison	40.310/95.214
		Clark	40.360/91.520
		Lincoln	39.080/91.130
	Nebraska	Antelope	42.367/98.180
		Dawson	40.908/99.955
		Dixon	42.333/96.916
	Ohio	Delaware	40.212/82.826
		Wyandot	40.880/83.352
8	Illinois	Boone	42.178/88.809
		Douglas	39.749/88.055
		LaSalle	41.428/89.083
		Logan	40.259/89.221
		McLeon	40.675/88.824
		Moultrie	39.755/88.703
	Indiana	Carroll	40.712/86.593
		Gibson	38.288/87.352
		Lake	41.294/87.345
		Montgomery	40.211/86.854
		Vermilion	39.622/87.498
	Iowa	Butler	42.717/92.674
		Chickasaw	43.131/92.395
		Floyd	43.134/92.805
		Jefferson	41.122/91.900
		Kossuth	43.299/94.310
		O'Brien	43.035/95.399

Table 11. (con't)

Stratum	State	County	Latitude/Longitude
	Minnesota	Cottonwood	44.016/95.133
		Freeborn	43.787/93.429
	Ohio	Clinton	39.377/83.602

Segment Location.

Segment locations were selected using a modification of a computer program written for "Crop Inventory Using Full-Frame Classification", described in the final report of Contract NAS9-14970 (June, 1977). The design of the location procedure was based upon that used in LACIE. A grid was laid over each county with grid intersections five by six nautical miles apart. A random selection procedure was then used to select a grid intersection which determined the latitude and longitude coordinates of the center point of each segment.

Although only one segment was allocated to each county, several segments were selected to attain a high probability that at least one of them would be located in an agricultural area and would be accepted as a site. The number of sites to be located in each county was determined by the percent agricultural land in the county. The segment centers were randomly selected without replacement and the first segment located outside a nonagricultural area was to be used.

The ag/nonag delineation was conducted by NASA/JSC. Full-frame color composite Landsat imagery was used to delineate areas which were not agricultural. This was done on the basis of whether or not field patterns were apparent. Rangeland, forest, and urban areas were among the types of land uses which were delineated as nonag. Segment locations were compared with these boundaries and the segment was rejected if less than 5% of the segment fell into an agricultural area.

6. High Density Segments

Test Site Selection.

The high density segments were designed for intensive study of the remote sensing technology required for corn and soybean inventories. In order to sample more corn and soybeans, test sites were located in the Corn Belt where production of both crops is high. Test sites were

placed across the Corn Belt to sample the varied climatic conditions, soil types, crop distributions, and field sizes which are present (Figure 12). Each test site was selected to be relatively homogeneous within (same stratum, similar soil types and farming practices) to support classification studies, particularly of multisegment training. Each of the sites contained about ten counties and was approximately the size of a crop reporting district.

Test Site 1 is located in eastern Indiana which is an area of small farms. The other three test sites are located in large farm areas. Test Site 2 is comprised of counties in west central Indiana and east central Illinois. Test Site 3 is in north central Iowa and Test Site 4 is in west central Iowa.

Description of Test Sites 1 and 2. The climate across central Indiana and east central Illinois is continental with warm summers and cold winters. Normal mean temperature is -1.2°C in January and 31.1°C in July. In this semihumid region of the U.S., the average annual precipitation is 950 to 1000 mm which does not limit crop production. Rainfall is greatest during the spring and early summer months with June typically receiving 107 to 118 mm of rain. Average precipitation in June is slightly excessive, adequate in July, and often inadequate in August for corn. The crops survive because of some moisture stored in the soil profile.

Test Site 1 is composed of two major soil associations. Soils of the northern two-thirds of this district (Allen, Wells, Adams, Blackford, Jay, and parts of Madison, Delaware, and Randolph counties) belong to the Blont-Pewano-Mortley soil association. These soils were formed on clayey glacial till and are nearly level and poorly to very poorly drained. The Brookston-Crosby-Miami-Parr assocation which predominates in the remainder of Test Site 1 was formed in thin loess (wind-blown materials) over loamy glacial till and is also poorly drained. These two soil associations are suited to intensive cropping but are subject to problems associated with wet soils unless adequate artifical drainage is provided. Typically, approximately 287,700 hectares of

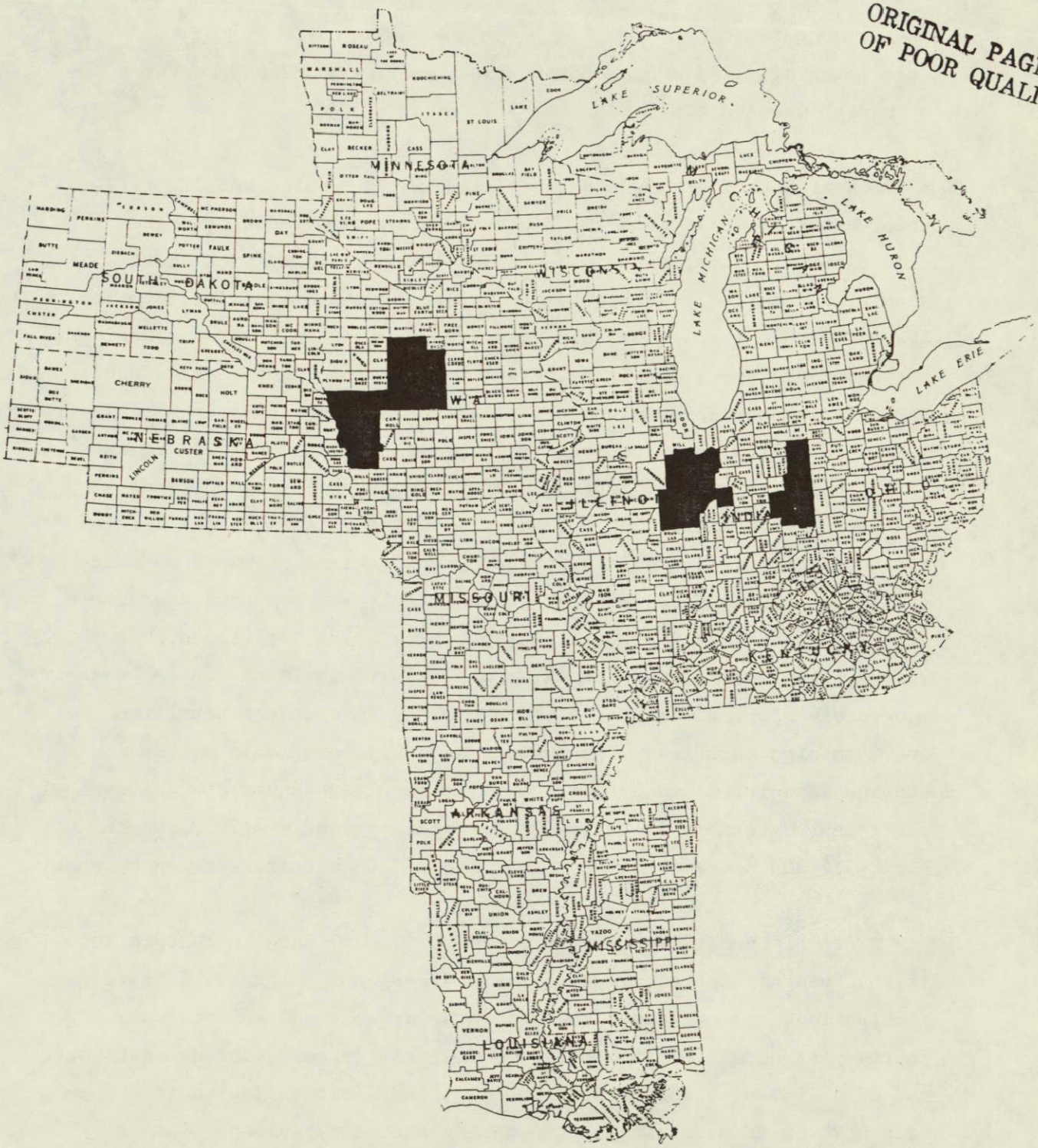

Figure 12. Locations of high density test sites.

corn for grain; 245,300 hectares of soybeans; and 87,300 hectares of winter wheat are planted.

Test Site 2 includes dark-colored prairie soils and light-colored forest soils both of which were formed in loess-covered glacial till. Topography is generally gently rolling with short slopes and nearly level areas interrupted by depressions or potholes. The northern one-third of this district (Newton, Jasper, Kankakee, and northern Ford and Iroquois counties) has soils which are sandy and variable in subsoil development. These soils tend to be droughty, low in fertility, and require a high level of management for moderate yields. In Tippecanoe, Benton, Warren, southern Ford and Iroquois, and northern Vermilion and Champaign counties in the central portion of the district, the soils developed under prairie or mixed prairie and forest vegetation, are dark to moderately dark colored, and are generally imperfectly drained. Crop yields are moderately high to high with a high level of management. Dark-colored soils on nearly level to moderately sloping upland areas are typical in southern Vermilion and Champaign counties. These soils have high available moisture storage capacities and are very highly productive under a high level of management. Farmers in Test Site 2 typically plant 667,700 hectares of corn; 557,200 hectares of soybeans; and 39,200 hectares of winter wheat.

Description of Test Sites 3 and 4. The climate in western Iowa is continental, characterized by marked seasonal changes. Temperature fluctuations are extreme with winters being cold and summers warm. Thirty-year normal temperatures are -8.4 ^{0}C in January, the coldest month, and 23.6° in July, the warmest month. Annual precipitation is 762 mm with most of it occurring in the spring and early summer. Summer precipitation is variable from year to year with the largest amount (132 mm) generally falling in June.

The Clarion-Nicollet-Webster soil association, which is the only major soil group in Test Site 3, was derived from glacial till. About 75 percent of the area has level to gently sloping topography and is well suited to intensive production of corn, soybeans, and alfalfa.

Table 12. Allocation of sample segments to counties in each of the four high density test sites.

Test Sites	State	County	No. of Segments
1	Indiana	Adams	2
		Allen	2
		Blackford	2
		Delaware	2
		Henry	2
		Jay	2
		Madison	2
		Randolph	2
		Wayne	2
		Wells	2
2	Indiana	Benton	2
		Jasper	2
		Newton	2
		Tippecanoe	2
		Warren	2
	Illinois	Champaign	3
		Ford	1
		Iroquois	3
		Kankakee	2
		Vermilion	3
3	Iowa	Calhoun	2
		Emmet	2
		Hamilton	2
		Hancock	2
		Humboldt	2
		Kossuth	2
		Palo Alto	2
		Pocahontas	2
		Webster	2
		Wright	2
4	Iowa	Crawford	2
		Harrison	2
		Ida	2
		Monona	2
		Pottawatomie	3
		Sac	2
		Shelby	2
		Woodbury	3

Sample Location.

The method used for sample selection was the same as described for the low density samples. More segments were located than were allocated to permit for loss of some segments in nonagricultural areas. Locations of the sample segments by latitude and longitude coordinates can be found in Table 13.

7. Summary and Conclusions

A stratification was performed and sample segments were selected for an initial investigation of Multicrop problems. The effort was to support:

- Development and evaluation of procedures for using LACIE and other technologies for the classification of corn and soybeans.
- Identification of factors likely to affect classification performance.
- Evaluation of problems encountered and techniques which are applicable to the crop estimation problem in foreign countries as well.

The two types of samples, low density and high density, supporting these requirements were selected as a research data set for an initial evaluation of technical issues and should not be used in an aggregation scheme. In summary, looking at the geographic location of the strata, the system appears to be logical and the various strata seem to represent different conditions. This result is supportive not only of the variables and the methodology employed in the stratification, but also of the validity of the data sets employed.

Table 13. Locations of the high density sample segments by latitude and longitude coordinates of the segment centers.

Test Site	State	County	Latitude/Longitude
1	Indiana	Adams	40.785/84.880
		Adams	40.620/85.016
		Allen	40.956/85.273
		Allen	40.952/84.877
		Blackford	40.541/85.412
		Blackford	40.457/85.413
		Delaware	40.290/85.285
		Delaware	40.123/85.549
		Henry	39.789/85.424
		Henry	40.039/85.419
		Jay	40.370/85.022
		Jay	40.451/84.889
		Madison	40.128/85.810
		Madison	40.295/85.808
		Randolph	40.038/85.159
		Randolph	40.036/84.899
		Wayne	39.785/84.904
		Wayne	39.954/85.161
		Wells	40.789/85.276
		Wells	40.650/85.230
2	Indiana	Benton	40.627/87.382
		Benton	40.520/87.210
		Jasper	40.879/86.990
		Jasper	40.963/87.122
		Newton	41.125/87.521
		Newton	40.794/87.384
		Tippecanoe	40.515/87.027
		Tippecanoe	40.335/86.835
		Warren	40.378/87.117
		Warren	40.293/87.378
	Illinois	Champaign	40.172/88.307
		Champaign	40.339/88.435
		Champaign	40.310/88.100
		Ford	40.588/88.300
		Iroquois	40.919/88.030
		Iroquois	40.752/88.034
		Iroquois	40.831/87.768
		Kankakee	41.248/87.757
		Kankakee	41.086/88.026
		Vermilion	40.078/87.657
		Vermilion	40.415/87.910
		Vermilion	40.330/87.650

Table 13 (con't)

Test Site	State	County	Latitude/Longitude
3	Iowa	Calhoun	42.294/94.838
		Calhoun	42.380/94.569
		Emmet	43.464/94.725
		Emmet	43.298/94.585
		Hamilton	42.219/93.489
		Hamilton	42.300/93.893
		Hancock	43.052/93.625
		Hancock	43.135/93.762
		Humboldt	42.801/94.036
		Humboldt	42.717/94.303
		Kossuth	42.966/94.301
		Kossuth	43.135/94.172
		Palo Alto	42.963/94.852
		Palo Alto	43.127/94.855
		Pocahontas	42.713/94.711
		Pocahontas	42.794/94.848
		Webster	42.384/94.164
		Webster	42.549/94.166
		Wright	42.886/93.897
		Wright	42.217/93.876
4	Iowa	Crawford	41.948/95.635
		Crawford	41.952/95.367
		Harrison	41.615/95.624
		Harrison	41.778/95.763
		Ida	42.454/95.382
		Ida	42.530/95.655
		Monona	41.941/96.037
		Monona	42.113/95.775
		Pottawatomie	41.285/95.348
		Pottawatomie	41.446/95.619
		Pottawatomie	41.362/95.749
		Sac	42.205/95.374
		Sac	42.457/95.111
		Shelby	41.699/95.493
		Shelby	41.622/95.224
		Woodbury	42.358/96.054
		Woodbury	42.216/95.784
		Woodbury	42.480/95.870

APPENDIX

Appendix. Problems Encountered with County Estimates Data

Numerous difficulties were encountered with the county estimates data. The original tape which was transmitted from NASA/JSC was in ASCI format on an 800 BPI tape.

There were some unreadable characters on the tape, indicating that the original data tape may have been bad. The problems were found in the first few columns of a record, so that "educated guesses" could be made to fill in the missing information. The missing information was sometimes restricted to the first five columns which were constant throughout the entire data set. If state or county codes were missing, these could be determined by examining the placement of the card in the data deck. For all bad data lines, the missing information was overlaid, but the first five columns (containing a constant code which was irrelevant to the study) were left bad so that these lines could be located again if necessary.

There were also some codes encountered which were not documented. A visit with Bob Cole of the Indiana USDA/SRS office helped identify an appropriate course of action.

The first column of each record was supposed to indicate the card number and should have been "2" for all data on the tape. One record was encountered, however, which had "3" in the first column. As it was learned that card three did not exist, this was determined to be a key-punching error and was changed on the data file.

Table A-1 lists crops and their codes for the data set. Nonexistent commodity codes were encountered in the data files. Some of the unusual codes might have been mispunched or might have been specific to a state; an example of this type is the code 17163 (for class and crop code). Class code 33 was not included on the list in Table A-1, but the Indiana office of the USDA/SRS was able to inform us that this class code represented

Table A-1. Commodity Codes.

Class	Crop Code	Utilization	Crop Name
10	119	9	Winter Wheat
10	129	9	Durum Wheat
10	139	9	Other Spring Wheat
10	199	9	Wheat, All
10	499	9	Rye, All
10	619	9	Rice, All
11	199	1	Corn for Grain
11	199	2	Corn for Silage
11	299	9	Oats, All
11	399	9	Barley, All
11	499	9	Sorghum, All
12	129	9	Cotton, All (Neither Ginning Status nor Staple Type Specied)
12	121	9	Cotton, Upland
12	122	9	Cotton, American Pima
			Tobacco:
14	111	1	Flue-cured, type 11
14	111	2	Flue-cured, type 12
14	111	3	Flue-cured, type 13
14	111	4	Flue-cared, type 14
14	122	1	Fire-cured, type 21
14	122	2	Fire-cured, type 22
14	122	3	Fire-cured, type 23
14	133	1	Air-cured, type 31
14	133	2	Air-cured, type 32
14	133	5	Air-cured, type 35
14	133	6	Air-cured, type 36
14	133	7	Air-cured, type 37
14	244	1	Cigar-filler, type 41
14	255	1	Cigar-binder, type 51
14	255	2	Cigar-binder, type 52
14	255	4	Cigar-binder, type 54
14	255	5	Cigar-binder, type 55
15	299	9	Flaxseed
15	399	1	Peanuts
15	499	1	Soybeans
16	171	1	Dry Edible Beans - Pea (Navy)
16	171	2	- Great Northern
16	171	4	- Flat Small White
16	171	6	- Pinto
16	171	7	- Red Kidney
16	172	1	- Pink
16	172	2	- Small Red
16	199	9	Dry Beans (All Mich.)
16	319	9	Dry Peas - Smooth Green Kinds
16	329	9	- Yellow and White Kinds
83	161	8	Wrinkled Peas for Seed
16	599	9	Lentils
16	819	9	Austrian Winter Peas
36	129	9	Green Peas for Processing
37	829	9	Tomatoes for Processing
83	104	2	Bush Garden Seed Beans (Idaho)

miscellaneous vegetables. Another problem was class codes which matched the list given, but whose corresponding crop code or utilization code did not exist. The code "14558", for example, does not exist, but all of class 14 is tobacco so this observation was included there. The utilization "0" is not used for 10129 (durum wheat) but was included in that crop type anyway. There were approximately 40 more cases which were handled in a similar fashion.

Duplicate cards were also encountered in the winter wheat, corn, barley, and miscellaneous crops data files. There were several different varieties of duplicates. Some cards were exact duplicates, a situation which had a straightforward solution. Some cards were encountered containing different estimates of a crop for the same county and the same year, but which were punched in different years. In this case, the most recently entered information was selected to be correct. Some duplicate cards had a third type of problem: yields differed by a factor of ten while the rest of the information was identical. In this situation, the card was selected for which acres times yield was equal to production.

There were many zeros for acreage, yield, and production in the data files. By looking at the values for a given crop in a given county over the five year period, it was determined that a zero might represent two situations: either no acreage of that crop was grown in that county or the true data value was missing. Missing values could possibly have been determined by consulting state crop production publications; time constraints for this project, however, did not permit this type of verification. Years with zero values were excluded from consideration in computation of crop averages. If the data were indeed missing, this approach yielded a much more realistic estimate. If the data were truly zero, a good estimate would be obtained by averaging the other non-zero years which would be small numbers.

Additional steps in data verification were attempted by summing individual estimates to obtain a total for a given crop, crop reporting

district, or state. These methods were abondoned as a data verification aid again due to resource considerations. As a rule, summing did not work. Some examples are given as follows.

Theoretically, the "all wheat" data file should be the sum of the winter wheat, durum wheat, and other spring wheat files. This was supposed to be true according to Bob Cole of the Indiana USDA/SRS office, but was found to be not necessarily true in the data. Sometines all wheat was larger than the sum of the three component files and sometimes the sum was larger. Occasionally, the numbers were about equal. Some counties reported total wheat, but did not divide it down into its components, while other counties appeared to do the reverse.

Finally, crop reporting district and state area and production estimates of a crop should be the sum of estimates for the counties comprising them. This check also failed frequently, a possible result of missing data or a mixture of preliminary and final estimtes.