APPENDIX D

METHOD OF DESIGNATING SEGMENTS AS SPRING, WINTER, OR MIXED WHEAT

The U.S Department of Agriculture Statistical Reporting Service[1] estimates of winter and spring wheat production for each county in South Dakota and Montana for the years 1965-76 were taken into consideration to determine the county contribution to the state total production. A county-to-state contribution threshold of 1 percent was used for each crop type. If a county containing allocated segments contributed 1 percent or more to the state winter wheat production, the segments were designated as winter wheat; the same method was used for spring wheat. The counties were thus divided into three groups: pure spring, pure winter, and mixed wheat. Further, those counties in the pure spring and pure winter wheat groups were designated mixed wheat if the within-county contribution for either crop type to the total wheat for the county was between 25 and 75 percent. For example, a county contributed more than 1 percent to state winter wheat production but less than 1 percent to state spring wheat production; however, spring wheat made up 50 percent of the county's total wheat production and therefore the county was designated as mixed wheat. The resulting segment designations are shown in the following table. In the group titled "Nonaggregation segments," those segments marked with an asterisk were processed by the Classification and Mensuration Subsystem as mixed wheat segments for evaluation purposes only.

[1]Now called the Economics, Statistics, and Cooperative Service.

South Dakota				
Mixed wheat segments				
1485	1668	1677	1689	1805
1486	1669	1686	1697	1808
1488	1670	1687	1698	
1666	1676	1688	1699	
Spring wheat segments				
1484	1525	1671	1679	1756
1487	1548	1673	1680	1784
1489	1599	1674	1681	
1498	1665	1675	1690	
1499	1667	1678	1755	
Winter wheat segments				
1597	1683	1696	1804	
1598	1694	1803	1806	
Nonaggregation segments				
1800*	1802*	1809	1812	
1801	1807*	1811*	1813	
Montana				
Mixed wheat segments				
1528	1537	1734	1741	1937
1529	1538	1735	1929	1938
1530	1539	1736	1932	1939
1531	1540	1737	1933	1941
1534	1555	1738	1934	1942
1535	1732	1739	1935	
1536	1733	1740	1936	
Spring wheat segments				
1532	1542	1545	1559	1944
1533	1543	1546	1940	1945
1541	1544	1547	1943	1946
Winter wheat segments				
1101	1552	1728	1743	1753
1102	1556	1729	1744	1930
1104	1557	1730	1745	1931
1549	1558	1731	1747	1948
1550	1725	1742	1750	1949
Nonaggregation segments				
1103	1553	1752*	1947	
1551	1554	1928		

APPENDIX E

LACIE PHASE III INTENSIVE TEST SITES

APPENDIX E

LACIE PHASE III INTENSIVE TEST SITES

The field data acquisitions from 24 U.S. and 10 Canadian intensive test sites were an integral part of Large Area Crop Inventory Experiment (LACIE) operations (see tables E-1 and E-2). These sites were located prior to LACIE Phase III operations; their identities and locations are available to all LACIE personnel. Field data acquired from these sites by U.S. Department of Agriculture/Agricultural Stabilization and Conservation Service (USDA/ASCS) personnel include the following:

a. Aerial photography (once yearly)

b. Field maps annotated by USDA/ASCS personnel

c. Inventories of all fields

   (1) After fall planting for winter wheat areas

   (2) At harvest for spring and winter wheat areas

d. Observations of a subsample (approximately 50 fields) of each intensive test site every 18 days, coincident with each Landsat overpass

TABLE E-1.— LACIE PHASE III U.S. INTENSIVE TEST SITES

Segment	State	County	Center coordinates		Site size		Ground truth (a)
			Lat., N.	Long., W.	Kilometer	Mile	
1975	Idaho	Oneida	42°04.5'	112°29.5'	4.8×4.8	3×3	SW
1976	Idaho	Franklin	42°08.0'	111°58.0'	4.8×4.8	3×3	SW
1977	Idaho	Bannock	42°56.5'	112°25.5'	4.8×4.8	3×3	SW
1981	Indiana	Shelby	39°27.6'	85°47.2'	4.8×4.8	3×3	W
1982	Indiana	Madison	40°13.5'	85°37.5'	4.8×4.8	3×3	W
1983	Indiana	Boone	40°05.7'	86°33.5'	4.8×4.8	3×3	W
1960	Kansas	Morton	37°16.0'	101°54.0'	8×9.7	5×6	W
1962	Kansas	Saline	38°41.8'	97°28.4'	4.8×4.8	3×3	W
1963	Kansas	Rice	38°17.0'	98°12.7'	4.8×4.8	3×3	W
1964	Kansas	Ellis	38°50.1'	99°13.0'	4.8×4.8	3×3	W
1988	Kansas	Finney	38°10.2'	100°43.2'	8×9.7	5×6	W
1987	Minnesota	Polk	47°49.0'	96°41.0'	8×9.7	5×6	S
1969	Montana	Toole	48°53.0'	111°46.5'	3×16	2×10	SW
1970	Montana	Liberty	48°44.0'	110°51.0'	3×16	2×10	SW
1971	Montana	Hill	48°42.0'	109°55.0'	3×9.7	2×6	SW
1965	N. Dakota	Burke	48°53.2'	102°10.0'	8×9.7	5×6	S
1966	N. Dakota	Williams	48°19.2'	103°24.7'	8×9.7	5×6	S
1687	S. Dakota	Hand 1	44°35.0'	98°58.0'	8×9.7	5×6	SW
1986	S. Dakota	Hand 2	44°21.0'	98°45.1'	8×9.7	5×6	SW
1978	Texas	Randall	35°09.5'	102°04.4'	4.8×4.8	3×3	W
1980	Texas	Oldham	35°15.0'	102°32.0'	4.8×4.8	3×3	W
1973	Washington	Whitman	46°50.4'	117°48.3'	4.8×4.8	3×3	SW

[a]S = spring wheat; W = winter wheat; SW = spring and winter wheat.

TABLE E-2.— LACIE PHASE III CANADIAN INTENSIVE TEST SITES

Segment	Province	County	Center coordinates		Site size		Ground truth (a)
			Lat., N.	Long., W.	Kilometer	Mile	
1958	Saskatchewan	Melfort	52°48'	104°44'	3.2×16	2×10	S
1959	British Columbia	Dawson Creek	55°48'	120°12'	3.2×16	2×10	S
1984	Saskatchewan	Delisle	51°55'	107°28'	3.2×16	2×10	S
1985	Saskatchewan	Swift Current	50°19'	107°53'	3.2×16	2×10	S
1989	Alberta	Lethbridge	49°30'	112°48'	3.2×16	2×10	S
1990	Manitoba	Stony Mountain	50°04'	97°21'	3.2×16	2×10	S
1991	Manitoba	Starbuck	49°47'	97°29'	3.2×16	2×10	S
1992	Alberta	Olds	51°54'	113°32'	3.2×16	2×10	S
1994	Alberta	Ft. Saskatchewan	53°38'	113°07'	3.2×16	2×10	S
1995	Manitoba	Altona	49°12'	97°38'	1.6×8	1×5	S
(b)	Saskatchewan	Torquay	49°05'	103°22'	1.6×8	1×5	S

[a]S = spring wheat.

[b]Ground-truth data were reported, but Landsat imagery was not obtained; therefore, there is no segment number.

APPENDIX F

THE SCREENING PROCEDURE

APPENDIX F

THE SCREENING PROCEDURE*

The basic approach to screening remains the same as that given in reference 1. The variable defined by the ratio $\bar{r} = \bar{y}/X$, where $\bar{y}$ is the average of Classification and Mensuration Subsystem (CAMS) wheat proportion estimates for sample segments in a county and X is the historical wheat proportion for the county, provides a measure of representativeness of a county by its sample segments. In reference 1, the ratio $r = y/X$, where y is the CAMS wheat proportion estimate for a segment in the county, was considered for the measure of representativeness; however, when a large within-county variance exists for the CAMS segment estimates, as observed for certain counties in Colorado (ref. 2), r is likely to represent the county poorly. Conversely, the average ratio $\bar{r}$ can be a very good measure of it, as the use of $\bar{r}$ eliminates the bias in a county estimate that might be caused by deletion of a subset of segments. The logarithmic transformation is applied to the values of $\bar{r}$ to maintain the normal approximation hold for the underlying distribution.

Winter and spring wheat regions are treated separately; each region is stratified by the size of historical wheat acreage at the county level. The winter wheat region is divided into the following four strata:

$$S_1 = \{X: \ 0 < X \leq 5\}$$

$$S_2 = \{X: \ 5 < X \leq 15\}$$

$$S_3 = \{X: \ 15 < X \leq 30\}$$

$$S_4 = \{X: \ X > 30\}$$

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*Chhikara, R. S.: A Revised Screening Procedure for Large Area Crop Inventory Experiment (LACIE) Phase III Data in the U.S. Great Plains, LEC-12723 (to be published).

For the spring wheat region, three strata are formed:

$$S_1' = \{X: \ 0 < X \leq 5\}$$

$$S_2' = \{X: \ 5 < X \leq 25\}$$

$$S_3' = \{X: \ X > 25\}$$

There is one less stratum in the spring wheat case because its region is smaller than the winter wheat region.

The statistical procedure for testing outliers is quite different from the one used in reference 1. The critical values for the test of significance do not correspond to the percentage points of the normal distribution; instead, these values are developed by using the Monte Carlo technique for the test statistic computed for the normal samples. Simulations are used because the exact distribution of the test statistic cannot be obtained. The significance test is developed to detect as many as 19 outliers in a data set. Thus far in the statistical literature, detection has been developed for a maximum of four outliers (ref. 3). This test procedure was documented in reference 4.

The screening was applied to final LACIE Phase III CAMS segment estimates obtained after thresholding from each of the above strata. Counties were flagged whose z values (where $z = \log \bar{r}$) were declared outliers. Consequently, CAMS segment estimates for these counties were deleted from the Crop Assessment Subsystem (CAS) data base, and the counties were treated as "group III" in the CAS aggregation.

The revised U.S. Great Plains (USGP) winter and spring wheat acreage estimates by states are presented in table F-1. Also given are the official LACIE Phase III estimates. The numerical results show that there is a better

TABLE F-1.— LACIE PHASE III ACREAGE ESTIMATES OBTAINED WITH THE SCREENING PROCEDURE APPLIED TO CAMS THRESHOLDED DATA

Region	USDA/ESCS estimate ($\times 10^3$)		LACIE Phase III							
			Previous screening				Revised screening			
			No. of segments used	Estimate ($\times 10^3$)		CV*	No. of segments used	Estimate ($\times 10^3$)		CV
	Sq hm	Acres		Sq hm	Acres			Sq hm	Acres	
Winter wheat										
Colorado	1 032	2 550	24	1 401	3 463	10	30	1 151	2 844	12
Kansas	4 897	12 100	106	5 062	12 508	4	109	5 010	12 380	4
Nebraska	1 194	2 950	39	1 392	3 440	9	43	1 310	3 237	10
Oklahoma	2 630	6 500	42	2 299	5 682	8	43	2 278	5 630	8
Texas	1 902	4 700	29	1 815	4 485	16	26	1 988	4 913	15
USSGP* total	11 655	28 800	240	11 969	29 578	4	251	11 737	29 004	4
South Dakota	275	680	15	367	906	35	20	363	897	44
Montana	1 133	2 800	43	1 366	3 375	8	54	1 200	2 965	9
USGP-7* total	13 063	32 280	298	13 702	33 859	3	325	13 300	32 866	4
Spring wheat										
Minnesota	1 304	3 222	38	953	2 354	15	38	909	2 247	18
North Dakota	3 703	9 150	73	3 723	9 200	4	72	3 731	9 220	4
Montana	915	2 260	32	881	2 178	10	35	904	2 233	12
South Dakota	945	2 336	35	787	1 944	15	29	910	2 249	12
USNGP* total	6 867	16 968	178	6 344	15 676	4	174	6 454	15 949	4

*CV = coefficient of variation; USSGP = U.S. southern Great Plains; USGP-7 = USGP seven-state region; and USNGP = U.S. northern Great Plains.

agreement between the revised estimates and the U.S. Department of Agriculture/Statistical Reporting Service[1] (USDA/SRS) end-of-season estimates when compared to the agreement between the official LACIE Phase III estimates and the USDA/ESCS estimates.

REVISED VERSUS OFFICIAL LACIE PHASE III ACREAGE ESTIMATES

The revised and the official LACIE Phase III acreage estimates given in table F-1 were obtained on the CAS Development System using the LACIE Phase III CAS data base with thresholding and screening applied to the final CAMS segment estimates. Thresholding precedes screening and is the same in both cases; thus, the difference between the two estimates is due only to the use of different screening procedures. The official estimates (column 5) correspond to the screening procedure employed previously in LACIE Phase III, and the revised estimates (column 9) correspond to the updated procedure discussed in the previous section. (There is a slight difference between the estimates given in column 5 and the officially reported LACIE estimates because of a difference in the number of significant digits to which the CAMS estimates were carried in the two CAS systems – development and operational.)

A state-by-state comparison between the two estimates shows that the revised LACIE winter wheat acreage estimates are closer to their corresponding USDA/ESCS estimates. The only exception is for the State of Oklahoma, where the difference between the two estimates was slightly larger. For the seven states combined, the difference between the LACIE estimate and the USDA/ESCS estimate was reduced from 639 000 square hectometers (1 579 000 acres) to 237 000 square hectometers (586 000 acres) as a result of updating the screening procedure.

In obtaining the revised estimate, 325 CAMS segment estimates were used compared to 298 CAMS segment estimates used for the LACIE estimate at the

[1] Now called the Economics, Statistics, and Cooperative Service (ESCS).

seven-state level, a deletion of 27 segments. This is an expected result, provided the assumption of a uniform change in county wheat acreages from epic year to current year holds for counties in each stratum. The outlier test procedure applied in reference 1 is conservative, as it tends to declare false outliers more often than is allowed under the 5-percent level of significance presently used. Although the revised screening procedure flags counties and results in deleting all segments in them, compared to flagging and deleting individual segments, there should be no adverse effect.

No significant change is noticed in spring wheat estimates obtained using different screening procedures. There is a difference of 110 000 square hectometers (273 000 acres) between the revised and the official LACIE estimates, with the largest change in South Dakota. The revised spring wheat acreage estimate for South Dakota is below the USDA/ESCS estimate by 3.7 percent; the previous estimate was 16.8 percent below the USDA/ESCS estimate. There is very little change in the LACIE estimates for the three other spring wheat States of Minnesota, Montana, and North Dakota.

CONCLUSION

The revised screening procedure has a sound statistical basis and eliminates the two major drawbacks of the reference 1 procedure. The revision resulted in a substantial decrease in the official LACIE winter wheat acreage estimate and some increase in the spring wheat acreage estimate, bringing the two estimates into better agreement with corresponding USDA/ESCS estimates.

REFERENCES

1. A Segment Screening Procedure for U.S. Great Plains. An attachment to letter from R. S. Chhikara to W. McAllum, dated Sept. 9, 1977.

2. Colorado Blind Sites (Action Item RTEB SF3-134). A memorandum from Jon Erickson to the Transition Year Project Manager, dated June 15, 1978.

3. Rosner, Bernard: Percentage Points for the RST Many Outlier Procedure. Technometrics, 19, Aug. 1977.

4. Chhikara, R. S.; and Feiveson, A. H.: A Statistical Test Procedure for Detecting Multiple Outliers in a Data Set. Technical Report JSC-14594, LEC-12910, Nov. 1978.

APPENDIX G

LACIE PHASE III GROUND-TRUTH CROP AND NONCROP CODES

APPENDIX G

LACIE PHASE III GROUND-TRUTH CROP AND NONCROP CODES

Specific crop and noncrop codes are used in the delineation of agricultural and nonagricultural features in aerial photographs. These codes identify crops in each field and provide other pertinent information to describe the entire area of the blind site. The aerial photograph codes are presented in table G-1, and special crop codes are given in table G-2.

TABLE G-1.— AERIAL PHOTOGRAPH CODES FOR FEATURE DELINEATION

Crop or feature	Baseline code	Field type				
		Harvested	Abandoned	Strip fallow	Strip fallow, abandoned	Strip fallow, harvested
Problem field*	80					
Alfalfa	90	115	140	165	190	215
Beans	91	116	141	166	191	216
Corn	92	117	142	167	192	217
Safflower	93	118	143	168	193	218
Sunflower	94	119	144	169	194	219
Sudan grass	95	120	145	170	195	220
Sorghum	96	121	146	171	196	221
Soybeans, guar	97	122	147	172	197	222
Sugar beets	98	123	148	173	198	223
Winter wheat	99	124	149	174	199	224
Spring wheat	100	125	150	175	200	225
Barley	101	126	151	176	201	226
Rye	102	127	152	177	202	227
Flax	103	128	153	178	203	228
Oats	104	129	154	179	204	229
Grass	105	130	155			
Hay	106	131	156			
Pasture	107	132	157			
Trees	108	133	158			
Other small grains†	109	134	159	184	209	234
Voluntary wheat	110	135	160	185	210	235
Cotton	111	136	161	186	211	236
Millet	112	137	162	187	212	237
Water	240					
Mountains	241					
Nonagriculture	242					
Homestead	250					
Idle cropland, stubble	251					
Idle cover crop	252					
Idle cropland, residue	253					
Idle cropland, fallow	254					

*Mixed crops; mostly weeds, replants, etc.

†Triticale, speltz, buckwheat, durum wheat.

TABLE G-2.— SPECIAL CROP CODES

Crop code	Description of scene	Approximate relative area proportions
1 to 15	Special field number indicates percentage of winter wheat	
16 to 30	Special field number plus 15 indicates percentage of spring wheat	
61	Wheat and small grains*	1:1
62	Wheat and small grains (two or more)	1:2
63	Wheat and one or more other annual crops (OAC)*	1:1
64	Wheat and OAC	1:2
65	Wheat and OAC	2:1
66	Wheat, small grains, and OAC	1:1:1
67	Wheat, small grains, and OAC	1:2:1
68	Wheat, small grains, and OAC	1:1:2
69	Wheat, small grains, and fallow*	1:1:1
70	Wheat, small grains, and fallow	1:2:1
71	Wheat, small grains, and fallow	1:1:2
72	Wheat, OAC, and fallow	1:1:1
73	Wheat, OAC, and fallow	1:2:1
74	Wheat, OAC, and fallow	1:1:2
75	Small grains and OAC	1:1
76	Small grains and OAC	1:2
77	Small grains and OAC	2:1
78	Small grains, OAC, and fallow	1:1:1
79	Small grains, OAC, and fallow	1:2:1
81	Small grains, OAC, and fallow	1:1:2

*Class designations: Wheat indicates winter or spring wheat; small grains include barley, rye, triticale, oats, and flax; the category OAC includes beans, sunflowers, safflowers, Sudan grass, corn, soybeans, sorghum, potatoes, peas, mustard, etc.; and fallow indicates idle fallow or idle residue.

APPENDIX H

GLOSSARY

APPENDIX H

GLOSSARY

biowindow or biophase — Biological window or biological phase – a Landsat data acquisition period that is related to the biostages of wheat development. The LACIE approach is based on the judgment that wheat can be separated adequately from other crops by machine analysis of up to four acquisitions of Landsat data during the growing season. The biowindow may be updated if there is a significant lag or advancement in the current crop calendar. The sequence chosen generally includes acquisitions during the following biowindows:

1. Crop establishment – from field preparation to jointing (biostages 1.0 to 3.0)
2. Green – from jointing to heading (biostages 3.0 to 4.0)
3. Heading – from heading to soft dough (biostages 4.0 to 5.0)
4. Mature – from soft dough to harvest (biostages 5.0 to 7.0)

biostage — Biological stage – the specific stage of development of a crop which can be recognized by a major change in plant structure; i.e., emergence after germination, jointing, heading, soft dough, ripening, and harvest, which are represented by integers on the Robertson biometeorological time scale.

blind sites — LACIE sample segments chosen at random for which ground truth is obtained in order to test classification performance. The identity of the blind sites is withheld from the CAMS analysts so that these segments will be treated the same as the other segments.

classification — In computer-aided analysis of remotely sensed data, the process of assigning data points to various classes by a testing process in which the spectral properties of each unknown data point are compared with spectral properties typical of these classes.

classification error — A measure of the degree to which the LACIE classification either overestimates or underestimates the wheat acreage in a specific area.

crop calendar	A calendar depicting the biostages of the major crop types within a specified region during a calendar year.
crop calendar adjustment	An adjustment made to the historical crop calendar on the basis of current meteorological data.
group II counties	A group of counties that historically has small quantities of wheat/small grains; counties are allocated a sample segment on the basis of probability proportional to size.
group III county	A county which historically has very little wheat/small grains. No sample segments are allocated to group III counties.
intensive test site	A LACIE test segment in the United States or Canada on which detailed crop information is collected by using ground and airborne equipment.
multispectral scanner	The remote sensing instrument on Landsat that measures reflected sunlight in various spectral bands or wavelengths.
90/90 criterion	Criterion that the LACIE U.S. Great Plains at-harvest production estimate be within 10 percent of the true value with a probability of at least 0.9.
sample segments	The 5- by 6-nautical-mile areas used as samples in LACIE to make acreage estimates. They are selected by a sampling strategy which is described in appendix A of this report.