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A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

Foreign Commodity Production Forecasting

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TRANSITION YEAR LABELING ERROR CHARACTERIZATION STUDY FINAL REPORT

N. James Clinton

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16. Abstract

Labeling errors made in the Large Area Crop Inventory Experiment Transition Year estimates by Earth Observation Division image analysts are identified and quantified in this document. The analysis was made from a subset of blind sites in six U.S. Great Plains states (Oklahoma, Kansas, Montana, Minnesota, and North and South Dakota). The image interpretation basically was well done, resulting in a total omission error rate of 24 percent and a commission error rate of 4 percent. The largest amount of error was caused by factors beyond the control of the analysts who were following the interpretation procedures. The odd signatures, the largest error cause group, occurred mostly in areas of moisture abnormality. Multicrop labeling was tabulated showing the distribution of labeling for all crops.

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TECHNICAL REPORT

TRANSITION YEAR LABELING ERROR CHARACTERIZATION STUDY
FINAL REPORT

Job Order 74-402

This report describes the accuracy assessment activities of the Foreign Commodity Production Forecasting project of the AgRISTARS program.

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FIGURES

1. INTRODUCTION

1.1 BACKGROUND

During Phase III of the latter part of the Large Area Crop Inventory Experiment (LACIE) and the Transition Year (TY), Procedure 1 was used to estimate small-grain proportions for 5- by 6-nautical-mile sample segments (ref. 1, section 4-8, ref. 2, section 4-5). During the TY in the Northern Great Plains, analysts using this procedure identified 209 picture elements (pixels) as barley, other small grains, or nongrains (ref. 3). One of the major sources of proportion estimation error was the misidentification of the labeled pixels (ref. 4, section 6, ref. 5, section entitled Technology Labeling Accuracy). As part of the accuracy assessment evaluation of the TY results, a labeling error characterization similar to the one conducted in LACIE Phase III (ref. 6) was performed. The intent was to identify, quantify, and characterize to the best degree possible the causes for analyst mislabeling of pixels.

In addition to estimating the proportion of small-grain acreage in the segments used in the TY, the analysts were required to separate barley from the other small grains of spring wheat, oats, and flax in the four northern states of Minnesota, Montana, North Dakota, and South Dakota. The analysts were also required to specifically label every identifiable crop in the nonsmall-grain category. The nonsmall-grain crops are indicated in figure 1-1 as multilabeling categories. For the two remaining U.S. Great Plains states of Kansas and Oklahoma, the analysts were to label only the winter wheat and nonwheat. These labels were used to compute two-category proportion estimates (winter wheat and nonwheat).

Though proportion estimates were not made for the nonsmall-grain crops, there were two reasons for labeling the nonsmall-grain pixels. First was the need for evaluation, an aspect of evaluation which was simplified because the analyst had recorded the crop label for each nonsmall-grain crop. Specifically, after the season the confusion crops could easily be identified and the errors quantified when the ground truth was compared with the analyst labels. Prior

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The following four groups are labeling categories designed for the multilabeling task:

Group I Small grains, includes wheat

Category code:	Category description:
W* --------	Winter small grains
S* --------	Spring small grains
G* --------	Total grains, winter and spring small grains
B* --------	Barley

Group II Field crops, nonsmall grains

Category code:	Category description:
H --------	All cultivated hays and grasses (alfalfa and clover, examples)
C --------	Corn
J --------	Sorghum
E --------	Sugarbeets
L --------	Sunflowers
Y --------	Soybeans
D --------	Any identified crop not listed in Group II

Group III Other signatures, identified

Category code:	Category description:
K --------	Idle cropland, clean tilled
M --------	Idle cropland, residue/stubble remaining or weeds/field cover growing
P --------	Natural grasses and pastures
T --------	Trees, timber, and shrubs
Z --------	Nonagriculture. Includes lakes, rivers, ponds, sand hills, mountains, dry lake beds, highways, cities, airfields, etc.
X* --------	Clouds, haze, shadows, and other obstructions

Group IV Other signatures, not identified

Category code:	Category description:
N* --------	No discernible identification Note: This code is used ONLY after all other category codes have been exhausted.

*Sent to classifier with coded category. All others changed to "N".

Figure 1-1.- Multilabeling categories.

to the TY multilabeling of nonsmall grains, omission errors were simply labeled as nonsmall grains.

The second reason was to aid in analyst labeling. Omission errors have usually been larger than commission errors (ref. 4, section 6, ref. 5, section entitled *Technology Labeling Accuracy*). It has been suspected that since small grains are the crop of interest, if an analyst were not sure of the proper label, he would tend to identify the pixel as nonsmall grain. However, if small grains were not the only crop of interest but rather there were several crops of interest for the analyst to identify, then the tendency for the analyst to label toward nongrains might be counterbalanced with an opposing tendency for the analyst to more consistently label the pixels of both small grains and nongrains. Thus, a less biased proportion estimate might result.

Characterization results could then be summarized to depict the relationships between the rate of error and the various combinations of factors. These results can provide data that will enable project management to attack the larger sources of error first and then direct remedial action toward reducing the label error through the most efficient use of manpower and financial resources.

1.2 OBJECTIVES

The objectives of the performance analysis using the blind site data were to

A. quantify the labeling errors

B. characterize the labeling errors

C. identify the causes of labeling errors and the factors involved in either overestimation or underestimation of the small-grain acreage

2. DATA

The performance analysis was made using sixty-eight segments located in six states. These particular segments were selected by the LACIE TY project management based on the availability of ground truth data, processing of the blind site data, and accuracy of the proportion estimation. The number of sites selected from each state was determined from the acreage estimation accuracy for the state, the available number of blind sites within the state, the importance of the state in small-grain and barley production, and the availability of resources for the evaluation. A listing of the states and the number of segments analyzed from each are as follows:

State	Number
Kansas	18
Minnesota	5
Montana	9
North Dakota	22
Oklahoma	5
South Dakota	9

The ground-truth data consisted of large-scale photographs and overlays, with the crop type indicated by field personnel of the U.S. Department of Agriculture (USDA).

The blind site ground-truth data were collected late in the growing season, thus permitting only the final season estimate to be used. Therefore, the results of this study are relative only to the final estimate passed to the Crop Assessment Subsystem (CAS). All data examined were in reference to the last classification estimate of the crop year.

Detailed data on the growth stage development and correlative spectral manifestations of these crops on the production film converter (PFC) imagery were not given to the analysts. Hence, the analysts were somewhat restricted by a lack of supporting information. They were, however, provided with data showing the limits of each crop's phenological stages and the county statistics of each crop. No procedures on spectral colors or variation of colors for the multilabeled crops (crop labeled as other than wheat, see figure 1-1) were provided.

Results of the multicrop labeling of the nonsmall-grain crops were tabulated on the multicrop labeling data sheet for each segment (shown as figure 2-1), and the results were combined for each state. (See section 6 for results.) Since the data on the spectral responses of the growth stages for the non-small-grain crops were not available to the analysts, there was no labeling error characterization (LEC) evaluation for the nonsmall-grain crops, even when the wrong multilabeled crop symbol was used. Only a tabulation matrix for all dots erroneously or correctly labeled was made.

Investigation and assessment of the TY labeling for small-grain acreage estimates revealed that, in practice, the analysts deviated from the established procedures when Products 1 and 3 (defined in section 3.5 of references 1 and 3) were obviously different spectrally. The analysts used Product 1 for interpretation and labeling, as well as for field boundary definition, when the two film products differed. This use is contrary to the requirements stated in the procedures (see section 3.3, references 1 and 3) in which the analysts are requested to use Product 3 for labeling when there is color distortion in Product 1. Assessment of the labeling accuracy did not show this deviation to be detrimental, however, and the evaluation of the labeling error pertinent to this report necessarily followed the analysts' practice.

The analyst labels, as shown on the multicrop labeling data sheet (see figure 2-1), are according to those listed in figure 1-1. Symbols for

MULTICROP LABELING DATA

Segment ____________________ Type 1, 2

GROUND TRUTH LABEL		ANALYST LABEL																	Total no. pixels labeled per ground truth	Total no. pixels correctly labeled	% correctly labeled
		W	S	B	H	C	J	E	L	Y	D	K	M	P	T	Z	X	N			
	W																				
	S																				
	B																				
	H,A																				
	C																				
	SR																				
	SB																				
	SU																				
	SY																				
	SF																				
	CN																				
	BN																				
	I/F																				
	I/CC ST RE																				
	P,G																				
	T																				
	X																				
	N																				
No. correctly labeled																					
No. pixels labeled																					
Labeled crop, % correct																					
Commission proportion																					
% Commission error																					

Figure 2-1.- Sample multicrop labeling data sheet.

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the ground-truth labels were taken from a list furnished by USDA field personnel. The following list includes both the analyst and ground-truth labels.

Analyst label	Ground-truth labels	
W — winter small grains	W	— winter small grains
S — spring small grains	S	— spring small grains
B — barley	B	— barley
H — hay	H, A	— hay, alfalfa
C — corn	C	— corn
J — sorghum	SR	— sorghum, millet
E — sugar beets	SB	— sugar beets
L — sunflowers	SU	— sunflowers
Y — soybeans	SY	— soybeans
D — other crops not listed above	SF	— safflowers
	CN	— cotton
	BN	— beans
	Blank	— additional crops, peas, etc.
K — fallow	I/F	— fallow
M — cover crop, stubble residue	I/CC, ST, RE	— cover crop, stubble, residue
P — pasture	P, G	— pasture, grass
T — trees	T	— trees
Z — nonagriculture, homestead, water, etc.	X	— nonagriculture, homestead, water, etc.
X — clouds, shadows		
N — no identification discernible	N	— nonsmall-grain group

The location on the PFC imagery of each labeled dot was compared to the corresponding location on the large-scale aerial photograph. The ground truth was recorded on an overlay of the large-scale photograph by USDA field personnel. The dot label was then compared to the ground truth recorded for the field in which the dot was located. At least two, and sometimes as many as five, evaluators verified the comparison of the analyst label and ground-truth. This helped to minimize the error of comparison between the analyst label and the ground truth.

It should be recognized that the ground-truth labels used for the evaluation were obtained by visually comparing the USDA field overlay with the PFC imagery and not from the digitized ground-truth data derived by Accuracy Assessment (AA). The visual comparison was made because the digitized labels were unavailable at the time of evaluation. The visually derived ground-truth tabulation of the total pixels per crop differs somewhat from the digitized ground-truth data used by AA primarily due to registration errors.

3. APPROACH

The rationale behind the TY LEC was to first identify and tabulate the following, relative to the small-grain interpretation:

a. The normal physical condition of the growth stages for small grains that could be expected or deduced from single or temporal image interpretation of the imagery

b. The normal range of the temporal spectral colors for each condition of the growth stages, for comparison of the abnormal colors in the imagery

c. The manifestations of the PFC imagery's spectral response to episodic events

d. The spectral capabilities of the acquisitions available and missing acquisitions that have influenced the interpretation and labeling

Then, by comparing normal to abnormal data for identified errors, each labeling error could be associated with various error factors systematically. Summarization could then be performed to portray the relationship between the rate of error and various combinations of factors.

4. DESCRIPTION OF THE LABELING ERROR CHARACTERIZATION FORMAT

The various forms for and techniques of recording labeling data for the TY 1978 season were the same as those used for labeling the Phase III data (ref. 6, section 4). The descriptions of these forms are repeated in this report, along with changes from and additions to the Phase III formats.

4.1 DOT COMPARISON FORM

The dot comparison form (fig. 4-1) was used to record the analyst's label in juxtaposition with the ground-truth label for each particular dot. The form and the manner for marking it were the same as that used in Phase III (see reference 6). The only changes were the substitution of the crop name symbols (see figure 1-1) for the nonsmall-grain (NSG). Since digital ground-truth data for all 209 dots were unavailable for use, the performance evaluation needed only to record the number of integrated (I) signature dots. Therefore, an I rather than the numerical indicator was marked on the dot. Without the availability of the digital ground-truth data, the need for the double-disagreement category was eliminated. Second, additional space was made on the form for recording either winter grain or barley separation.

4.2 SEGMENT TABULATION SHEET

The format and use of the segment tabulation sheet (fig. 4-2) are the same as for Phase III, with one addition: Spectral aids were added to the analysts' tools for the TY analysis. These aids were comprised of two items, the trajectory plots and scatter plots. A detailed description of these plots, as well as information concerning their use and capabilities, may be found in references 3 and 7. For this report, the spectral aids were evaluated for each error for which they were available. Use of these aids was determined by their potential in separating the confusion between the nonsmall-grain and small-grain signatures. Basically, the trajectory plot was used to separate the nonsmall-grain and small-grain signatures. When barley was indicated in the historical data, the scatter plots were used to separate barley from the other small-grain signatures.

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Segment number:

Classification acquisitions: 8194, 8176, 8256

Reference acquisition: 8222

Code:

Border/edge				Pixel Columns																			Ground-truth labels			Errors		
Small grain	Wheat	Other	Pixel line	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	Small grain	Wheat	Other	Small grain	Wheat	Other
1		2	10	S	K	B	P	K	P	S	P	P	P	P	P	S	P	S	S	K	K	K	5	1	10	1	1	
				–	–	W	P	K	P	S	P	P	P B	P	P	S	P	S	S	–	S B	K B						
		1	20		P		K B		S		P		P		P		S		S		S		2		6			2
					K		K		S		P		–		P		K		S		SF							
			30	P	P	P	K	K	P	P	S	P	P	P	P	K	P	S	S	K	B	K	5		14	2		
				P	P	P	K	K	P	P	S	P	P	P	P	K	S	S	S	K	S	K						
			40		P		P		S		K		P		P		K		S		K		2		6			
					P		P		S		P		P		–		K		S		K							
			50	P	P	P	P	P	P	P	K	S	S	P	P	P	K	S	K	S	S	S	5		13			1
				P	P	P	P	K	–	P	K	S	S	P	P	G	G	K	K	S	S	S						
			60		P		P		P		P		P		P		S		P		P		1		8			
					P		P		P		P		P		P		S		P		P							
			70	P	K	S	K	P	Z	P	P	P	K	P	P	P	P	P	K	K	K	S	6		12	4		
				–	K	S	S I	P	Z	P	P	P	K	P	P	P	G	S I	K	S	S	S						
			80		K		K		Z		K		P		P		P		S		P		1		8			
					–		P		Z		K		P		P		P		S		Z							
1		1	90	S	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	S	S	K	5		13	2		
				S	S I	P	P	P S B	P	K	P	S B	P	P	Z	P	P	K	K	S	S	K						
1			100		K		Z		B		S		P		P		K		P		K		3		6	3		1
					K		S B	D	S		P		SF		P		SF		P		S							
		2	110	K	P	P	P	K	P	K	P	P	P	P	P	N		N	P	K	P	K	1		18	1		
				K	P B	P	P	K	K	P	P	P	P	P	P	P		K B	P	K	K	S I						
3	0	6																				Totals	36	1	114	13	1	4
Total number of integrated (I) signatures 4																						Disagreement	+1		−1	+1		
Total number of signatures labeled "other" 4																						Adjusted total	37	1	113	14	1	4

Analyst interpretation
Ground truth

Spring grain errors normally recorded

Multicrop errors that are not part of the estimate

Figure 4-1.- Dot comparison form for performance evaluation.

Dot type	Dot number	Condition	Acquisitions available a	b	c	g	h	Confusion vegetation	Cause	Spectral aid follows crop Yes	No	Identification of crop
2	45	4	A	B	A	A	J	2.9	e		✓	Fallow
	81	4	A	B	A	A	J	2.9	λ_2		✓	Fallow
2	83	1	A	B	C	B	B	3.0	θ		✓	Spring wheat, durum
	119	1	A	B	H	H	H	3.0	ρ		✓	Spring wheat
	129	1	A	B	A	G	A	3.0	β	✓		Spring wheat, durum
	207	1	C	F	B	G	A	3.0	ρ		✓	Spring wheat, durum
1	32	4	A	A	C	F	H	2.9	ν		✓	Safflowers
	34	1	A	A	E	G	H	3.0	ϵ	✓		Spring wheat, durum
	38	1	A	B	H	G	G	3.0	ϵ	✓		Spring wheat, durum
	96	1	A	B	C	G	G	3.0	λ_2	✓		Spring wheat, durum
	112	1	A	B	E	G	H	3.0	ϵ	✓		Spring wheat, durum
	188	1	A	B	C	G	G	3.0	ρ	✓		Durum
Disagreement												
2	115								σ			

Blind-site number: Acquisition: 8230 base, 8176, 8140

Figure 4-2.- Segment tabulation sheet.

4.3 STATE TABULATION SHEET

The format and use of the state tabulation sheet (fig. 4-3) remained the same for the TY season with the exception of changes made in the meaning of some error causes which are discussed under the appropriate heading. For example, the digital matrix totals are changed to mean the labeled ground truth from crops labeled on overlays of aerial photographs by the USDA field personnel. Since there were a few errors in the field's crop identification, only a small difference in the totals of errors was recorded between the two error categories.

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Symbol	Segment																		Total	Percentage
α																				
β																				
γ_1																				
γ_2																				
ϵ																				
λ_1																				
λ_2																				
μ																				
π																				
ϕ																				

[a]Small fields procedure; no data.

(a) Part A

Figure 4-3.– State tabulation sheet form.

Symbol	Segment																		Total	Percentage
	1522	1523	1513	1512	1520	1521														
x																				
ω_1																				
ω_2																				
θ																				
v																				
τ																				
σ																				
β																				

(b) Part A — Concluded.

Figure 4-3.— Continued.

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Error group	Segment																		Total	Percentage
Basic data totals																				
Spring grain labels																				
Other labels																				
Total labels																				
Labeled ground truth																				
Omission errors																				
Commission errors																				
Total errors																				
Labeling error characterization evaluation totals																				
Omission errors																				
Commission errors																				
Total errors																				

(c) Part B.

Figure 4-3.– Concluded.

5. CAUSE CATEGORIES AND THEIR USE

Basically, the cause categories and related items used in the TY were similar to those of Phase III. For the TY labels, however, some changes were made so that these categories and items would be more applicable to the TY requirements.

5.1 AVAILABLE ACQUISITIONS

All of the acquisitions that were available in the segment packet to the analyst at the time of the labeling for the classification estimate were to be considered, even those acquisitions that were not used for processing. Although some acquisitions were not used for the estimate, the spectral condition of these acquisitions still influences the labeling decision. Even those with clouds and some snow cover contributed value toward the interpretation and labeling. Those acquisitions that were placed in the segment packet after the analyst's estimate were not used for the LEC evaluation, however, because they were not available to the analyst for the classification.

After determining the acquisitions available for the estimate from the segment packet data, the LEC evaluator placed the acquisitions on a light table and assigned a growth stage symbol to each acquisition, represented by a lowercase letter, as indicated in the color/growth-stage correlation on table 5-1.

The latest acquisition available for classification was the sole acquisition upon which judgment was made for the determination of the adjusted crop calendar (ACC). The majority of the signatures for small-grain fields of the last available acquisition determined the designation of the ACC. As indicated before, some small-grain field signatures may be either ahead of or behind the ACC on the particular acquisition. A comparison was made between the numerical value of the ACC, as scribed on the PFC image by the analyst, and the spectral signature of the majority of the small-grain fields. The overall spectral signature was allowed a range of colors that would be reasonable for the scribed ACC value. The latest acquisition's signature was then assessed to be either in agreement with, behind, or ahead of the ACC. This decision

TABLE 5-1.- COLOR/GROWTH-STAGE CORRELATION

Color symbol (a)	Color description	LEC growth-stage symbol (a)	Robertson scale	Feekes scale	Growth-stage description
A	Dark gray, light green, tan	a	1.0 to 2.5	1	Planting through emergence
B	Light pink, light red	b	1.0 to 2.5	2	Early emergence
C	Pink, light red	c	2.0 to 3.0	3-5	Postemergence, tillering
D	Pink, light brown/gray/green	d	2.3	—	Dormancy
E	Red, bright red, or pink	e	3.0 to 3.9	6-10	Tillering, jointing
F	Deep/dark red	f	4.0 to 4.9	10.1 - 10.5	Heading
G	Mottled red, yellow, olive or greyish green, tan	g	5.0 to 6.9	11.1 - 11.3	Turning, ripening
H	Green, white grayish green	h	7.0	11.4	Harvested
J	Purple, magenta, dark gold, yellow, tan	—	—	—	—

[a]Symbols used to identify relationship of pixels or acquisitions to the ACC: <, behind; >, ahead; =, equal to the mean of the ACC.

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was then applied to all the error pixels according to the manner described in the condition category on the segment tabulation sheet (figure 4-2).

The colors or shades on table 5-1 were used as a guide or general description to convey the shade of the acquisition's colors, but by no means do they comprise the complete list of shades and colors for each stage. Generally, for any particular crop, the interpreter expects to see some variations in shade within each growth stage.

The assignment of growth stages to the acquisitions was determined by the small-grain signature of the majority of the small-grain fields deemed to be at a certain growth stage. This assignment was made for each acquisition available.

Verification of the growth stages for the majority of the spring grain fields of interest was made by USDA field personnel using the Feekes' method of growth stage discrimination: Fifteen fields at each site were observed at 18-day intervals.

Each growth stage was recorded only once on the segment tabulation sheet even though there may have been more than one acquisition for a particular stage. Under multiple acquisition conditions for a growth stage, all the applicable acquisitions to a single growth stage were averaged by the evaluator.

5.2 ERROR ASSESSMENT OF INDIVIDUAL PIXELS

Each pixel was listed on the segment tabulation sheet in numerical order, with Type 1 and 2 dots grouped separately. The individual error pixel is evaluated to be either equal to, ahead of, or behind the majority of the small-grain fields in the last available acquisition. This condition in conjunction with the type of crop, either small grains or nonsmall grains, determines the condition of the pixel.

If the error pixel was labeled small grains on the ground-truth overlay, the condition is either in agreement with the ACC (= 1), behind the ACC (= 2), or ahead of the ACC (= 3).

If the error pixel was labeled as nonsmall grains on the ground-truth overlay, the condition is either in agreement with the ACC (= 4), behind the ACC (= 5), or ahead of the ACC (= 6).

5.2.1 AVAILABLE GROWTH STAGES

Lowercase letters were recorded beneath the column heading entitled "Acquisitions available" (table 4-1) to indicate the growth stages represented by acquisitions. The letters correspond to the growth stages listed in table 5-1. The behind (<) or ahead (>) symbol over a letter indicates that the spectral response for that growth stage, manifested by the spectral response of the majority of the small-grain fields, was either behind or ahead of the ACC. If no symbol is written over the letter, the growth stage was in agreement with the ACC.

The uppercase letters in each column are the color representatives taken from the color list in table 5-1 and applied to the growth stage. If the uppercase and lowercase letter fail to correspond, the signature is then assumed to be ahead or behind the ACC for that particular growth stage.

5.3 CATEGORIES OF ERROR CAUSES

5.3.1 CONFUSION VEGETATION

The confusion vegetation category indicates the crop or vegetation with which the spectral signature of the pixel (field) was confused. Table 5-2 defines the code used to specify particular confusion crops. Those confusion crops of the "other" category were identified on the segment tabulation sheet.

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TABLE 5-2.— CONFUSION VEGETATION

Winter Wheat

1.0	Winter wheat labeled as other, not listed below
1.1	Winter wheat labeled as barley
1.2	Winter wheat labeled as corn
1.3	Winter wheat labeled as sorghum
1.4	Winter wheat labeled as sugar beets
1.5	Winter wheat labeled as sunflowers
1.6	Winter wheat labeled as hay
1.7	Winter wheat labeled as soybeans
1.8	Winter wheat labeled as spring wheat
1.9	Winter wheat labeled as oats
1.10	Winter wheat labeled as flax

Nonwheat

2.0	Nonwheat labeled as wheat, not listed below
2.1	Unlisted nonwheat labeled as barley
2.2	Unlisted nonwheat labeled as corn
2.3	Unlisted nonwheat labeled as sorghum
2.4	Unlisted nonwheat labeled as sugar beets
2.5	Unlisted nonwheat labeled as sunflowers
2.6	Unlisted nonwheat labeled as hay
2.7	Unlisted nonwheat labeled as soybeans
2.8	Unlisted nonwheat labeled as winter wheat
2.9	Unlisted nonwheat labeled as spring wheat
2.10	Unlisted nonwheat labeled as oats
2.11	Unlisted nonwheat labeled as flax

Spring wheat

3.0	Spring wheat labeled as other, not listed below
3.1	Spring wheat labeled as barley
3.2	Spring wheat labeled as corn
3.3	Spring wheat labeled as sorghum
3.4	Spring wheat labeled as sugar beets
3.5	Spring wheat labeled as sunflowers
3.6	Spring wheat labeled as hay
3.7	Spring wheat labeled as soybeans
3.8	Spring wheat labeled as winter wheat
3.9	Spring wheat labeled as oats
3.10	Spring wheat labeled as flax

Barley

4.0	Barley labeled as other, not listed below
4.1	Barley labeled as winter wheat
4.2	Barley labeled as corn
4.3	Barley labeled as sorghum
4.4	Barley labeled as sugar beets
4.5	Barley labeled as sunflowers
4.6	Barley labeled as hay
4.7	Barley labeled as soybeans
4.8	Barley labeled as spring wheat
4.9	Barley labeled as oats
4.10	Barley labeled as flax

Corn

5.0	Corn labeled as other, not listed below
5.1	Corn labeled as barley
5.2	Corn labeled as winter wheat
5.3	Corn labeled as sorghum
5.4	Corn labeled as sugar beets
5.5	Corn labeled as sunflowers
5.6	Corn labeled as hay
5.7	Corn labeled as soybeans
5.8	Corn labeled as spring wheat
5.9	Corn labeled as oats
5.10	Corn labeled as flax

Sorghum

6.0	Sorghum labeled as other, not listed below
6.1	Sorghum labeled as barley
6.2	Sorghum labeled as corn
6.3	Sorghum labeled as winter wheat
6.4	Sorghum labeled as sugar beets
6.5	Sorghum labeled as sunflowers
6.6	Sorghum labeled as hay
6.7	Sorghum labeled as soybeans
6.8	Sorghum labeled as spring wheat
6.9	Sorghum labeled as oats
6.10	Sorghum labeled as flax

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TABLE 5-2.— Continued

Sugar beets

7.0 Sugar beets labeled as other, not listed below
7.1 Sugar beets labeled as barley
7.2 Sugar beets labeled as corn
7.3 Sugar beets labeled as sorghum
7.4 Sugar beets labeled as winter wheat
7.5 Sugar beets labeled as sunflowers
7.6 Sugar beets labeled as hay
7.7 Sugar beets labeled as soybeans
7.8 Sugar beets labeled as spring wheat
7.9 Sugar beets labeled as oats
7.10 Sugar beets labeled as flax

Sunflowers

8.0 Sunflowers labeled as other, not listed below
8.1 Sunflowers labeled as barley
8.2 Sunflowers labeled as corn
8.3 Sunflowers labeled as corn
8.4 Sunflowers labeled as sugar beets
8.5 Sunflowers labeled as winter wheat
8.6 Sunflowers labeled as hay
8.7 Sunflowers labeled as soybeans
8.8 Sunflowers labeled as spring wheat
8.9 Sunflowers labeled as oats
8.10 Sunflowers labeled as flax

Hay

9.0 Hay labeled as other, not listed below
9.1 Hay labeled as barley
9.2 Hay labeled as corn
9.3 Hay labeled as sorghum
9.4 Hay labeled as sugar beets
9.5 Hay labeled as sunflowers
9.6 Hay labeled as winter wheat
9.7 Hay labeled as soybeans
9.8 Hay labeled as spring wheat
9.9 Hay labeled as oats
9.10 Hay labeled as flax

Soybeans

10.0 Soybeans labeled as other, not listed below
10.1 Soybeans labeled as barley
10.2 Soybeans labeled as corn
10.3 Soybeans labeled as sorghum
10.4 Soybeans labeled as sugar beets
10.5 Soybeans labeled as sunflowers
10.6 Soybeans labeled as hay
10.7 Soybeans labeled as winter wheat
10.8 Soybeans labeled as spring wheat
10.9 Soybeans labeled as oats
10.10 Soybeans labeled as flax

Oats

11.0 Oats labeled as other, not listed below
11.1 Oats labeled as barley
11.2 Oats labeled as corn
11.3 Oats labeled as sorghum
11.4 Oats labeled as sugar beets
11.5 Oats labeled as sunflowers
11.6 Oats labeled as hay
11.7 Oats labeled as soybeans
11.8 Oats labeled as spring wheat
11.9 Oats labeled as winter wheat
11.10 Oats labeled as flax

Flax

12.0 Flax labeled as other, not listed below
12.1 Flax labeled as barley
12.2 Flax labeled as corn
12.3 Flax labeled as sorghum
12.4 Flax labeled as sugar beets
12.5 Flax labeled as sunflowers
12.6 Flax labeled as hay
12.7 Flax labeled as soybeans
12.8 Flax labeled as spring wheat
12.9 Flax labeled as oats
12.10 Flax labeled as winter wheat

5.4 EXPLANATION OF ERROR CAUSES

The various causes of error are listed below with the corresponding explanation and symbol.

α = Insufficient acquisitions. A lack of informative acquisitions (those useful to the estimation) contributed to the cause of the labeling error. (Acquisitions that are hazy or cloudy, etc., or reflect the same biostage may be only partially useful.)

β = Poor stand of small grains, usually caused by abnormal weather conditions or cropping practices. (Reserved for use with 18-day field observations for specific fields.)

γ = Abnormal development of small grains.

γ_1 = Behind ACC (late planting and development).

γ_2 = Ahead of ACC (early planting and development).

ε = Narrow strip fields. Contain single narrow fields, in which the field's signature may or may not be overridden by surrounding signatures.

λ = Clerical error.

λ_1 = Wrong acquisition used for labeling, which is the base acquisition. Analyst simply wrote the wrong acquisition number.

λ_2 = The error pixel clearly followed a temporal sequence for its category. However, since other pixels with the same temporal sequence were consistently identified correctly, this error pixel was most likely misidentified.

μ = Double-cropping practice of a second crop or weeds may have become the dominant signature and caused the increase in the infrared response after harvest.

π = Border and edge pixels. Indicates spectral and spatial confusion between two or more fields of different types.

ϕ = Unknown cause. Error does not apply to any of the known causes.

χ = Dates used in separating confusion crops do not show spectral differences and should not have been used as the key dates for separation.

ω = Field destroyed by grazing, plowing, disking, etc.

ω_1 = Analyst *should* be able to detect destruction of field.

ω_2 = Analyst *should* not be able to detect destruction of field.

θ = Signature of a small-grain crop that does not follow the expected temporal color sequence of small grains throughout the acquisitions.

ν = Signature of a nonsmall-grain crop that does follow the expected temporal color sequence of small grains throughout the acquisitions.

τ = Volunteer wheat signature that does follow the temporal color sequence. Labeling from volunteer wheat was considered an error only after the availability of an acquisition in which a signature indicating plowed soil occurred.

σ = Disagreement with ground-truth map (field) label.

5.5 APPLICATION OF ERROR CAUSES

The determination of the error causes is somewhat subjective. Even though the analyst was consulted as to why an error was made, it was difficult for him to recall the reason for labeling the pixel as he did. Therefore, to maintain as much objectivity and consistency as possible, a review was made of each error analysis based on observed fact.

Understandably, an error can be related to more than one cause. However, it was decided to record only the single, most outstanding cause for each error and to develop the correlation between two or more causes in the synthesis. It is believed that the error analysis is reasonably accurate, although the exact degree of accuracy cannot be estimated.

A discussion of how each error cause was used follows.

α = Insufficient acquisitions. These are usually obtained when clouds obscure the scene during the overpass of Landsat. This physical constraint is an

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overriding factor in the evaluation of errors. This cause, plus β (poor stand), γ (abnormal signature development), and θ (signature does not follow the spectral color sequence), can be applied at times to the same error. If the acquisition available cannot adequately supply the data necessary to separate the confusing signatures, then this cause is not used. However, if the separation cannot be made, this cause must prevail as the best reason for the error.

β = Poor stand of small grains. This cause was determined during the labeling error evaluation, but re-evaluation suggests that "poor stand" should be reserved for an evaluation in which the specific field of the error pixel has a record of the 18-day observations to support it. The β poor stand causes that have been verified showed the field to either be retarded in growth or be behind the ACC.

γ = Abnormal development of small grain (wheat). Both types of causes (γ_1 and γ_2, behind and ahead of the ACC) are related to the growth stage of the specific field that the error pixel represents to the ACC value of the last acquisition. Regardless of the growth stage of most of the small-grain fields, this cause was assessed to a particular field. The evaluation of all data from the six U.S Great Plains states suggests that the γ_1, behind-the-ACC cause, should include the number of errors from the β poor stand.

ε = Narrow strip fields. This cause is similar to the border/edge pixel problem but is partly due to the scanner resolution's inability to differentiate the isolated, small-size field.

λ = Clerical errors. Clerical errors are of two types:

λ_1 = Wrong acquisition used for labeling. This cause stems from the analyst's use of an acquisition for labeling the pixels which differs from that indicated on the CAMS evaluation form as the base acquisition. In other words, the acquisition indicated was misregistered from the one used for labeling.

λ_2 = Inadvertent error. This cause is used only when a signature has been labeled correctly several to many times and then mislabeled once or twice, all on one acquisition.

ξ = Double-cropping practice. There is no difficulty in understanding this cause or its use.

ρ = Border and edge pixels. The border pixel occurs as a result of confusing the identification of two different field types. The spectral signature of each type is similar, with each showing similar integration of the spectral reflectance. The pixel is on the border of both fields. An edge pixel error should not occur for Type 1 dots because of the requirements of Procedure 1, but it does occur occasionally. Unlike the border pixel, the edge pixel is clearly in one field or another on several acquisitions The analyst did not recognize that, due to a one-pixel shift in registration between two acquisitions, the error pixel changed crop type.

ϕ = Unknown case. Sometimes the evaluator cannot determine reasonable evidence for the error.

χ = The wrong acquisition date was used for the separation of barley from spring grains.

ω = Destruction by plowing, grazing, etc. This cause requires the use of data acquired from a specific field observed at 18-day intervals. It is not often, however, that such a field is the error field and that the analyst can be sure this type of event has occurred.

θ = Small-grain signature that does not follow the temporal color sequence.

υ = Nonsmall-grain signature that does follow the temporal color sequence. Both θ and υ may override the importance of other causes that may also be true, much like the α causes do, and generally for the same reasons. For instance, an error also may be caused by the fact that the crop is a poor stand (β); but if the signature does not follow the expected temporal color sequence, which is the basis of the image interpretation for small-grain classification, then the analyst cannot correctly label the pixel.

τ = Volunteer wheat error cause that can be used only when ground-truth data for a specific field are available to the evaluator.

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δ = Disagreement factors were not causes of analyst labeling error but were reasons for the LEC evaluator to disagree with the field-labeled ground truth. Nevertheless, pixels over which disagreements exist are considered to be labeled correctly, thereby reducing the error rate.

6. RESULTS

The labeling accuracy results for the TY will be treated in the following manner. The results will first be presented in a combined fashion using the data from all six states. Next, the labeling results from the two winter small-grain states of Kansas and Oklahoma will be presented; and, finally, the labeling assessment of the remaining four spring- and mixed-grain states of Minnesota, Montana, and North and South Dakota. Each set of results will be described in terms of labeling accuracy and the relationship of error causes.

6.1 COMPARISON OF ALL SEGMENT DATA

A comparison of the accuracy of all Phase III and TY segments is made in table 6-1, showing the percentage of correctly labeled pixels for both the TY and the previous growing season of Phase III. Because Kansas and South Dakota were not evaluated in Phase III, the labeling accuracy between the two seasons for these states cannot be compared.

Labeling accuracy of the small grains was higher in the winter grain states (i.e., Kansas and Oklahoma) than in the remaining states which are mixed- or spring-grain states. The TY labeling accuracy for crops in Oklahoma improved over the Phase III period, and the TY labeling accuracy for Kansas crops was the highest for all six states.

The labeling accuracy of the TY nonsmall grains proved higher in the winter-grain states than in the other states, showing an improvement from 91 to 98 percent in Oklahoma and a near perfect 99 percent in Kansas.

A comparison of small-grain accuracy from all states between the Phase III and TY seasons shows little difference for both small grains and nonsmall grains (Phase III, 78.6 percent, TY, 76 percent).

TABLE 6-1.- ACCURACY IN THE TYPE 2 DOT LABELING OF SMALL AND NONSMALL GRAINS FOR PHASE III AND TY BLIND SITES

Statistics	South Dakota		Montana		Minnesota		North Dakota		Oklahoma		Kansas	
	Phase III	TY	Phase III	TY	Phase III	TY	Phase III	TY	Phase III	TY	Phase III	TY
Percentage of pixels correctly labeled:												
Small grain		81.9	87.2	82.0	77.9	68.6	74.9	65.9	72.8	84.4		92.8
Nonsmall grain		95.2	96.6	97.5	95.6	98.0	94.7	94.0	90.7	98.1		99.1
Number of pixels correctly labeled:												
Small grain		138	297	168	145	156	455	1202	318	90		307
Nonsmall grain		774	498	692	206	444	563	2161	462	210		760
Total		912	795	860	351	600	1018	3363	780	300		1067
Total segments observed		9	10	9	6	5	18	22	11	5		18
Segments common to Phase III and TY			2				2		2			

Phase III labeled average: Small grain — 78.6 percent
Nonsmall grain — 94.9 percent

TY labeling average: Small grain — 76 percent
Nonsmall grain — 96 percent

6.2 WINTER SMALL-GRAIN ERROR CHARACTERIZATION

Areal distributions of the blind sites for both Kansas and Oklahoma are shown in figures 6-1 and 6-2. These figures indicate the spatial relationship of the segments to each other and within the individual states. In addition, the figures show the spatial distribution of the Type 2 errors with respect to each other. Based on the changes indicated on the crop moisture index maps, no significant moisture abnormality occurred throughout the growing season. No geographical grouping of error rates on either the Kansas or Oklahoma maps appears to show a concentration of errors in a specific area.

The crop moisture index maps are a part of the weekly meteorological summary provided to the analysts through a joint effort by the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and USDA. The maps show the significant weekly changes in the available moisture to the crops within the United States. Areas of abnormality in moisture, either too much or too little, are not interpreted from a single map but from many over a period of several weeks. As a season progresses, analysts should be able to visually see the moisture abnormality and make reasonable judgments about the crop signatures that are relative to the growth-stage development for any particular area of the United States.

The scale of the crop moisture index maps is quite small, and the weather data points are not optimally located. Thus, use and interpretation of the maps are not precisely accurate. However, they are still quite useful because they present the sequence of the moisture pattern. These maps are not included in this report since they are made for each season and are, therefore, too numerous to reproduce here.

6.2.1 WINTER SMALL-GRAIN OMISSION CAUSES

Table 6-2 shows that the largest categories of TY error causes in winter small grains continue the Phase III trends of the "boundary errors" and the "odd signature" groups (ref. 6, section 6.4), which are as follows.

TABLE 6-2.- OMMISSION ERROR RATE FOR TY WINTER SMALL-GRAIN BLIND SITES IN OKLAHOMA AND KANSAS

[No. = number of pixels; % = percentages of pixels]

Pixel label	Oklahoma				Kansas			
	Type 1		Type 2		Type 1		Type 2	
	No.	%	No.	%	No.	%	No.	%
Inadequate acquisitions								
Odd signatures								
Poor stand	2	20.0						
Behind adjusted crop calendar	1	10.0	2	14.3	1	6.3	3	13.6
Ahead of adjusted crop calendar	3	30.0	3	21.4	1	6.3	3	13.6
Abnormal small grain signature			2	14.3	1	6.3	3	13.6
Abnormal non-small grain signature								
TOTAL	6	60.0	7	50.0	3	18.9	9	40.8
Double cropping practice or weeds					1	6.3		
Volunteer wheat								
Detectable field destruction								
Nondetectable field destruction								
TOTAL					1	6.3		
Clerical errors:								
Wrong acquisition used for labeling							1	4.5
Inadvertent error	2	20.0	1	7.1	4	25.0	6	27.3
TOTAL	2	20.0	1	7.1	4	25.0	7	31.8
Wrong acquisition for confusion separation								
Unlike other causes								
Boundary errors.								
Border/edge	2	20.0	6	42.9	8	50.0	6	27.3
Narrow field								
TOTAL	2	20.0	6	42.9	8	50.0	6	27.3
GRAND TOTAL	10	100.0	14	100.0	16	100.0	22	100.0
Total boundary pixels labeled	8	12.1	12	13.3	19	9.1	37	12.1

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OKLAHOMA

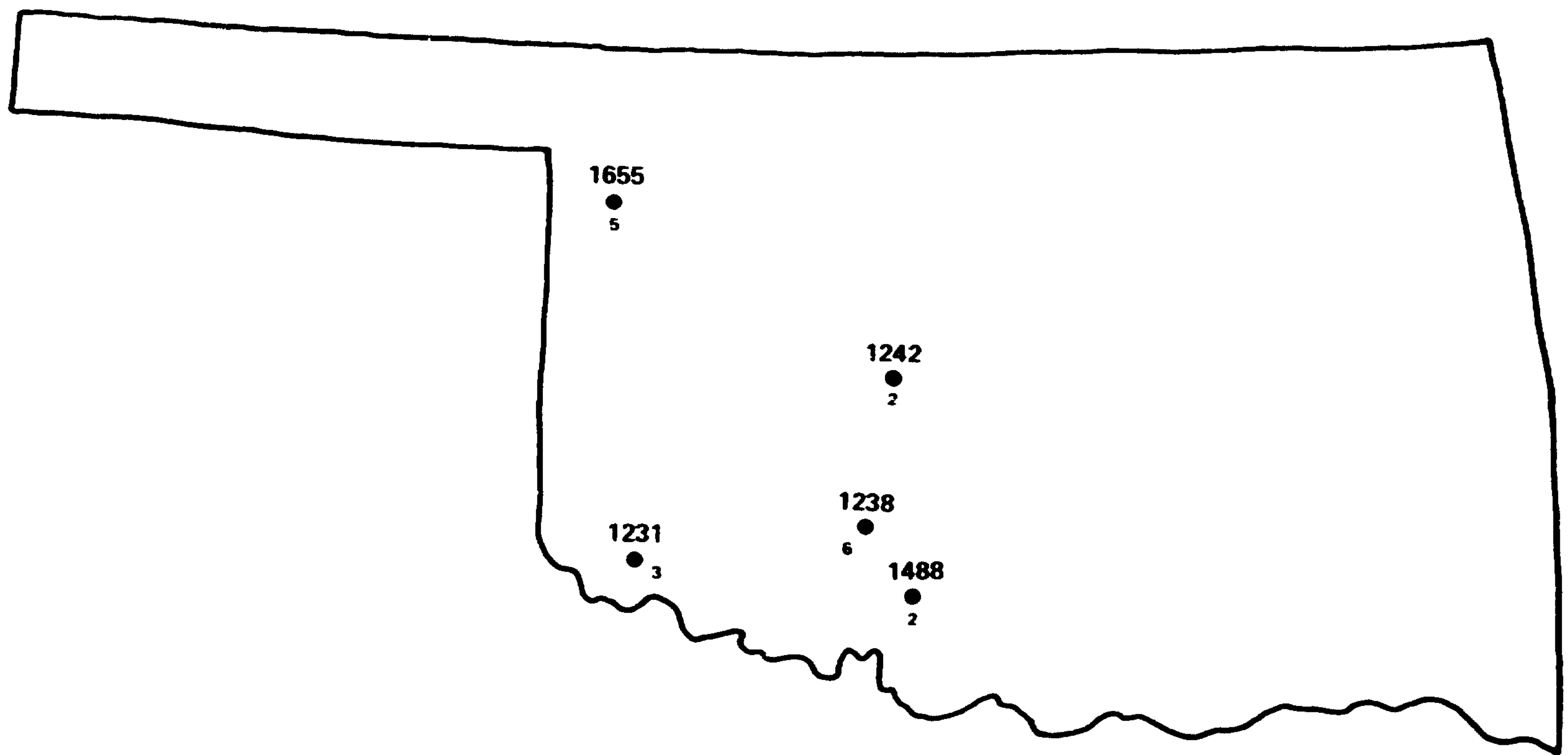

Figure 6-1.- TY blind-site map for Oklahoma. No abnormal moisture conditions occurred during the growing season. The small number below the larger segment number represents the total number of Type 2 errors per segment.

KANSAS

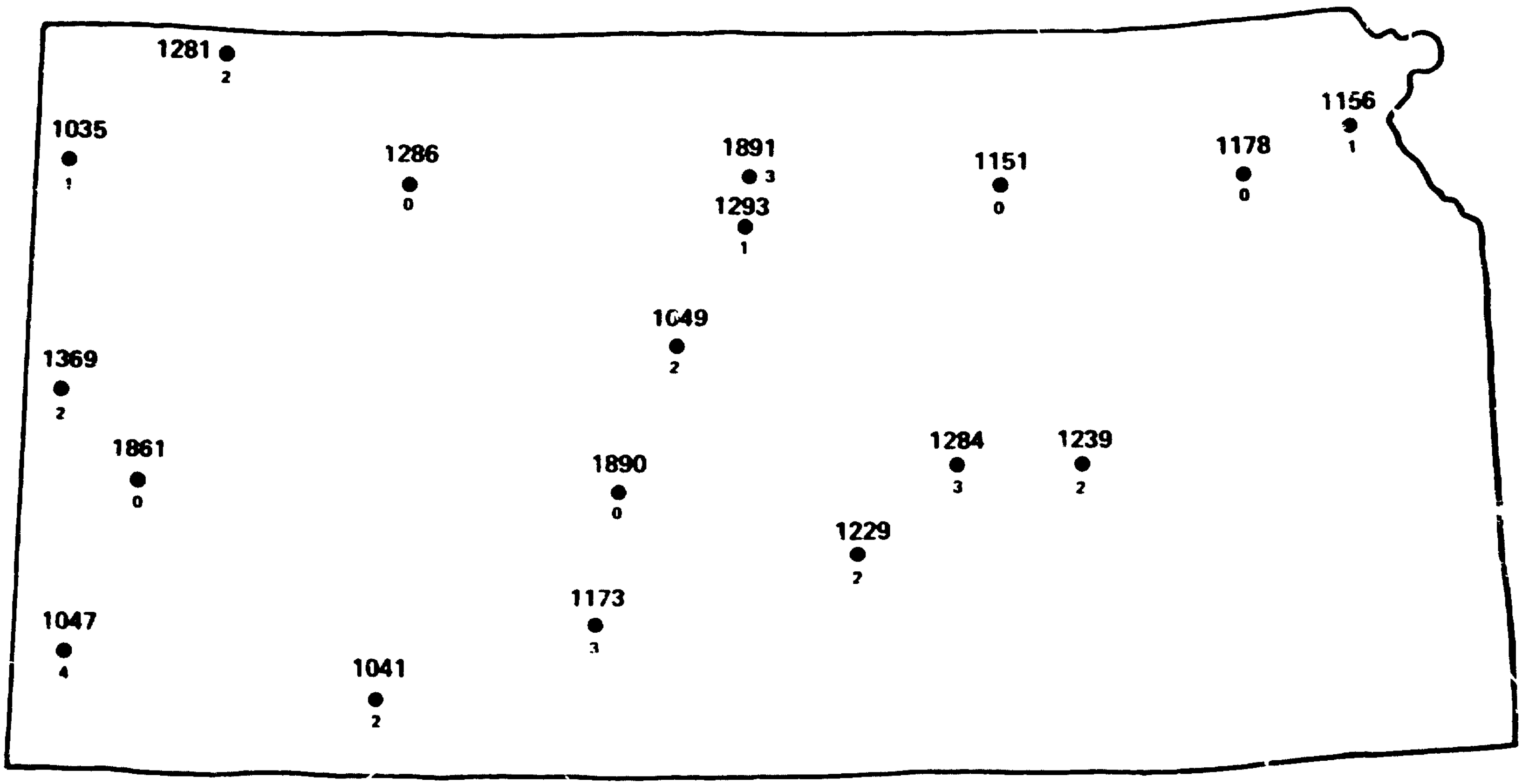

Figure 6-2.- TY blind-site map for Kansas. No abnormal moisture conditions occurred during the growing season. The small numbers located below the larger segment numbers indicate the total number of Type 2 errors per segment.

- Poor stand
- Signature out of phase with the ACC
- Color signatures that fail to follow the normal growth-stage sequence

While the percentage of labeled Type 1 pixels for Oklahoma is larger for the TY (12.1 percent) than for Phase III (6.1 percent), the increase in actual numbers is only one pixel (TY, 8 pixels; Phase III, 7 pixels).

6.2.2 WINTER SMALL GRAIN COMMISSION CAUSES

For Oklahoma, the commission error rate improved over that of Phase III (see table 6-3). There were so few commission errors in the Oklahoma TY blind sites that the usual pattern of higher errors in the "odd signatures" did not occur. The distribution of the error cause in Kansas appears to be similar to that of other states, both in Phase III and the TY, with the odd signatures and border/edge being the highest cause.

6.3 SPRING SMALL-GRAIN ERROR CHARACTERIZATION

6.3.1 AREAL DISTRIBUTION AND INTERRELATIONSHIP OF BLIND SITES

The areal relationship of blind sites, as well as their geographical distribution within the states, is shown on maps of the four states, South Dakota, Montana, Minnesota, and North Dakota (see figures 6-3, 6-4, 6-5, and 6-6, respectively). From a comparison of the NOAA crop moisture index maps for the TY, the effect of the season's available moisture is indicated for each state and then explained accordingly on each map.

There does appear to be a correlation between the amount of moisture available in an area and the labeling errors or causes of labeling errors for some of the states. For example, crops in the southeastern portion of South Dakota had excessive moisture at planting, maturity, and just before harvest of the spring grains. The planting was delayed 1 to 3 weeks, and the maturity and harvest stages were delayed by more rain, causing the small-grain signatures to fall behind the estimated dates on the ACC. Winter grain planting was delayed as well in the previous fall.

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TABLE 6-3.- COMMISSION ERROR RATE FOR TY WINTER-GRAIN
BLIND SITES IN OKLAHOMA AND KANSAS.

[No. = number of pixels; % = percentage of pixels]

Pixel label	Oklahoma				Kansas			
	Type 1		Type 2		Type 1		Type 2	
	No.	%	No.	%	No.	%	No.	%
Inadequate acquisitions								
Odd signatures:								
Poor stand								
Behind adjusted crop calendar							2	20.6
Ahead of adjusted crop calendar							1	14.3
Abnormal small grain signature								
Abnormal non-small grain signature					2	18.2	1	4.3
TOTAL					2	18.2	4	57.2
Double cropping practice or weeds								
Volunteer wheat								
Detectable field destruction								
Nondetectable field destruction	2	100.0	1	25.0				
TOTAL	2	100.0	1	25.0				
Clerical errors:								
Wrong acquisition used for labeling								
Inadvertent error					3	27.3		
TOTAL					3	27.3		
Wrong acquisition for confusion separation								
Unlike other causes					1	9.1		
Boundary errors:								
Border/edge			3	75.0	5	45.5	3	42.9
Narrow field								
TOTAL			3	75.0	5	45.5	3	42.9
GRAND TOTAL	2	100.0	4	100.0	11	100.0	7	100.0
Total boundary pixels labeled	16	10.1	18	8.5	22	3.8	26	3.4

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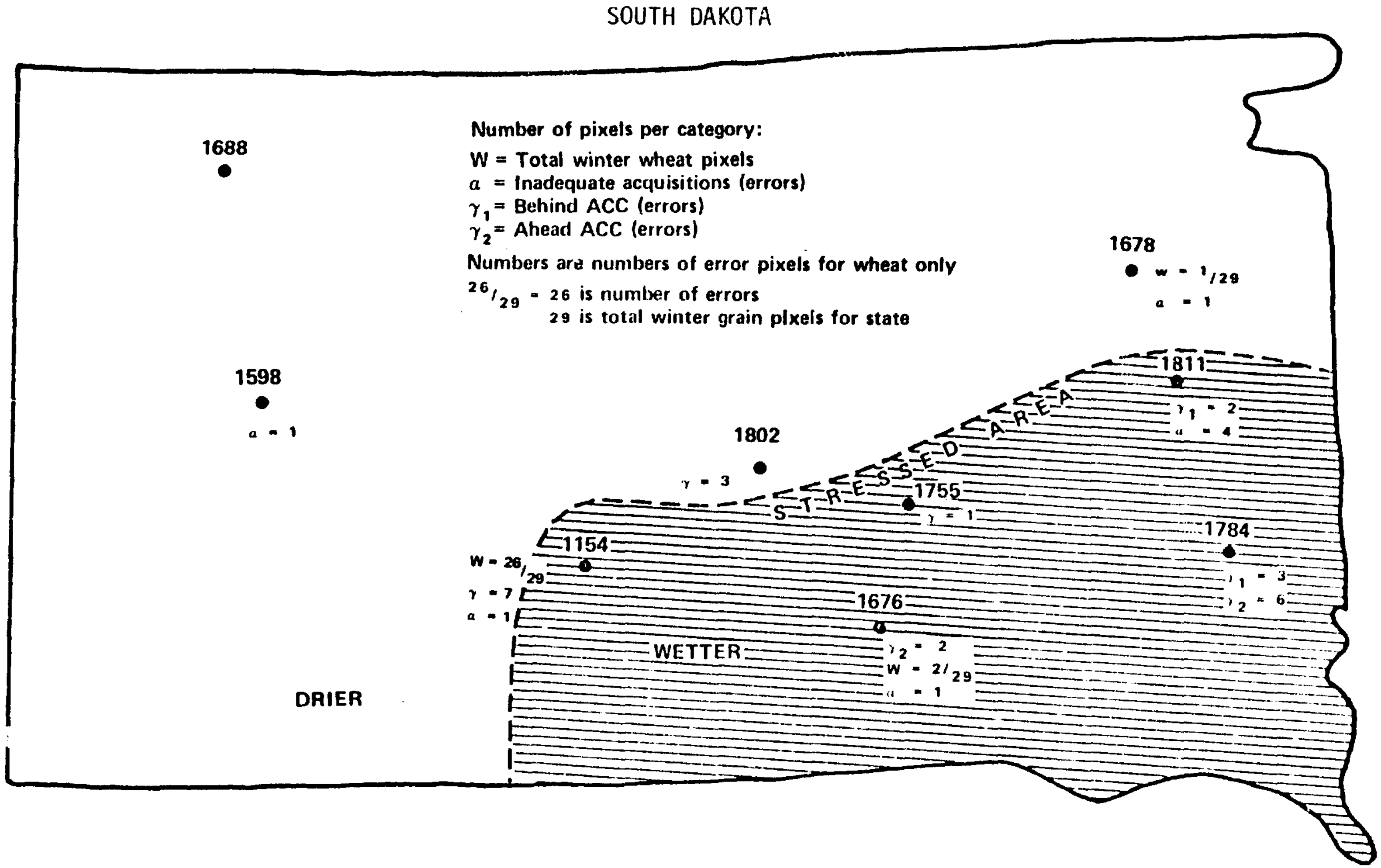

Figure 6-3.- TY blind-site map for South Dakota. Dotted line indicates the boundary of excessive moisture during spring planting, maturity, and just before harvest. Winter wheat was planted late because of lack of moisture. The variability of spring wheat planting was 1 to 3 weeks.

MONTANA

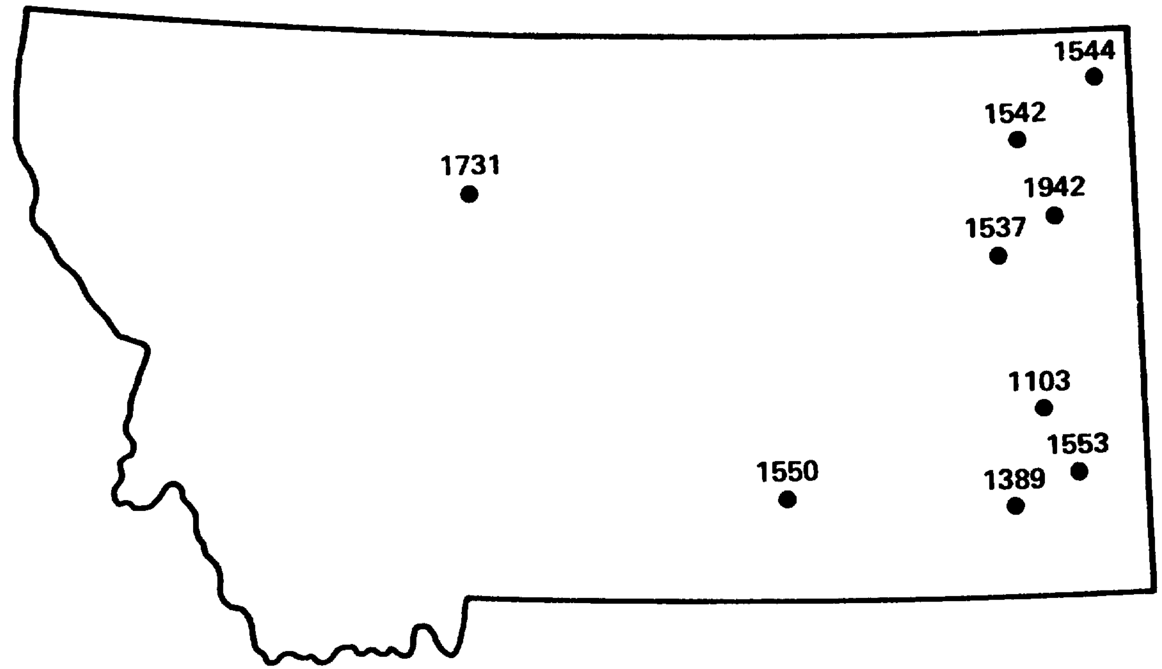

Figure 6-4.- TY blind-site map for Montana. The only significant meteorological influence was rain, which delayed planting by 2 to 3 weeks in the southeastern portion of the state. Segment numbers are indicated.

MINNESOTA

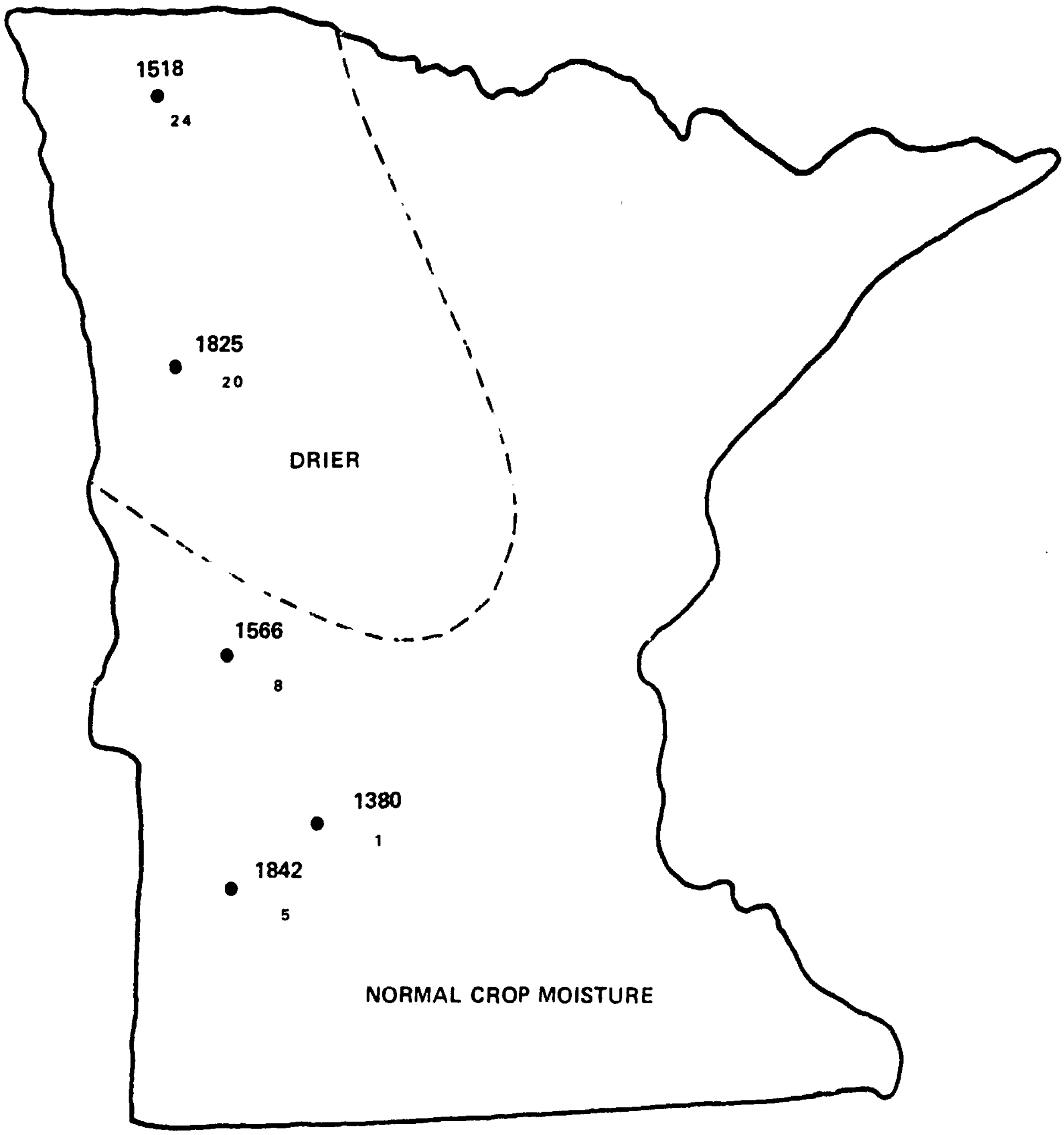

Figure 6-5.- TY blind-site map for Minnesota. Dry soil in the latter growth stages caused early harvest and odd signatures. The small numbers located below the larger segment numbers indicate the total number of Type 2 errors per segment.

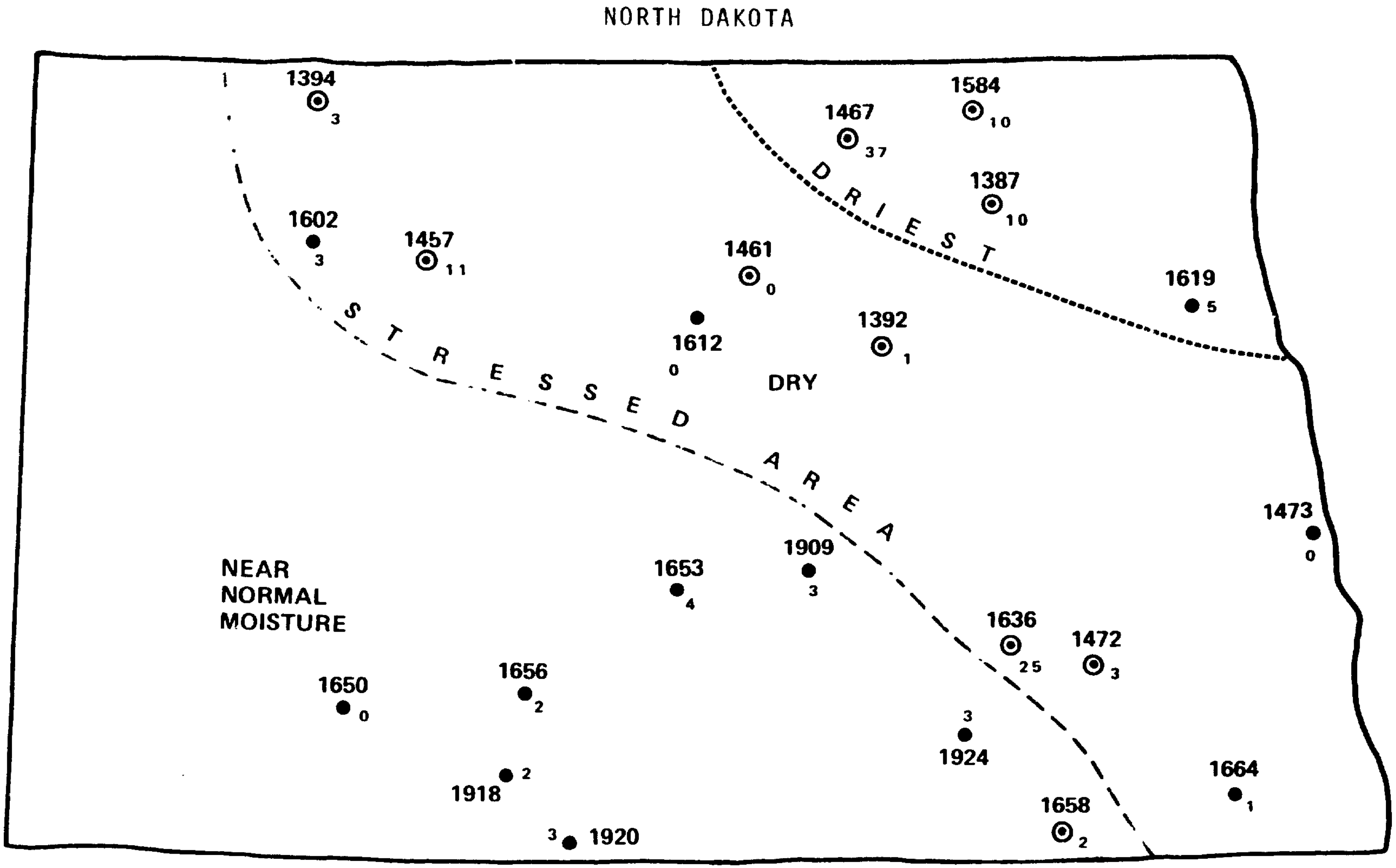

Figure 6-6.- TY blind-site map of North Dakota. Crops in the stressed area were planted 2 weeks late. The area was excessively dry the rest of the season. Segments with 25 or more commission and omission errors are indicated by the symbol ◉ . The small numbers located below the larger segment numbers represent the number of Type 2 omission errors caused by signatures behind the mean of the ACC.

The Montana crop moisture index data did not indicate any significant difference from the normal moisture availability (see figure 6-4).

Minnesota was excessively dry in the northwestern portion of the state (see figure 6-5) which correlated with that of North Dakota (figure 6-6). Fifty-three percent of the Minnesota omission Type 2 dot errors were caused by the odd signatures that were either ahead of the ACC or did not follow the temporal color sequence of spring small grain.

North Dakota errors are fairly well correlated geographically with the abnormal moisture pattern (see figure 5-6).

Comparisons of drought occurrences that took place in various portions of the U.S. Great Plains during Phases II, III, and the TY (1976, 1977, 1978) demonstrate that abnormal moisture conditions take place somewhere in that area almost every year and, therefore, should be expected. Usually these conditions involve either too much or too little moisture or combinations of these factors at critical times of the growing season. Unfortunately, the influence of these conditions in the U.S. Great Plains has not been interpreted well by analysts. However, it is also fair to say that specific procedures on spectral developments with respect to growth stage relationship with the available soil moisture were not adequately provided to the analysts. To be sure, the abnormal moisture conditions were identified and pointed out to the analysts by NOAA personnel as part of the joint effort of the LACIE/TY program; however, the technique for translating the affects to image interpretation was not provided.

Since abnormal weather conditions apparently have a severe effect on a considerable number of square miles in the Great Plains each year and the spectral condition of the small-grain signature is thereby markedly changed, a major effort should be made to provide the analysts with a procedure for correcting the abnormal spectral signatures in the imagery.

To partially solve the problem, the analysts' interpretation of the PFC spectral colors of the small-grain growth stages should be based on a more objective and consistent selection of color ranges for each growth stage. The analysts then might be able to recognize the more unusual colors of the various growth stages when the crop is under the stress of abnormal weather conditions and the spectral colors are changed from the normal, expected temporal sequence.

This could be accomplished through a range of colors representing all growth stages recognizable on sequential Landsat imagery. These colors would be standardized by the 3-dimensional color model. Within each growth stage, the colors representing both normal and stressed conditions would be identified. The basis of this method is explained more thoroughly in reference 8, section 2.

Under operational conditions, as the abnormal moisture condition develops, the analyst must be alerted by some type of meteorological data. The type of abnormality and the expected direction of each growth stage's color range should be indicated. As the season progresses, the data regarding development of the growth stage (either slower or faster) should be transmitted to the analysts along with the expected spectral shades.

In addition, this use of a specific spectral range of colors for each growth stage might aid the analysts in reducing the small-grain omission error by reducing the mislabeling of the small grain as confusion crops. This would be made possible by pinpointing the temporal color sequence of the small-grain temporal color sequence in a more specific pattern. Since a major portion of the omission error rate of small grains is made because of confusion with nonsmall grain signatures, this procedure could significantly reduce the total omission error rate if the expected results proved true.

6.3.2 SPRING SMALL-GRAIN OMISSION ERRORS

"Odd signatures" and "boundary errors", both of which are Type 2 error causes, comprise the largest percentage of errors in the labeling of spring small-grain crops in Minnesota, Montana, and North Dakota (see table 6-4). In Phase

TABLE 6-4.- OMISSION ERROR RATE FOR SPRING SMALL GRAINS

[No. = number of pixels; % = percentage of pixels]

Pixel label	South Dakota				Montana				Minnesota				North Dakota			
	Type 1		Type 2		Type 1		Type 2		Type 1		Type 2		Type 1		Type 2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Inadequate acquisitions	8	36.4	11	21.6	4	16.7	5	10.4			1	2.0	25	18.7	57	19.9
Odd signatures:																
Poor stand			1	2.0			1	2.0			1	2.0			3	0.7
Behind adjusted crop calendar	1	4.6	13	25.5	6	25.0	7	14.0	3	13			45	33.6	128	31.2
Ahead of adjusted crop calendar			8	15.7					2	8.7	11	22.5	7	1.5	15	3.7
Abnormal small grain signature	3	13.6	7	13.7	4	16.7	10	20.0	11	47.8	14	28.6	12	9.0	49	12.0
Abnormal non-small grain signature																
TOTAL	4	18.2	29	56.9	10	41.7	18	36.0	16	69.5	27	55.1	59	44.1	195	49.6
Double cropping practice or weeds			1	2.0											2	0.5
Volunteer wheat	1	4.6	1	2.0												
Detectable field destruction																
Nondetectable field destruction																
TOTAL	1	4.6	2	4.0											2	0.5
Clerical errors:																
Wrong acquisition used for labeling	2	9.1	1	2.0			9	18.0	1	4.3			3	2.2	20	4.9
Inadvertent error	4	18.2	2	3.9	2	8.3	7	14.0	3	13.0	13	28.5	23	17.2	56	13.7
TOTAL	4	27.3	3	5.9	2	8.3	16	32.0	4	17.3	13	28.5	26	19.4	76	18.6
Wrong acquisition for confusion separation													5	3.7	13	3.2
Unlike other causes	1	4.6											1	0.9	4	1.0
Boundary errors:																
Border/edge	1	4.6	6	11.8	5	20.8	10	20.0	3	13.0	6	12.2	16	11.9	47	11.5
Narrow field	1	4.6			3	12.5	1	2.0			3	6.1	2	1.5	16	3.9
TOTAL	2	9.2	6	11.8	8	33.3	11	22.0	3	13.0	9	18.3	18	13.4	63	15.4
GRAND TOTAL	22	100	51	100	24	100	50	100	23	100	49	100	134	100	410	100
Total boundary pixels labeled	12	24.5	18	3.0	10	12.4	22	13.1	14	25.9	13	11.6	49	12.9	[illegible]	15.0

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III these same two groups of errors for the same states also comprised the largest percentage of errors. The comparison of the error causes for the two seasons is shown in table 6-5.

6.3.3 SPRING SMALL-GRAIN COMMISSION ERROR

The commission errors listed in table 6-6 show little difference in most Type 2 error categories between the TY and Phase III. Some variation was evident in the "clerical error" category, which increased in the TY, as shown in table 6-7.

6.3.4 SPRING WHEAT AND BARLEY SEPARATION

As part of the labeling objectives for the TY season, the analysts were asked to separate other spring small grains (spring wheat, oats, and flax) from barley. A detailed analysis of this effort is documented in reference 7, sections 3, 4, and 6. The comparison of the TY season labeling accuracy relative to the separability is shown in table 6-8.

All three sets of figures shown in table 6-8 exclude any nonsmall-grain omission or commission errors. If these errors were included, the percentages of correctly labeled spring wheat and barley would be further reduced. However, to reduce some of the confusion, these sets of figures are presented without the nonsmall grain data to show the potential of the analysts' procedures for separating other spring small-grain from barley without the additional crops.

The upper set of percentages in the table 6-8 shows the analysts were able to separate other spring small grain from barley 92 percent of the time. This percentage of correct labeling includes only the total spring small-grain data.

The second and third sets of figures show that, although the analysts could identify the other spring small grains rather well, they still encountered more difficulty in separating the barley from the other spring small grains when barley was present. Two factors accounted for the difficulty: the relative amounts of barley in the segment and the soil moisture.

TABLE 6-5.- COMPARISON OF TY AND PHASE III LARGEST ERROR CAUSES

Season	State	"Odd signature" (no. of pixels)	"Boundary errors" (no. of pixels)	total no. error pixels	Error percentage
TY	Minnesota	27	9	49	
	Montana	18	11	50	
	North Dakota	195	63	410	
	Total	240	83	509	63.5
Phase III	Minnesota	8	13	32	
	Montana	11	8	38	
	North Dakota	45	33	114	
	Total	64	54	184	59.8

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TABLE 6-6.- COMMISSION ERROR RATE FOR SPRING SMALL GRAINS

[No. = number of pixels; % = percentage of pixels]

Pixel label	South Dakota				Montana				Minnesota				North Dakota			
	Type 1		Type 2		Type 1		Type 2		Type 1		Type 2		Type 1		Type 2	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Inadequate acquisitions	4	19.1	9	24.3			2	11.8					3	7.7	7	5.4
Odd signatures:																
Poor stand																
Behind adjusted crop calendar															2	1.5
Ahead of adjusted crop calendar															1	0.8
Abnormal small-grain signature																
Abnormal non-small grain signature	6	28.6	15	40.5	4	67.0	7	41.2			2	22.2	13	33.3	34	26.2
TOTAL	6	28.6	15	40.5	4	67.0	7	41.2			2	22.2	13	33.3	37	28.5
Double cropping practice or weeds																
Volunteer wheat																
Detectable field destruction															1	0.8
Nondetectable field destruction													5	12.8	10	7.7
TOTAL													5	12.8	11	8.5
Clerical errors:																
Wrong acquisition used for labeling	1	4.8			1	16.7	2	11.8					2	5.1	5	3.9
Inadvertent error	5	23.8	6	16.2			3	17.7	1	50.0	5	55.6	5	12.8	28	21.5
TOTAL	6	28.6	6	16.2	1	16.7	5	29.5	1	50.0	5	55.6	7	17.9	33	25.4
Wrong acquisition for confusion separation															1	0.8
Unlike other causes													6	15.4	17	13.1
Boundary errors:																
Border/edge	5	23.8	7	18.9			1	5.9			2	22.2	5	12.8	20	15.4
Narrow field					1	16.7	2	11.8	1	50.0					4	3.1
TOTAL	5	23.8	7	18.9	1	16.7	3	17.7	1	50.0	2	22.2	5	12.8	24	18.5
GRAND TOTAL	21	100.0	27	100.0	6	100.0	17	100.0	2	100.0	9	100.0	39	100.0	130	100.0
Total boundary pixels labeled	28	6.1	37	4.8	18	4.4	28	4.0	15	10.2	27	6.1	80	11.4	239	11.1

TABLE 6-7.- COMPARISON OF TY AND PHASE III COMMISSION ERRORS

State	Clerical errors, No. of pixels		Total errors, No. of pixels		Errors, percentage	
	TY	Phase III	TY	Phase III	TY	Phase III
Montana	5	4	17	17		
Minnesota	5	2	9	9	27.6	19.6
North Dakota	33	5	130	30		
Totals	43	11	156	56		

TABLE 6-8.- PERCENTAGES OF CORRECTLY LABELED SPRING WHEAT AND BARLEY SEPARATION FOR TY SPRING-GRAIN BLIND SITES

[S = spring small grains, B = barley]

Label	South Dakota	Montana	Minnesota	North Dakota	Total
$\frac{\text{S labeled S + B labeled B}}{\text{S labeled S and B + B labeled B and S}}$	$\frac{71}{85} = 83.5$	$\frac{59}{63} = 93.7$	$\frac{107}{119} = 89.9$	$\frac{792}{853} = 92.8$	$\frac{1029}{1120} = 91.9$
$\frac{\text{B labeled B}}{\text{S labeled S + S labeled B}}$	$\frac{61}{67} = 91$	$\frac{56}{58} = 96.6$	$\frac{102}{109} = 93.6$	$\frac{695}{715} = 97.2$	$\frac{914}{949} = 96.3$
$\frac{\text{B labeled B}}{\text{B labeled B + B labeled S}}$	$\frac{10}{18} = 56$	$\frac{3}{5} = 60$	$\frac{5}{10} = 50$	$\frac{97}{138} = 70.3$	$\frac{115}{171} = 67.3$

The amount of other spring small grains in the four states is much greater (949 labeled pixels) than the amount of barley (171 labeled pixels). The North Dakota segments had 138 pixels of barley labeled.

These high amounts of other spring small grains had a significant influence on the results of barley separation results as shown in table 6-8; i.e., the data infer that the analyst's labeling performance improves with higher amounts of a crop in a segment. As stated in section 6.3.1, the abnormally dry weather conditions were identified as causing the abundance of "odd signatures" errors. The temporal small-grain signatures of other spring small grains and barley are alike and are separable only by time differential. Under normal conditions barley ripens earlier than the other spring small grains. However, in the TY season, the late spring combined with the dry conditions hastened the senescence of all small grains and caused the confusion between the two types of grain, thereby reducing the separation accuracy of barley and other spring small grains.

6.3.5 USEFULNESS OF SPECTRAL AIDS

During the TY season, the analysts were furnished two additional tools to aid them, trajectory plots and scatter plots. As explained in section 4.2, the trajectory plots were used for the nonsmall grain separation and the scatter plots for the spring wheat and barley separation.

In seeking to determine whether the spectral aids would have been beneficial in eliminating the spectral confusion, the performance evaluators were limited to assessment of the mislabeled dots. No evaluation of the usefulness of the spectral aids was made for the correctly labeled pixels. The results of the assessment of the mislabeled pixels is shown in table 6-9. The top three rows show omission small grains divided into three categories of other spring small grains (spring wheat, oats, and flax), barley, and winter small grains. The fourth row shows the sums of the omission errors, the fifth row follows with the total commission errors, and the last row shows the total number of error pixels labeled. Data in the vertical columns (left to right) specify the total number of error pixels per category and percentage, indicate whether or

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TABLE 6-9.- USEFULLNESS COMPARISON OF SPECTRAL AIDS FOR SPRING GRAIN TY BLIND SITES (S. Dak., Mont., Minn., N. Dak.)

Type		Total error pixels	%	Useful	No. of pixels	Percentage
Omission	Spring wheat (Spr. Wht., Oats, Flax)	187	69.5	Yes	109	58.3
				No	78	41.7
	Barley	43	16.0	Yes	28	65.1
				No	15	34.9
	Winter grain (Rye)	39	14.5	Yes	10	25.6
				No	29	74.4
	Subtotal	269	100		147 122	
Total omission (Sw, Bly, Wg)		269	74.5	Yes	147	54.7
				No	122	45.4
Total commission (non-small grain)		92	25.5	Yes	45	48.9
				No	47	51.1
Total pixels labeled in error		361	100	Yes	192	53.2
				No	169	46.8

not the aid was useful in separating the particular confusion, show the number of error pixels, and give the associated percentage.

A review of the percentages would suggest that 58 and 65 percent of the error pixels of other spring grains and barley, respectively, would benefit from use of the spectral aids in separating them from the confusion signatures. However, the indication that the spectral aids would be effective in only 25.6 percent of the winter small-grain error pixels is not encouraging when considering the future use of such aids. A summary of all the spectral aid percentages would tend to support the continued use of the aids for spring small grains and barley identification.

6.4 UNDERESTIMATION

Misidentification of small-grain signatures, which are omission errors, was the major source of underestimation of the classification estimates during the TY. The misidentification of nonsmall-grain signatures, which are commission errors, causes overestimation and comprises a relatively small percentage of the labeling error. Table 6-10 shows the omission and commission errors for all segments of Type 2 dots in the six states.

In the six states evaluated, the omission error was 29.0 percent, which was higher than the 21.4 percent obtained in Phase III. The commission error was 4.1 percent, which was lower than that of Phase III, 5.1 percent. There were 5.3 percent more total Type 2 pixels labeled in the TY than Phase III.

The required identification of the nongrain crops did not improve the omission error rate as expected. The spectral response and related growth stages for each nongrain crop were not provided to the analysts in the same detail or as adequately as for small grains. This lack of information contributed to the analyst's confusion between small grains and nongrains by not providing the analyst with data to compare the data and prove that the suspect pixel was not a nongrain signature.

TABLE 6-10.- NUMBER OF OMISSION AND COMMISSION ERRORS FOR ALL SEGMENTS OF TYPE 2 DOTS IN SIX STATES

State	Omission		Commission	
	No. error pixels	No. pixels labeled	No. error pixels	No. pixels labeled
Kansas	22	306	7	761
Minnesota	49	156	9	444
Montana	50	167	17	693
North Dakota	410	1202	131	2161
Oklahoma	14	90	4	210
South Dakota	51	138	37	774
Total	596	2059	205	5043

$\frac{596}{2059}$ = 29.0 percent omission error

$\frac{205}{5043}$ = 4.1 percent commission error

6.5 MULTICROP LABELING

Figures 6-7, 6-8, 6-9, and 6-10 are labeling tabulation matrices of all the labeling done during the TY season. The matrices are not meant to show the characterization of the labeling error. The tables do show, however, the results of all segments except those segments with confusion between the spectral signatures of spring small grain and barley (code 35). Code 35 segments did not have the critical acquisition needed for barley separation. Spring-grain segments classified as code 35 were not included because the other spring small-grain and barley acreage estimates were lumped together by the analysts. This was because incorrect estimates of the model were made using the separation apparent in surrounding segments. The tables show only the distribution of all pixels both correctly and incorrectly labeled. The four matrices included are both Type 1 and 2 dots labeled for winter and other spring small grains, barley, and all nonsmall grains (figures 6-7 and 6-9). Figures 6-7 and 6-9 have all multilabeled crops lumped into the nonsmall-grain category and considered correctly labeled even though nonsmall grains were sometimes mislabeled as other nonsmall grains. Figures 6-8 (Type 2 labels) and 6-10 (Type 1 labels) show only those segments with multilabeled crop separation.

The matrices allow quick determination of how often a crop is mislabeled as another crop, as well as the number of correctly labeled pixels per crop. Since the matrices show the raw data, the reader can study numerous relationships between the various crops in the manner he wishes. Therefore, after giving a brief explanation of some of the table columns and examples, this report emphasizes only the major confusion crops of small grains.

In each of the figures 6-7 through 6-10, the right-hand column indicates the percentage of correctly labeled pixels. Data given in the third row from the bottom answers the following question: Given that a crop label is used, what percentage of the labeling has been correctly applied? The bottom row shows the percent of commission error, indicating what percentage of the crop is labeled as some other crop The intersection of the matrix per crop is the number of correctly labeled pixels and outlined by heavier lines.

MULTICROP LABELING DATA

Segment All 45 segments (except segments coded 35) Type 1, 2

Analyst label codes: Barley, Nongrain, Spring grain, Winter grain — Minnesota, Montana, North Dakota, South Dakota

GROUND TRUTH LABEL	W	S	B	H	C	J	E	L	Y	D	K	M	P	T	Z	X	N	Total no. pixels labeled per ground truth	Total no. pixels correctly labeled	% correctly labeled
W	43	21	4	3							6	2	2				9	90	43	47.[illegible]
S	4	915	35	34	66		6	15	17	4	59	14	94	10	14		31	1318	915	69.4
B	1	56	115	7	6			3		1	9		16		2		4	220	115	[illegible]
H,A	5	14	3															22		
C		11	1															12		
SR	1	2																3		
SB		1																1		
SU		14																14		
SY		1																1		
SF	1	1																2		
CN																				
BN																				
	1	6																7		
I/F		40	22															62		
I/CC ST RE	1	9	1															11		
P,G	15	34																49		
T		2																2		
X		5	2															7		
N																	4813	4813	4813	
No. correctly labeled	43	915	115														4813		[illegible]	[illegible]
No pixels labeled	72	1132	183	44	72		6	18	17	5	74	16	112	10	16		[illegible]	[illegible]		
Labeled crop, % correct	59.7	80.8	62.8														9[illegible]			
Commission proportion	29/5544	217/4316	68/5414														46/1356			
% Commission error	0.5	5.0	1.3														[illegible]			

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Figure 6-7.- Labeling tabulation matrix of Type 2 dot labeling for all segments during the TY season.

MULTICROP LABELING DATA

Segment 35 segments (except segments coded 35) Type 1, 2

Barley, Nongrain, Spring grain, Winter grain — ANALYST LABEL — Minnesota, Montana, North Dakota, South Dakota

GROUND TRUTH LABEL	W	S	B	H	C	J	E	L	Y	D	K	M	P	T	Z	X	N	Total no. pixels labeled per ground truth	Total no. pixels correctly labeled	% correctly labeled
W	24	14	4	3							6	2	2				6	61	24	[illegible]
S	2	886	35	34	66		6	15	17	4	59	14	94	10	14		18	1274	886	69.5
B	1	54	112	7	6			3		1	9		16		2		4	215	112	52.1
H,A	2	14	3	142	8	1	1	7	6		17	4	127	10	31	1	11	387	142	36.7
C		11	1	23	122	1	2	16	65		7		13	3	2		8	274	122	44.5
SR	1	2		10	3	1		3			5		5		1			31	1	3.2
SB		1					2	13										16	2	12.5
SU		14		17	22		6	100	15		3	4	11	5	3	1	4	205	100	48.8
SY		1		2	9			6	92		1			1	1			113	92	81.4
SF		1						1			3		1					6		0
CN																			0	
BN				2				8	4	2					1		6	23	2	8.7
	1	6					2	10	3	3	2						1	28	3	10.7
I/F		35	22	15	3		1	9	13		356	12	53	3	9	3	11	545	356	65.3
I/CC ST RE		9	1	9	8				1		84	2	20	2	14		5	155	2	1.3
P,G	12	34		80	16	1	1	12	15	0	24	12	878	41	167	2	9	1304	878	67.3
T		2		2	3								4	106	1			118	106	89.8
X		5	2	21	8			5	4		8		34	6	147	5	4	249	147	59.0
N																				
No. correctly labeled	24	886	112	142	122	1	2	100	92	5	356	2	878	106	147				2975	59.5
No. pixels labeled	43	1089	180	367	274	4	21	206	235	10	584	50	1258	187	395	12	87	5004		
Labeled crop, % correct	56	31	62	39	45	25	10	43	39	50	61	4	70	57	37	0	0			
Commission proportion	19/4943	203/3730	68/4789	225/4617	152/4752	3/4973	19/4983	108/4722	149/4891	5/4947	228/4458	48/4849	380/3700	81/4886	548/4755	12/5004	87/5004	[illegible]	[illegible]	
% Commission error	0.4	3.4	1.4	4.9	3.2	0.06	0.4	2.3	2.9	0.1	5.1	1.0	10.3	1.7	5.2	0.2	1.7	2.5		

Figure 6-8.- Labeling tabulation matrix of Type 2 dot labeling for 35 segments during the TY season.

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MULTICROP LABELING DATA

Segment All 45 segments (except segments coded 35) Type 1, 2

Analyst label: Barley, Nongrain, Spring grain, Winter grain; Minnesota, Montana, North Dakota, South Dakota

GROUND TRUTH LABEL	W	S	B	H	C	J	E	L	Y	D	K	M	P	T	Z	X	N	Total no. pixels labeled per ground truth	Total no. pixels correctly labeled	% correctly labeled
W	17	6	1	1							1						13	39	17	43.6
S	5	291	7	20	23			2	7	2	29	3	19	2	6		12	428	291	70.0
B	1	28	30					1	1	1	3		6		1			72	30	41.7
H,A	4	3	1															8		
C		7																7		
SR			1															1		
SB																				
SU		7																7		
SY																				
SF		3																3		
CN																				
BN																				
		3																3		
I/F	2	8	10															20		
I/CC ST RE	1	3																4		
P,G	6	7	2															5		
T																				
X		3																3		
N																	1626	1626		
No. correctly labeled	17	291	30														1626		1964	87.9
No. pixels labeled	36	369	52	21	23			3	8	3	33	3	25	2	7		1651	2236		
Labeled crop, % correct	48.6	78.9	57.7																	
Commission proportion	19/2196	78/1807	22/2211														25/609			
% Commission error	0.9	4.3	1.0														[illegible]			

Figure 6-9.- Labeling tabulation matrix of Type 1 dot labeling for all segments during the TY season.

MULTICROP LABELING DATA

Segment 35 segments (except segments coded 35) Type 1, 2

Analyst label key: Barley, Nongrain, Spring grain, Winter grain; Minnesota, Montana, North Dakota, South Dakota

GROUND TRUTH LABEL	W	S	B	H	C	J	E	L	V	D	K	M	P	T	Z	X	N	Total no. pixels labeled per ground truth	Total no. pixels correctly labeled	% correctly labeled
W	1	3		1							1						5	11	1	9.1
S	1	268	7	20	23			2	7	2	29	3	19	2	6		4	391	[illegible]	[illegible]
B	1	25	30					1	1	1	3		6		1			[illegible]	[illegible]	[illegible]
H,A	3	3	1	30	8		1	1	3		4	1	63	6	12		2	[illegible]	30	[illegible]
C		7		7	47			4	24		4	1	10		2		3	[illegible]	[illegible]	[illegible]
SR			1	1	2			3			4		2		1			14		0
SB																				
SU		7		3	5		1	34	1		4	1	1	4			1	62	34	54.8
SY					6		3	3	31		1						1	45	31	68.9
SF		1																1		
CN																				
BN							3	1	1						1		2	8	1	12.5
		3					2	1										[illegible]		
I/F	1	9	10	5	2			4	3	1	103	7	22	2	3		2	[illegible]	104	[illegible]
I/CC ST RE		3		1					2		15	2	3		2			30	2	[illegible]
P,G	5	7	2	21	7			3	3		12	3	357	12	49		2	[illegible]	357	[illegible]
T													1	32	1			34	[illegible]	[illegible]
X		3		4	2	1		1	2		1		7	1	[illegible]	1		[illegible]	[illegible]	[illegible]
N																				
No. correctly labeled	1	288	30	30	47			34	31	1	103	[illegible]	357	[illegible]	[illegible]				994	[illegible]
No. pixels labeled	12	339	51	93	102	1	7	60	78	5	181	18	498	59	[illegible]	1	24	[illegible]		
Labeled crop, % correct	8	79	59	32	46	0	0	57	40	20	57	11	73	54	[illegible]	[illegible]	[illegible]			
Commission proportion	11/1646	71/1587	19/1588	63/1519	55/1548	1/1648	[illegible]/1657	26/1595	47/1612	4/1641	78/1489	16/1622	435/1174	27/1623	[illegible]	1/1657	[illegible]/1657	[illegible]	[illegible]	
% Commission error	0.7	4.4	1.2	4.2	3.6	0.06	0.4	1.6	2.9	0.2	5.2	1.0	37.1	1.7	5.0	0.06	1.4	[illegible]		

Figure 6-10.- Labeling tabulation matrix of Type 1 dot labeling for 35 segments during the TY season.

Figure 6-7, Type 2, shows the percentages of correctly labeled winter grains, spring grains, and barley as 48, 69, and 52 percent, respectively. In addition, figure 6-7 shows that when winter grain, spring grain, and barley labels were used, the percentage rate of their correct application was 60, 81, and 63 percent, respectively. The commission rate for winter grains, spring grains, and barley is 0.5, 5.0, and 1.3 percent, respectively, as indicated in the bottom row. The overall percentage of correctly labeled ground-truth pixels for Type 2 was 87 percent.

The commission rates listed above for winter grain, other spring small grain, and barley were computed as follows:

Example: winter grain

a. [Total pixels labeled (72)] - [Number of correctly labeled pixels (43)] = numerator (29)

b. [Total number of pixels (5634)] - [Total number of winter pixels labeled per ground truth (90)] = denominator (5544)

c. Percentage of commission error is the ratio of $a \div b \times 100 = 0.5$

A summary of some of the major confusion crops and their relationship to small grains is reflected in the following list which is an excerpt from figure 6-8, Type 2, multicrop labeling data.

Spring grain labeled fallow (59 pixels) = 4.6 percent of spring grains

Spring grain labeled corn (66 pixels) = 5.2 percent of spring grains

Spring grain labeled pasture (94 pixels) = 7.4 percent of spring grains

Barley labeled spring grains (54 pixels) = 25.1 percent of barley

Hay labeled pasture (127 pixels) = 32.8 percent of hay

Corn labeled soybeans (65 pixels) = 23.7 percent of corn

Winter grain labeled spring grains (14 pixels) = 23 percent of winter grains

Winter grain labeled fallow (6 pixels) = 9.8 percent of winter grains

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Two multicrops were well labeled, soybeans (81 percent correct) and trees (89 percent correct). The labeling accuracies of the remaining multilabeled crops ranged from fair to poor.

The untitled ground-truth line below BN (beans) is a group of crops that contain few pixels per crop, and the crop type varies from segment to segment. Crop names of the group are buckwheat, peas, rape seed, potatoes, and canary seed.

Future multicrop labeling of the ground-truth labels should combine all the idle crop land of stubble, residue, and fallow into fallow, because for the small grain and multicrop labeling procedure, they are considered alike. If an idle cover crop is so labeled, then the cover crop should be identified by the field personnel. Further, because alfalfa and hay are treated alike, they should be combined into a single entity with one symbol.

USDA field personnel should be cautioned to label swales or glacial depressions according to the crops they contain, usually grass. Because of the multitude of these depressions, they should be deemed important and should not be labeled merely as nonagriculture (label X). It should be noted, however, that those swales that were labeled X by field personnel were included in the P, G (pasture, grass) category for this report.

6.6 ADDITIONAL DATA

For Phase III, a table was prepared showing a comparison between the growth stages available by acquisitions and the error rate for the small-grain estimates for each segment (ref. 3, p. 3). Insufficient acquisitions (growth stages) correlated with the higher error rate. Because of the TY multicrop labeling requirements, the acquisition windows were opened earlier and closed later than in Phase III. This was done to ensure sufficient coverage for the multicrop labeling. The Phase III correlation condition between the insufficient acquisition coverage (critical growth stages of early emergence, heading, and senescence) and error rate are not present in the TY. The comparison tabulation for the TY was made, but because there is no correlation, the data will be presented as an appendix to the report.

In phase III, the strip/fallow designation by the digital ground truth was assessed by the labeling error evaluator for true strip/fallow conditions that would be potential problems for the analyst. This required the evaluator to determine if an integrated signature was present for those strip/fallow designations by the digital ground truth. (An integrated signature is a mixed spectral response from two or more areas smaller than the resolution size of the Landsat sensor and displayed as one; i.e., very narrow fields of strip/fallow combined into an integrated spectral response.) The labeling error evaluator for Phase III measured the number of integrated signatures that were labeled "other." However, for the TY, at the time of the labeling evaluation, no digital ground-truth data were available. Thus, the number of integrated signatures and the number of signatures labeled nonsmall grain were counted.

The net result of the Phase III Type 2 dot tabulation showed that the number of integrated signature dots labeled nonsmall grain was half the total number of integrated signature dots. Therefore, the integrated signatures of strip/fallow fields did not contribute to the underestimation of the small-grain acreage in Phase III.

The TY percentages are like the Phase III percentages in demonstrating that the integrated signatures do not account for a significant proportion of the underestimation of small grains.

State	Total integrated signature, percent	Total integrated signature labeled nonsmall grain, percent
Minnesota	0.2	0
Montana	2.8	1.9
North Dakota	.4	.2
South Dakota	.6	.2

Labeling requirements of the TY acreage estimation called for identification of nonsmall grains, barley, and winter and other spring small grains. The other spring small-grain estimate included triticale, oats, flax, and spring wheat. Table 6-11 shows the percentage of each crop per state.

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TABLE 6-11.- PERCENTAGES AND NUMBER OF COMPONENT PARTS OF THE TY SPRING SMALL GRAINS

State	Dot type	Triticale		Oats		Flax		Spring wheat		Other spring small grains	
		Number of pixels	Percent	Number of pixels	Percent	Number of pixels	Percent	Number of pixels	Percent	Number of pixels	Percent
South Dakota	2	5		50	55.6	5	5.6	35	38.9	90	100
	1			18	62.1	1	3.5	10	34.5	29	100
Montana	2			2	2.4			80	97.6	82	100
	1							39	100	39	100
Minnesota	2	1	0.7	39	27.3	6	4.2	97	67.8	143	100
	1			18	37.5	2	4.2	28	58.3	48	100
North Dakota	2			89	8.9	26	2.6	889	88.6	1004	100
	1			32	10.1	7	2.2	279	87.7	318	100

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Flax and triticale are minor components of the spring small grain. In the four states studied, spring wheat comprises the largest portion of the other spring small grain in all four states combined, as well as in each individual state except South Dakota, where oats comprise the largest percentage of the other spring small grains (56 percent).

7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions from the labeling error characterization study for the TY are:

- The overall accuracy of the spring small-grain labeling was less accurate in the TY than in LACIE Phase III (TY, 76 percent; Phase III, 78 percent).
- The mixed-wheat states of Montana and South Dakota had a more accurate small-grain labeling percentage than did the spring small-grain states of Minnesota and North Dakota (Minnesota, 68.6 percent; Montana, 82 percent; North Dakota, 65.9 percent; and South Dakota, 81.9 percent).
- The winter-wheat states of Kansas and Oklahoma had a more accurate small-grain labeling percentage than did the mixed or spring wheat states (Kansas, 92.8 percent; and Oklahoma, 84.4 percent).
- Other spring wheat was most frequently confused with pasture, corn, and fallow (pasture 7.4 percent; corn, 5.2 percent; and fallow, 4.6 percent).
- Barley was confused most with other spring wheat (25.1 percent).
- Trajectory and scatter plots appear to help in the separation of other spring small grain and barley.
- Integrated signatures of strip/fallow fields did not contribute to the underestimation in the TY because half the strip/fallow fields were labeled nonsmall grain.
- The largest single cause of labeling error is the unusual or odd signatures for small-grain development, which are concentrated mostly in segments of abnormal moisture conditions (with ranges from 36 percent to 47.6 percent).
- Abnormal moisture conditions seem to occur somewhere in the Great Plains each year and seem to be related to labeling error (see section 6.3.1).
- Separation of the other spring small grains from barley was not very accurate because the ripening signature of both groups appeared at approximately the same date, thus preventing the separation of the crops according to procedures (section 6.3.1).

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- The analysts did a good job of labeling in the TY. The combined omission error rate was 24 percent, and the commission error rate was 4 percent. The major portion of the underestimation (omission error) was caused by factors (abnormal signatures) beyond the control of the analysts who were following the interpretation procedures (sections 6.3.1 and 6.3.5).

Recommendations based upon the results of the labeling in the TY are as follows:

- Idle crop land, stubble, residue, and fallow should all be combined into one ground truth label.
- The idle crop cover ground-truth label should identify the cover crop.
- Field personnel should label swales and glacial depressions according to the ground cover in the swale, taking care not to label these areas merely as nonagricultural.
- A constant search for moisture stress should be carried out during each growing season; the abnormal moisture data, e.g. crop moisture index, should be used to influence the interpretation of this stress.
- Improvement of the labeling accuracy in regions of stress (abnormal moisture) is the most important effort to be made toward decreasing labeling errors.
- A more objective and systematic interpretation procedure should be provided if the labeling accuracy is to be improved in the stressed areas.
- If multicrop labeling is to continue, the temporal spectral changes of each crop's phenology throughout the growing season should be more specifically detailed and given to the analysts as part of the labeling procedure.

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8. REFERENCES

1. Phase III CAMS Detailed Analysis Procedures. LACIE-00720 (JSC-11693), Aug. 1977

2. Austin, W. W.: Detailed Description of the Wheat Acreage Estimation Procedure Used in the Large Area Crop Inventory Experiment. Lockheed Electronics Company, Inc. Tech. Memo. LEC-11497, Feb. 1978.

3. Detailed Analysis Procedures for Transition Project (FY79). LACIE-00724 (JSC-13756), Lockheed Electronics Company, Inc. LEC-13222, May 1979.

4. LACIE Phase III Accuracy Assessment: Final Report. LACIE-00478 (JSC-13766), Lockheed Electronics Company, Inc. LEC-13493

5. Transition Year World Multicrop Accuracy Assessment: Final Report (in publication).

6. Clinton, N. J.: LACIE Phase III Labeling Error Characterization Final Report. Lockheed Electronics Company, Inc. Tech. Memo. LEC-13012, March 1979.

7. Magness, E. R.; and Spikes, G. D.: Evaluation of the Transition Year Barley/Other Spring Grain Labeling Procedure. Part 1: Minnesota, Part 2: North Dakota. Lockheed Electronics Company, Inc. Tech. Memo. LEC-13657, June 1979.

8. Cate, R. B., Phinney, D. E., Kinsler, M. C., Sestak, M. L., Hodges, T., and Dishler, J. J.: Interpretation of Landsat Digital Data Using a Cubic Color Model Based on Relative Energies. SR-LO-00418, JSC-13776, LEMSCO-13499, Feb. 1980.

APPENDIX A

RANKING OF GROWTH STAGES

TABLE A-1.- RANKING OF GROWTH STAGES ACCORDING TO PERCENTAGE OF TOTAL ERRORS

Segment number	State	Total error, %	Growth stages not represented	Available growth stages represented
1467	N. Dak.	38.4	c, f	a, b, e, g, h
1636	N. Dak.	38.1	b, c, d	a, e, f, g, h
1387	N. Dak.	25.4	c, e, f	a, b, g, h
1811	N. Dak.	24.3	c	a, b, d, e, f, g, h
1394	N. Dak.	20.2	b, c	a, e, f, g, h
1658	N. Dak.	19.6	c, d, f	a, b, e, g, h
1461	N. Dak.	17.5	b, d	a, c, e, f, g, h
1472	N. Dak.	16.9	b, c, d, e, f	a, g, h
1457	N. Dak.	16.9	b, c, f	a, e, g, h
1584	N. Dak.	16.8	b, e	a, c, f, g, h
1392	N. Dak.	16.8	c, e	a, b, f, g, h
1784	S. Dak.	16.7	b, c, h	a, e, f, g
1566	Minn.	16.7	b, c, f	a, e, g, h
1825	Minn.	16.6	b, c, d	a, e, f, g, h
1664	N. Dak.	16.2	b, e, f	a, c, g, h
1518	Minn.	14.5	b, h	a, c, e, f, g
1920	N. Dak.	14.0	b, c, e	a, f, g, h
1909	N. Dak.	13.3	b, c, d, h	a, e, f, g
1650	N. Dak.	13.1	a, b, c	e, f, g, h
1602	N. Dak.	13.0	a, b, c, d, f	e, g, h
1924	N. Dak.	12.6	c, d, e, h	a, b, d, g
1653	N. Dak.	12.2	b, c	a, e, f, g, h
1918	N. Dak.	11.5	a, c, e, f	b, g, h
1537	Mont.	11.3		a, b, c, d, e, f, g, h
1544	Mont.	11.1	e, f	a, b, c, g, h
1154	S. Dak.	10.8	c	a, b, d, e, f, g, h
1619	N. Dak.	10.5	a, c, e	b, f, g, h
1665	Okla.	9.9	d, g, h	a, b, c, e, f
1473	N. Dak.	9.6	b, c, f	a, e, g, h
1178	Kans.	9.3	b, g, h	a, c, d, e, f
1942	Mont.	9.3	b, c	a, d, e, f, g, h
1542	Mont.	8.5	c, d	a, b, e, f, g, h
1284	Kans.	8.3	c, g, h	a, b, d, e, f
1676	S. Dak.	8.2	c	a, b, d, e, f, g, h

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TABLE A-1.- Concluded.

Segment number	State	Total error, %	Growth stages not represented	Available growth stages represented
1231	Okla.	7.8	d, g, h	a, b, c, e, f
1553	Mont.	7.7	d	a, b, c, e, f, g, h
1229	Kans.	7.4	h	a, b, c, d, e, f, g
1389	Mont.	7.3	b	a, c, d, e, f, g, h
1047	Kans.	6.6	f, g, h	a, b, c, d, e
1678	S. Dak.	5.8	a, d, e, f, g, h	b, c
1556	N. Dak.	5.8	b, c, h	a, e, f, g
1238	Okla.	5.6	a, g, h	b, c, d, e, f
1731	Mont.	4.7	a, b, c, d	e, f, g, h
1041	Kans.	4.5	a, d, g, h	b, c, e, f
1173	Kans.	4.5	c, g, h	a, b, d, e, f
1891	Kans.	3.9	d, g, h	a, b, c, e, f
1281	Kans.	3.7	g, h	a, b, c, d, e, f
1488	Okla.	3.6	a, f, g, h	b, c, d, e
1612	N. Dak.	3.5	b, c, g	a, e, f, h
1842	Minn.	3.4	c	a, b, e, f, g, h
1598	S. Dak.	3.3	b, c, d	a, e, f, g, h
1755	S. Dak.	3.3	d, f	a, b, c, e, g, h
1103	Mont.	3.0	a, b, e	c, d, f, g, h
1802	S. Dak.	2.7	a, c, e, f, g	b, h
1239	Kans.	2.7	c, h	a, b, d, e, f, g
1293	Kans.	2.4	c, f, g, h	a, b, d, e
1242	Okla.	1.9	c, d, g, h	a, b, e, f
1286	Kans.	1.9	b, g, h	a, c, d, e, f
1049	Kans.	1.9	c, d, g, h	a, b, e, f
1369	Kans.	1.9	a, f, g, h	b, c, d, e
1380	Minn.	1.9		a, b, c, e, f, g, h
1156	Kans.	1.7	b, f, g, h	a, c, d, e
1035	Kans.	0.9	d, g, h	a, b, c, e, f
1151	Kans.	0.0	g, h	a, b, c, e, f
1861	Kans.	0.0	g, h	a, b, c, d, e, f
1890	Kans.	0.0	d, g, h	a, b, c, e, f
1668	S. Dak.	0.0	b, c, g,	a, e, f, h
1550	Mont.	0.0	b, d, f	a, c, e, g, h

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TABLE A-2.- RANKING OF GROWTH STAGES ACCORDING TO PERCENTAGE OF ODD SIGNATURE

Segment number	State	Total error, %	Growth stages not represented	Available growth stages represented
1467	N. Dak.	25.3	c, f	a, b, e, g, h
1636	N. Dak.	25.3	b, c, d	a, e, f, g, h
1392	N. Dak.	15.6	c, e	a, b, f, g, h
1457	N. Dak.	13.9	b, c, f	a, e, g, h
1566	Minn.	11.4	b, c, f	a, e, g, h
1518	Minn.	10.2	b, h	a, c, e, f, g
1394	N. Dak.	9.3	b, c	a, e, f, g, h
1387	N. Dak.	8.0	c, e, f	a, b, g, h
1784	S. Dak.	7.6	b, c, h	a, e, f, g
1811	S. Dak.	6.8	c	a, b, d, e, f, g, h
1584	N. Dak.	6.7	b, e	a, c, f, g, h
1658	N. Dak.	6.2	c, d, f	a, b, e, g, h
1553	Mont.	6.2	d	a, b, c, e, f, g, h
1676	S. Dak.	5.8	c	a, b, d, e, f, g, h
1942	Mont.	5.6	b, c	a, d, e, f, g, h
1619	N. Dak.	5.5	a, c, e	b, f, g, h
1154	S. Dak.	5.4	c	a, b, d, e, f, g, h
1537	Mont.	5.4		a, b, c, d, e, f, g, h
1924	N. Dak.	5.3	c, d, e	a, b, f, g, h
1825	Minn.	5.3	b, c, d	a, e, f, g, h
1664	N. Dak.	5.2	b, d, e, f	a, c, g, h
1665	Okla.	5.0	d, g, h	a, b, c, e, f
1461	N. Dak.	4.9	b, d	a, c, e, f, g, h
1473	N. Dak.	4.6	b, c, f	a, e, g, h
1653	N. Dak.	4.4	b, c	a, e, f, g, h
1909	N. Dak.	3.9	b, c, d, h	a, e, f, g
1284	Kans.	3.7	c, g, h	a, b, d, e, f
1602	N. Dak.	3.4	a, b, c, d, f	e, g, h
1656	N. Dak.	2.9	b, c, h	a, e, f, g
1231	Okla.	2.9	d, g, h	a, b, c, e, f
1891	Kans.	2.9	d, g, h	a, b, c, e, f
1918	N. Dak.	2.4	a, c, e, f, g	b, g, h
1755	S. Dak.	2.2	d, f	a, b, c, e, g, h
1238	Okla.	1.9	a, g, h	b, c, d, e, f

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TABLE A-2.- Concluded.

Segment number	State	Total error, %	Growth stages not represented	Available growth stages represented
1544	Mont.	1.9	e, f	a, b, c, g, h
1920	N. Dak.	1.9	b, c, e	a, f, g, h
1173	Kans.	1.8	c, g, h	a, b, d, e, f
1103	Mont.	1.8	a, b, e	c, d, f, g, h
1389	Mont.	1.8	b	a, c, d, e, f, g, h
1542	Mont.	1.5	c, d	a, b, e, f, g, h
1472	N. Dak.	1.5	b, c, d, e, f	a, g, h
1842	Minn.	1.1	c	a, b, e, f, g, h
1242	Okla.	1.0	c, d, g, h	a, b, e, f
1612	N. Dak.	1.0	b, c, g	a, e, f, h
1041	Kans.	0.9	a, d, g, h	b, c, e, f
1178	Kans.	0.9	b, g, h	a, c, d, e, f
1229	Kans.	0.9	h	a, b, c, d, e, f, g
1369	Kans.	0.9	a, f, g, h	b, c, d, e
1488	Okla.	0.9	a, f, g, h	b, c, d, e
1380	Minn.	0.7		a, b, c, e, f, g, h
1598	S. Dak.	0.7	b, c, d	a, e, f, g, h
1650	N. Dak.	0.5	a, b, c	e, f, g, h
1802	S. Dak.	0.0	a, c, e	b, h
1678	S. Dak.	0.0	a, d, e, f, g, h	b, c
1668	S. Dak.	0.0	b, c, g	a, e, f, h
1731	Mont.	0.0	a, b, c, d	e, f, g, h
1550	Mont.	0.0	b, d, f	a, c, e, g, h
1293	Kans.	0.0	c, f, g, h	a, b, d, e
1286	Kans.	0.0	b, g, h	a, c, d, e, f
1281	Kans.	0.0	g, h	a, b, c, d, e, f
1156	Kans.	0.0	b, f, g h	a, c, d, e
1239	Kans.	0.0	c, h	a, b, d, e, f, g
1049	Kans.	0.0	c, d, g, h	a, b, e, f
1047	Kans.	0.0	f, g, h	a, b, c, d, e
1035	Kans.	0.0	d, g, h	a, b, c, e, f
1890	Kans.	0.0	d, g, h	a, b, c, e, f
1861	Kans.	0.0	g, h	a, b, c, d, e, f
1151	Kans.	0.0	d, g, h	a, b, c, e, f

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APPENDIX B

LABELING ACCURACY FOR EACH SEGMENT

```
1 S T A T I S T I C A L   A N A L Y S I S   S Y S T E M
NOTE: CMS/SAS RELEASE 79.4B AT PURDUE UNIVERSITY (0844).

          *NOTE* TYPE 1 DOTS. SEG = SEGMENT NUMBER
                 ST= STATE
                 PXL= TOTAL NUMBER OF PIXELS
                 OSGACC= OTHER SMALL GRAIN ACCURACY (SPRWHT FLAX OATS)
                 OSGPXL= OTHER SMALL GRAIN NUMBER OF PIXELS
                 BYACC= BARLEY ACCURACY
                 BYPXL= NUMBER OF BARLEY PIXELS
                 WGACC= WINTER WHEAT ACCURACY
                 WGPXL= NUMBER OF WINTER GRAIN PIXELS
                 NSGACC= NONSMALL GRAIN ACCURACY
                 NSGPXL= NUMBER OF NONSMALL GRAIN PIXELS;

          CMS FILEDEF INDATA DISK LABEL1 CHARCT B;
          DATA AI DATA;
          INFILE INDATA;
          INPUT SEG 1-4 ST $ 6-7 OSGACC 9-13 1 OSGPXL 15-17 BYACC 19-23 1 BYPXL 25-27
                WGACC 29-33 1 WGPXL 35-37  NSGACC 39-43 1 NSGPXL 45-47;

NOTE: INFILE INDATA IS FILE LABEL1 CHARCT B1
NOTE: 68 LINES WERE READ FROM INFILE INDATA.
      THE MINIMUM LINE LENGTH IS 80.
      THE MAXIMUM LINE LENGTH IS 80.
NOTE: DATA SET WORK.AI HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: DATA SET WORK.DATA HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: THE DATA STATEMENT USED 0.51 SECONDS AND 444K.

          PROC SORT;
          BY SEG;
          TITLE 1978 LABELING ACCURACY PER SEGMENT;
          TITLE3 TYPE 1 DOTS;

NOTE: DATA SET WORK.DATA HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: THE PROCEDURE SORT USED 0.10 SECONDS AND 960K.

          PROC PRINT;

NOTE: THE PROCEDURE PRINT USED 0.19 SECONDS AND 484K AND PRINTED PAGE 1.

NOTE: SAS INSTITUTE INC.
      SAS CIRCLE
      BOX 8000
      CARY, N.C. 27511
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1979 LABELING ACCURACY PER SEGMENT

TYPE 1 DOTS

OBS	SEG	ST	OSGACC	OSGPXL	BYACC	BYPXL	WGACC	WGPXL	NSGACC	NSGPXL
	1035	KS	.	.	.	.	100.0	15	100.0	32
	1041	KS	.	.	.	.	100.0	17	93.9	33
	1047	KS	.	.	.	.	92.3	13	93.9	33
	1049	KS	.	.	.	.	100.0	10	100.0	35
	1103	MT	0.0	1	.	.	.	.	100.0	60
	1151	KS	.	.	.	.	100.0	8	100.0	41
	1154	SD	.	.	.	.	57.1	7	97.4	39
	1156	KS	.	.	.	.	.	.	.	.
	1173	KS	.	.	.	.	90.9	11	97.4	39
	1178	KS	.	.	.	.	.	.	97.9	48
	1229	KS	.	.	.	.	73.7	19	96.6	29
	1231	OK	.	.	.	.	87.5	24	89.5	19
	1234	OK	.	.	.	.	100.0	3	100.0	44
	1239	KS	.	.	.	.	75.0	4	100.0	46
	1242	OK	.	.	.	.	100.0	19	100.0	24
	1281	KS	.	.	.	.	85.7	7	97.6	42
	1284	KS	.	.	.	.	80.0	25	95.7	23
	1286	KS	.	.	.	.	90.9	11	97.1	35
	1293	KS	.	.	.	.	75.0	4	100.0	32
	1369	KS	.	.	.	.	100.0	16	100.0	30
	1380	MN	80.0	5	.	.	.	.	97.7	44
	1387	ND	60.0	15	0.0	8	.	.	91.3	23
	1389	MT	.	.	.	.	50.0	4	97.8	45
	1392	ND	91.0	11	33.3	3	.	.	65.7	35
	1394	ND	63.2	19	50.0	2	.	.	92.0	25
	1457	ND	71.4	14	0.0	2	.	.	69.7	29
	1461	ND	95.5	22	50.0	2	.	.	70.8	24
	1467	ND	44.4	27	0.0	3	.	.	100.0	16
	1472	ND	83.3	12	100.0	3	.	.	93.8	32
	1473	ND	91.7	12	87.5	8	.	.	88.5	26
	1488	OK	.	.	.	.	80.0	10	100.0	40
	1518	MN	50.0	4	0.0	1	.	.	100.0	26
	1537	MT	16.7	6	0.0	2	67.0	6	98.8	86
	1542	MT	100.0	7	.	.	.	.	95.2	42
	1544	MT	54.5	11	.	.	.	.	97.3	37
	1550	MT	.	.	.	.	100.0	4	100.0	45
	1553	MT	.	.	0.0	1	50.0	2	100.0	33
	1566	MN	62.5	16	0.0	5	.	.	100.0	18
	1584	ND	89.5	19	54.6	11	.	.	90.0	20
	1598	SD	50.0	2	.	.	0.0	1	97.9	47
	1602	ND	68.8	16	.	.	.	.	97.0	33
	1612	ND	62.5	8	.	.	.	.	100.0	89
	1619	ND	86.7	15	50.0	4	.	.	100.0	23
	1636	ND	29.4	17	100.0	1	.	.	64.0	25
	1650	ND	30.0	10	.	.	.	.	100.0	37
	1653	ND	54.6	11	.	.	.	.	93.4	36
	1656	ND	50.0	4	100.0	1	.	.	100.0	45
	1658	ND	63.2	19	75.0	4	.	.	85.2	27
	1664	ND	86.7	15	100.0	1	0.0	3	92.6	27
	1665	OK	.	.	.	.	50.0	10	100.0	31
	1668	SD	100.0	4	.	.	.	.	100.0	43
	1676	SD	50.0	6	100.0	1	0.0	2	93.6	94
	1678	SD	.	.	.	.	0.0	4	98.7	75
	1731	MT	100.0	1	0.0	1	94.4	18	96.6	29
	1755	SD	100.0	1	100.0	1	0.0	1	100.0	38
	1784	SD	75.0	4	0.0	2	.	.	92.9	42
	1802	SD	.	.	.	.	.	.	100.0	50
	1811	SD	75.0	12	0.0	1	.	.	64.5	31
	1825	MN	58.8	17	.	.	.	.	95.7	23
	1842	MN	83.3	6	.	.	.	.	100.0	36
	1861	KS	.	.	.	.	100.0	18	100.0	21
	1890	KS	.	.	.	.	100.0	15	100.0	27
	1891	KS	.	.	.	.	100.0	17	96.2	26
	1902	ND	60.0	10	0.0	2	.	.	100.0	35
	1918	ND	50.0	10	0.0	1	.	.	97.4	39
	1920	ND	53.8	13	.	.	.	.	100.0	36
	1924	ND	71.4	14	100.0	1	0.0	1	100.0	25
	1942	MT	92.3	13	0.0	1	0.0	1	100.0	32

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1 S T A T I S T I C A L   A N A L Y S I S   S Y S T E M

NOTE: CMS/SAS RELEASE 79.4B AT PURDUE UNIVERSITY (0844).

         *NOTE* TYPE 2 DOTS SEG = SEGMENT NUMBER
                ST= STATE
                PXL= TOTAL NUMBER OF PIXELS
                OSGACC= OTHER SMALL GRAIN ACCURACY (SPRWHT FLAX OATS)
                OSGPXL= OTHER SMALL GRAIN NUMBER OF PIXELS
                BYACC= BARLEY ACCURACY
                BYPXL= NUMBER OF BARLEY PIXELS
                WGACC= WINTER WHEAT ACCURACY
                WGPXL= NUMBER OF WINTER GRAIN PIXELS
                NSGACC= NONSMALL GRAIN ACCURACY
                NSGPXL= NUMBER OF NONSMALL GRAIN PIXELS;

         CMS FILEDEF INDATA DISK LABEL2 CHARCT B;
         DATA AI DATA;
         INFILE INDATA;
         INPUT SEG 1-4 ST $ 6-7 OSGACC 9-13 1 OSGPXL 15-17 BYACC 19-23 1 BYPXL 25-27
               WGACC 29-33 1 WGPXL 35-37  NSGACC 39-43 1 NSGPXL 45-47;

NOTE: INFILE INDATA IS FILE LABEL2 CHARCT B1
NOTE: 68 LINES WERE READ FROM INFILE INDATA.
      THE MINIMUM LINE LENGTH IS 80.
      THE MAXIMUM LINE LENGTH IS 80.
NOTE: DATA SET WORK.AI HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: DATA SET WORK.DATA HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: THE DATA STATEMENT USED 0.26 SECONDS AND 442K.

         PROC SORT;
         BY SEG;
         TITLE 1978 LABELING ACCURACY PER SEGMENT;
         TITLE3 TYPE 2 DOTS;

NOTE: DATA SET WORK.DATA HAS 68 OBSERVATIONS AND 10 VARIABLES.
NOTE: THE PROCEDURE SORT USED 0.11 SECONDS AND 960K.

         PROC PRINT;

NOTE: THE PROCEDURE PRINT USED 0.19 SECONDS AND 476K AND PRINTED PAGE 1.

NOTE: SAS INSTITUTE INC.
      SAS CIRCLE
      BOX 8000
      CARY, N.C. 27511
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ORIGINAL PAGE IS
OF POOR QUALITY

1978 LABELING ACCURACY PER SEGMENT

TYPE 2 DOTS

OBS SEG	ST	OSGACC	OSGPXL	BYACC	BYPXL	WGACC	WGPXL	NSGACC	NSGPXL
1035	KS	.	.	.	.	95.8	24	100.0	36
1041	KS	.	.	.	.	95.0	20	95.0	40
1047	KS	.	.	.	.	84.2	19	97.6	41
1049	KS	.	.	.	.	93.8	16	97.7	44
1103	MT	.	.	100.0	1	25.0	4	99.0	100
1151	KS	.	.	.	.	100.0	11	100.0	49
1154	SD	100.0	1	.	.	57.7	26	98.7	75
1156	KS	.	.	.	.	0.0	1	100.0	59
1173	KS	.	.	.	.	82.4	17	100.0	43
1178	KS	.	.	.	.	100.0	1	100.0	59
1229	KS	.	.	.	.	90.9	22	100.0	38
1231	OK	.	.	.	.	93.8	32	95.4	28
1234	OK	.	.	.	.	70.0	10	94.0	50
1239	KS	.	.	.	.	75.0	4	98.2	56
1242	OK	.	.	.	.	92.0	25	100.0	35
1281	KS	.	.	.	.	90.5	21	100.0	39
1284	KS	.	.	.	.	91.7	24	97.2	36
1285	KS	.	.	.	.	100.0	15	100.0	45
1293	KS	.	.	.	.	90.9	11	100.0	36
1359	KS	.	.	.	.	95.2	25	97.1	34
1380	MN	100.0	15	.	.	.	.	98.9	90
1387	ND	82.8	58	14.3	27	.	.	92.9	70
1389	MT	.	.	.	.	100.0	3	91.2	57
1392	ND	84.8	45	37.5	8	.	.	85.7	105
1394	ND	69.0	54	50.0	8	.	.	91.4	81
1457	ND	67.0	60	.	.	.	.	95.0	96
1461	ND	93.1	72	0.0	5	0.0	1	81.0	79
1467	ND	57.8	71	37.5	16	.	.	98.4	61
1472	ND	63.0	46	76.5	17	0.0	2	92.1	39
1473	ND	92.0	48	34.7	29	.	.	90.7	75
1488	OK	.	.	.	.	60.0	10	100.0	50
1514	MN	55.6	45	67.0	3	.	.	97.2	107
1537	MT	33.3	9	0.0	2	75.0	12	97.3	81
1542	MT	73.0	37	.	.	0.0	1	96.5	113
1544	MT	79.0	19	100.0	2	.	.	94.9	39
1550	MT	.	.	.	.	100.0	6	100.0	54
1553	MT	57.1	7	0.0	1	55.3	15	98.5	135
1566	MN	79.0	19	0.0	4	.	.	100.0	52
1584	ND	79.4	68	50.0	16	.	.	94.7	75
1598	SD	33.3	3	.	.	.	.	100.0	99
1602	ND	59.8	43	0.0	2	0.0	1	95.5	112
1612	ND	66.5	13	.	.	.	.	100.0	93
1619	ND	53.0	53	79.0	19	.	.	95.4	87
1636	ND	43.1	72	50.0	4	0.0	1	79.3	72
1650	ND	43.8	32	.	.	.	.	98.4	127
1653	ND	40.5	32	.	.	.	.	100.0	124
1655	ND	33.3	3	100.0	1	.	.	95.0	149
1658	ND	67.9	53	41.7	12	0.0	3	97.8	91
1664	ND	55.9	41	80.0	10	0.0	2	93.5	92
1665	OK	.	.	.	.	61.5	13	100.0	47
1668	SD	100.0	4	.	.	.	.	100.0	56
1676	SD	75.0	12	.	.	0.0	2	95.7	91
1678	SD	.	.	.	.	0.0	1	96.6	58
1731	MT	100.0	1	0.0	2	93.5	32	100.0	66
1755	SD	72.7	11	100.0	4	.	.	90.4	126
1784	SD	67.0	21	50.0	12	.	.	58.0	117
1802	SD	0.0	3	.	.	.	.	100.0	57
1811	SD	71.4	35	0.0	3	.	.	84.2	95
1825	MN	54.3	35	60.0	5	0.0	1	95.9	88
1843	MN	95.6	29	.	.	.	.	95.3	107
1861	KS	.	.	.	.	100.0	31	100.0	29
1890	KS	.	.	.	.	100.0	10	100.0	50
1891	KS	.	.	.	.	90.9	33	100.0	27
1909	ND	44.8	24	50.0	2	0.0	1	97.5	124
1914	ND	43.3	15	0.0	3	.	.	92.0	137
1920	ND	31.5	33	0.0	1	.	.	95.2	124
1924	ND	61.1	53	33.3	3	0.0	4	93.6	94
1942	MT	67.0	4	.	.	0.0	3	97.9	48

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