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A DESCRIPTION OF THE REFORMATTED SPRING SMALL GRAINS LABELING PROCEDURE USED IN TEST 2, PART 2 OF THE U.S./CANADA WHEAT AND BARLEY EXPLORATORY EXPERIMENT

W. F. Palmer and E. R. Magness

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A DESCRIPTION OF THE REFORMATTED SPRING SMALL GRAINS LABELING
PROCEDURE USED IN TEST 2, PART 2 OF THE U.S./CANADA
WHEAT AND BARLEY EXPLORATORY EXPERIMENT

Job Order 74-414

This report describes Multicrop Classification Technology activities of the
Foreign Commodity Production Forecasting project of the AgRISTARS program.

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1. INTRODUCTION

The Reformatted Spring Small Grains Labeling Procedure reduces the labeling decisions to a series of steps. These steps, when executed in an objective manner, allow analysts with limited experience to follow the procedure and arrive at crop identification labels with consistency. The development and description of this procedure are presented in this document.

The U.S./Canada Wheat and Barley Exploratory Experiment (ref. 1) was designed to evaluate the procedure. Test 1 (Shakedown Test) was completed in the second quarter of fiscal year 1980 (FY80). Following a critical examination of the results, refinements and modifications were made to the Reformatted Spring Small Grains Labeling Procedure in preparation for additional testing. Test 2, Part 2, of the experiment began in the third quarter of FY80 using the procedure described in section 4.

2. BACKGROUND

In support of the acreage estimation processes of the Large Area Crop Inventory Experiment (LACIE) [ref. 2], agricultural analysts have relied on temporal analysis of Landsat data (ref. 3) to identify specific crops. Although the accuracy of identification was sufficient to provide estimates which met the goals of the experiment, consistent results between analysts were difficult to obtain without an intricate system of quality assurance and teamwork. A more objective procedure was clearly needed.

Subsequent to the LACIE, developmental efforts were directed toward the expansion of the crop identification procedures to include other crops in addition to wheat, the principal crop of interest in the LACIE. The other crops initially selected for emphasis were corn and soybeans, with the U.S. Corn Belt as the primary area of concern.

The procedure (ref. 4) which resulted from this developmental effort utilized decision-tree methodology and was designed to reduce the impact of analyst subjectivity. The step-by-step design provided an additional benefit of allowing error sources to be isolated, thus providing meaningful feedback for procedure modification.

Because of the apparent success of this procedure, conversion of the U.S. spring small grains procedure to a similar format was a logical step. This reformatting was accomplished in preparation for the U.S./Canada Wheat and Barley Exploratory Experiment.

3. DEVELOPMENT

3.1 OBJECTIVE

The objective was to develop a procedure for labeling spring small grains in the U.S. Northern Great Plains (USNGP) segments by converting the U.S. spring small grains and barley separation procedure used during the Transition Project to a format similar to the corn and soybeans decision logic (ref. 4). The techniques used in the Transition Project were to be enhanced whenever possible.

3.2 APPROACH

Following a comprehensive review of the Transition Project labeling procedures (ref. 4), scientists identified alternative methods for performing some of the steps. These methods leave fewer subjective decisions in the labeling process to the analyst. The new techniques were tested using segments from the developmental data set (section 3.3). Necessary modifications and revisions were made before incorporating them into the overall labeling procedure.

3.3 DEVELOPMENTAL DATA SET

The labeling procedure is based primarily on analysis and observations of the segments comprising the developmental data set. These segments are shown in figure 3-1. The shaded areas represent the major barley producing regions of each state. Criteria used for selecting the segments were based upon (a) the segments having a sufficient number of acquisitions to adequately describe the growth cycle of spring small grains and (b) the segments having a reasonably large proportion of spring small grains, particularly barley.

In South Dakota and Montana, one intensive test site (ITS) and two LACIE Phase II blind sites were used in order to obtain segments which were suitable for development of the labeling procedure.

3.4 DISCUSSION

Essentially three major divisions exist within the labeling procedure. These divisions are:

1. The separation of dots [picture elements (pixels)] into either cropland or noncropland
2. The separation of cropland dots into spring small grains or non-spring small grains (in this document, non-spring small grains includes all crops other than spring small grains in addition to all nonagricultural areas such as forests, water, urban areas, and bare soil.)
3. The separation of spring-small-grain dots into barley or other spring small grains

For the cropland and noncropland separation, the procedure relies on a slightly modified portion of the decision logic for major land-use categories, a part of the corn and soybeans procedure (ref. 4).

Because segments can be processed without an acquisition during the time when barley is green vegetation, the first major division had to be modified to ensure that barley would be labeled cropland. This modification allows fields to be labeled cropland (provided specific conditions are satisfied) even though acquisitions showing the crop growing are unavailable. Additionally, when responses are such that the decision is clearly noncropland, the dot is labeled as noncropland instead of attempting a further breakdown into range, forest, and other.

The successful identification of spring small grains is usually the result of an analyst's ability to recognize fields which follow the development pattern of spring small grains and isolate acquisitions on which most or all of the spring small grains exhibit similar characteristics (e.g., bare soil, green vegetation, and harvested). If the coupling of two or more of these acquisitions provides a unique signature for spring small grains (e.g., bare soil on acquisition 1 and green vegetation on acquisition 2), accurate labeling should result. In order to develop procedures for this process, a window technique was devised to select acquisitions on which the appearance of spring small

grains would be predictable. The desired characteristics of spring small grains on acquisitions selected to represent each window are presented in table 3-1.

If the correct acquisitions are selected, a description of the desired appearance of spring small grains as a function of window should allow accurate separation of spring small grains from non-spring small grains. In an attempt to provide a more objective description of appearance, green numbers and brightness (refs. 5, 6, and 7) were used in lieu of color descriptions for this procedure.

Observation of the behavior of the green number and brightness of spring small grains on segments from the developmental data set was used to establish the green number and brightness criteria for spring small grains as a function of acquisition and window. These criteria cutoffs were utilized in the decision logic for spring small grains.

For the separation of barley and other spring small grains, much of the Transition Project labeling procedure (ref. 4) was retained. However, there are several important modifications including the following:

- a. The separation acquisition is selected using an objective procedure. This is the window 3 acquisition.
- b. The decision boundary on the green number versus brightness scatter plot is a straight line with fixed slope.
- c. The concept of dot drift is introduced to assist in determining the location of the decision boundary. Dot drift is the direction of movement in the green number and brightness plane from the window 2 acquisition to the window 3 acquisition.

3.5 MINIMUM ACQUISITION AND WINDOW REQUIREMENTS

The definition of a minimum data set for processing segments with this labeling procedure reflects extensive LACIE experience in addition to observations of the segments from the developmental data set.

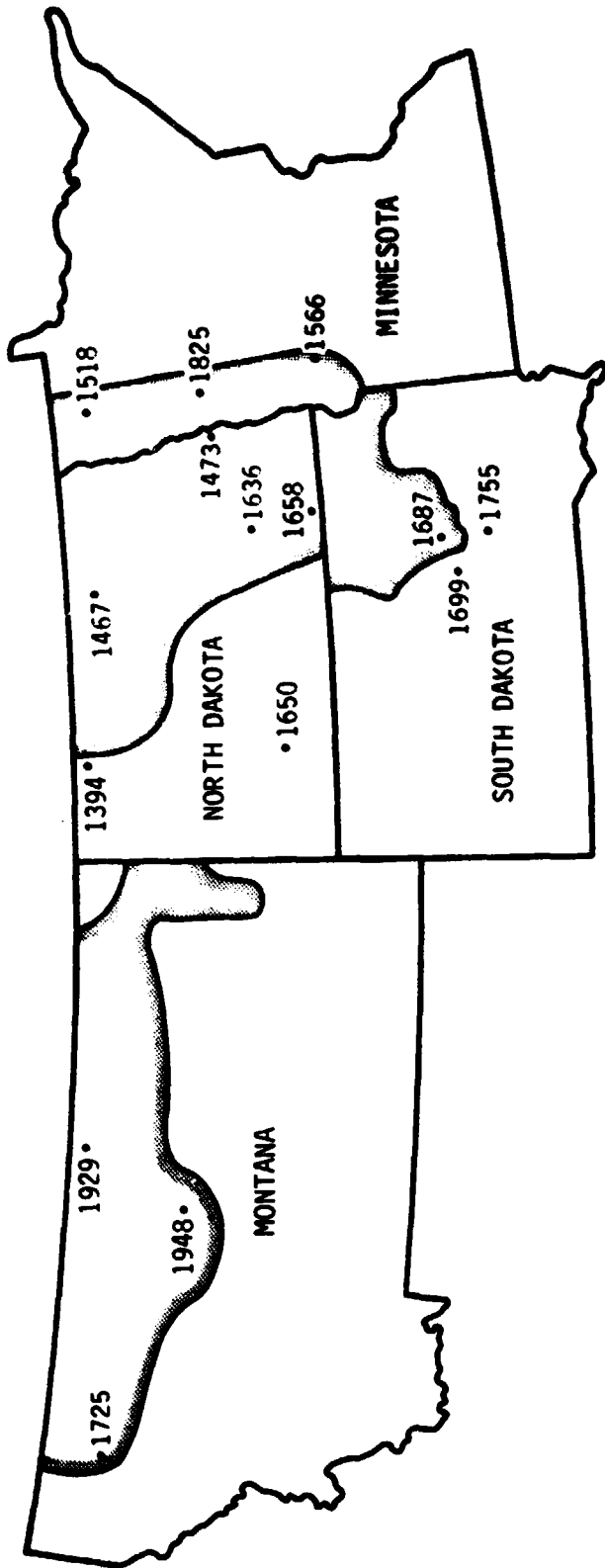
An acquisition in window 1 was known to be a requirement in mixed wheat areas to provide separation between winter and spring small grains. This requirement was extended to all of the areas of interest because of its additional value for separating natural vegetation and hay.

An acquisition in window 2 or window 3 is required to provide a date when spring small grains are growing. Since the barley separation technique relies on the observation of barley turning and harvested while the other spring small grains are in earlier stages, a window 3 acquisition is required to execute that portion of the procedure.

An acquisition in window 4 is essential in areas such as South Dakota and Minnesota to avoid confusion of summer crops such as corn with spring small grains.

**TABLE 3-1.- DESIRED CHARACTERISTICS OF ACQUISITIONS
AS A FUNCTION OF WINDOW**

Window	Description of spring small grains	Product 1 appearance of spring small grains
1	<p>Plowing/planting for spring small grains All spring small grains appear to be bare soil Spring wheat Robertson stage 0.8 to 2.6</p>	<p>Light to dark green, light to dark gray, and black</p>
2	<p>All spring small grains appear to be green vegetation. (Most of the summer crops appear to be bare soil.) Spring wheat Robertson stage 3.8 to 4.5</p>	<p>Red, pink, brown, and orange</p>
3	<p>Spring barley is turned/harvested; spring wheat, oats, and flax appear to be green vegetation. Spring wheat Robertson stage 4.7 to beginning of harvest.</p>	<p>Deep red, reddish brown, brown, orange, pink, yellow, gold, olive, white, gray, and green</p>
4	<p>All spring small grains appear to be turned/harvested.</p>	<p>Light to dark green, light to dark gray, white, yellow, gold, olive, and black</p>



North Dakota	Minnesota	South Dakota	Montana
1394 - 1978 blind site	1518 - 1978 blind site	1687 - Intensive test site	1725 - 1977 and 1978 blind site
1467 - 1978 blind site	1825 - 1977 and 1978 blind site	1755 - 1978 blind site	1948 - 1977 and 1978 blind site
1636 - 1978 blind site	1566 - 1978 blind site	1699 - 1977 blind site	1929 - 1977 blind site
1473 - 1978 blind site			
1650 - 1978 blind site			
1658 - 1978 blind site			

Figure 3-1.- Developmental data set.

4. REFORMATTED SPRING SMALL GRAINS LABELING PROCEDURE

The crop proportion estimation techniques being studied in the U.S./Canada Wheat and Barley Exploratory Experiment require labeled dots. The Reformatted Spring Small Grains Labeling Procedure is designed to be used for assigning crop identification labels to a predetermined and selected number of dots.

The general flow of the steps involved in the procedure is detailed in the diagram in figure 4-1. Following acquisition selection (Step I), the combination of acquisitions and windows available are considered to determine the type of labeling, if any, that can be performed using the procedure.

If the available acquisitions and windows are sufficient for barley separation, the entire procedure can be executed. If no acquisition from window 3 is available, only the spring-small-grain portion (Steps IV through VII) of the procedure can be used.

4.1 ACQUISITION SELECTION

STEP 1 – SELECT ACQUISITION

Using crop calendars for spring wheat and spring barley, determine the opening and closing dates for each of the following four windows.

<u>Window</u>	<u>Open</u>	<u>Closed</u>
1	Spring wheat, 50 percent planted minus 5 days	Spring wheat, 50 percent planted plus 18 days
2	Spring wheat, 50 percent headed minus 10 days	Spring wheat, 50 percent headed plus 10 days
3	Spring barley, 50 percent turning to ripe minus 6 days	Spring barley, 50 percent turning to ripe plus 6 days
4	Spring wheat, 50 percent harvested plus 15 days	Spring wheat, 50 percent harvested plus 30 days

Then, sort all available acquisitions covering the growing season for spring small grains (beginning of planting to one month after the completion of harvest) into these windows.

If available, the window 3 acquisition is to be used as the base acquisition for labeling. If there is no window 3 acquisition, use the window 2 acquisition. If neither of these windows contains an acquisition, the segment is unprocessable.

If more than one acquisition falls within the window, the one closest to the middle of the window is the first choice. If two acquisitions are equidistant from the middle, the latest one is the first choice.

Next, screen the base acquisition for data quality. If the acquisition contains excessive (greater than 40 percent) clouds, cloud shadows, haze, or snow or other problems such as data dropouts and banding, revert to the second choice for the base acquisition. If the data quality on the second choice is unacceptable, revert to the third choice. Continue until a base acquisition with acceptable data quality has been selected or the list of candidates has been exhausted. Acquisitions with light and uniform haze are usually acceptable for processing.

Now, select one acquisition from each of the remaining windows that contain acquisitions. Follow the same procedure and use the same criteria plus registration to the base acquisition within plus or minus one pixel. Do not allow the combined area from all selected acquisitions that are lost to data quality (clouds or shadows) to exceed 40 percent. In each case, if the acquisition fails the data quality test, revert to the second choice, third choice, or until an acceptable acquisition has been found or all possible choices have been rejected.

The decision logic for spring small grains utilizes acquisitions in addition to those previously selected, if available. Acquisitions collected within the time period beginning with the close of window 3 plus 40 percent of the time

between the close of window 3 and the opening of window 4 and ending with the opening of window 4 are considered to be in time period A. This period is graphically described in figure 4-2.

Record the acquisitions selected from the windows and time period A acquisitions on the acquisition recording form, figure 4-3. To determine the number for recording in the acquisition columns on this form, take the last digit of the year (e.g., 8 in 1978) and the number of the day of the year and write together. For example, the number 8124 indicates the 124th day of the year 1978.

4.2 DATA REQUIREMENTS FOR SPRING SMALL GRAINS LABELING

STEP II – CHECK FOR MINIMUM DATA

Refer to the map in figure 4-4 to determine if the combination of windows and acquisitions available meets the minimum requirements for processing. If the combination available is not listed as a processable data set, there are inadequate data for spring small grains labeling using this procedure.

4.3 DATA REQUIREMENTS FOR BARLEY SEPARATION

STEP III – CHECK FOR MINIMUM DATA FOR BARLEY SEPARATION

The barley separation procedure is based on the assumption that barley ripens and is harvested before spring wheat, oats, and flax. The acquisition selection process for selecting the window 3 acquisition is intended to isolate the acquisition where this difference is maximized. Therefore, an acquisition in window 3 is required for this procedure.

4.4 CATEGORIZATION OF DOTS

STEP IV – CATEGORIZE EACH DOT AS PURE, MIXED, MISREGISTERED OR OBSCURED BY CLOUDS, CLOUD SHADOWS, HAZE, OR DATA DROPOUT

Definitions used in this step are:

- a. Pure dot (P) – a dot which is completely within the same field/area on all of the acquisitions selected from windows.

- b. **Mixed dot (M)** – a dot which is only partially within a field/area on the base acquisition.
- c. **Misregistered dot (R)** – a dot which is completely within a field/area on the base acquisition but shifts either partially or completely out of the field/area on one or more of the acquisitions selected from windows.

Using the base acquisition, locate the field/area associated with the dot of interest. If the pixel is not the same color as the field/area that it is associated with, consider the dot to be mixed. For example, in figure 4-5, the dot of interest is associated with field A, a white field. If the pixel at this location appears pink rather than approximately the same color as the other pixels in field A, consider the dot to be mixed.

If the dot is not mixed, apply the same test to the pixel at this location on each of the remaining acquisitions selected from windows. If the dot shifts partially or completely to another field, consider it to be misregistered. If the dot remains completely within the same field/area on all of the acquisitions selected from windows, consider it to be pure.

Record the determination of pure, mixed, or misregistered dots in column 13 of the labeling form as shown in figure 4-6. If the dot is found to be mixed, attempt to locate a pure dot within the associated field/area. If a pure dot cannot be located, attempt to locate a misregistered dot. If a misregistered dot cannot be found, try to find a mixed dot which is more clearly within the field/area.

Record the coordinates of the alternate dot in columns 49 through 55; record the determination of pure, mixed, or misregistered for the alternate dot in column 56. If an alternate dot cannot be selected, leave these columns blank.

If the dot is found to be misregistered, attempt to locate a pure dot within the same field/area. Record the coordinates of this alternate dot in columns 49 through 55 and record a P in column 56. If a pure dot cannot be

located, leave these columns blank. Execute all subsequent steps of the procedure using the alternate dot.

If the field/area on which a dot falls is obscured by clouds, cloud shadows, or haze on any of the acquisitions selected from windows, leave the pure, mixed, or misregistered column (column 13) blank and record a U in the FINAL label column (column 47).

If the field/area on which a dot falls is distorted due to data dropout on any of the acquisitions selected from windows, leave the PURE, MIXED, or MIS-REGISTERED column (column 13) blank and record an X in the FINAL label column (column 47).

4.5 SEPARATION OF PURE DOTS INTO CROPLAND AND NONCROPLAND

STEP V – SEPARATE PURE DOTS INTO CROPLAND OR NONCROPLAND

Using the acquisitions selected from windows, execute the decision logic shown in figure 4-7 for each pure dot and record your responses in columns 15 through 19 of the labeling form as shown in figure 4-8.

If the decision logic indicates that the dot is noncropland, enter a D in the first label column (column 45). If the dot is cropland, leave column 45 blank at this point.

The decision logic in figure 4-7 is a portion of the decision logic for major land-use categories (fig. 4-9) which has been slightly modified for this procedure. The complete decision logic for major land-use categories can be found in appendix B of ref. 4.

REVIEW

IF THERE IS NO WINDOW 2 ACQUISITION, CHECK TO ENSURE THAT THERE ARE NO Y'S IN COLUMN 16.

IF THERE IS A WINDOW 2 ACQUISITION, CHECK TO ENSURE THAT THERE ARE NO N'S IN COLUMN 16.

CHECK TO ENSURE THAT THE SERIES OF RESPONSES FOR EACH PURE DOT IS ONE OF THE FOLLOWING:

Y YY	} Cropland responses	Y YN	} Noncropland responses
Y NN		Y NY	
NNYYY		NY	
NNYNN		NNN	
	NNYYN		
	NNYNY		

4.6 SEPARATION OF PURE CROPLAND DOTS INTO SPRING SMALL GRAINS AND NON-SPRING SMALL GRAINS

STEP VI - SEPARATE PURE CROPLAND DOTS INTO SPRING SMALL GRAINS AND NON-SPRING SMALL GRAINS

For those pure dots determined to be cropland, execute the decision logic in figure 4-10. Those pure cropland dots which meet the green number and brightness criteria for spring small grains on the acquisitions selected from windows are subjected to a final test by requiring that the green number be less than 20 on all acquisitions collected during time period A. If the green number is not usable on one or more of these acquisitions due to misregistration and the green number is less than 20 on those acquisitions which are registered, reserve the dot for labeling along with the mixed and misregistered dots.

Record the green numbers and brightness values which are used in making the decisions in columns 20 through 43 of the labeling form as shown in figure 4-11. Record the labels of S for spring small grains and N for non-spring small grains in column 45.

4.7 LABELING OF MIXED, MISREGISTERED, AND RESERVED DOTS

STEP VII – LABEL MIXED, MISREGISTERED, AND RESERVED DOTS BY COMPARING TO PURE DOTS

On an overlay placed on the base acquisition, delineate and annotate enough of the fields/areas associated with dots which have been labeled D, N, or S to provide a representative cross section of each class. Compare the imagery appearance of each field/area associated with a mixed, misregistered, or reserved dot to the annotated fields/areas and select the field/area which is most similar in temporal appearance. (Use Product 1 or Product 3 as determined by criteria described in reference 4.) Record the label of the selected field/area for the mixed, misregistered, or reserved dot. Label reserved dots as either N or S. Record the labels in column 45 of the labeling form as shown in figure 4-12.

REVIEW

CHECK TO ENSURE THAT D, N, OR S IS IN COLUMN 45 FOR EACH DOT NOT OBSCURED BY CLOUDS, HAZE, SHADOW, OR DATA DROPOUT.

4.8 INITIAL LABELING OF SPRING-SMALL-GRAIN DOTS

STEP VIII – LABEL EACH SPRING-SMALL-GRAIN DOT AS B, S, Q, OR V

In column 46 of the labeling form, record one of the following labels for each spring small grain dot (fig. 4-13).

<u>Dot label</u>	<u>Definition</u>
B (barley)	This dot is spring small grains in the more advanced growth stages. The colors are bright pink, bright yellow, bright gold, bright tan, bright white, bright gray, bright green, and gray black on acquisition from window 3.
S (spring wheat, oats, and flax)	This dot is spring small grains in the least advanced stages. The colors are red, brown, reddish brown, olive green, gold, tan, or dirty gray on acquisition from window 3.

Dot label

Definition

Q

This dot is spring small grains that appear to be between the groups labeled B and S. Some spring wheat and oat fields may be at the soft dough or ripe stages as illustrated in figure 4-14. They will not have a bright appearance but otherwise may be confused with barley. Dots which fall into fields such as this should be labeled Q.

V

This dot is spring small grains that are determined to be mixed unless they are associated with a field containing a dot labeled B or S. If the dot is associated with a field containing a dot labeled B or S, it should receive the same label as the pure dot.

REVIEW

CHECK TO ENSURE THAT EACH SPRING-SMALL-GRAIN DOT (S IN COLUMN 45) IS LABELED B, S, Q, OR V IN COLUMN 46.

4.9 SCATTER PLOT GENERATION

STEP IX — GENERATE A GREEN NUMBER VERSUS BRIGHTNESS SCATTER PLOT OF THE B, S, Q, AND V DOTS USING THE WINDOW 3 ACQUISITION

Using the labels from column 46 of the labeling form, generate a green number versus brightness scatter plot using the window 3 acquisition. If a window 2 acquisition is available, request green number versus brightness trajectory plots using the acquisitions from windows 2 and 3. (Additional acquisitions up to a total of six may be included for the trajectory plots.)

The relationship between the location of a dot on the scatter plot and the imagery color/growth stage is generally as shown in figure 4-14. The barley dots will fall to the right of the decision line and be widely scattered. The other spring small grains will form a relatively tight cluster in the region noted as late headed to ripe for S dots.

4.10 DETERMINATION OF DECISION LINE

STEP X — DETERMINE DECISION LINE

If there are B and S dots, construct a line on the scatter plot of the form $GN = 1.1 BR + \text{constant}$ through the S dot where the constant is a minimum and no pure B dots fall to the left of the line (Line A). Construct a line of the form $GN = 1.1 BR + \text{constant}$ through the B dot where the constant is a maximum and no pure S dots fall to the right of the line (Line B).

If the location of the dots is such that a line cannot be constructed, re-examine the image appearance of the dot(s) which prevent construction of the line. If the original label(s) were in error, change the label(s) and continue. If the original labels are confirmed, place the line just to the right of the rightmost S dot in the case of Line B or just to the left of the leftmost B dot in the case of Line A.

If a window 2 acquisition is available, green number versus brightness trajectory plots will be used to assist in determining the decision line. Generally in the time period from window 2 to window 3, barley dots become less green but brighter. The dot drift or direction of movement on the trajectory plot will be down and to the right. During this same period, dots of spring wheat and oats become less green and less bright. The dot drift will be down and to the left.

If a window 2 acquisition is available, transfer the dot drift from the green number versus brightness trajectory plots to the scatter plot for each dot between Lines A and B. Place the decision line parallel to and between Lines A and B such that dots having different drift characteristics are separated. An example of this is shown in figure 4-15.

If a window 2 acquisition is not available, place the decision line between and parallel to lines A and B such that (a) no dots to the right of the line appear to group with the S dots and (b) dots to the right of the line are widely scattered as opposed to the closer knit group to the left of the line. This technique is illustrated in figure 4-16.

If no dots were labeled B, construct Line A. If a window 2 acquisition is available, check the dot drift of dots which fall to the right of the line to determine if they behave more like barley (increase in brightness with a decrease in green number) or spring wheat (decrease in brightness with a decrease in green number). Use the dot drift (scattering as opposed to clustering) and characteristics depicted in figure 4-14 to determine if Line A should be the decision line or if it should be to the right of and parallel to Line A. If no dots were labeled S, construct Line B. Use the same technique described above to determine if Line B should be the decision line or whether it should be placed to the left of and parallel to Line B.

4.11 RELABELING OF DOTS

STEP XI - RELABEL DOTS ACCORDING TO LOCATION OF DECISION LINE

For all S dots which fall to the left of the line and for all B dots which fall to the right of the line, transfer the labels from column 46 to column 47 of the labeling form.

Relabel all Q and V dots which fall to the right of the decision line as B in the FINAL label column. Relabel all Q and V dots which fall to the left of the decision line as S in the FINAL label column.

Reexamine the image appearance to see if the original interpretation can be confirmed for any pure B dots which fall to the left of the line and any pure S dots which fall to the right of the line.

Record the final labels on the labeling form in column 47 as shown in figure 4-17.

REVIEW

CHECK TO ENSURE THAT EACH SPRING-SMALL-GRAIN DOT (S IN COLUMN 45) IS LABELED B OR S IN THE FINAL LABEL COLUMN (COLUMN 47).

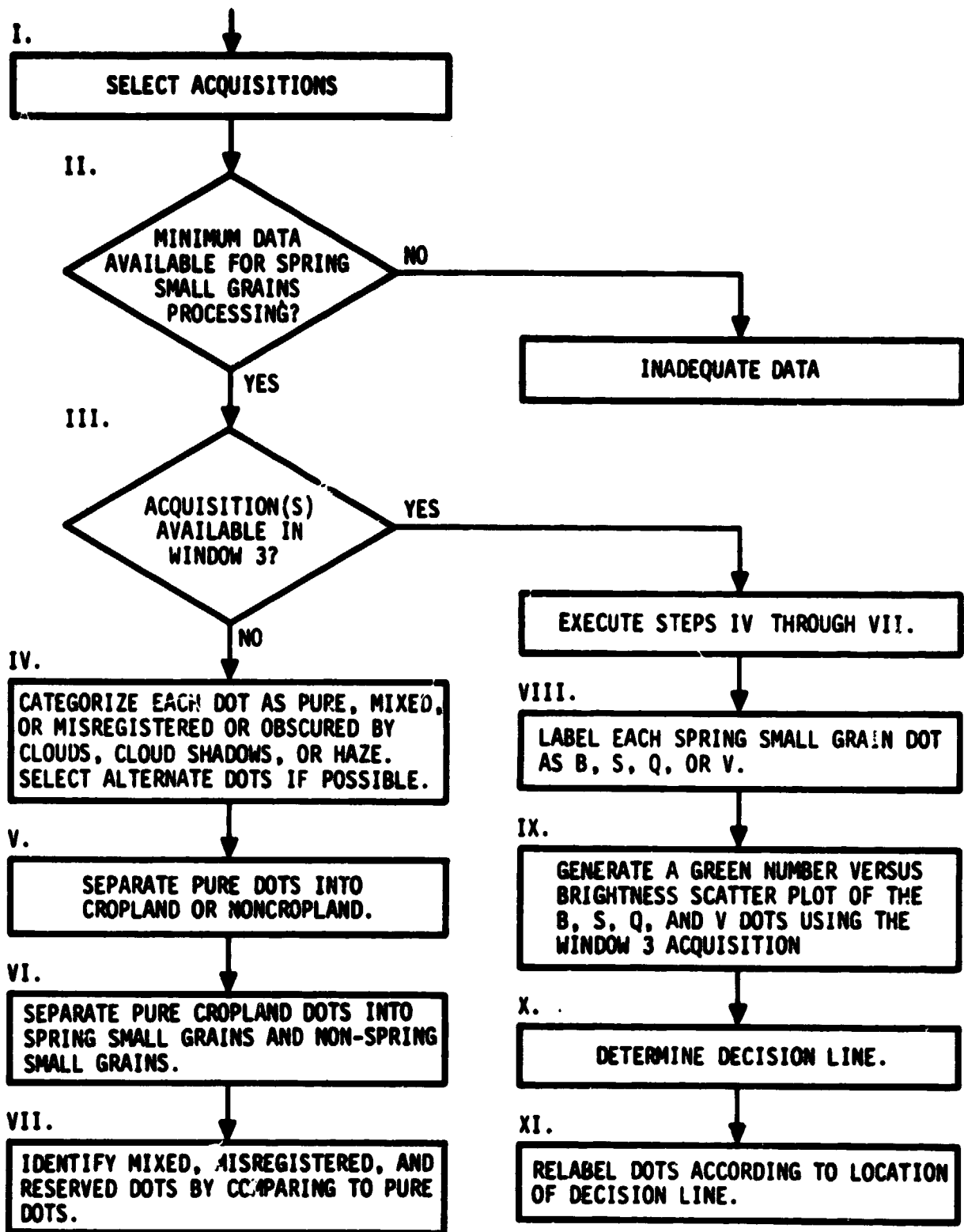
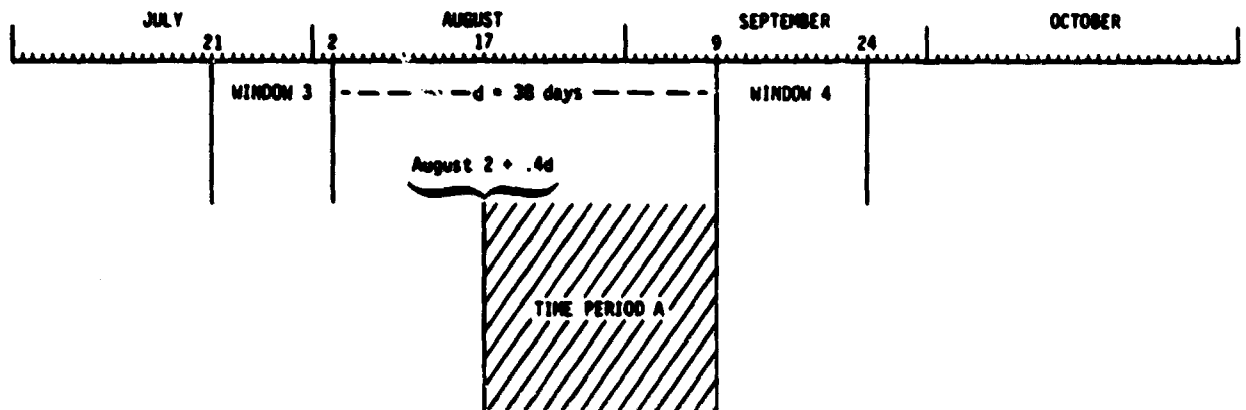
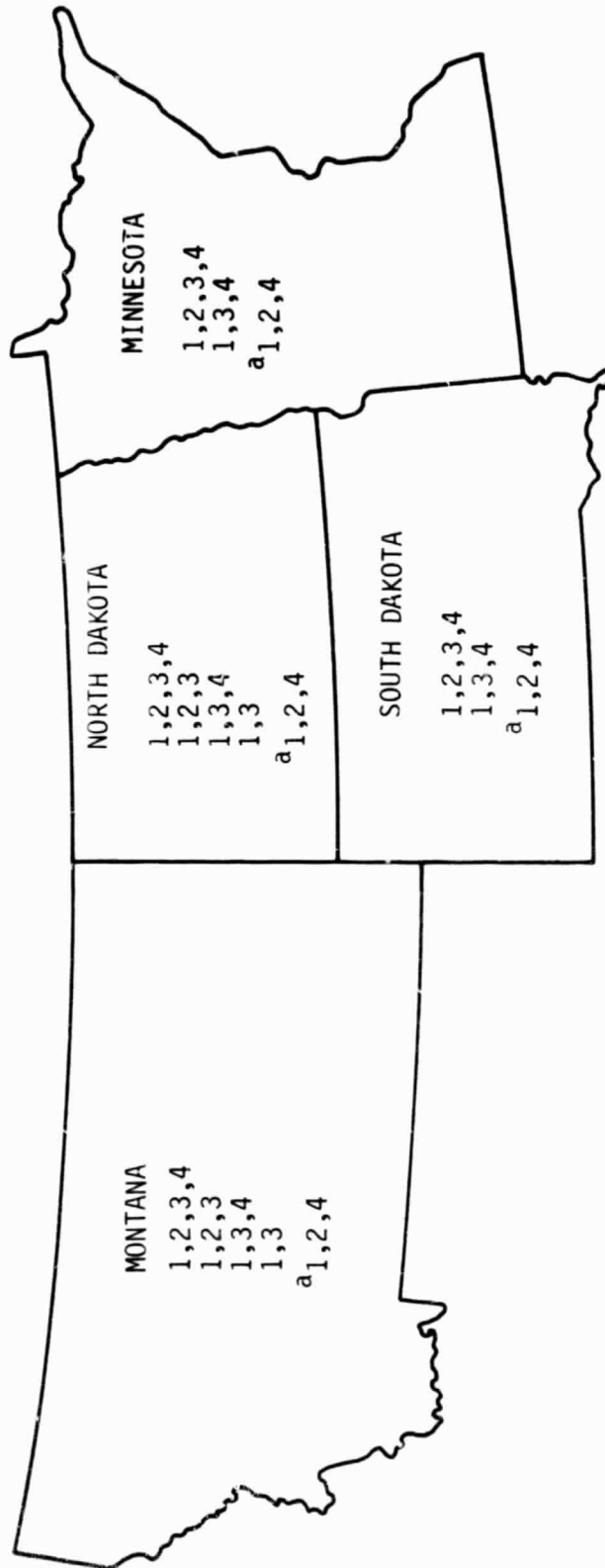


Figure 4-1.- The flow diagram of the reformatted spring small grains labeling procedure.



Time period A begins with a date calculated as follows: the date of the close of window 3 plus 40 percent of the number of days between the close of window 3 and the opening of window 4. For example: window 3 closes on August 2, and window 4 opens on September 9. There are 38 days between these two dates, and 40 percent of 38 equals 15 days. August 2 plus 15 days equals August 17 which is the start of time period A in this case. Time period A ends with the opening of window 4.

Figure 4-2.- Graphical description of the determination of time period A.



^a Inadequate for barley separation, spring small grains labeling only

Figure 4-4.- Processable data sets.

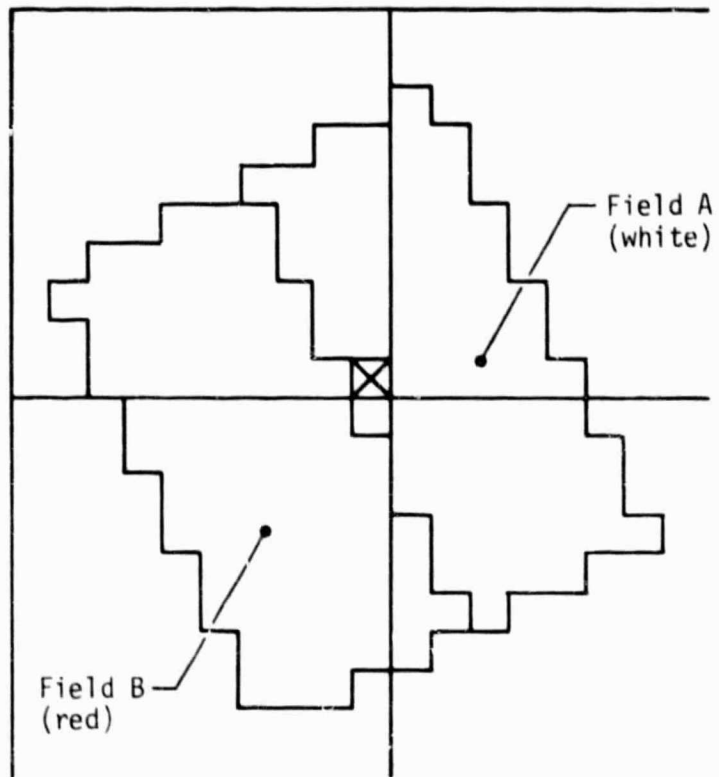


Figure 4-5.- Relationship between a dot and a field.

DOT NUMBER	LINE	PIXEL	P M OR R	I				GR ₁	GR ₂	GR ₃	GR ₄	II			LABEL L L L OR M R	III		IV	SEGMENT NUMBER
				1	2	3	4					5	6	7		LINE	PIXEL		
1	5	10		15	20	25	30	35	40	45	50	55	60						
1	10	10	P														1,825		
2	10	20	M												8	18R			
3	10	30	R																
4	10	40	P																
5	10	50	P																
6	10	60	P																
7	10	70	R																
8	10	80	R																
9	10	90	M											11	93P				
10	10	100	M											9	101M				
11	10	110	P																
12	10	120	P																
13	10	130	P																
14	10	140	R																
15	10	150												U					
16	10	160	R																
17	10	170	R																
18	10	180	P																
19	10	190	P																
SPRING SMALL GRAINS CRITERIA								≤10	≥8	≥8	≥50	≤13	<20						

LEGEND:

- I - RESPONSES TO QUESTIONS FROM DECISION LOGIC FOR MAJOR LAND USE CATEGORIES
- II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS
- III - COORDINATES OF ALTERNATE DOT
- IV - ALTERNATE DOT P, M, OR R

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4-6.- Recording of pure, mixed, and misregistered dots.

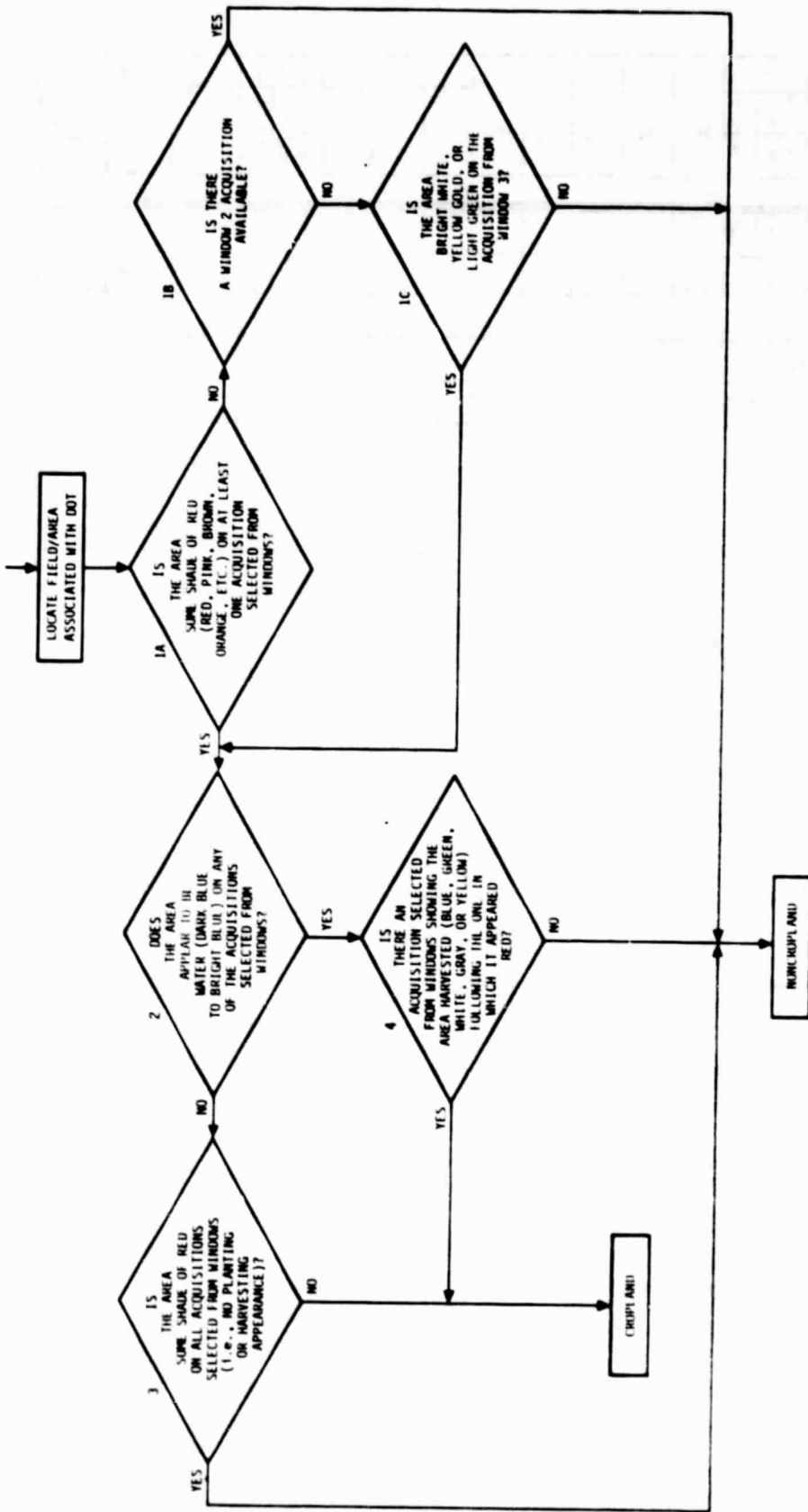


Figure 4-7.- Decision logic for cropland and noncropland.

DOT NUMBER	LINE	PIXEL	P M OR R	I				GN ₁	GN ₂	GN ₃	GN ₄	II			L A B E L P R O V I D E D	III		IV	SEGMENT NUMBER
				1a	1b	1c	2					1	2	3		LINE	PIXEL		
1	5	10		15	20	25	30	35	40	45	50	55	60						
1	10	10	P	Y	YY												1825		
2	10	20	M													8	18R		
3	10	30	R																
4	10	40	P	NY										D					
5	10	50	P	Y	NN														
6	10	60	P	Y	YY														
7	10	70	R																
8	10	80	R																
9	10	90	M	Y	NN										11	93P			
10	10	100	M												9	101M			
11	10	110	P	Y	NY									D					
12	10	120	P	Y	NY									D					
13	10	130	P	Y	NN														
14	10	140	R																
15	10	150												U					
16	10	160	R																
17	10	170	R																
18	10	180	P	Y	NN														
19	10	190	P	Y	YY														

SPRING SMALL GRAINS CRITERIA

$\leq 10 \geq 8 \geq 8 \geq 50 \leq 13 < 20$

LEGEND:

I - RESPONSES TO QUESTIONS FROM DECISION LOGIC FOR MAJOR LAND USE CATEGORIES

II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS

III - COORDINATES OF ALTERNATE DOT

IV - ALTERNATE DOT P, M, OR R

Figure 4-8.- Recording of responses from cropland decision logic.

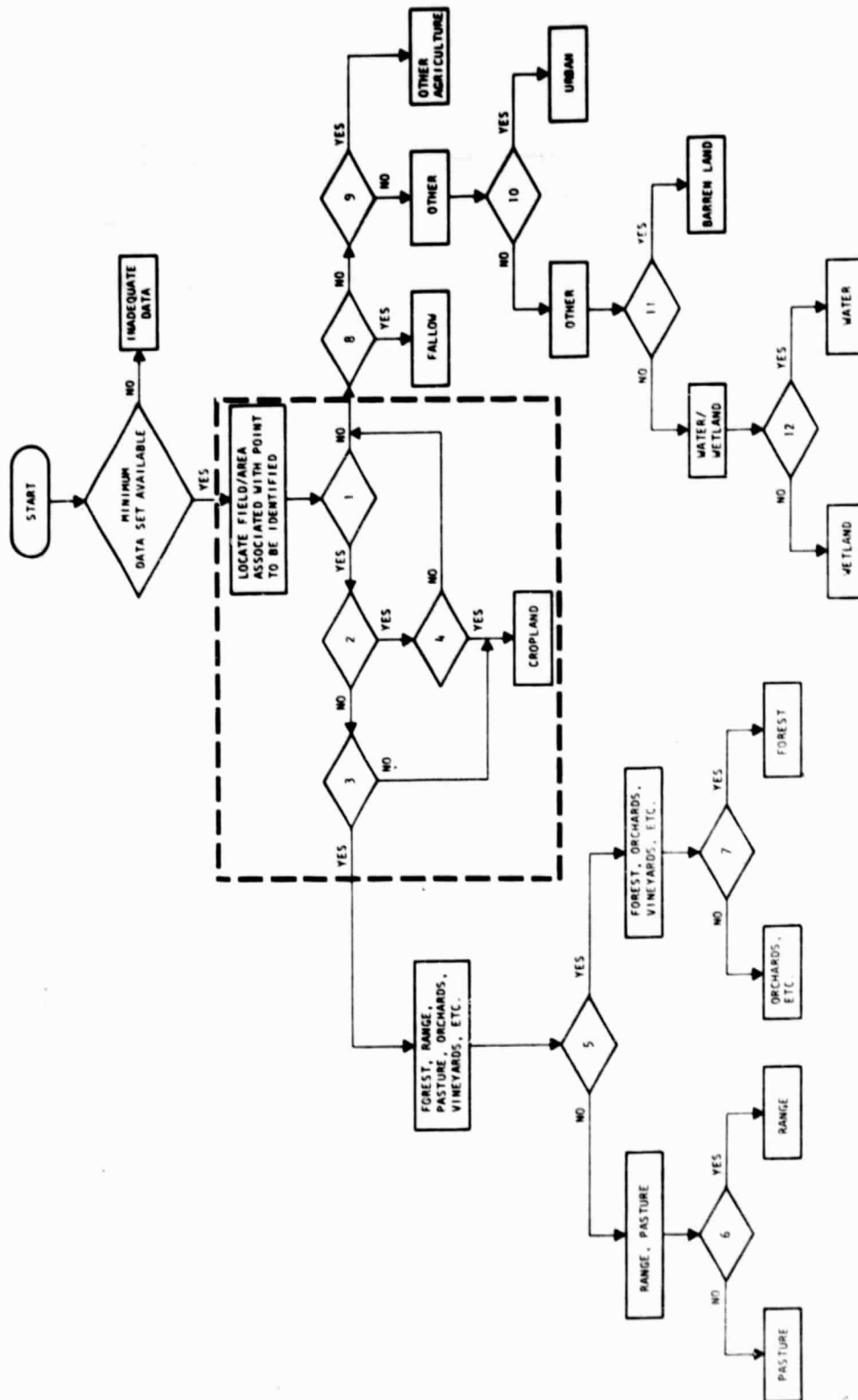


Figure 4-9.- Diagram of decision tree for major land-use categories.

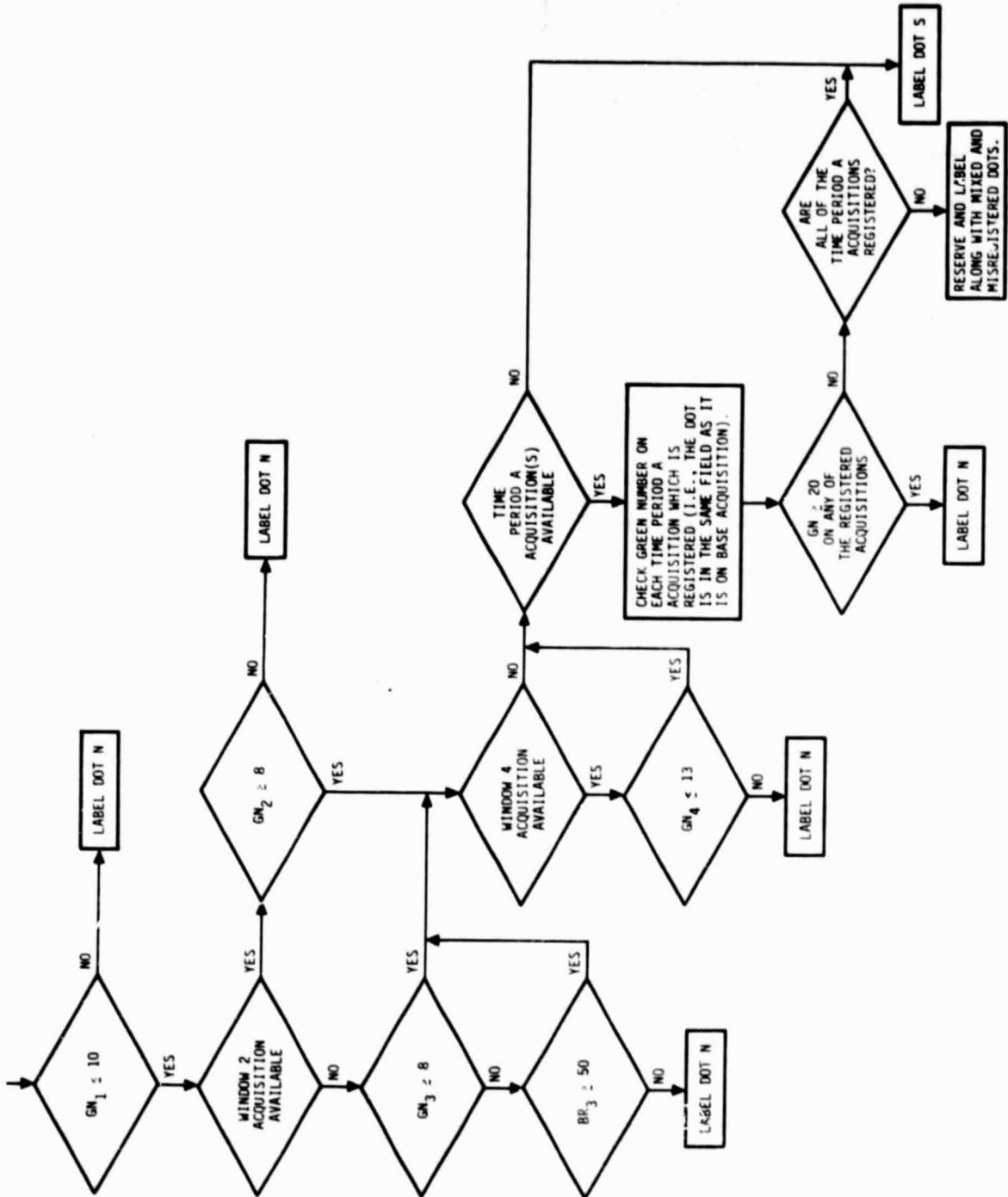


Figure 4-10.- Decision logic for pure cropland dots.

DOT NUMBER	LINE	PIXEL	P	I				GR ₁	GR ₂	GR ₃	GR ₄	II			LABEL	III		IV	SEGMENT NUMBER
				1	2	3	4					5	6	7		8	9		
1	5	10		14	15	16	17	20	25	30	35	40	45	50	55	60			
.1	10	10	P	Y	YY	-1	1	22				5	17	17	9	S			1825
.2	10	20	M														B	18R	
.3	10	30	R																
.4	10	40	P	NY												D			
.5	10	50	P	Y	NN		15									N			
.6	10	60	P	Y	YY		6	14				10	25			N			
.7	10	70	R																
.8	10	80	R																
.9	10	90	M	Y	NN		5	35				9	15	12	9	S	11	93P	
.10	10	100	M														9	101M	
.11	10	110	P	Y	NY											D			
.12	10	120	P	Y	NY											D			
.13	10	130	P	Y	NN		7	18				12	19	22		N			
.14	10	140	R																
.15	10	150															U		
.16	10	160	R																
.17	10	170	R																
.18	10	180	P	Y	NN		8	28				3	16	16	10	S			
.19	10	190	P	Y	YY		0	30				8	12	11	9	S			

SPRING SMALL GRAINS CRITERIA $\leq 10 \geq 8 \geq 8 \geq 50 \leq 13 < 20$

- LEGEND:
- I - RESPONSES TO QUESTIONS FROM DECISION LOGIC FOR MAJOR LAND USE CATEGORIES
 - II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS
 - III - COORDINATES OF ALTERNATE DOT
 - IV - ALTERNATE DOT P, M, OR R

Figure 4-11.- Recording of pure cropland dots as spring small grains or non-spring small grains.

DOT NUMBER	LINE	PIXEL	P	I					GR ₁	GR ₂	GR ₃	GR ₄	II			L	R	M	N	III		IV	SEGMENT NUMBER
				1	2	3	4	5					6	7	8					9	10		
1	10	10	P	Y	YY	1	22					5	17	17	9	S							1825
2	10	20	M													S				8	18R		
3	10	30	R													D							
4	10	40	P	NY												D							
5	10	50	P	Y	NN	15										N							
6	10	60	P	Y	YY	6	14					10	25			N							
7	10	70	R													N							
8	10	80	R													S							
9	10	90	M	Y	NN	5	35					9	15	12	9	S			11	93P			
10	10	100	M													N			9	101M			
11	10	110	P	Y	NY											D							
12	10	120	P	Y	NY											D							
13	10	130	P	Y	NN	7	18					12	19	22		N							
14	10	140	R													D							
15	10	150																					
16	10	160	R													S							
17	10	170	R													N							
18	10	180	P	Y	NN	8	28					3	16	16	10	S							
19	10	190	P	Y	YY	0	30					8	12	11	9	S							
SPRING SMALL GRAINS CRITERIA							≤10	≥8	≥8	≥50	≤13	<20											

LEGEND:

- I - RESPONSES TO QUESTIONS FROM DECISION LOGIC FOR MAJOR LAND USE CATEGORIES
- II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS
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- IV - ALTERNATE DOT P, M, OR R

Figure 4-12.- Recording of mixed, misregistered, and reserved dots as D, S, or N.

DOT NUMBER	LINE	PIXEL	P	M	R	I					II			LABEL	III		IV	SEGMENT NUMBER	
						1	2	3	4	5	6	7	8		9	10			11
1	5	10				15	20	25	30	35	40	45		50	55	60			
1	10	10	P	Y	YY	1	22			5	17	17	9	SB			1825		
2	10	20	M											SS	B	18R			
3	10	30	R											D					
4	10	40	P	NY										D					
5	10	50	P	Y	NN	15								N					
6	10	60	P	Y	YY	6	14			10	25			N					
7	10	70	R											N					
8	10	80	R											SQ					
9	10	90	M	Y	NN	5	35			9	15	12	9	SB	11	93P			
10	10	100	M											N	9	101M			
11	10	110	P	Y	NY									D					
12	10	120	P	Y	NY									D					
13	10	130	P	Y	NN	7	18			12	19	22		N					
14	10	140	R											D					
15	10	150												U					
16	10	160	R											SS					
17	10	170	R											N					
18	10	180	P	Y	NN	8	28			3	16	16	10	SQ					
19	10	190	P	Y	YY	0	30			8	12	11	9	SB					

SPRING SMALL GRAINS CRITERIA ≤ 10 ≥ 8 ≥ 8 ≥ 50 ≤ 13 < 20

LEGEND:

- I - RESPONSES TO QUESTIONS FROM DECISION LOGIC FOR MAJOR LAND USE CATEGORIES
- II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS
- III - COORDINATES OF ALTERNATE DOT
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Figure 4-13.- Recording of labels for scatter plot generation.

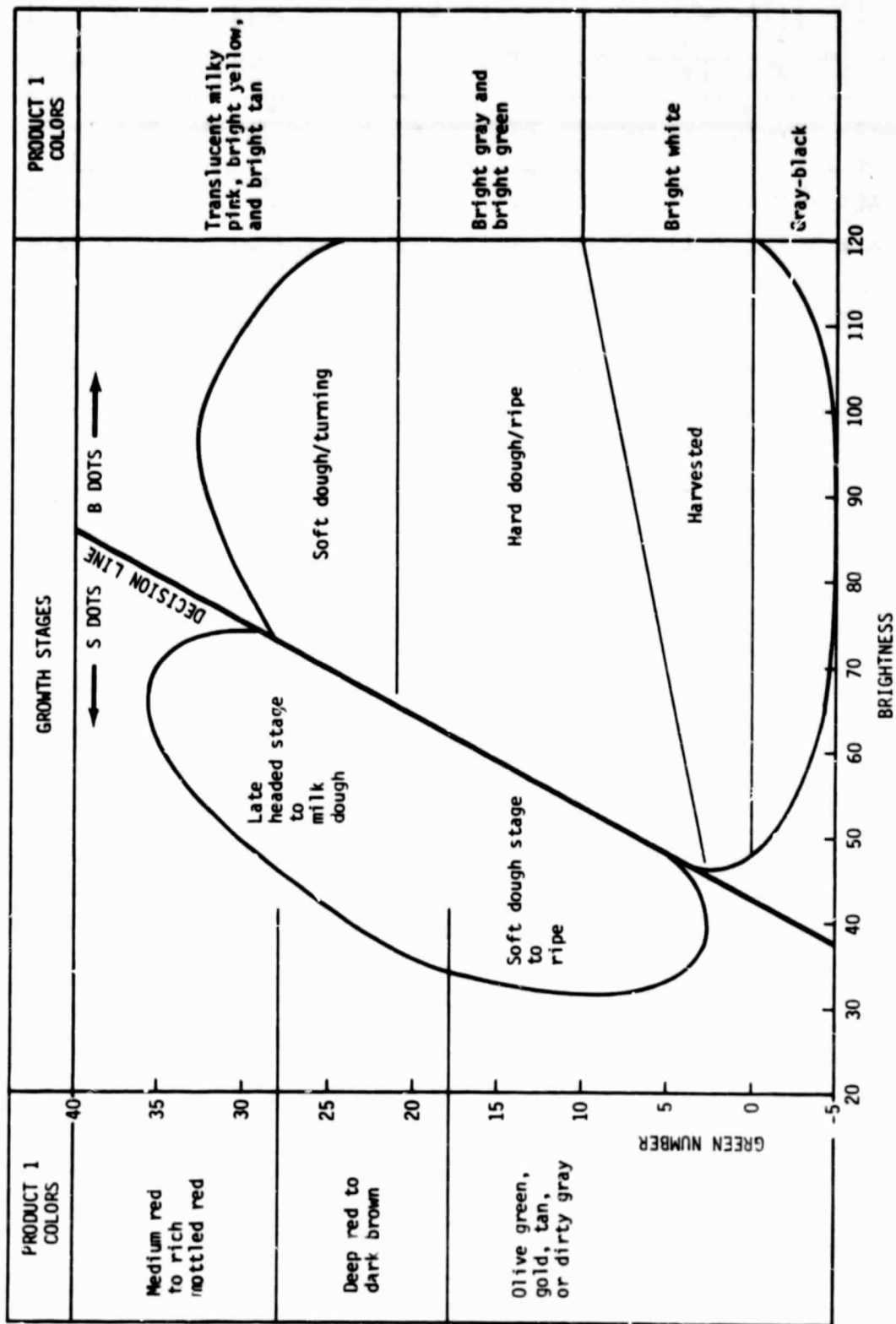
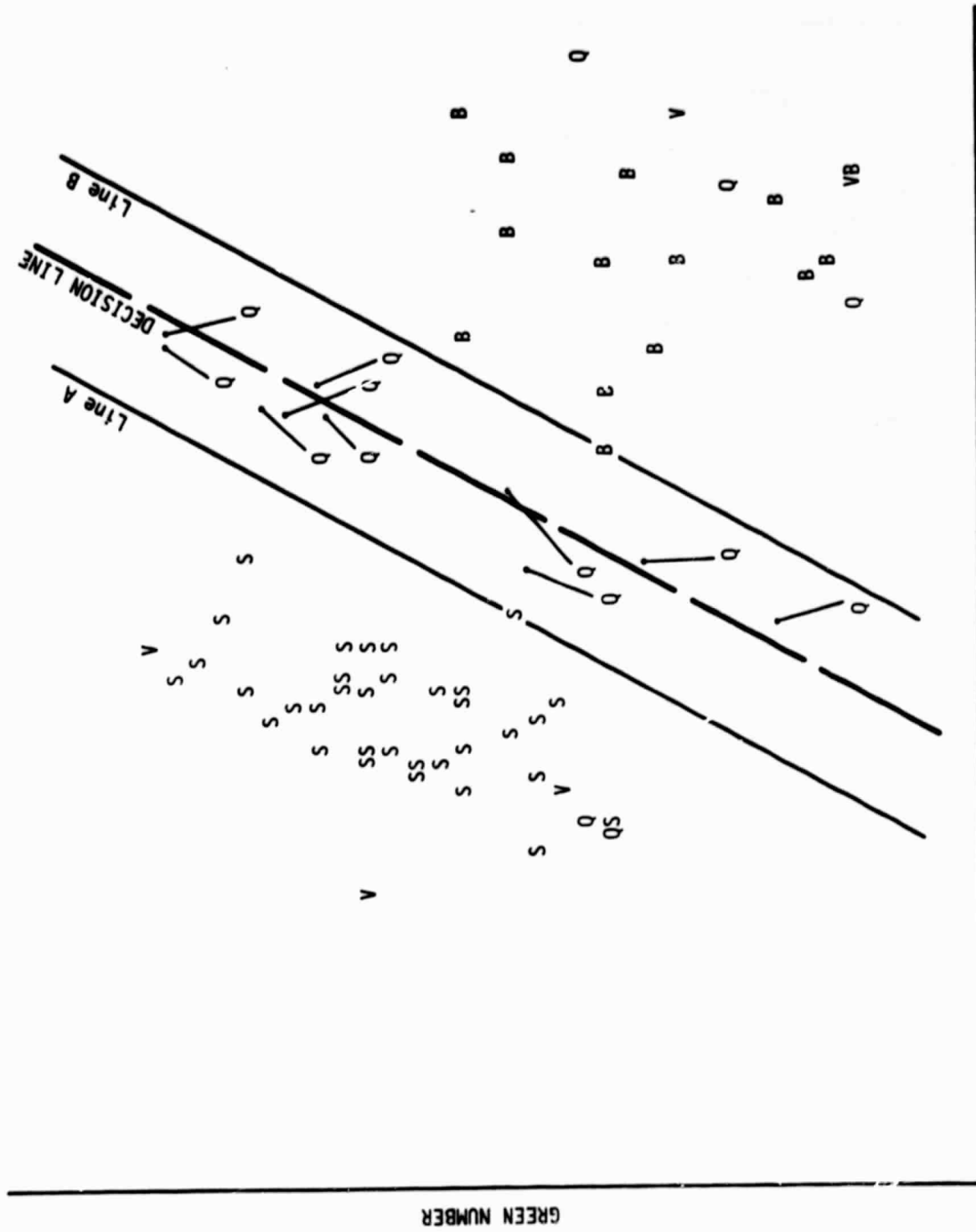


Figure 4-14.- General relationship between image appearance/growth stage and location on the scatter plot generated from window 3 acquisition.



BRIGHTNESS

Figure 4-15.- Illustration of the use of dot drift characteristics to determine decision line.

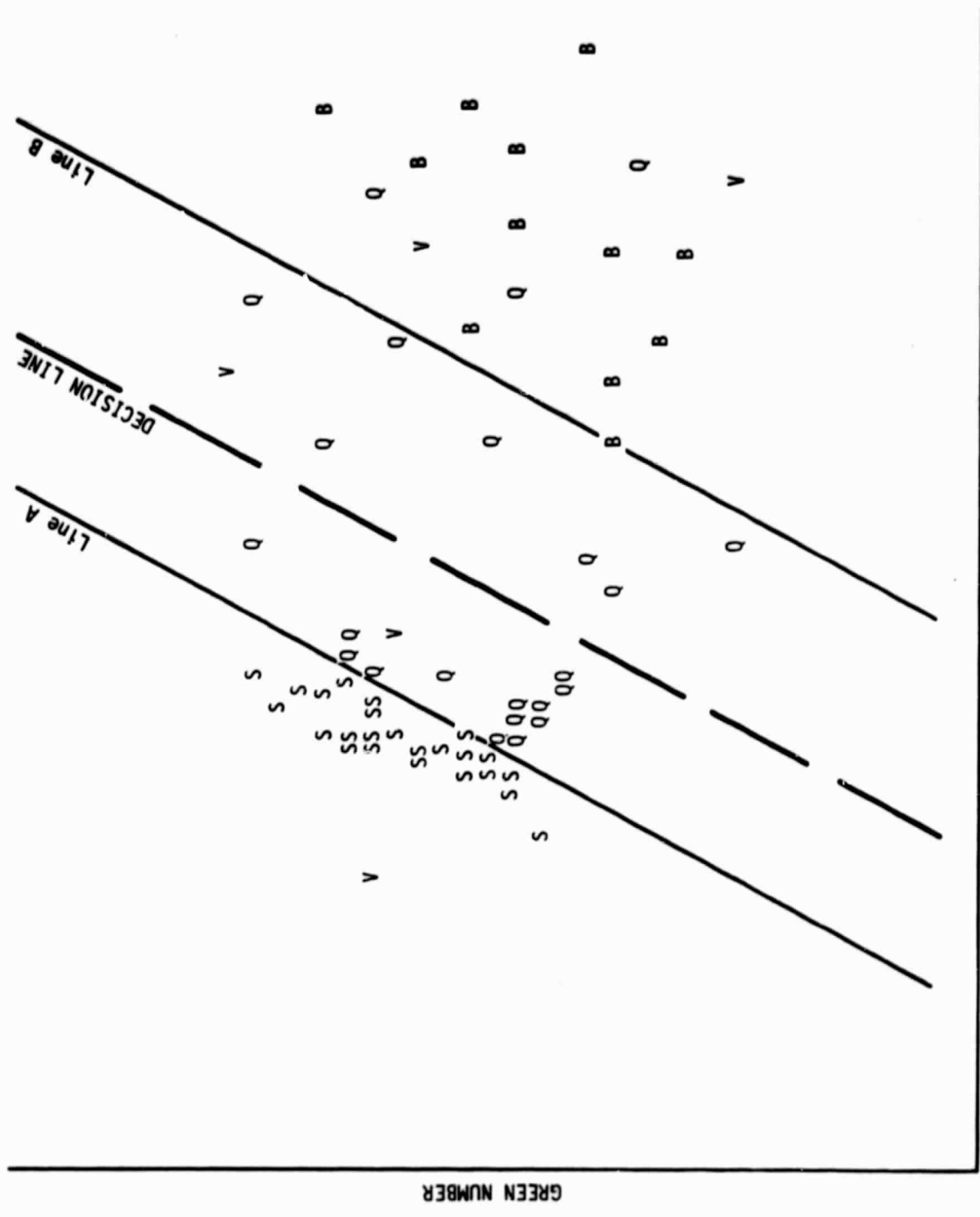


Figure 4-16.- An illustration of the determination of the decision line without a window 2 acquisition.

GREEN NUMBER

BRIGHTNESS

DOT NUMBER	LINE	PIXEL	P	I				GR ₁	GR ₂	GR ₃	GR ₄	II			LABEL	III		IV	SEGMENT NUMBER
				1	2	3	4					5	6	7		LINE	PIXEL		
1	5	10		14	15	16	17	20	25	30	35	40	45	50	55	60			
1	10	10	P	Y	YY	-1	1	22				5	17	17	9	SBB		1825	
2	10	20	M													SSS	B	18R	
3	10	30	R													D			
4	10	40	P	NY												D			
5	10	50	P	Y	NN	15										N			
6	10	60	P	Y	YY	6	14				10	25				N			
7	10	70	R													N			
8	10	80	R													SQB			
9	10	90	M	Y	NN	5	35				9	15	12	9	SBB	11	93P		
10	10	100	M													N	θ	101M	
11	10	110	P	Y	NY											D			
12	10	120	P	Y	NY											D			
13	10	130	P	Y	NN	7	18				12	19	22			N			
14	10	140	R													D			
15	10	150															U		
16	10	160	R													SSS			
17	10	170	R													N			
18	10	180	P	Y	NN	8	28				3	16	16	10	SQS				
19	10	190	P	Y	YY	0	30				8	12	11	9	SBB				

SPRING SMALL GRAINS CRITERIA $\leq 10 \geq 8 \geq 8 \geq 50 \leq 13 < 20$

LEGEND:

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- II - GREEN NUMBERS FROM TIME PERIOD A ACQUISITIONS
- III - COORDINATES OF ALTERNATE DOT
- IV - ALTERNATE DOT P, M, OR R

Figure 4-17.- Recording of final labels.

5. REFERENCES

1. U.S./Canada Wheat and Barley Exploratory Labeling Experiment Implementation Plan. NASA/JSC, JSC-16336, January 1980.
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4. Detailed Analyses Procedures for the Transition Project (FY79). NASA/JSC, JSC-13756 (LACIE-00724), May 1979.
5. Kauth, R. J. and Thomas, G. S.: The Tasselled Cap - A Graphic Description of the Spectral-Temporal Development of Agricultural Crops as Seen by Landsat. Proceedings of the Tenth Annual Symposium on Remote Sensing of the Environment; Ann Arbor, Michigan; October 1975.
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7. Wehmanen, O. A.: The Structure of Landsat Data for Wheat-Growing Regions. LEC-13015, December 1978, [presented at the American Association for the Advancement of Science (Houston, Texas) January 1979].