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LACIE-00412
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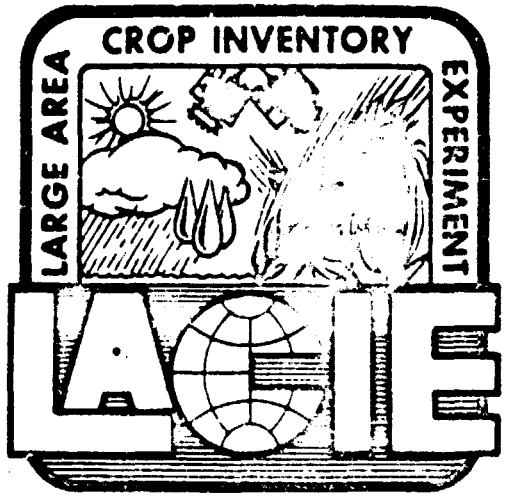
LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)



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SPECTRAL SIGNATURES OF SELECTED CROPS OBTAINED FROM LANDSAT MULTISPECTRAL SCANNER DATA

(E79-10118) LARGE AREA CROP INVENTORY EXPERIMENT (LACIE). SPECTRAL SIGNATURES OF SELECTED CROPS OBTAINED FROM LANDSAT MULTISPECTRAL SCANNER DATA (NASA) 27 p HC A03/MF A01 CSCL 02C G3/43

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SPECTRAL SIGNATURES OF SELECTED CROPS OBTAINED FROM LANDSAT MULTISPECTRAL SCANNER DATA

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October, 1975

SPECTRAL SIGNATURES OF SELECTED CROPS

OBTAINED FROM LANDSAT MULTISPECTRAL SCANNER DATA

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SPECTRAL SIGNATURES OF SELECTED CROPS OBTAINED FROM LANDSAT MULTISPECTRAL SCANNER DATA

1. Introduction

Landsat MSS (Multispectral Scanner) data were obtained over Finney County, Kansas and Hill County, Montana during portions of the 1973 and 1974 growing seasons. After displaying these data on the Aerojet DAS (Data Analysis Station) equipment, specific test fields of a few known crops were selected for histogram analyses. Coordinates for these fields were obtained by examination of DAS-produced gridded imagery, and then checked by displaying each field on the DAS television monitor. Histogram statistics were obtained and plotted for the following crops:

1. Finney County, Kansas on May 8, May 26 and July 1, 1974 for:
   a. Ten (10) winter wheat fields
   b. Six (6) alfalfa fields
   c. Seven (7) corn fields
   d. Seven (7) fallow fields
2. Hill County, Montana on May 23, June 10, June 27 and July 16, 1973, for:
   a. Nine (9) winter wheat fields
   b. Thirteen (13) spring wheat fields
   c. Seven (7) barley fields

2. Procedures

The radiance values for each picture element (Pixel) in each field were obtained from the histogram printouts and tabulated preparatory to plotting the values as signature curves. Because different size fields having different numbers of pixels were involved in this tabulation, it was deemed desirable to obtain a radiance value curve for what could be considered a composite or average field for each crop. This was accomplished by obtaining the sum of all pixels with the same radiance value in all of the test

fields for each crop. This sum was then divided by the total number of pixels involved for each crop to give a percentage of pixels assigned each radiance value for each crop. The relatively small number of pixels covering each field (10 to 100 pixels selected near the center of the field) meant that in some instances some radiance values contained no pixels within the normal range of values for each crop. This caused the plotted curves to contain numerous confusing peaks and valleys. To smooth the curves and eliminate the undesirable multi-nodal characteristics of the curves, the percentage of pixels assigned to each radiance value was recalculated to give a running average percentage for three adjacent radiance values. Smoothing of three adjacent radiance values was selected after comparing curves obtained from plotting percentages of raw data with those obtained by calculating running averages of five adjacent radiance values. The running average of three adjacent radiance values appeared to be a good compromise between the excessive multi-nodal curves of raw data and the excessive smoothing obtained when five radiance values were averaged.

Some caution must be exercised in analyzing the curves for Finney County. Winter wheat had already been harvested when the July 1 coverage was obtained. Therefore, only the curves for May 8 and May 26 are representative of wheat during its growth cycle. Likewise, the frequent cutting and regrowth of alfalfa during the growing season caused great variations in radiance values to occur in the same alfalfa fields over the three dates of data collection. Available ground truth was not sufficient to permit fields of recently-cut alfalfa to be separated from luxuriant growing alfalfa in constructing the composite alfalfa signature. Also the ground truth was not detailed enough to provide an explanation for many of the anomalies which were observable when the various curves were compared.

To avoid undue delay in making these signature curves available to other analysts, no attempt was made to make an exhaustive analysis

of the relationship of the individual curves to any current wheat classification effects. It is hoped that the general nature of this study will serve to direct the attention of other analysts to using these curves for possible clues in explaining any wheat classification anomalies they may have encountered in their more detailed research.

3. Observations

The following general observations were noted when a cursory comparison of the graphics accompanying this report was made for each county. Latitudinal differences between the counties suggested that the greatest similarity in crop development in the two counties would be observable by comparing Finney County curves for May 8 and May 26 with Hill County curves for June 10 and June 27, respectively.

3.1. Finney County versus Hill County

1. The radiance values recorded by MSS Bands 5 and 6 extend over a greater range of values than those recorded by MSS Bands 4 and 7.

2. The predominant radiance values for winter wheat in Finney County were considerably lower than those in Hill County. Since the values were lower for all MSS Bands, it is suspected that the differences in sun angles, atmospheric conditions and color of soils probably would be among the major variables contributing to the overall differences in radiance values between the two counties.

3. Although smoothing was done, the curves plotted from the MSS Band 6 data over Finney County appear to be much more multi-nodal than the curves plotted from data from the other Bands. This difference in roughness of the curves does not occur in the curves plotted from the Hill County data, except that some of the curves from Band 4 data have a few more peaks and valleys than do the other curves.

4. With few exceptions the curves for the two counties rarely resembled the bell-shaped normal curve. In general, the slope of the curve was steeper on one side than on the other. In the case of Finney County most of the curves had a steep slope for the low radiance values and then a gradual trailing off toward the higher radiance values. This is in contrast to the curves of Hill County where the high radiance value side of the curve seemed to have the steepest slope. No explanation can be suggested for these phenomena.

5. Since winter wheat was the only crop common to the two counties, special note should be made of the slight similarities of the winter wheat curves for MSS Bands 4 and 5 for May 8 (Finney County) and June 10 (Hill County) and for May 26 (Finney County) and June 27 (Hill County). The curves for Band 5 appear to have the most pronounced bi-nodal shapes, particularly for the two earlier dates. It is suspected that this tendency to be bi-nodal in the visible spectrum at this particular growth stage is the result of more soil being integrated into the vegetative signature than would occur at a later date. No explanation is suggested here why this bi-nodal shape should also occur on the curves for the infrared Bands 6 and 7 for May 26 (Finney County), but not on the curves for the comparable dates for Hill County.

More specific observations were noted when the curves for each crop were compared for each county separately.

3.2 Finney County

The following observations apply to the signature curves of Finney County only:

1. The winter wheat curves for MSS Bands 4 and 5 remain in the same relative position along the scale of radiance values for May 8 and May 26 with the predominant radiance values for Band 5 being lower than Band 4. However, on July 1, after the wheat has been harvested, the predominant radiance values for Band 5 are higher than Band 4.

2. A comparison of the winter wheat curves for MSS Bands 6 and 7 for the same dates reveals that the predominant radiance values for both bands decrease from May 8 to May 26 with the largest shift in values occurring in Band 6. However, it should be emphasized that the radiance values of the raw Landsat data for Band 7 are compressed by a factor of two. Therefore, if the curves were to be plotted in their true positions on the radiance value scale, the decreases in values between May 8 and May 26 would be approximately the same for both bands.

3. While the relative positions between the winter wheat curves for MSS Bands 4 and 5 remain the same between May 8 and May 26, the curves for MSS Bands 6 and 7 both shift to lower values and take on a bi-nodal appearance. By harvest time (July 1) both curves have returned to very similar positions and shapes as they had on May 8. The lower infrared radiance values for May 26 probably indicates the lower amount of chlorophyll in the wheat plant as it approaches the ripe stage.

3.2.1 Winter wheat versus alfalfa, corn and fallow (Finney County)

When the winter wheat curves for the various dates and MSS Bands were compared with those of alfalfa and corn, the following observations were noted:

1. The predominant radiance values for wheat and alfalfa are practically the same for MSS Bands 4 and 5 for May 8 and May 26, except that the range of values for alfalfa becomes much smaller on May 26. Also, the wheat curve for Band 5 is bi-nodal in appearance for both dates. As would be expected, the wheat and alfalfa curves are distinctly separated on July 1 after the wheat had been harvested.

2. A similar comparison of the wheat and alfalfa curves for MSS Bands 6 and 7 reveals that the alfalfa has much higher radiance values for all three dates, with the greatest difference occurring on May 26.

3. The curves for corn for May 8 cannot be considered representative of a growing corn crop. The ground truth indicates that five of the seven corn test fields had been planted in corn a little more than a week before May 8. One corn field was planted only two days before and one planted two days after the Landsat overpass. It is interesting to note that on May 26 corn and wheat occupy distinctly different positions on the radiance value scale for the two visible bands, but are virtually inseparable on the two infrared bands.

4. A comparison of the curves for the fallow fields reveals that while the general shapes of the curves change slightly over the three dates, the relative position of the curves on the radiance value scale remains fairly constant throughout the three dates. This probably would be indicative of fields which were kept free from any vegetative cover during this period of time.

3.3 Hill County

Detailed comparisons of the plotted curves for the three selected crops in Hill County provided the following observations:

1. The winter wheat curves for MSS Bands 4 and 5 tend to move to slightly lower radiance values as the growing season progresses from May 23 to June 27. This would indicate a darkening in the visible spectrum of the green wheat cover relative to the earlier growth stages. By July 16 as the wheat approaches the mature stage and a yellowing occurs, the radiance values for both visible bands increase, with Band 4 returning to approximately its May 23 position and Band 5 rising slightly higher than its May 23 position. Thus, the wheat curve for Band 5 shifts its position over a greater range of radiance values than does Band 4. Reference to the graphs of mean radiance values also reveal these changes in radiance values.

2. The winter wheat curves for MSS 6 and 7 also shift their position slightly on the radiance value scale during the growing season. The predominant radiance values for wheat increase on Band 7 from May 23 to June 10, but remain in essentially the same position on Band 6. A very slight decrease in values occur from June 10 to June 27

for both bands. Band 7 continues to decrease slightly from June 27 to July 16 when it reaches its former May 23 position. Band 6, on the other hand, increases by a very small amount between June 27 and July 16 to approximately the same position it occupied on May 23.

3.3.1 Winter wheat versus spring wheat and barley (Hill County)

The following observations were noted when the winter wheat curves were compared with the spring wheat and barley curves for each of the MSS Bands for each date:

1. May 23 was too early in the season to produce representative signature curves for spring wheat and barley.

2. On June 10 the predominant radiance values for barley on Bands 4, 5, and 7 appeared nearly coincident with winter wheat, whereas, on Band 6 barley was most coincident with spring wheat. At this time the range of radiance values for spring wheat was considerably greater than for barley or winter wheat. This would probably indicate that fields of spring wheat were less homogeneous than fields of barley or winter wheat at this growth atage.

3. The most pronounced separation between winter wheat and barley occurred on June 27 for MSS Bands 5, 6, and 7. Also, on this date the predominant radiance values for spring wheat were most nearly like those of barley on Bands 6 and 7 and most nearly like those of winter wheat on Bands 4 and 5. (Note the graphs of mean radiance values for the position of the means).

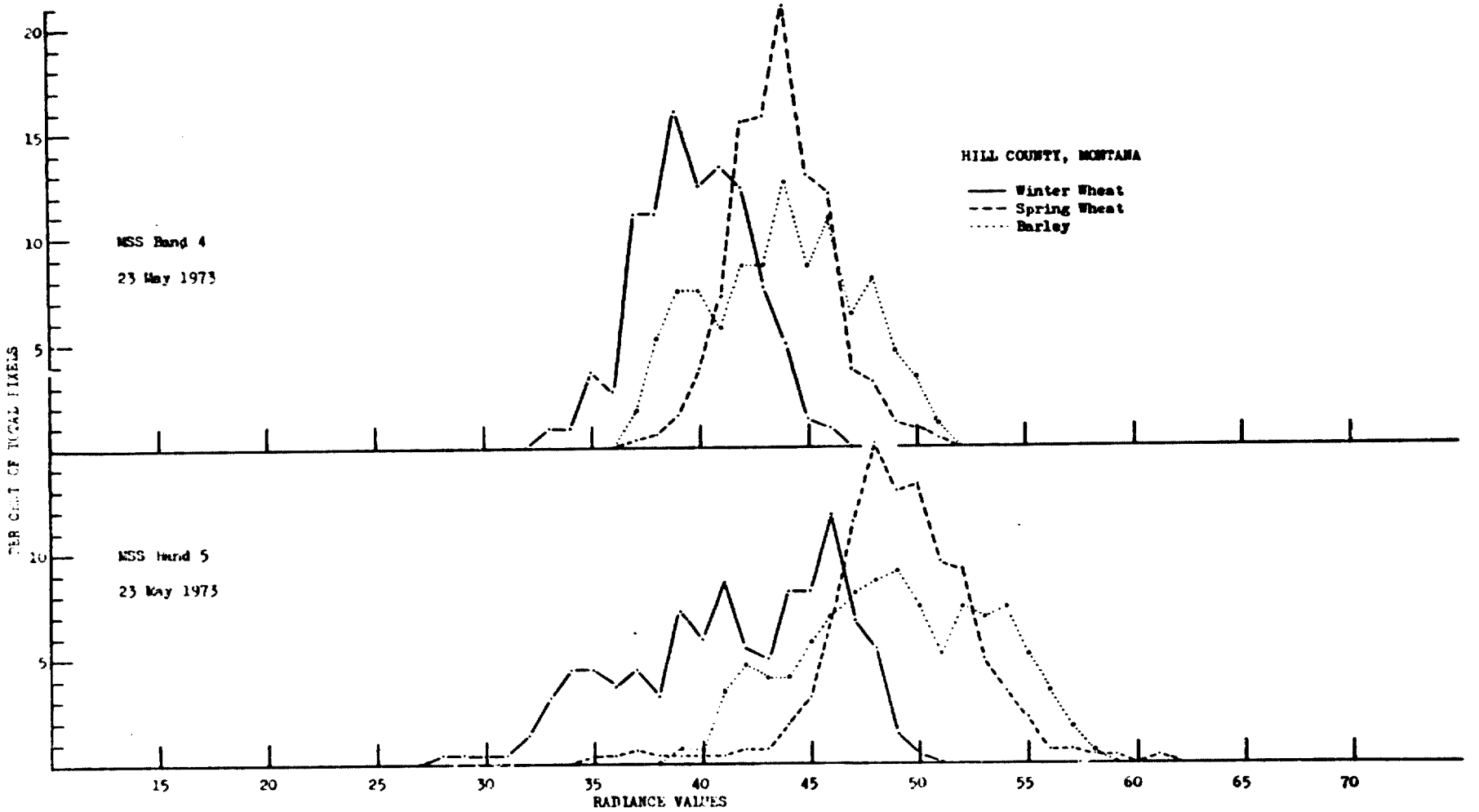
4. On July 16, MSS Band 5 provided the greatest degree of separation between winter wheat and the other two crops. A considerable amount of overlap occurred between the spring wheat and barley curves on all four bands.

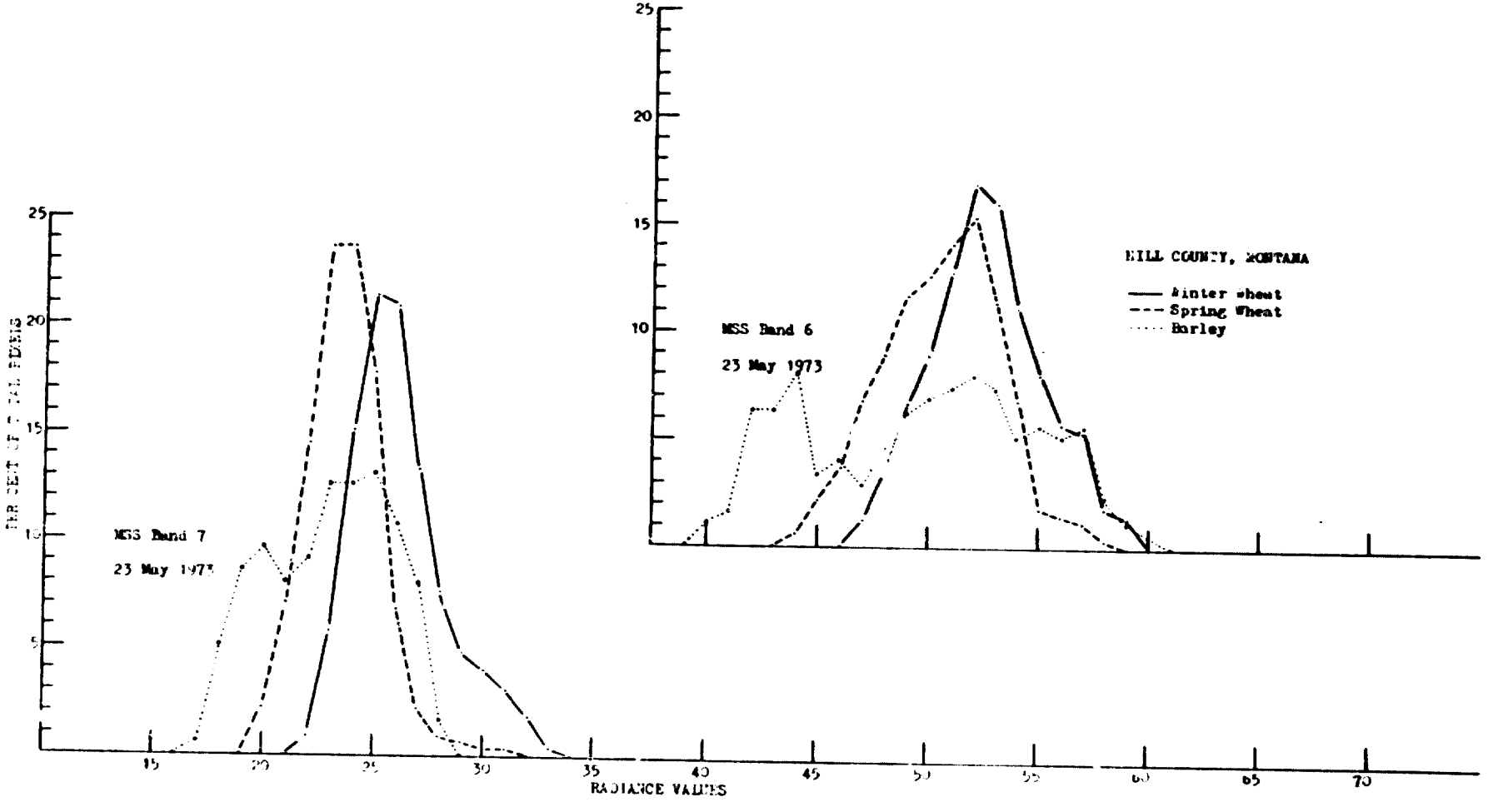
4. Conclusions

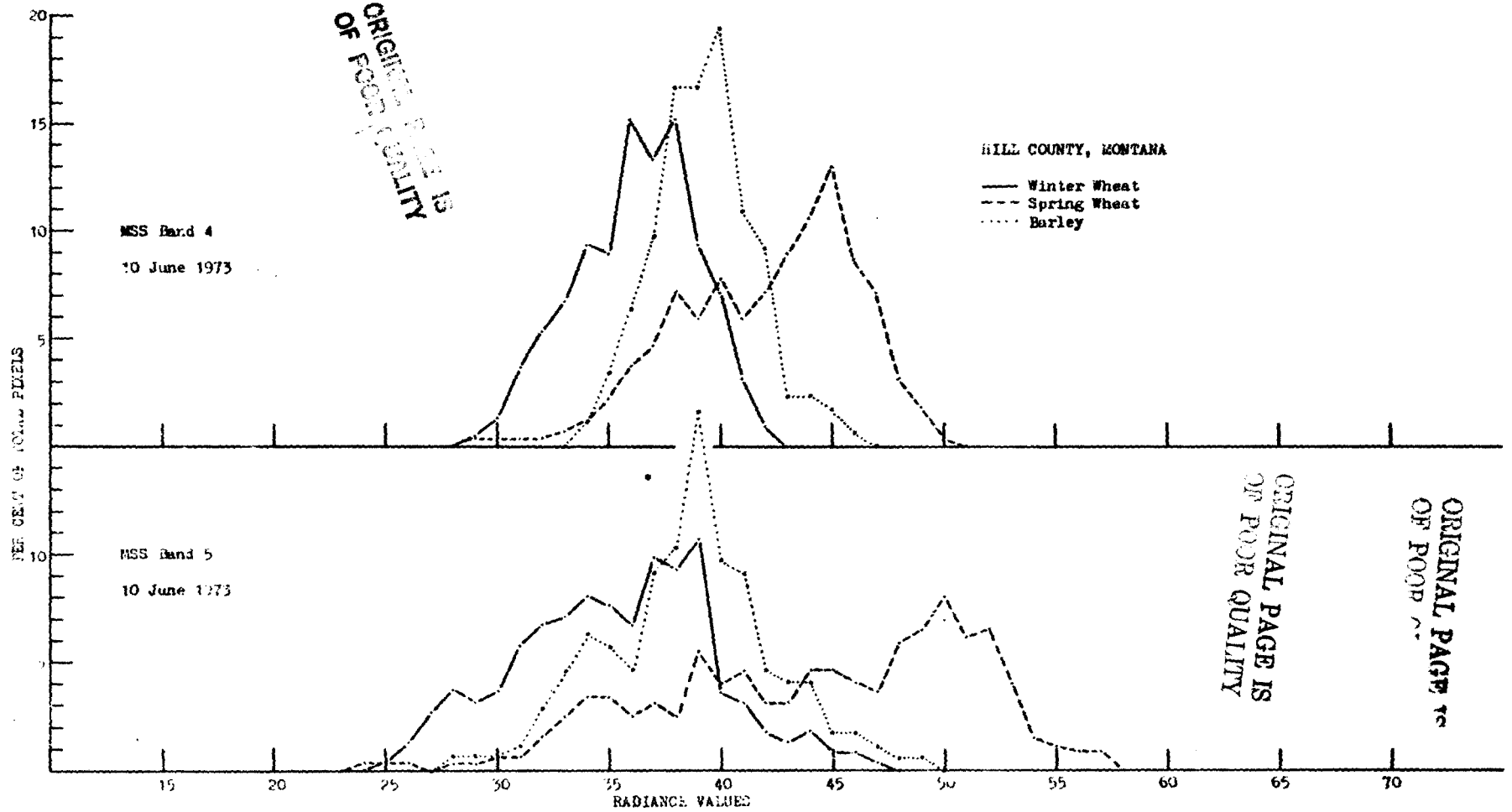
It was concluded from this brief study that graphic representation of the spectral histogram data for individual crops as depicted in the enclosed graphs provided a much better insight into

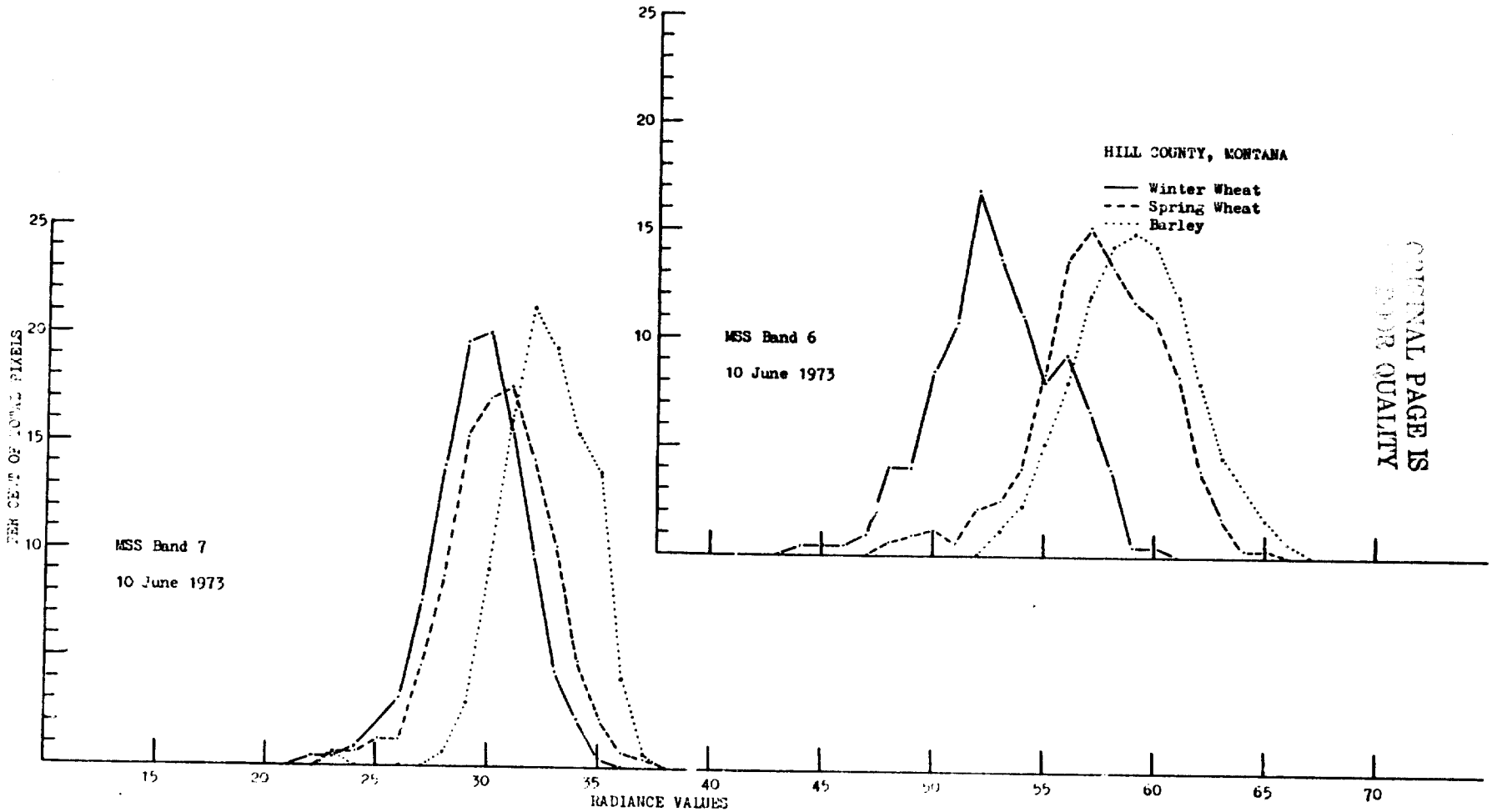
the inherent complexities involved in separating wheat spectrally from other crops than could normally be obtained from visual inspection of raw statistical data. Very quick, but detailed, comparisons of data were possible by overlaying one graph upon another. Graphs in the form of transparencies would have been advantageous in comparing more than two sets of data simultaneously. However, the lack of detailed ground truth precluded any detailed study of the numerous interrelationships that apparently exist between the various MSS Bands and the different combinations of dates and crops.

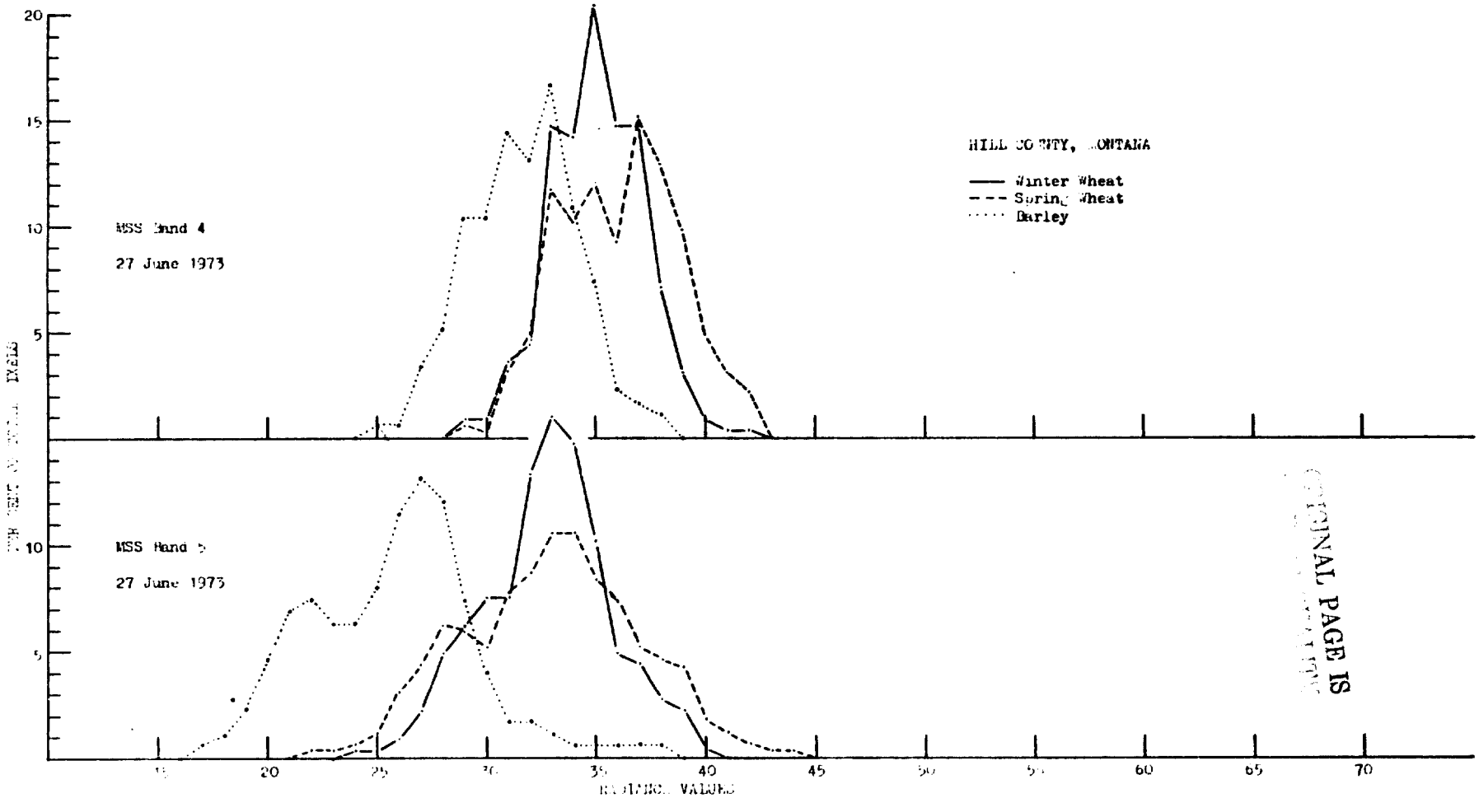
It became evident as these observations were being made that it might have been more prudent to have expanded the collection of histogram data to include several other crops, other type fallow fields, some non-agricultural areas (water, forest, native grass, etc.) and a few additional test sites, so that a more comprehensive comparison could be made between wheat and other confusion factors. However, since the original collection of histogram data was viewed as a trial study, requiring the expenditure of a minimum amount of time, it was decided that a charter to expand this type of study into a major effort would not be requested until the value of such data to the wheat classification research effort could be ascertained.

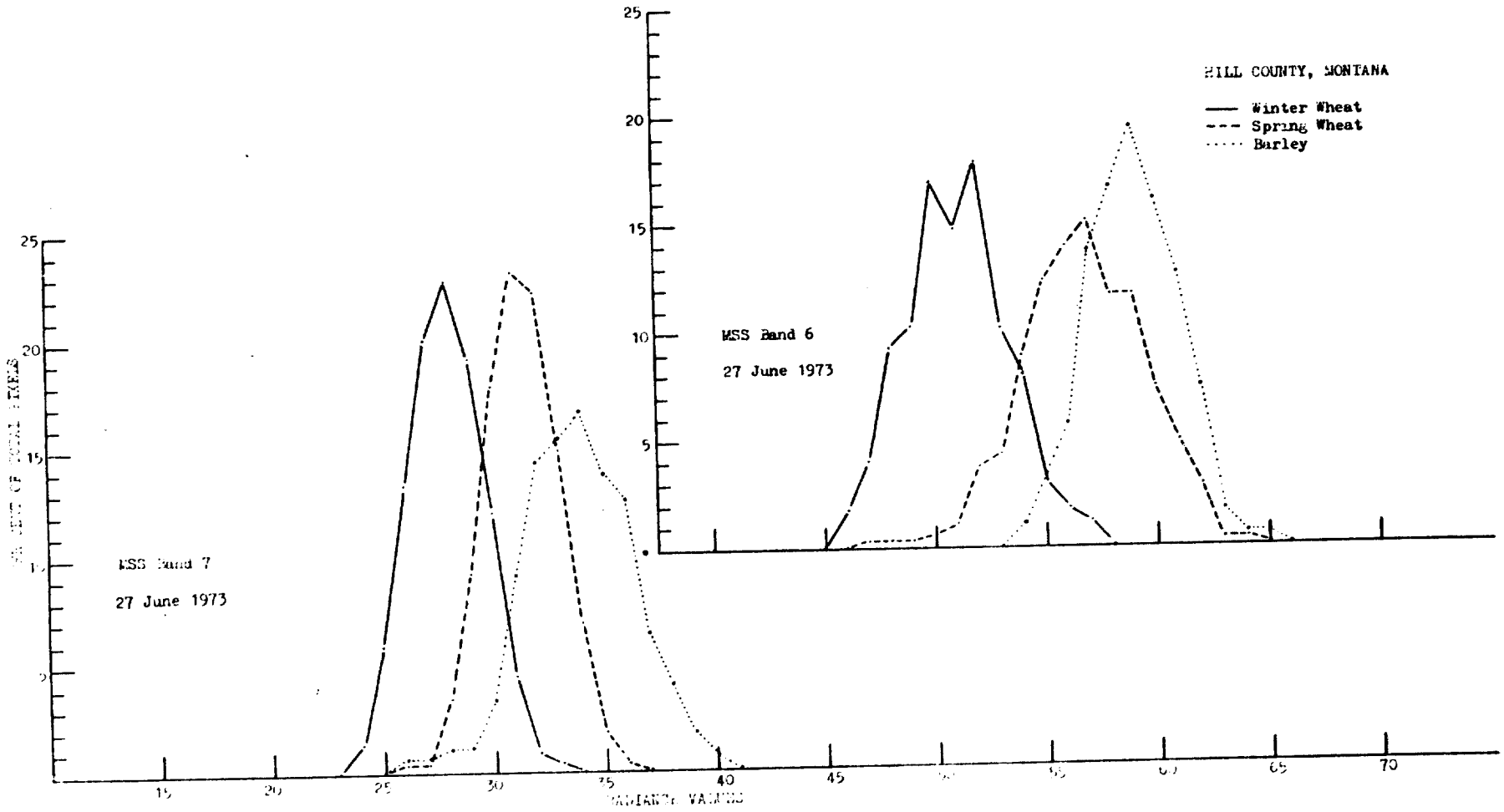

HILL COUNTY, MONTANA
Winter Wheat
Spring Wheat
Barley
MSS Band 4
23 May 1973
MSS Band 5
23 May 1973
PER CENT OF TOTAL PIXELS
RADIANCE VALUES
5
10
15
20
25
30
35
40
45
50
55
60
65
70

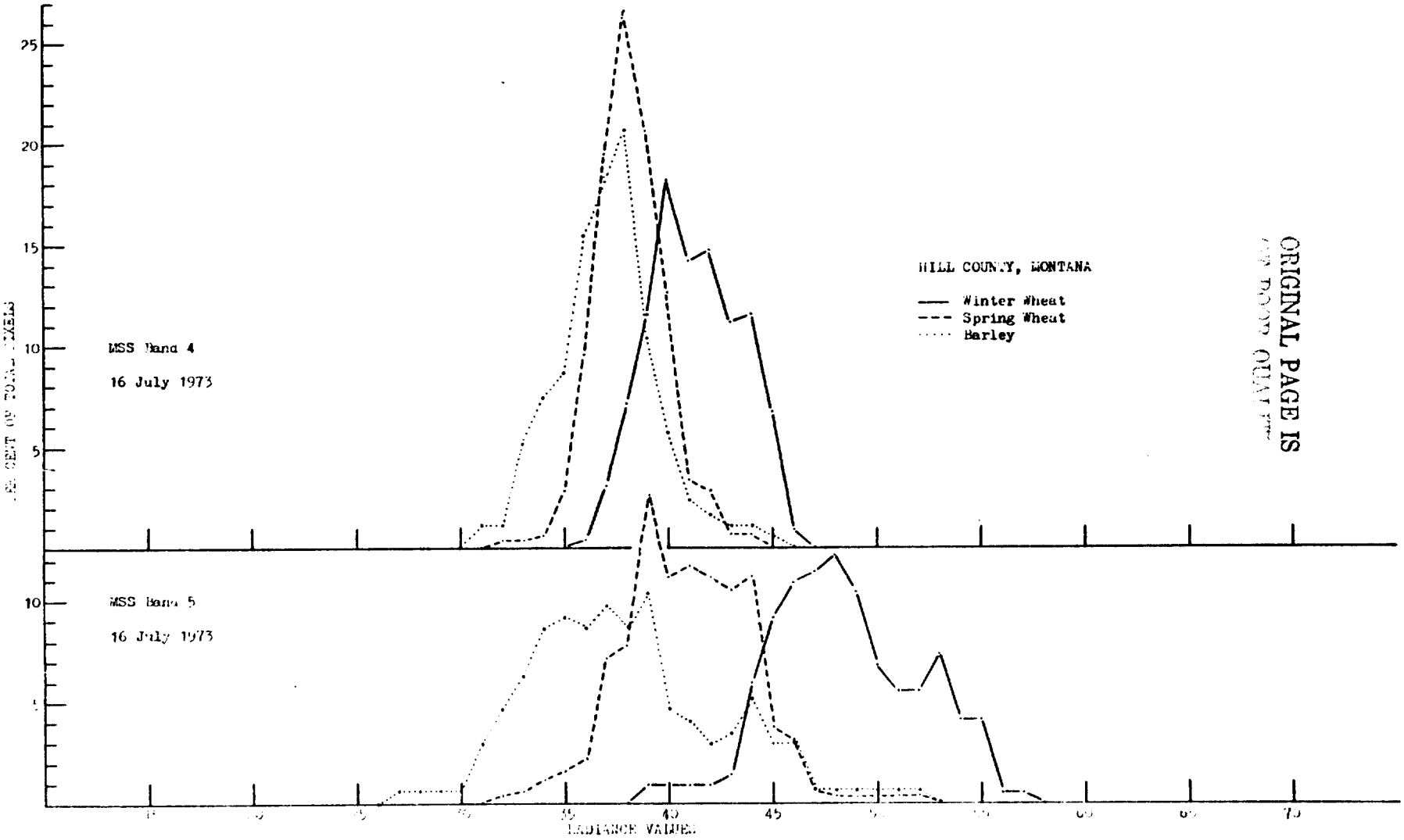

MSS Band 7
23 May 1973
MSS Band 6
23 May 1973
HILL COUNTY, MONTANA
Winter wheat
Spring Wheat
Barley
RADIANCE VALUES

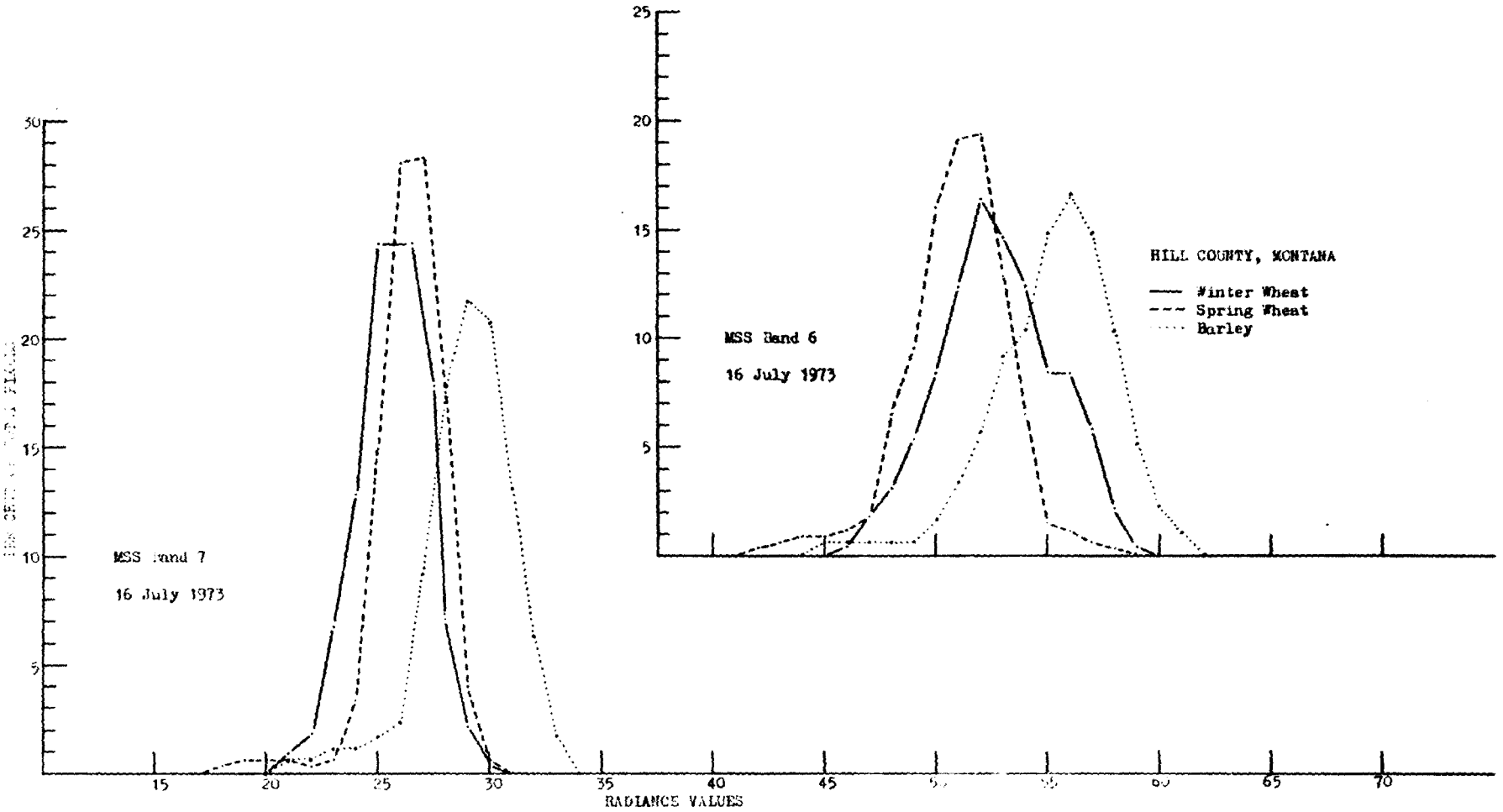

HILL COUNTY, MONTANA
Winter Wheat
Spring Wheat
Barley
MSS Band 4
10 June 1973
MSS Band 5
10 June 1973
PER CENT OF TOTAL PIXELS
RADIANCE VALUES
ORIGINAL PAGE IS OF POOR QUALITY

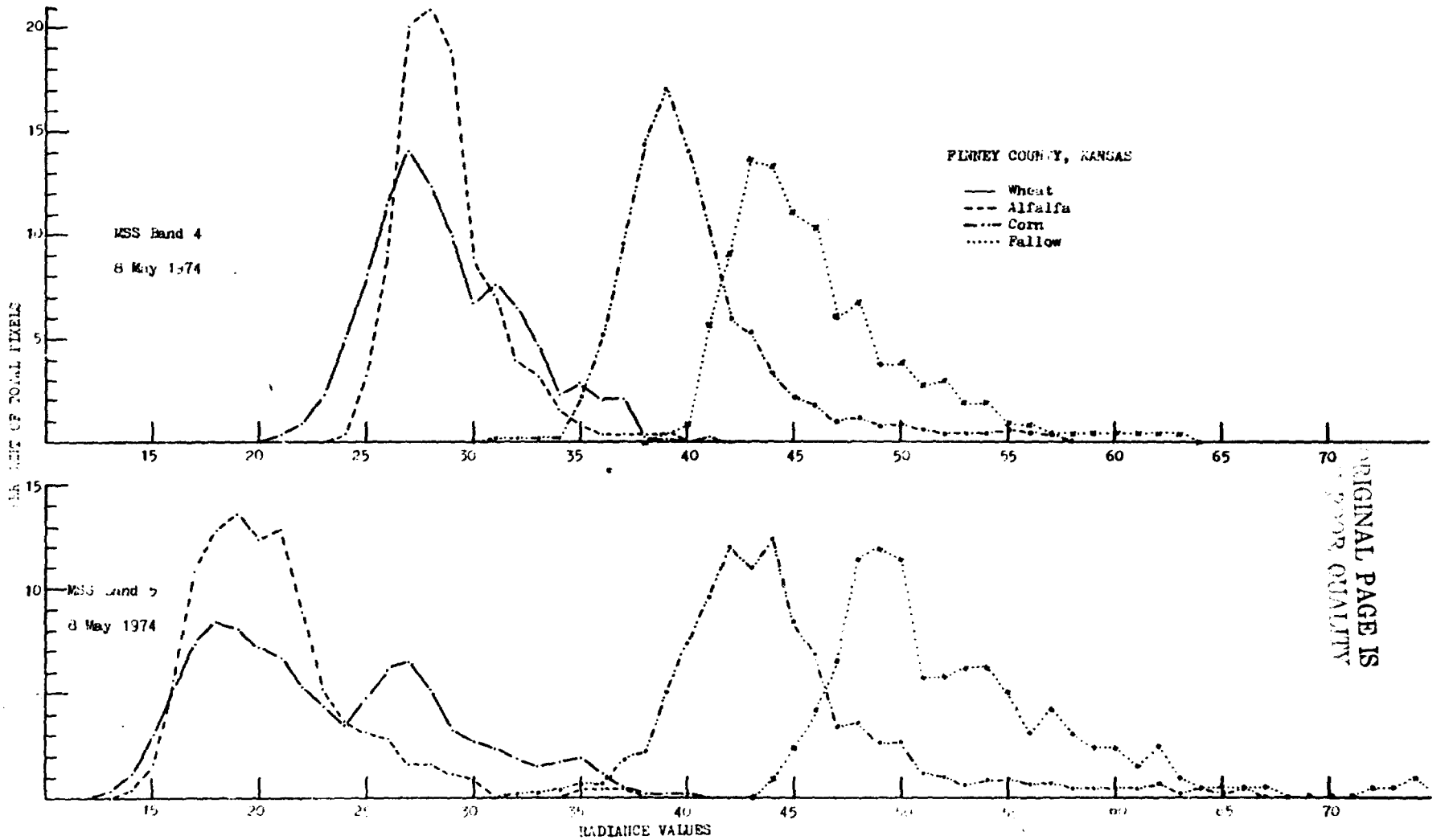


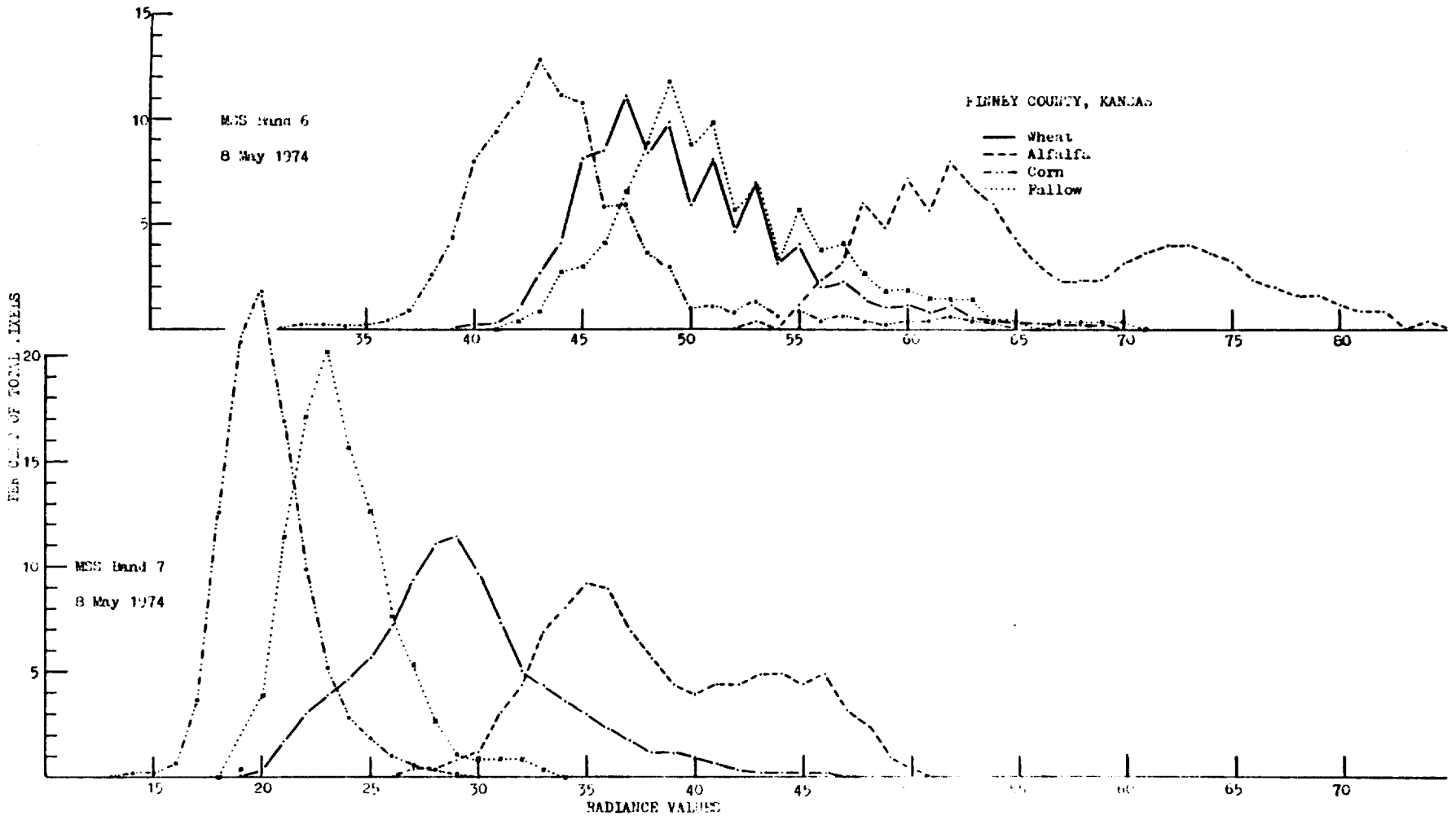


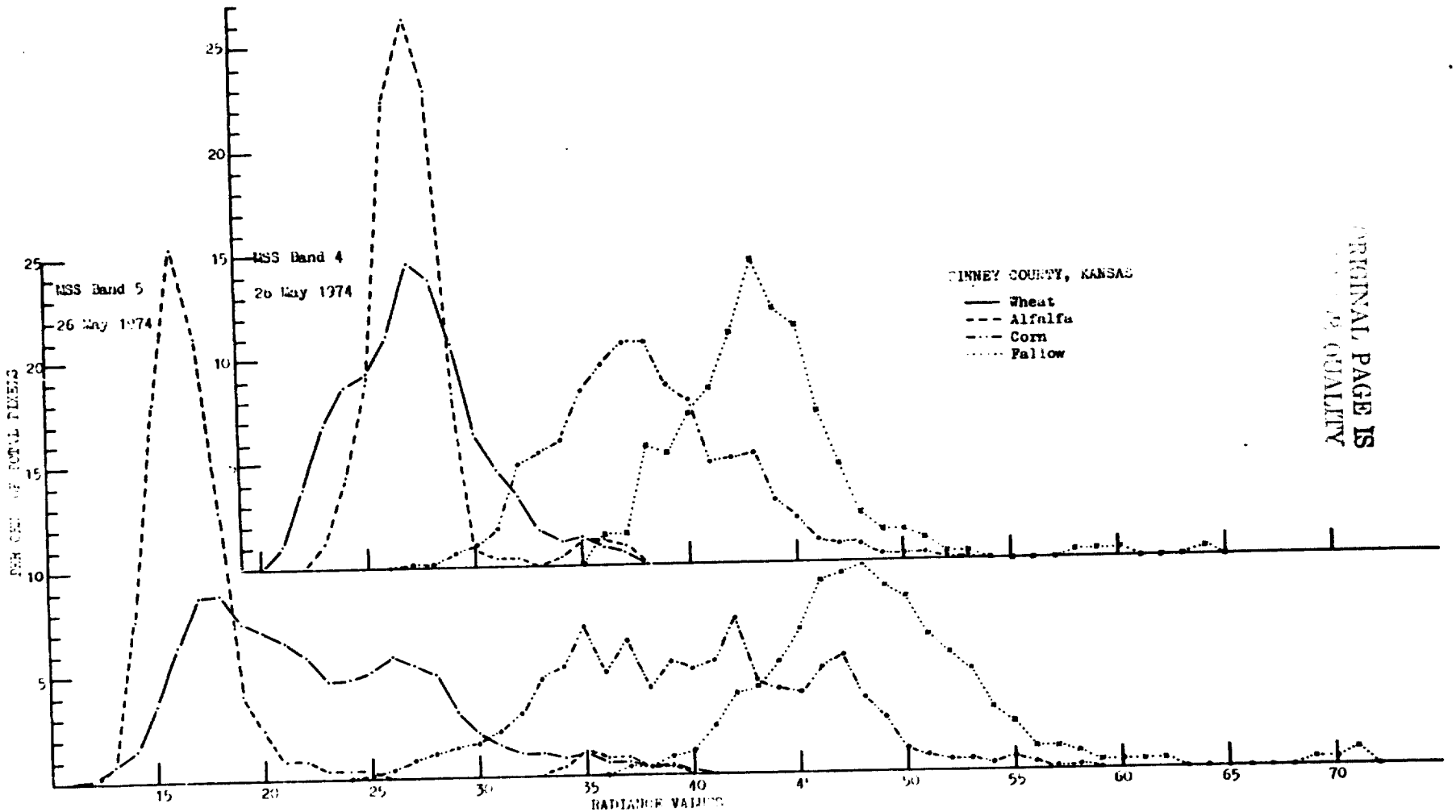

HILL COUNTY, MONTANA
Winter Wheat
Spring Wheat
Barley
MSS Band 6
27 June 1973
MSS Band 7
27 June 1973
25
20
15
10
5
15
20
25
30
35
40
45
50
55
60
65
70

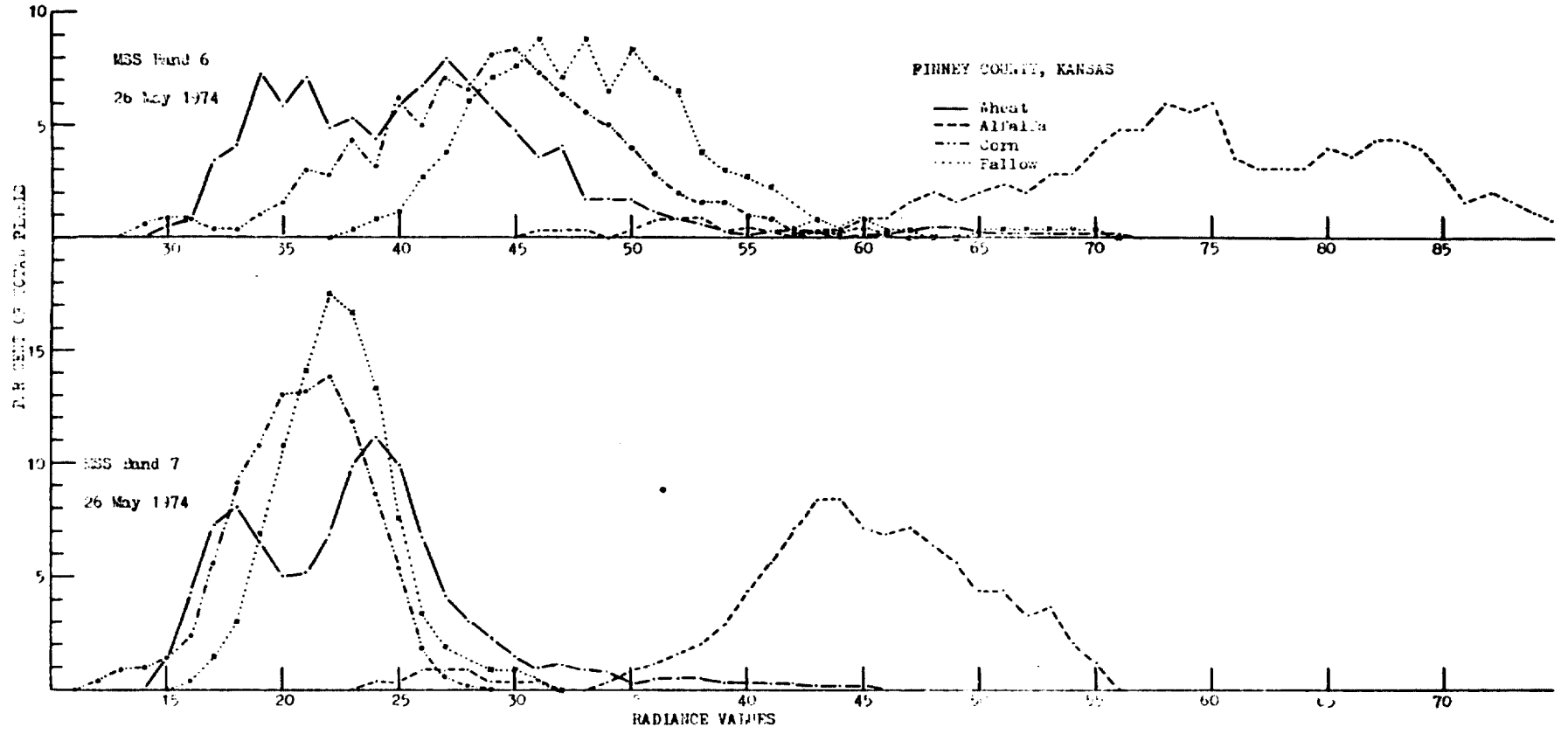


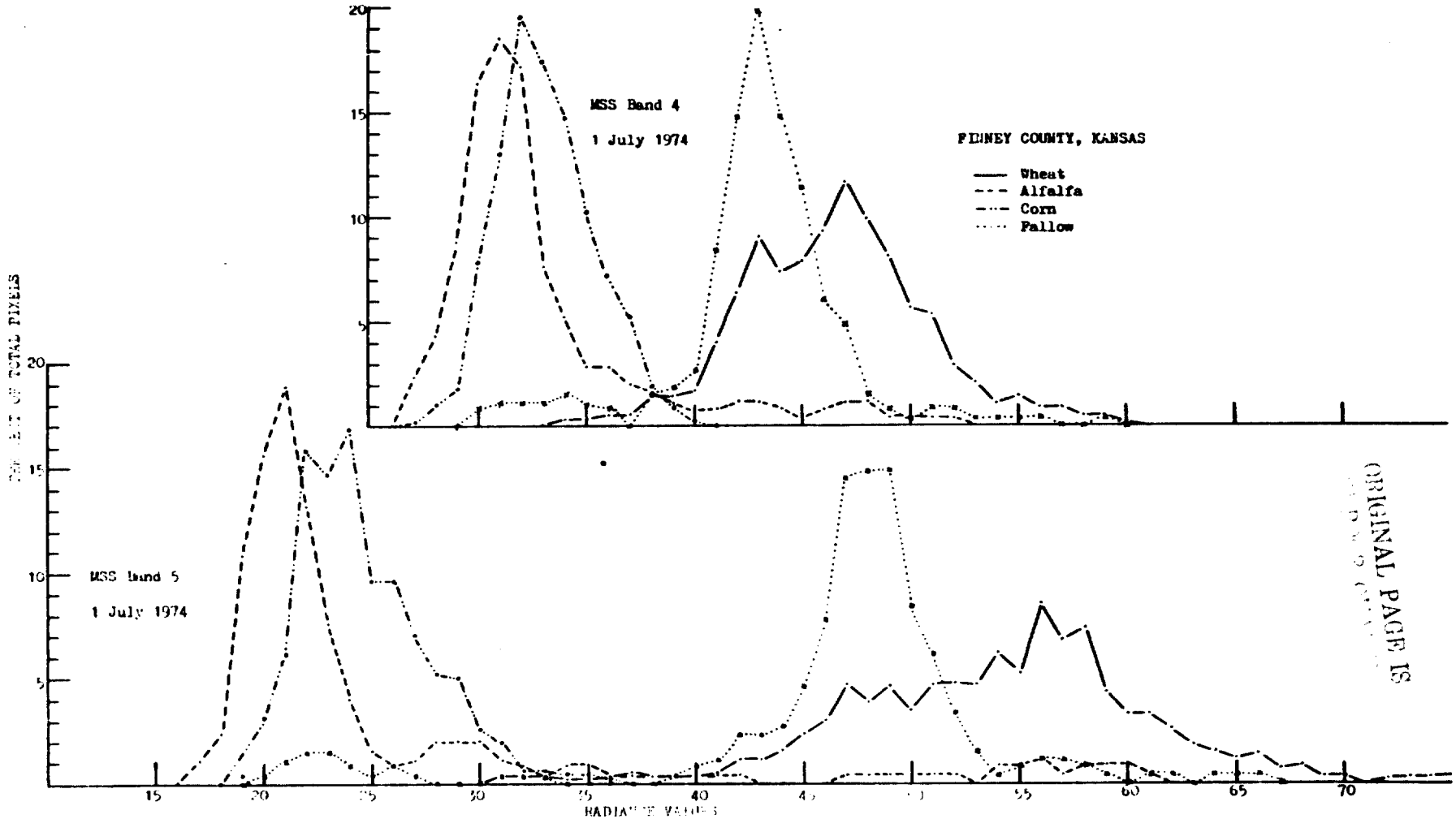

MSS Band 7
16 July 1973
MSS Band 6
16 July 1973
HILL COUNTY, MONTANA
Winter Wheat
Spring Wheat
Barley
RADIANCE VALUES

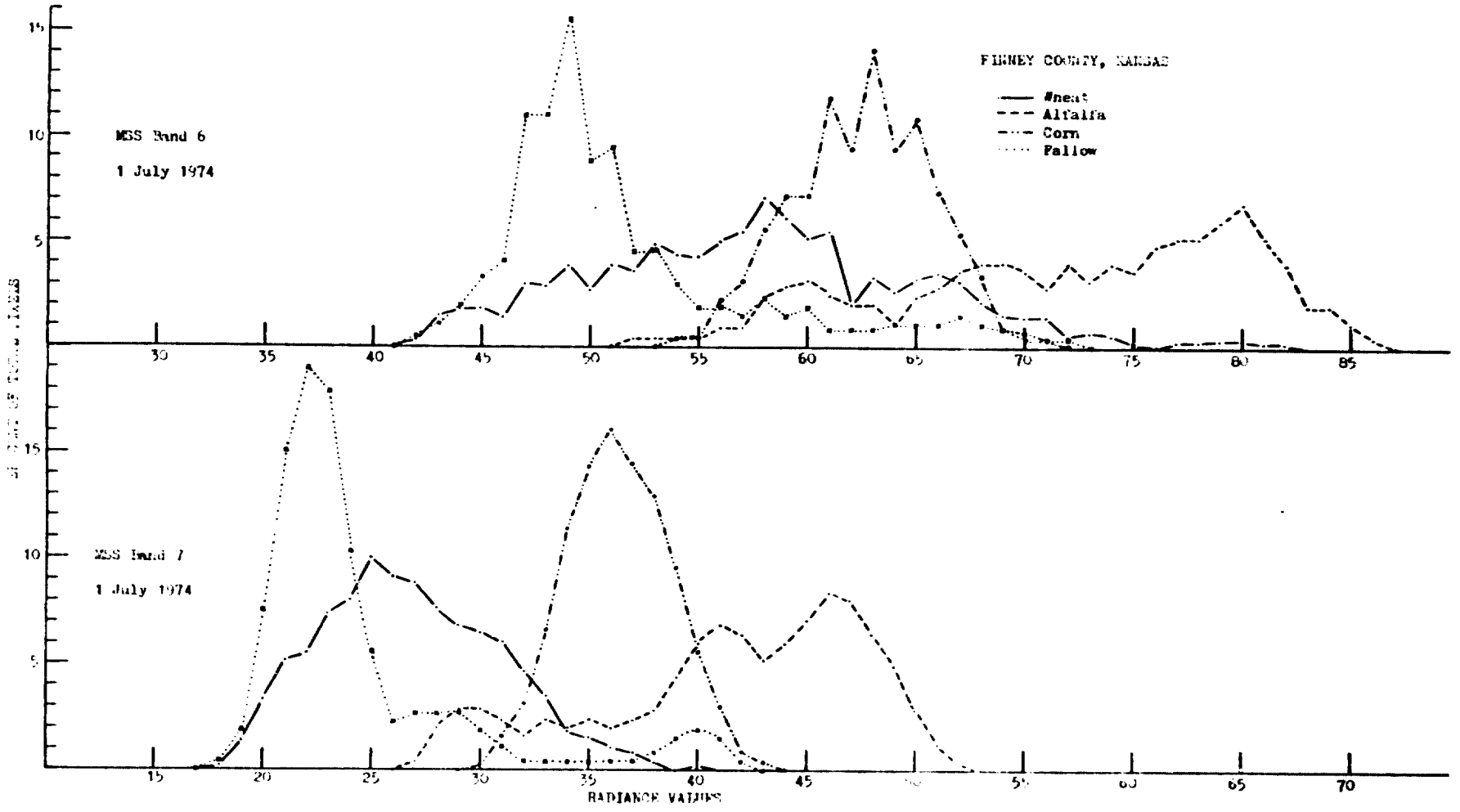


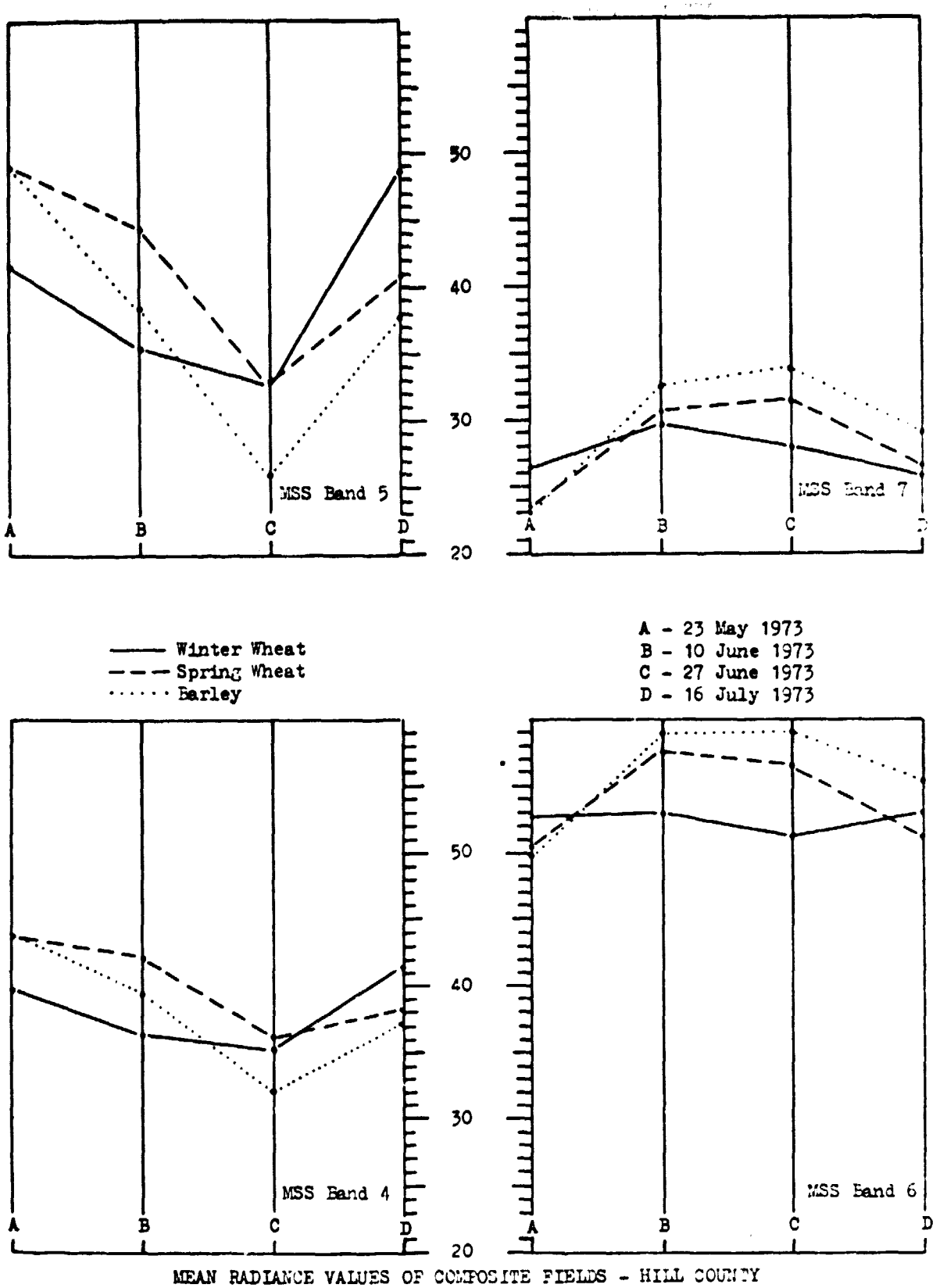

MSS Band 6
8 May 1974
FINNEY COUNTY, KANSAS
Wheat
Alfalfa
Corn
Fallow
MSS Band 7
8 May 1974
RADIANCE VALUES



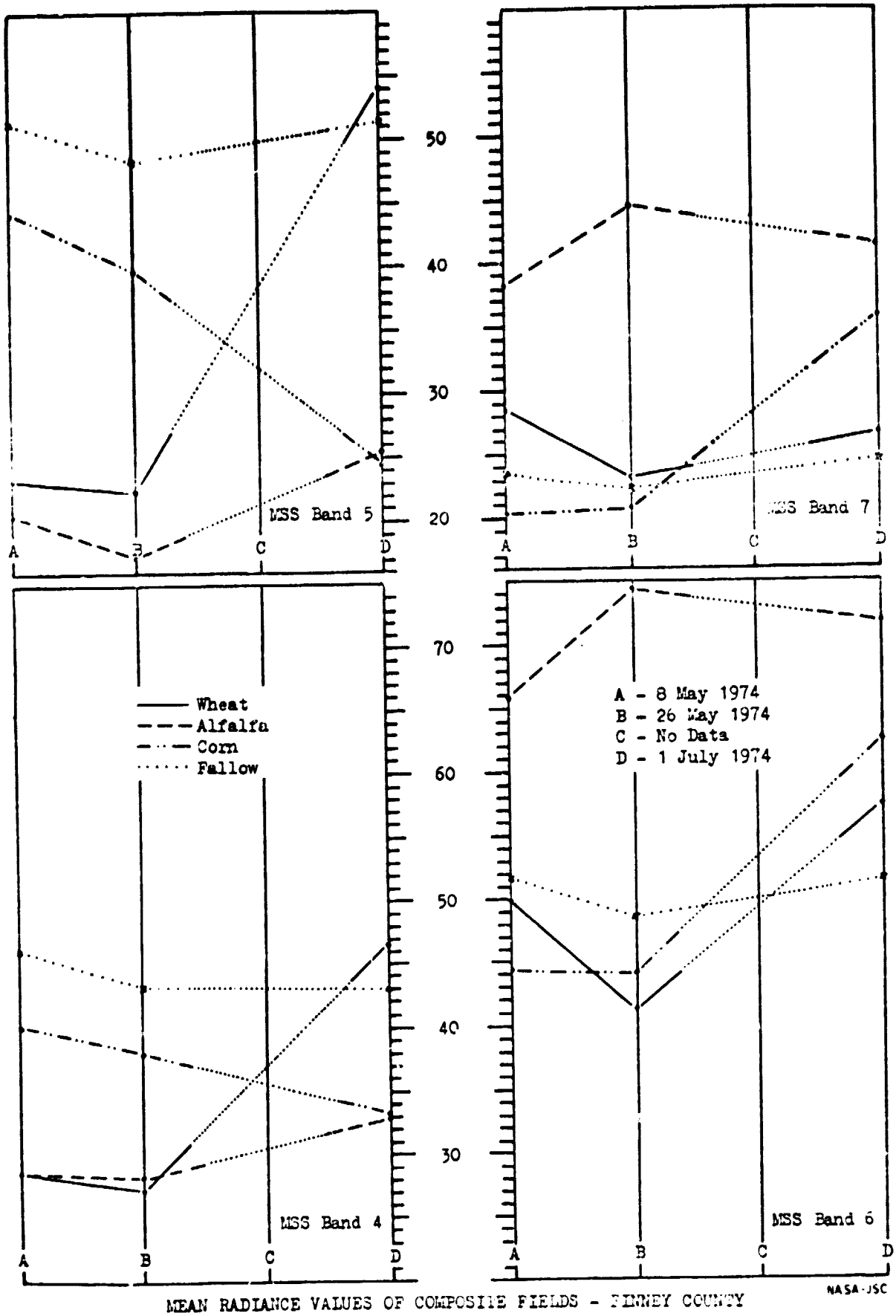

MSS Band 6
26 May 1974
PINNEY COUNTY, KANSAS
Wheat
Alfalfa
Corn
Fallow
MSS Band 7
26 May 1974
RADIANCE VALUES




FINNEY COUNTY, KANSAS
Wheat
Alfalfa
Corn
Fallow
MSS Band 6
1 July 1974
MSS Band 7
1 July 1974
RADIANCE VALUES



MEAN RADIANCE VALUES OF COMPOSITE FIELDS - HILL COUNTY



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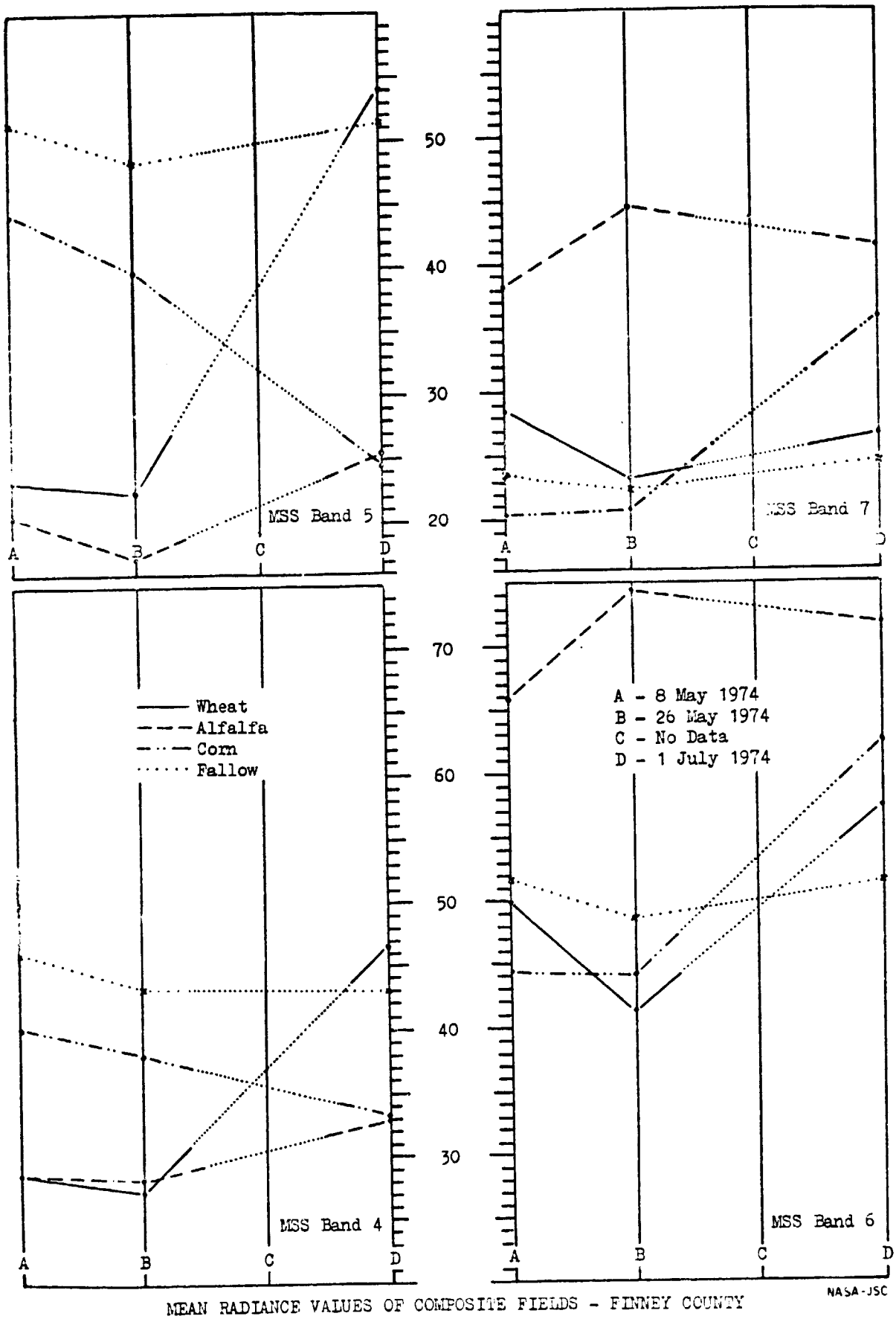
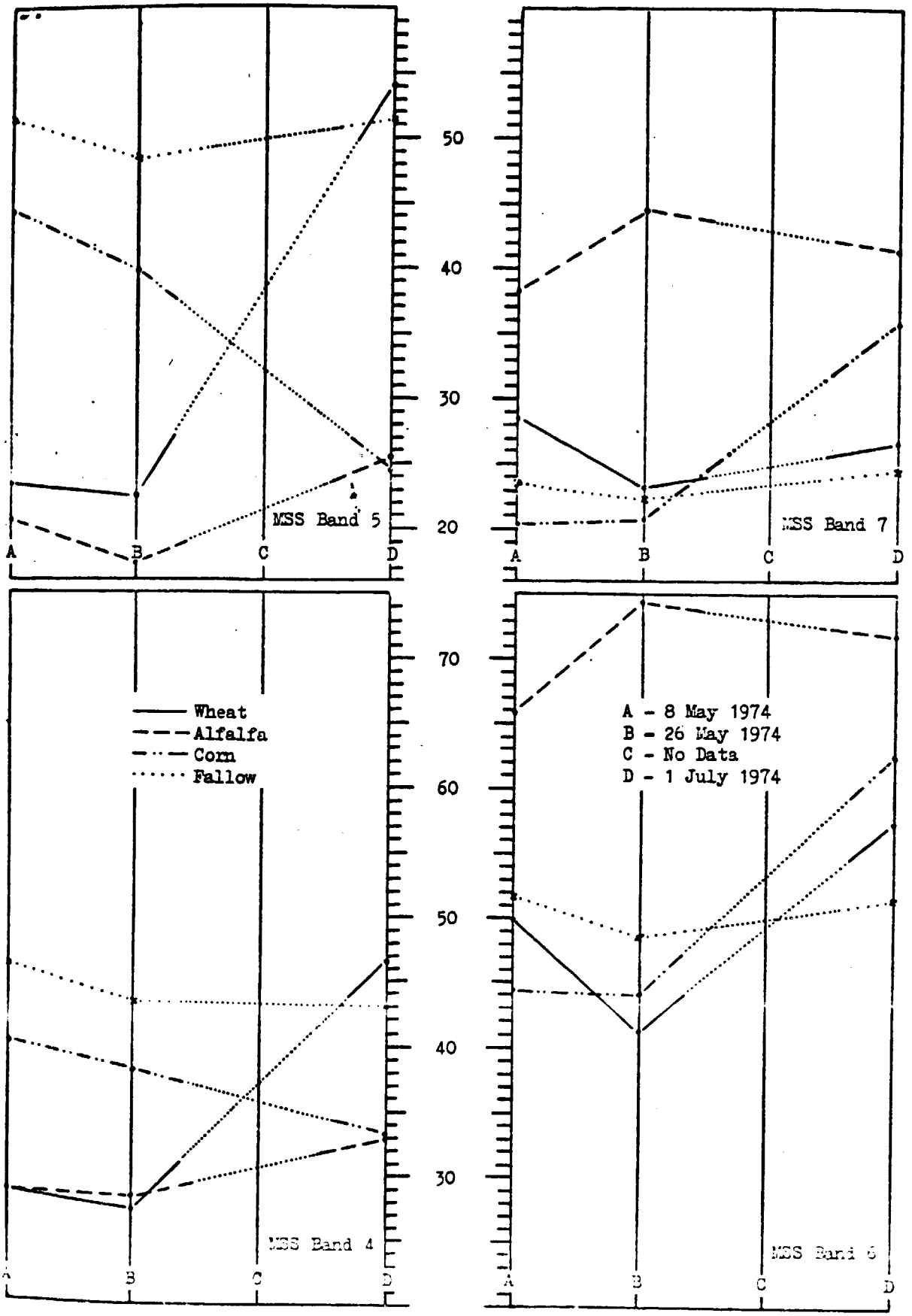


MEAN RADIANCE VALUES OF COMPOSITE FIELDS - FINNEY COUNTY



MEAN RADIANCE VALUES OF COMPOSITE FIELDS - FINNEY COUNTY

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