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ERTS

MONITORING THE VERNAL ADVANCEMENT AND RETROGRADATION (GREENWAVE EFFECT) OF NATURAL VEGETATION

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16. Abstract The Great Plains Corridor rangeland project successfully utilized natural vegetation systems as phenological indicators of seasonal development and climatic effects upon regional growth conditions. An effective method was developed for quantitative measurement of vegetation conditions, including green biomass estimates, over broad regions using ERTS-1 MSS data. Radiance values recorded in bands 5 and 6, corrected for sun angle, were used to compute a ratio parameter (TVI6) which is shown to be highly correlated with green biomass and vegetation moisture content. This final report summarizes the results of analyses of ERTS-1 digital data and correlated ground data. Attention has been given to analyzing weather influences and test site variables on vegetation condition measurements with ERTS-1 data. The report also discusses the implications of the successful results of this study to the needs of agriculture.

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PREFACE

Natural vegetation systems occupy broad areas of the Great Plains. Analysis of their behavior from ERTS-1 MSS data provides a quantitative indicator of seasonal drought and other bioclimatic influences which also impact on the agricultural management and production activities of this region of the United States. The overall objective of this investigation was to determine the effectiveness of ERTS-type data for monitoring natural vegetation systems as phenological indicators and to assess the value of this new information source relative to rangeland management and agri-business decisions in the Great Plains.

The project employed an extensive test site network for monitoring vegetation conditions from south Texas to North Dakota. Primary emphasis was given to quantitative use of satellite acquired MSS data for measuring green biomass and other vegetation parameters. The ERTS-1 data were compared with field measurements collected at ten test site areas. The initial efforts verified that the concepts were viable. This report shows that the project goals were obtained with the quality and quantity of ground observations, aircraft imagery, and ERTS-1 data received.

The project resulted in several significant findings, many of which far exceeded original expectations. In particular, verification of the basic hypothesis of the study was especially significant since this means that natural vegetation systems can be effectively employed as phenological indicators of seasonal development and, hence, this information could be made available to agri-business for possible use in crop yield predictions and cattle management decisions. The most striking, and unexpected, result of the work evolved from an extensive study at the Throckmorton, Texas test site. It was found at this site that the correlation of the ground data, weather data, and ERTS-1 MSS data (Band 5 and Band 6) was sufficiently good to permit estimates of green biomass in very useful increments as small as 250-300 kg/ha with a 95% probability of accuracy. These results represent a major breakthrough for the inventory and management of the nation's vast grazing resources.

On the basis of the results of this project, several recommendations can be made. A few potential uses of the ERTS-derived green biomass estimates are: quantitative assessment of the stage of crop development; determination of amounts of pasture forages; determination of the relative response of crops to environmental factors; and indexing of plant growth for yield predictions. The results of calculations (such as those above) based on the green biomass estimates should be used both directly and indirectly in the broad scope of agriculture. As an example of direct use, the TVI (Transformed Vegetation Index) can be utilized to follow grain crop development from seed bed preparation to harvest. The information content of the TVI is high, and since the simple calculation requires data from only two of the four bands, it is a cost effective use of the data. Indirectly, observations of native rangelands should be used to ascertain information on the status at a critical time of an important parameter concerning a cultivated crop. For instance, soil moisture at planting time is a determining factor in dryland winter wheat yield, and can be inferred from the condition of nearby native rangeland at that time since the grasses are integrators of the preceding environmental conditions. Finally, satellite observations of phenological indicator plants should be utilized to update the current year crop calendars, for improving crop production predictions and for determining the feasibility of introducing new plants to an area.

ACKNOWLEDGMENTS

The Great Plains Corridor project was conducted by a team of scientists coordinated by the Remote Sensing Center of Texas A&M University. Dr. J. W. Rouse, Jr. served as the Principal Investigator. The program management was under the direction of Dr. R. H. Haas. Dr. J. A. Schell was responsible for the computer analysis of the ERTS-1 MSS data. D. W. Deering coordinated the extensive test site network, conducted the extensive sampling programs at the Throckmorton test site which proved so significant to the success of the project, and performed the bulk of the analysis work presented in this report.

The project is indebted to the many researchers at the network test sites whose unselfish dedication to their profession made possible the success of this effort. These included: C. Gonzalez; Weslaco, Texas, Dr. L. B. Merrill; Sonora, Texas, Dr. M. M. Kothmann; Throckmorton, Texas, Dr. B. Blanchard; Chickasha, Oklahoma, Dr. E. H. McIlvain; Woodward, Oklahoma, Dr. J. L. Launchbaugh; Hays, Kansas, Dr. P. Seevers; Sand Hills, Nebraska, Dr. R. P. Gibbens; Cottonwood, South Dakota, and Dr. G. Rogler; Mandan, North Dakota.

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MONITORING THE VERNAL ADVANCEMENT AND RETROGRADATION (GREEN WAVE EFFECT) OF NATURAL VEGETATION

1.0 INTRODUCTION

The Great Plains of the central United States produces over forty percent of the nation's beef and much of the country's grain. The beef industry in six Great Plains Corridor states is a $23 billion operation, which is extremely vulnerable to adverse seasonal or climatic conditions. Stability of the beef and agricultural industry in the Great Plains Corridor is contingent upon decisions made by the 400,000 farmers and ranchers in this region. These private operators need timely information on regional range forage conditions and crop production levels upon which to base their management decisions. This ERTS-1 study of rangelands in the Great Plains has established the potential for using ERTS-type data to provide quantitative regional vegetation condition information required to support these agricultural operations.

The Great Plains Corridor rangeland project conducted at Texas A&M University utilized natural vegetation systems as phenological indicators of seasonal development and climatic effects upon regional growth conditions. The basic task has been that of monitoring the vernal advancement and retrogradation of vegetation (green wave effect) throughout the Mixed Prairie Grassland Association extending from south Texas into Canada, a distance of over 2000 miles.

The study employs a network of ten test sites at established range research stations in the six states extending northward from south Texas into North Dakota. Ground observations recorded every eighteen days at each site include green biomass, phenology of dominant species, moisture content of vegetation, weather information, etc. ERTS-1 MSS data have been acquired for all sites. Because of the unique geographical location of the Great Plains Corridor with respect to the orbital path of ERTS-1, the probability of obtaining cloud-free data during each cycle has been maximized.

The ERTS-1 MSS data were computer processed for selected areas coordinated with ground sample data from each test site. Spectral reflectance data were analyzed for each available date for each site from September 1972 through June 1974. The measurements were corrected for seasonal sun angle differences to permit temporal comparisons. Radiance values recorded in ERTS-1 spectral bands 5 and 7 were used to routinely compute a Band Ratio Parameter, which has been shown to be correlated with aboveground green biomass and vegetation moisture content (Progress Report RSC 1978-2). Other band-to-band ratios and single band values were evaluated for correlation with ground truth data to determine their potential for vegetation monitoring. ERTS-1 color composite imagery were used to delineate the areal extent of vegetation condition differences.

The Great Plains Corridor project has established methods applicable to the use of ERTS-1 digital data for quantitative measurement of vegetation conditions over broad regions. Initial efforts have been made toward extending these capabilities to monitoring rangeland "feed" conditions and developing growing condition indexes for this region. It is anticipated that this type of information will have broad applicability for ranch management and agri-business activities in the Great Plains.

This report reviews the progress of the Great Plains Corridor Project in developing procedures for appraising the impact of weather conditions, season, vegetation type and phenological development of natural vegetation within the region. Complete documentation is given for the ground observations, aerial photography, and ERTS-1 data obtained for the Great Plains region. The efficient data flow system used by the Remote Sensing Center is shown. Final analysis of the large data set obtained throughout the 22-month operation of the project gives specific attention to the detection and estimation of standing biomass conditions. The report further evaluates seasonal and environmental effects on rangeland production and the implications for measurement of these parameters for agriculture.

2.0 OBJECTIVES AND APPROACH

Natural vegetation systems occupy broad areas of the Great Plains and their behavior provides a reliable indicator of seasonal drought and other bioclimatic activities in this region of the United States. The overall objective of this investigation is to evaluate the effectiveness of ERTS-1 data for recognizing and monitoring the status of natural vegetation in the Great Plains Corridor (Figure 2-1).

The Great Plains Corridor Project has stressed the monitoring of the vernal advancement and retrogradation of natural vegetation (green wave effect) using natural vegetation systems as a phenological indicator of seasonal development and climatic effects on regional growth conditions. The basic task is that of monitoring seasonal variation, growth, and development of rangeland vegetation throughout the relatively uniform Mixed Prairie Grassland Association. Emphasis has been given to the reduction and analysis of ERTS-1 MSS spectral measurements as a quantitative indicator of the amount and condition of rangeland vegetation throughout the growing season.

Four specific hypotheses have been central to the Great Plains Corridor Study in its relation to the feasibility of an operating system for monitoring natural vegetation on a regional basis:

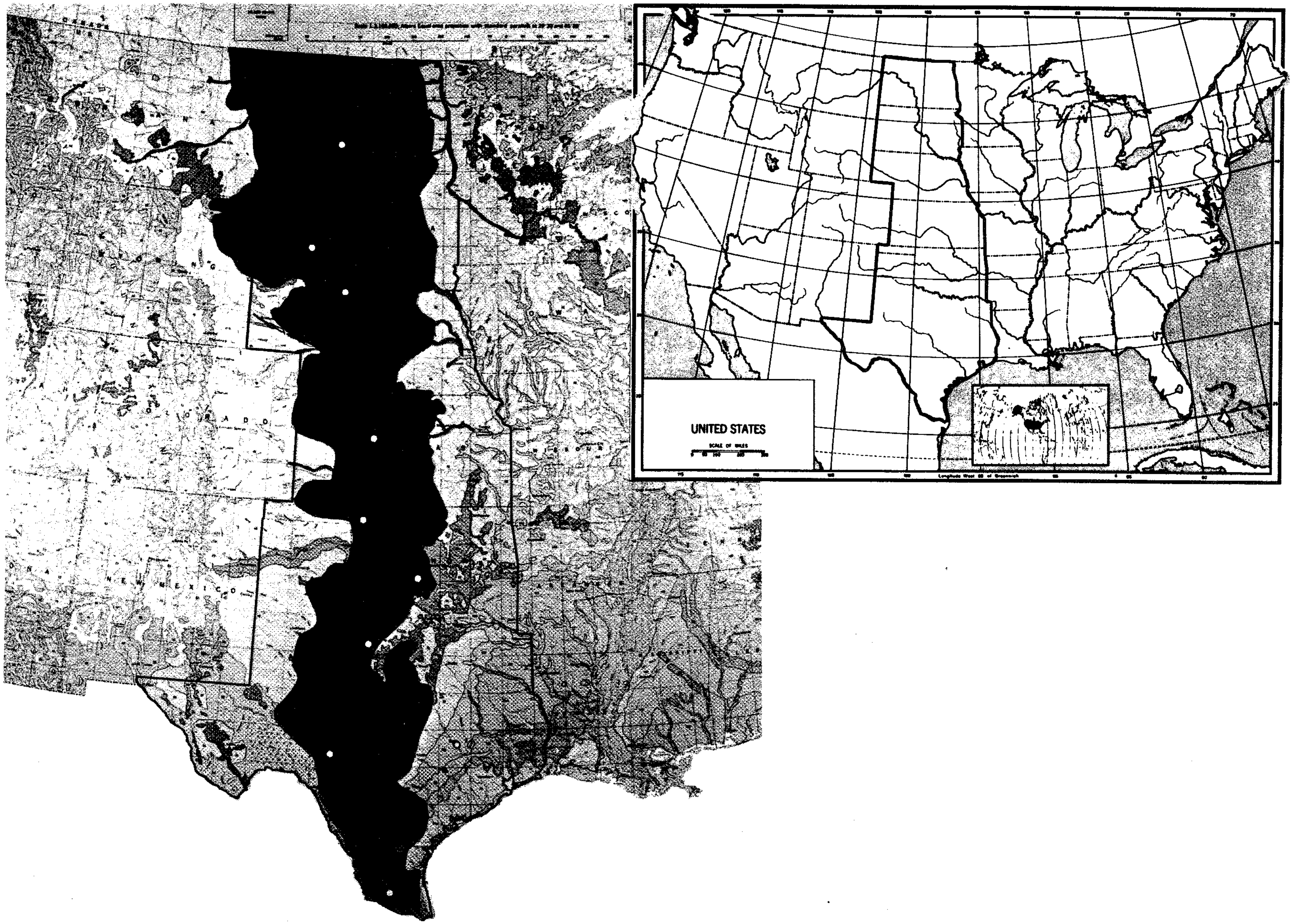


Figure 2-1. Great Plains Corridor and test site network.

<u>Hypothesis No. 1</u>: Time is an important factor in discriminating broad landforms, soil associations, vegetation types and other natural resource features.

<u>Hypothesis No. 2</u>: The vernal advancement and retrogradation of vegetation (green wave effect) can be recognized from repetitive multispectral imagery.

<u>Hypothesis No. 3</u>: Parameters obtainable by ERTS are suitable for modeling integrated gradients for natural vegetation systems over broad areas.

<u>Hypothesis No. 4</u>: Parameters of vegetation systems are adequately unique to provide a new information source for regional agri-business use.

Major decisions in agriculture are often based on regional vegetation and weather conditions. The quantity and quality of range and pasture vegetation influence the market for livestock. Furthermore, seasonal changes in vegetation conditions are difficult to assess on a local or regional basis. Since dryland agriculture is closely tied to characteristic climates for the region, adverse local or regional weather influences planting and harvesting dates. These factors have important implications for yield forecasts.

It is implicit in these hypotheses that the extent and duration of favorable or adverse conditions can be observed regionally through analysis of remotely sensed satellite data. It is well known that natural vegetation integrates the condition of its microenvironment. Consequently, an operational satellite would provide a first opportunity to use regional vegetation systems as phenological indicators for agricultural use. This study was designed to assess the possibility of applying ERTS data for rangeland condition reports and as an input into related agri-business activities.

Specific objectives of the ERTS-1 study are summarized as follows: (1) to determine plant community identification capabilities for the vegetation located in a north-south pass through the Great Plains Corridor, (2) to determine parameters obtainable from ERTS-1 suitable for modeling integrated radiance from natural vegetation systems, (3) to evaluate ERTS MSS data in regard to the feasibility of monitoring the regional status of natural vegetation, and (4) to correlate short term and seasonal changes in vegetation reflectance characteristics with extent and duration of rangeland vegetation growth.

ERTS-1 MSS data were computer processed for selected areas of each test site. Spectral reflectance data were analyzed for all available dates for which ground verification data were available. The spectral reflectance measurements were corrected for seasonal sun angle differences to permit temporal comparison. Because of the highly encouraging results from preliminary analysis of initial data, emphasis was given to evaluating the potential for using the transformed vegetation index (TVI) as a quantitative measure of green biomass. To assure maximum vegetation homogeneity, procedures were developed for extracting "subsite" data based on characterization of test sites by resource and land use type. The corrected radiance values have been extracted by subsite areas on a routine basis.

2.1 The Vernal Advancement

A surge of new growth in response to increased temperature signals the coming of spring and the onset of a new growing season. Phenological development of plants is dependent upon specific environmental requirements including day length, soil temperature, soil moisture, vernalization, etc. Yet, the spring "greenup" in the Great Plains region appears dramatically mainly as a result of the day length correlated events. The south to north progression of the spring "greenup" is known as the vernal advancement.

Phenological events (i.e., including "greenup", flowering, etc.) within the North American continent are timed according to their longitudinal, latitudinal, and elevational location. Daubenmire (1959) cites Hopkins Bioclimatic Law as a satisfactory generalization for defining this expected progression. The Hopkins Bioclimatic Law states: "Phenological events are delayed by 4 days for each 1° latitude north, 5° longitude east or 400 feet [120 m] increase in elevation." It is well known, however, that local topographic and other landscape features may have significant influences on local climate.

The expected progression of phenological events within the Great Plains Corridor has been calculated as the number of days of delay with respect to the College Station Test Site (Table 2-1). These calculations show that the expected progression of the vernal advancement should cover a period of 95 days or approximately five ERTS-1 cycles during the spring. When the expected progression of the vernal advancement at ERTS-1 test sites are plotted against degrees latitude north, it is apparent that there is a good distribution of the test sites within the latitudinal range of the Great Plains Corridor (Figure 2-2). However, it is apparent that elevational and longitudinal influences may overshadow the latitudinal effects at Throckmorton and Chickasha. Because of the large elevation and longitude difference, the Cottonwood test site could be expected to develop as early or earlier than the more southerly Sand Hills test site.

Table 2-1. Latitude, Longitude, Elevation, and Expected Progression of Phenological Events at Great Plains Corridor test site.[1]

Test Site	Location: Latitude	Location: Longitude	Elevation	Expected Progression[2]
	degrees N	degrees W	meters	days
Weslaco	26.5	98.6	60	-21
College Station	30.6	96.4	90	0
Sonora	30.3	100.6	640	+12
Throckmorton	33.3	99.2	430	+22
Chickasha	35.1	97.8	340	+24
Woodward	36.6	99.6	610	+37
Hays	38.9	99.4	610	+46
Sand Hills	42.6	100.6	880	+69
Cottonwood	43.8	101.9	730	+67
Mandan	46.8	100.8	550	+74

[1] Progression of phenological events calculated from Hopkins Bioclimatic Law which states: "Phenological events are delayed by 4 days for each 1° latitude north, 5° longitude east and 120 m increase in elevation."

[2] Expected progression of phenological events shown as days (±) from College Station, Texas.

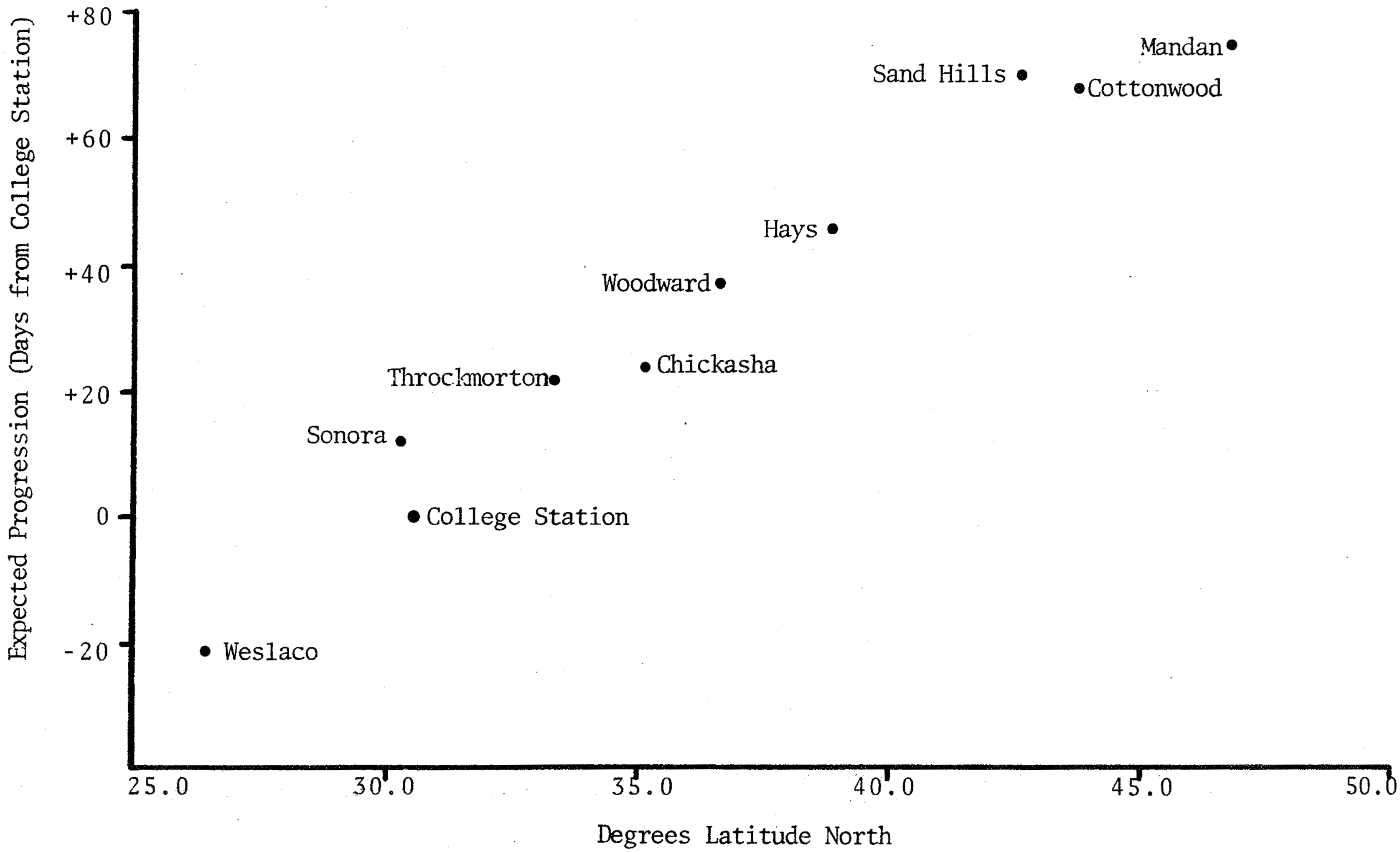


Figure 2-2. Expected progression of phenological events at ERTS-1 test sites located throughout the Great Plains Corridor.

The ERTS-1 Great Plains Corridor study employs the generalization expressed by <u>Hopkins Bioclimatic Law</u>; however, 22 months of data are much too meager to test the validity of applicability of the law. Yet, these calculations are useful for plotting against the vernal period as measured by ERTS-1 derived parameters and ground verification data.

3.0 DATA ACQUISITION AND PROCESSING

The approach employed for the Great Plains Corridor study centered upon using an extensive test site network throughout the Mixed Prairie region of central USA. The ten test site network employs existing research stations of state Agricultural Experiment Stations or the United States Department of Agriculture. This approach permitted use of the extensive background information available for the sites, highly experienced field personnel, existing instruments at the sites, and rangeland types needed to evaluate the established hypotheses. The ongoing research at each of the ten stations in the Great Plains Corridor is oriented to the study of rangelands--those natural vegetation systems used for grazing (Figure 3-1). Consequently, the results of the program are rapidly and effectively applied to ongoing work by the resident organizations.

A comprehensive and efficient data flow network was established to assemble the sequential data acquired from the test site network and ERTS (Figure 3-2). The system provided for cataloging and filing operations of both data types in computer compatible formats; assembly of ground measurements according to time and latitude parameters; processing of ERTS MSS measurements for site location and spectral characteristics on a subsite integrated basis; photo analysis of black and white and color products; and

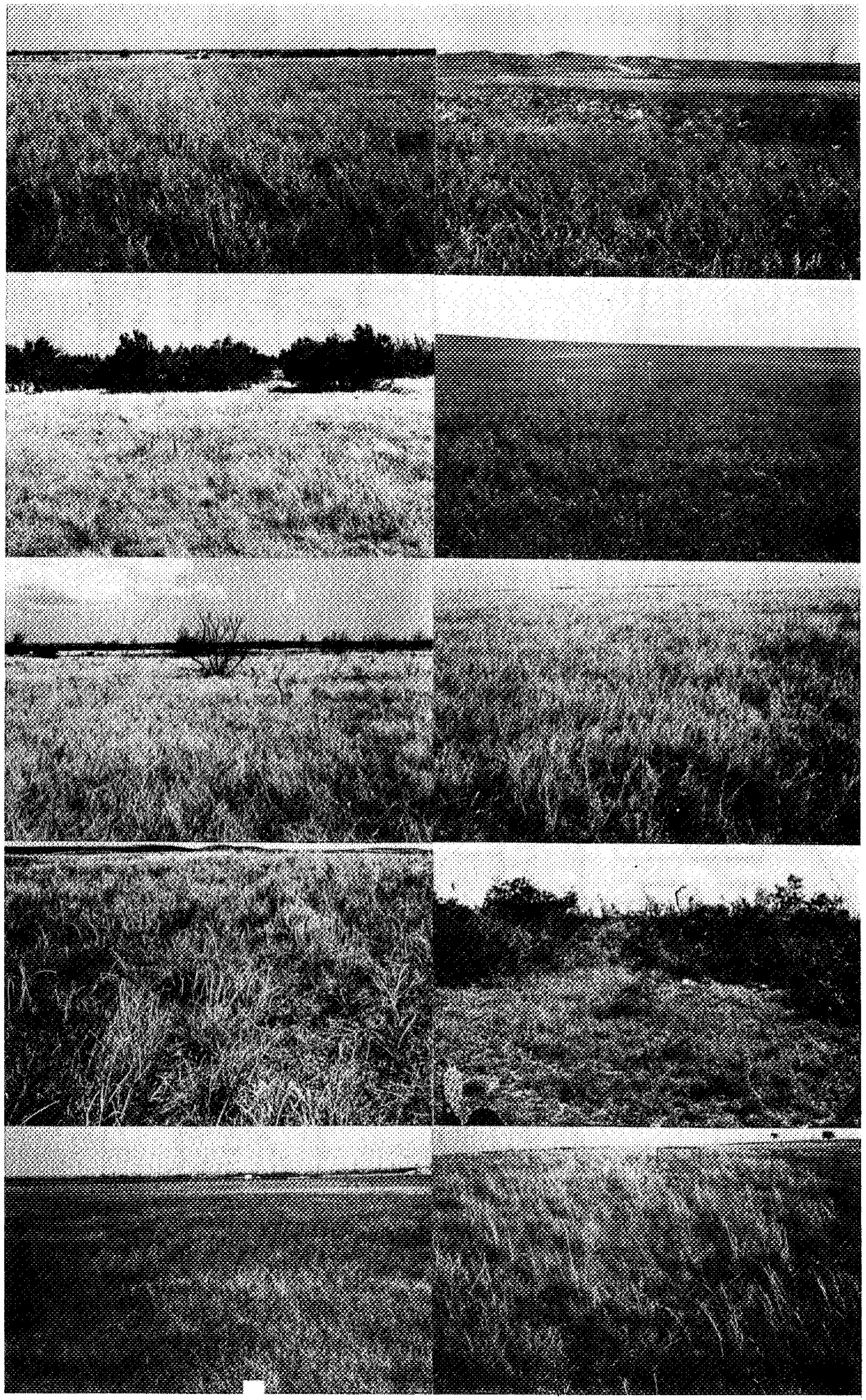


Figure 3-1. Great Plains Corridor test sites - 1. College Station, Tex.; 2. Sonora, Tex.; 3. Throckmorton, Tex.; 4. Woodward, Okla.; 5. Hays, Kans.; 6. Sand Hills, Nebr.; 7. Cottonwood, S.D.; 8. Mandan, N.D.; 9. Weslaco, Tex.; Chickasha, Okla.

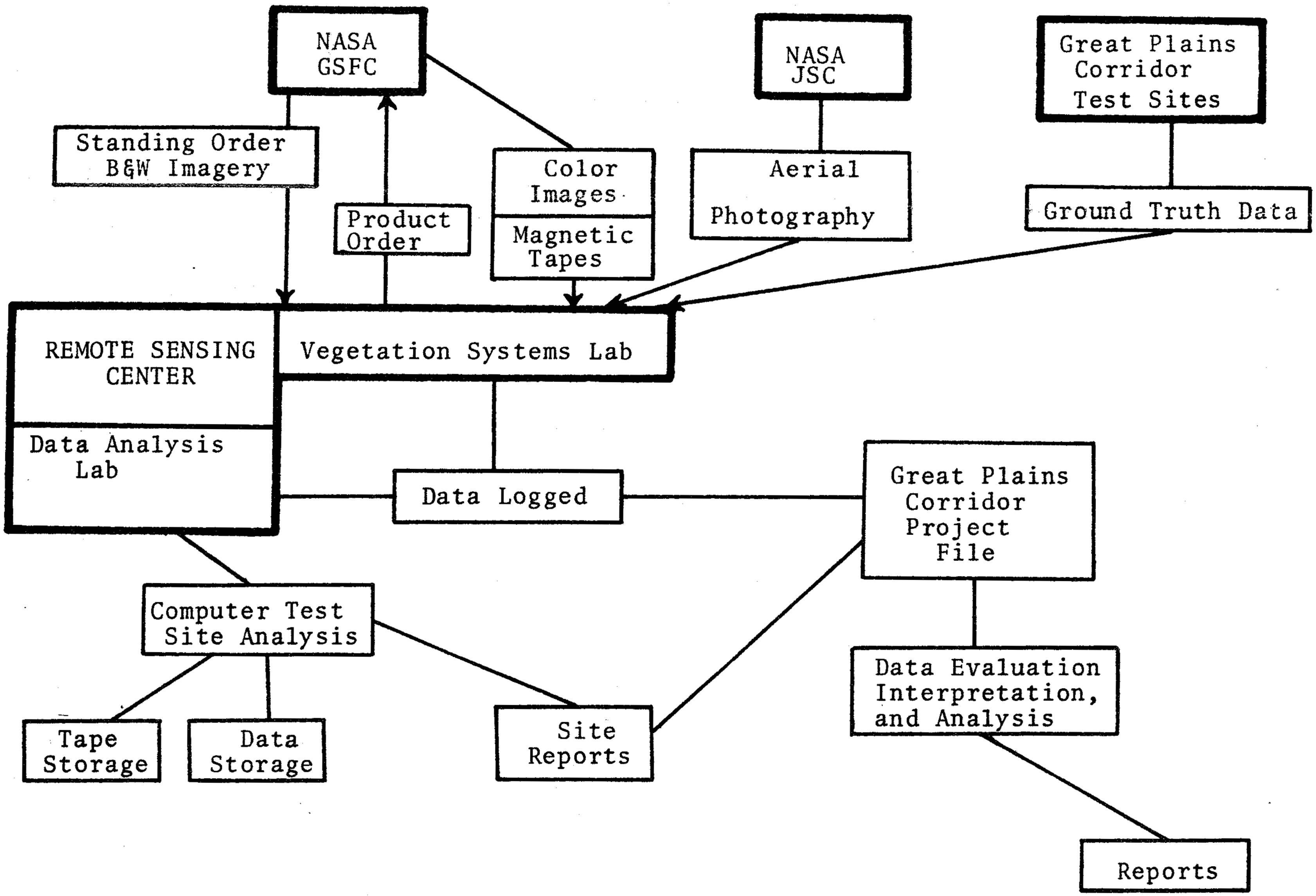


Figure 3-2. Operational flow chart for the ERTS-1 Great Plains Corridor Project.

a periodic data summary reporting procedure. The data handling system provided data products for internal analysis and for the users in the Great Plains. The system is formalized by a series of processing request forms which insure accurate and timely processing of the data from all sites.

3.1 Ground Observations

3.1.1 Great Plains Corridor Test Site Network

The effective rangeland test site network, established within the Great Plains Corridor region during the initial phases of the ERTS-1 investigation, consists of ten study sites (Figure 3-1). Nine of the sites lie within the Mixed Prairie grassland association. The headquarters study site at College Station, Texas occurs within the closely allied but somewhat more humid True Prairie grassland association.

The "Great Plains Corridor Rangeland Test Sites" are described by Deering and Haas (1972) in Technical Memorandum RSC-63 (Appendix A). With the exception of the College Station and Weslaco study sites, which are at elevations of 96 and 69 m, respectively, the Great Plains Corridor test site elevations span only 550 m, from Texas through North Dakota. Their elevations range between 340 and 880 m.

Loamy soils predominate on most of the study areas within the Corridor. However, one southern site (Woodward) and one northern site (Sand Hills) are dominated by sandy soils. Two southern sites (Sonora and Throckmorton) and one northern site (Cottonwood) are dominated by more clayey soils.

Important community dominants within the Corridor include warm-season grasses (bluegrama, buffalograss, sideoats grama, and big and little bluestems) and cool season grasses (western wheatgrass, needle-and-thread, and Texas wintergrass). Stipa and Bouteloua genera are considered to be characteristic of the Mixed Prairie and are present throughout the association. The relative homogeneity of the Great Plains Corridor study sites, in terms of vegetation types, reflects the integration of climatic and soils factors.

Most of the test site areas are essentially treeless, but overuse of the prairie in the past has led to invasion of trees and shrubs in some areas. Most notable of these are the Weslaco and Sonora study sites where woody legumes and other undesirable brush species have changed the prairie into a brushland type. Climax dominant grasses have mostly been replaced by less desirable species at these locations. However, the understory vegetation retains many features of the Mixed Prairie. Brush invasion is evident but less prominent on several of the remaining study sites (Figure 3-1).

Due to the nature of the data and techniques for handling the data used in the Great Plains Corridor project, the terminology for describing locations and areas can be confusing. Consequently, Figure 3-3 is included to illustrate the terms that will be used henceforth.

The TEST SITE is the tract of land managed by the cooperating organization within which ground truth data were collected. These test sites are described in Technical Memorandum RSC-63. SAMPLING SITES are the specific locations (usually five) within the test site where ground truth samples were taken. The areas are permanent plot locations photographed and sampled every 18 days during the growing season as described in Technical Memorandum RSC-71 (Appendix B).

The procedures used for extracting ERTS-1 digital data for analyses are described in detail in Technical Report RSC-54 (Appendix C). In brief, it involves generation of a 32 km by 32 km locator greymap ("greyscale" computer printout map) of ERTS band 5 data including the test site. The test site is then manually located on the greymap and a 7 km x 7 km rectangular area (9840 pixels) is then centered on the test site. This is referred to as the

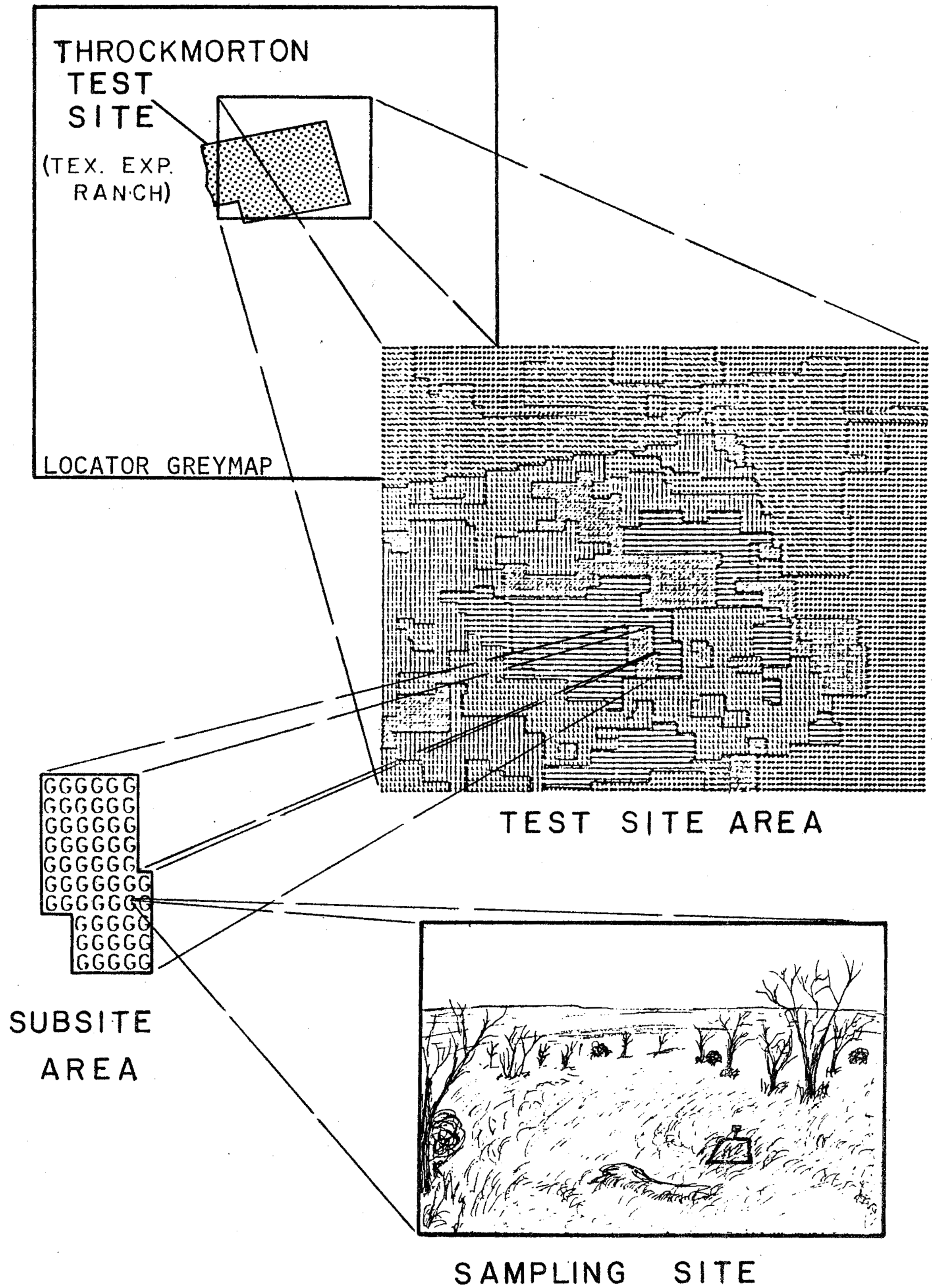


Figure 3-3. Terms used for describing locations and areas for Great Plains Corridor test sites.

TEST SITE AREA. The test site area is then subdivided into SUBSITE AREAS arising from test site characterization. These subsite areas are the relatively homogeneous landscapes for which the MSS data were extracted and analyzed. Selected subsite areas correspond to ground sample locations.

3.1.2 Ground Sampling Procedures

The ground truth data collection for the ERTS-1 project was performed by highly skilled field personnel experienced in sampling rangeland vegetation. Procedures for ground data collection are presented formally by D.W. Deering in the Technical Memorandum RSC-71 (Appendix B). The procedures provided for the collection of a uniform data set from the cooperating research stations. Background information on climate, soils, vegetation and grazing management was also obtained for each of the test site areas during the study.

The following is a step by step summary of the collection procedures established for each ERTS-1 correlated ground truth data collection: (1) locate a permanently staked photo point which identified the sampling site, (2) a 1-meter square (or similar) clipping plot frame was placed in an area representative of the vegetation of the site within the sampling area; approximately 15 to 30 m north of the camera's location, (3) affix appropriate site and date labels to an aluminum plot marker stake and position the marker at the center of the far side of the plot frame, (4) take one oblique photo of the preselected scene that includes the clipping plot, recording the camera f-stop and shutter speed settings, (5) take another oblique photo from approximately 4.5 m south of the sampling plot centered on the sampling plot, (6) lay the aluminum marker in the edge of the plot frame and photograph the clipping plot vertically from 1.2 to 1.5 m directly above the plot, (7) select and photograph the plant or situation which represents the dominant physical aspect of the sampling site, (8) estimate the percentage of the standing vegetation in the sampling plots that is green matter (projected to a dry weight basis), (9) record the conditions of vegetation, current utilization, dominant species, phenological stage of plant development and record on data collection form, (10) clip the standing vegetation in the plot to within 1 to 2 cm of the soil surface and place sample in labeled paper bag, (11) place the labeled collection bag in a large plastic bag to reduce the amount of moisture loss, (12) after all sites have been clipped, return to headquarters and weigh each biomass sample, (13) dry biomass samples at 65-70° C for 24 hours (if air dry weights were used, it was so indicated on each data collection form), (14) repeat steps 1-13 for each designated sample site, (15) mail the film in preaddressed mailer supplied by the Vegetation Systems Laboratory, (16) return all records of sampling data to the Remote Sensing Center, College Station, Texas.

The above procedures also provided uniform data on weather conditions existing at the test sites prior to and after the time of ERTS-1 satellite coverage and on the condition of vegetation at the sampling site. Four parameters were systematically summarized for each satellite overpass at each location. These parameters were total standing biomass, the water content of the vegetation, the percent green estimate and a calculated value for green biomass (i.e., dry weight x green estimate).

3.1.3 Summary of Ground Data Acquired

Following confirmation of the successful ERTS-1 launch on July 23, 1972 and receipt of orbital tracking information, schedules of satellite overpass were prepared for each of the ten G.P.C. test sites. The test site cooperators were then provided with overpass schedules for their locations. Beginning with ERTS-1 Cycle No. 1, the cooperators were instructed to obtain ground truth samples (Technical Memorandum RSC-71) on the day of each satellite overpass ±3 days. The ground data collection was not requested during the winter dormant seasons, which followed the first hard freeze. Post-freeze samples in the fall and pre-greenup samples in the spring were taken when possible.

Thirty-nine (39) ERTS-1 cycles occurred from the time the first ground samples were taken in mid-August 1972, until ground data collection was terminated on July 1, 1974. Two-hundred and twenty (220) ground truth data sets were collected during this period (Figure 3-4). This is 85% of the possible number of data sets that could have been collected (i.e., growing season samples plus one pre-greenup and post-freeze sample) under ideal conditions.

There are several reasons for the lack of ground truth data for a few ERTS overpasses shown in Figure 3-4. Occasionally, satellite overpass would occur at a given test site when weather conditions obviously precluded data acquisition by ERTS. When this situation was known prior to ground sampling, the ground data were generally not taken. At some test sites, particularly Weslaco, an obvious lack of significant change in the vegetation and soil conditions from one sampling period to the next resulted in no ground samples being taken on a few dates. The Hays test site cooperator was unable to allocate the manpower necessary to sample in the 1974 growing season.

GROUND TRUTH DATA ACQUIRED

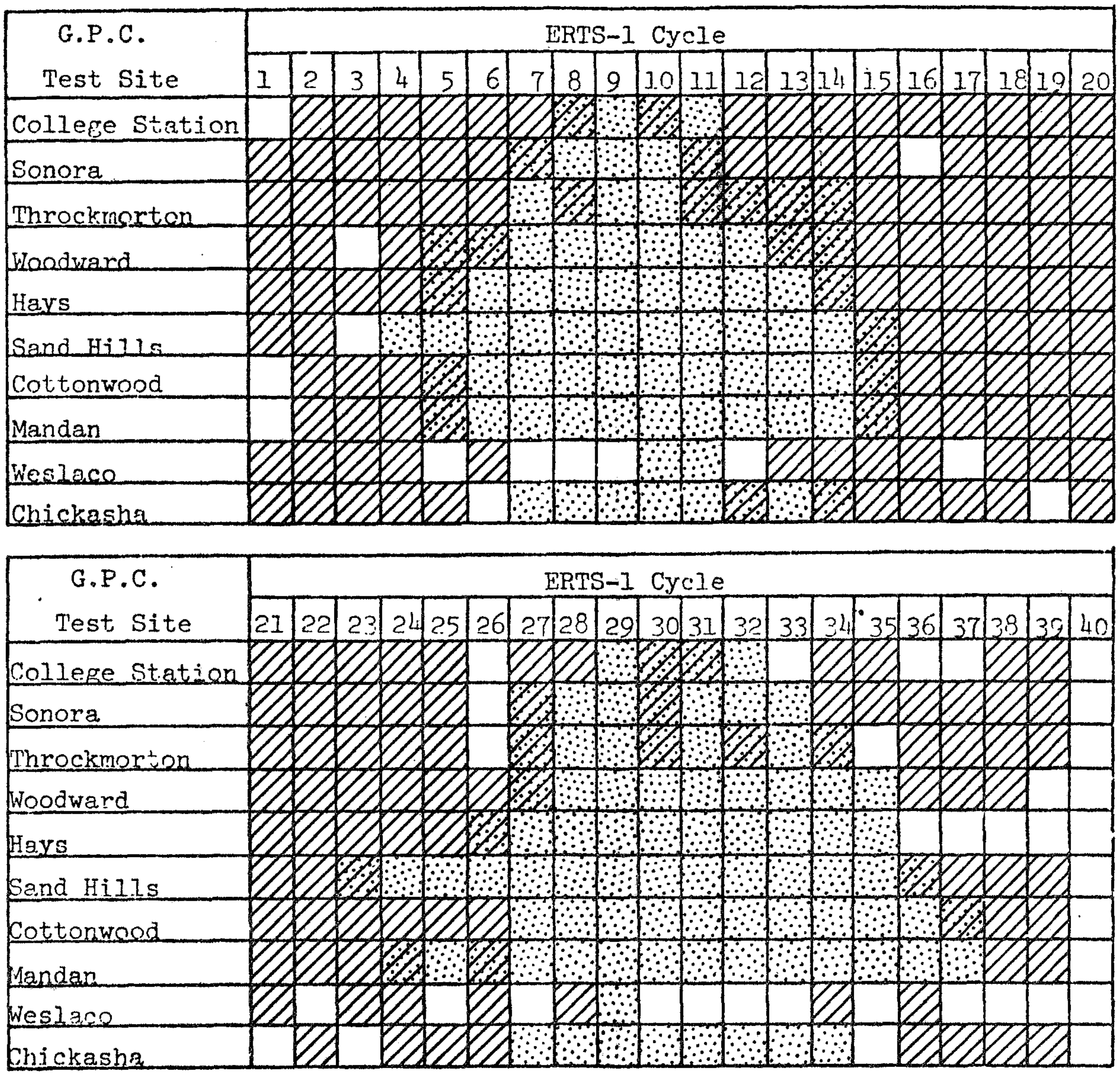


Figure 3-4. Ground data collected at the Great Plains Corridor test sites coincident with ERTS-1 overpass cycles. Hatched blocks indicate that ground samples were taken, and stippled blocks indicate the dates bounded by the first killing frost in the fall and the last killing frost in the spring.

Ground data collection was accomplished at College Station, Sonora, and Throckmorton, Texas test sites primarily by the personnel from the Remote Sensing Center. Samples were taken throughout the 22-month period to document both growing season and winter dormancy conditions at these locations. This sampling resulted in 30, 29 and 30 sets of ground truth data for College Station, Sonora, and Throckmorton, respectively. The least number of samples obtained was 15 at Sand Hills where the length of the growing season is relatively short and the test site is isolated.

3.2 Aerial Photography

The original proposal for this project specified that high altitude aerial photography should be acquired a maximum of 5 times and be coordinated as underflights to ERTS-1 coverage. The aircraft data were to have been used to document the conditions of maximum seasonal development and change. These requirements were later changed to accommodate NASA/JSC limitations on photographic coverage.

Five attempts were made by NASA to obtain the specified photographic coverage of the Great Plains Corridor test sites. Only partial coverage of the ERTS Great Plains Corridor test site areas was obtained during each of the missions. Appendix D shows composite tables of the NASA acquired aerial photography and an evaluation of each of the photo sets. This information had been reported earlier in Technical Reports RSC 1978-1, RSC 1978-3, and Type I Progress Report No. 8.

Large scale aerial photography was obtained at several dates in support of the intensive sampling carried out at the Throckmorton test site. The photography obtained on May 29, July 24, and October 17, 1973 and May 23, 1974 were obtained as underflight to ERTS overpass coverage. The RSC-obtained aerial photography was flown by the Texas Forest Service of the Texas A&M University System.

At least two acceptable aerial photo missions of high flight imagery were obtained from NASA/JSC for each of the test sites. This information was used extensively in characterizing the test sites and in mapping resource boundaries. Both the small scale aerial photography acquired by NASA and the large scale aerial photography acquired by the RSC are continuing to be used in evaluating the characteristics of the resources observed from ERTS-1 data.

3.3 ERTS-1 Data

During the course of the investigation, both imagery products and MSS digital data were used in various phases of the investigation. Standing order products included imagery of single MSS bands 4, 5, 6, and 7 and the digital tapes which included the scenes for the 10 Great Plains Corridor test sites. Color composites of MSS bands 4, 5, and 7 and 4, 5, and 6 were ordered as required.

3.3.1 Data Handling Procedures

As outlined in the data handling plan, ERTS-1 standing order product data were received by the Vegetation Systems Laboratory and logged and filed by appropriate test site (Figure 3-2). A routine evaluation was made of the imagery quality with respect to the location of the test site within the scene, cloud cover, image noise and other factors which may be important to subsequent data analysis. For those satellite passes having a favorable evaluation, and for which data digital products were to be ordered, a retrospective order was placed for MSS digital data tapes and the color composite print.

Processing of ERTS-1 MSS data for this project effort was accomplished by the Data Analysis Laboratory. Distinct stages of the computer analysis procedures were performed upon the receipt of the digital ERTS MSS data tapes. Specific digital computer analysis included: (1) a statistical estimation of spectral signatures means and covariances, and (2) computation of phenological indicator parameters. Various statistical analyses have been performed to determine the relationship between the ground data measurement at the network test sites and the satellite measurements. A computer generated summary report was prepared for each of these analyses. A software package was developed to provide the fundamental analysis capabilities in the area of signature evaluation and data summary. Primary data used in this investigation were mean reflectance values from test site subsite areas.

3.3.2 Test Site Characterization and Processing

Initial ERTS-1 MSS data analyses used mean values from the overall test site area, and in some cases exhibited a considerable "within" variation. Since all test sites include extraneous landscape features, such as bodies of water, cropland, severely eroded areas, etc., it was deemed essential to restrict the use of ERTS-1 data to areas characteristic of sampling sites.

An approach for characterizing landscapes within the test site area was based on identifying uniform soil, vegetation and land use patterns. The procedure for isolating the uniform resource types is given by Thompson and Haas in "Classifying Land Resource Types at ERTS-1 Test Site Areas" (Appendix C). From this procedure, a "mask" was developed for each test site area, permitting the retrieval and analysis of MSS digital data from relative uniform landscapes characteristic of subsite areas.

An evaluation of the "masking" procedure for reducing the variation in MSS Band 5 and Band 7 radiance values within the test site area and selected subsite areas was examined at the Throckmorton test site. The assumption is made that the lower the variability in radiance values, the more homogeneous the ground scene. It is further hypothesized that the standard deviation relative to mean radiance for several dates provides a good estimate of the homogeneity of subsite areas.

At the Throckmorton test site, coefficients of variation (C.V.) were calculated and plotted (Figure 3-5) for Band 5 and Band 7 radiance values for 14 ERTS-1 overpass dates. The subsite area values were obtained and averaged for the four subsite areas which include the ground sampling sites. The graph reveals that the coefficients of variation for both bands are considerably reduced when subsite area data are used. For 14 dates, the Throckmorton test site area mean C.V. was 15.9% for Band 5 and 11.1% for Band 7 data. The corresponding subsite area mean C.V. was 11.5% for Band 5 and 8.6% for Band 7. In this example, the coefficient of variation was reduced 27.9% and 22.6%, respectively, when subsite area data for Bands 5 and 7 were used rather than test site area data.

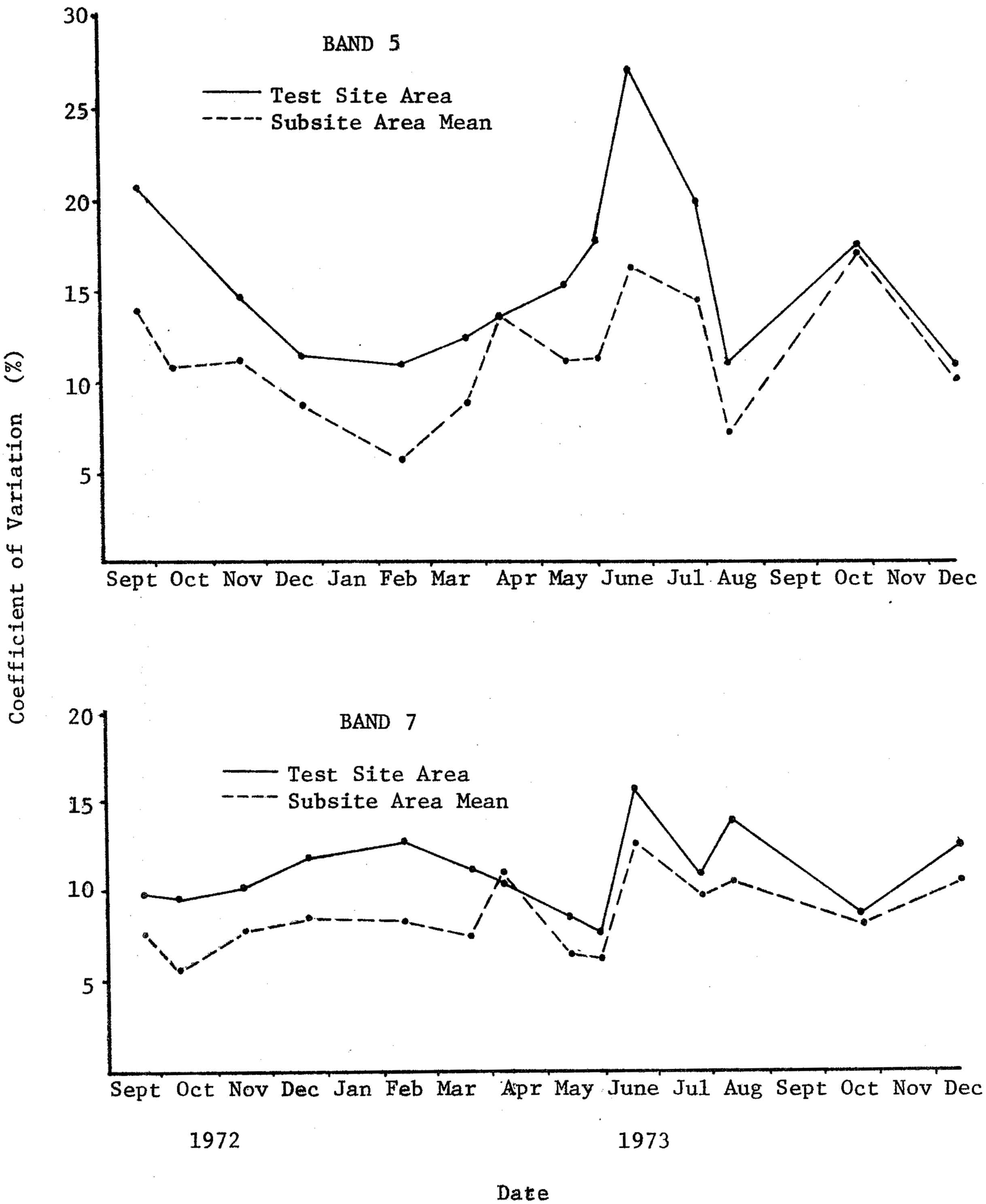


Figure 3-5. Coefficients of variation for ERTS-1 MSS radiance measurements in Bands 5 and 7 on fourteen dates at the Throckmorton test site.

Since the vegetation, soils, and land use within the Throckmorton test site area result in a relatively homogeneous composite scene, it was expected that an even greater benefit from the masking technique would be realized at some of the other test sites. This reduction in variability within data sets has resulted in a substantial improvement in the quality of satellite data and enhanced satellite-ground data relationships.

Processing of ERTS-1 MSS data has been accomplished by digital computer analysis. These analyses have been completed in distinct stages upon receipt of the digital ERTS MSS data tapes from retrospective order. Figure 3-6 shows the ERTS data handling plan.

The Texas A&M University Data Processing Center has been used to execute the data handling plan. Upon receipt of the standing order imagery by the Remote Sensing Center, the data were logged and filed by the Vegetation Systems Lab (VSL). Standing order products were utilized to evaluate data quality prior to the initiation of data analysis. ERTS-1 digital data tapes were ordered via retrospective requests, logged into the data file upon receipt, and a data processing request was generated by the VSL. The data tapes accompanied the processing request to the Data Analysis Laboratory where site processing was performed. This multistep process included: (1) extracting the data for a 1000 sq. km area from the digital tape and storing on disk for high speed processing; (2) computer generating a grey-map for Band 5 data; (3) accurately locating test site areas and identifying the corresponding coordinates on the greyscale printout; (4) processing test site area data, which includes calculation of mean radiances corrected for sun angle for each specified subsite area; (5) generating a site processing report and updating the computer data catalog; and (6) filing the digital data tapes in the Data Analysis Lab and transferring the site processing reports to the Vegetation Systems Lab.

Figure 3-6 also shows the relationship between ERTS and ground data processing relative to a final data product for interpretation and analysis.

3.3.3 Atmospheric and Illumination Corrections

Changing atmospheric and illumination conditions were anticipated as a serious problem for making temporal comparisons of digital data values. An investigation of the effects of atmospheric illumination resulted in the application of a solar angle correction for all radiance data used in this investigation. Atmospheric effects were minimized by using only cloud-free data.

The mathematical relationship of the intensity of solar radiation falling on a horizontal plane is presented

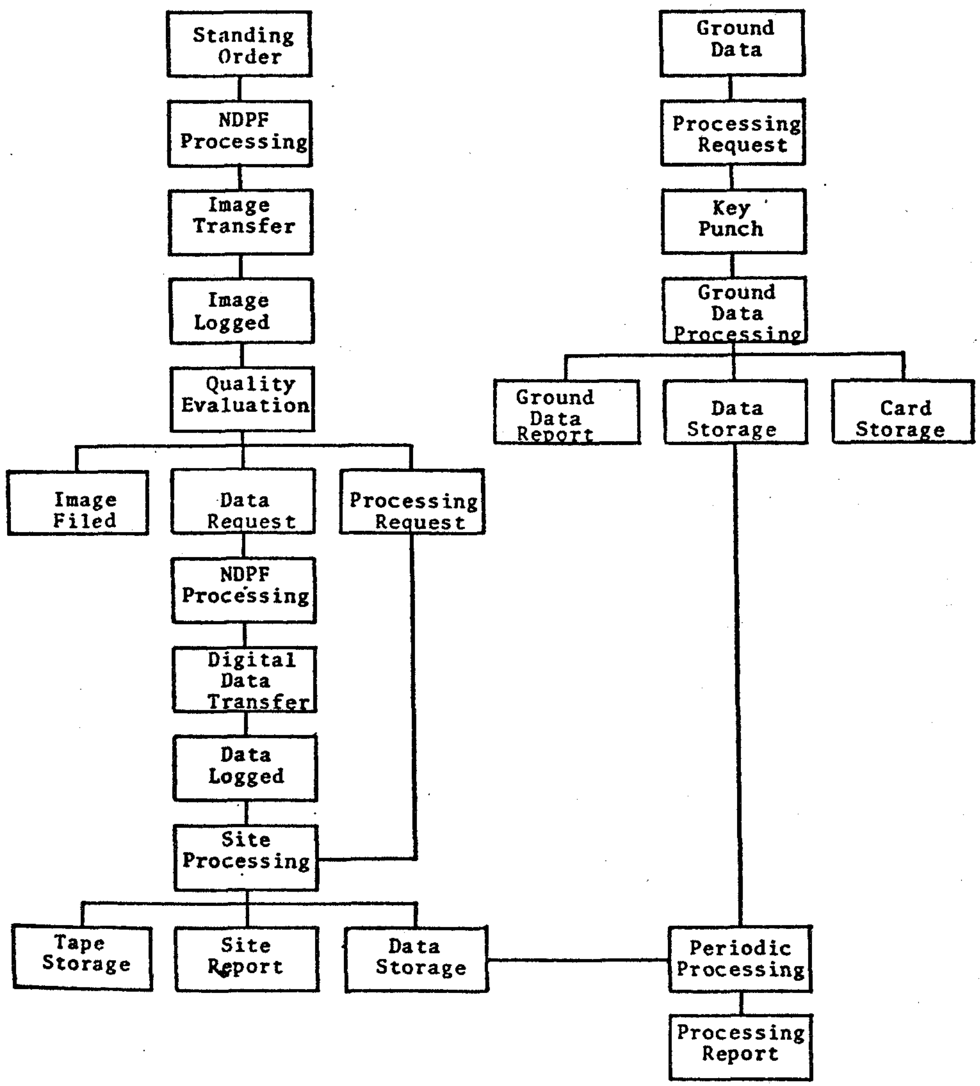


Figure 3-6. ERTS Data Handling Plan

by Robertson (1966). In this model, the solar intensity is a function of the solar constant I_o, and the solar elevation γ. The relationship

$$I_H = I_o \sin \gamma$$

was used to correct MSS digital data for changes in solar intensity as a function of solar elevation angle.

Early tests by the Data Analysis Lab confirmed that the solar angle correction removed most of the variation due to solar angle (Type II Progress Report, No. 1); thus, permitting temporal comparison at a given test site and among test sites for a given ERTS-1 cycle. These investigations confirm the contentions that the sun angle correction is adequate to provide meaningful signatures from ERTS MSS data under clear sky conditions.

3.3.4 Data Quality

The useability of ERTS-1 data for the Great Plains Corridor project has been dependent on the quality of the data relative to atmospheric perturbations, such as clouds and bad or missing lines of data.

During the first 13 or 14 months of ERTS coverage, almost all of the ERTS data acquired for the Corridor test sites resulted in images unblemished by obviously bad or missing data for all four bands. Beginning in the latter part of 1973, however, an increased number of data sets were observed to have bad or missing data for one or more of the four MSS bands. This caused problems in getting retrospective orders filled for CCTs because GSFC normally will not process the tapes when this condition exists. Special requests for these tapes were placed when Bands 5 and 7 obviously had good data even though bands 4 or 6 may have been poor. These data were always carefully examined before use in analyses for correlation with ground truth data.

Cloud cover most often limits the quality of the data available for a test site, although ERTS-1 provided abundant cloud-free coverage of the Great Plains Corridor test sites during this study, as detailed in Section 3.3.5. Overlap of adjacent ERTS-1 coverage swaths sometimes enabled the acquisition of satellite data for a particular test site when during a given coverage cycle the test site was cloud covered on the scheduled overpass date. When a test site lies within the overlap area or the preceeding or following day, and cloud free conditions exist over the test site, the ERTS-1 test site data can be obtained for that cycle.

In the Great Plains Corridor, this sidelap double coverage was very valuable for several of the test sites. Image sidelap ranged from about 24% at the south end of the Corridor to about 43% at the north end. Approximately 15% of the usable data were available due to the sidelap characteristic.

Due to satellite east-west drift, however, sidelap double coverage was not consistent for some of the test sites. For example, at the Throckmorton, Texas test site, double coverage due to image sidelap was possible during the first eleven ERTS-1 cycles (Figure 3-7). In late February or early March 1973, the satellite's orbit had drifted to the west such that the primary test site area fell outside of the sidelap double coverage area. At that time, the orbit apparently became more stable also, as evidenced in Figure 3-7. This situation existed until the first part of October 1973 (Cycle No. 24), when double coverage was again possible. By the end of March 1974 (Cycle No. 34), single coverage at the test site recurred and persisted until the conclusion of the study.

While the orbit shift decreased the chances for good ERTS-1 coverage at the Throckmorton and Woodward test sites, it correspondingly increased the chances at the College Station, Sonora, Chickasha, and Mandan test sites. Coverage of the other four sites was essentially unchanged.

3.3.5 Summary of ERTS Data Received and Processed

The ERTS-1 imagery and tape receipts and orders "quick-look" chart (Appendix E) shows by test sites and ERTS-1 cycles the products that were requested and received for this investigation.

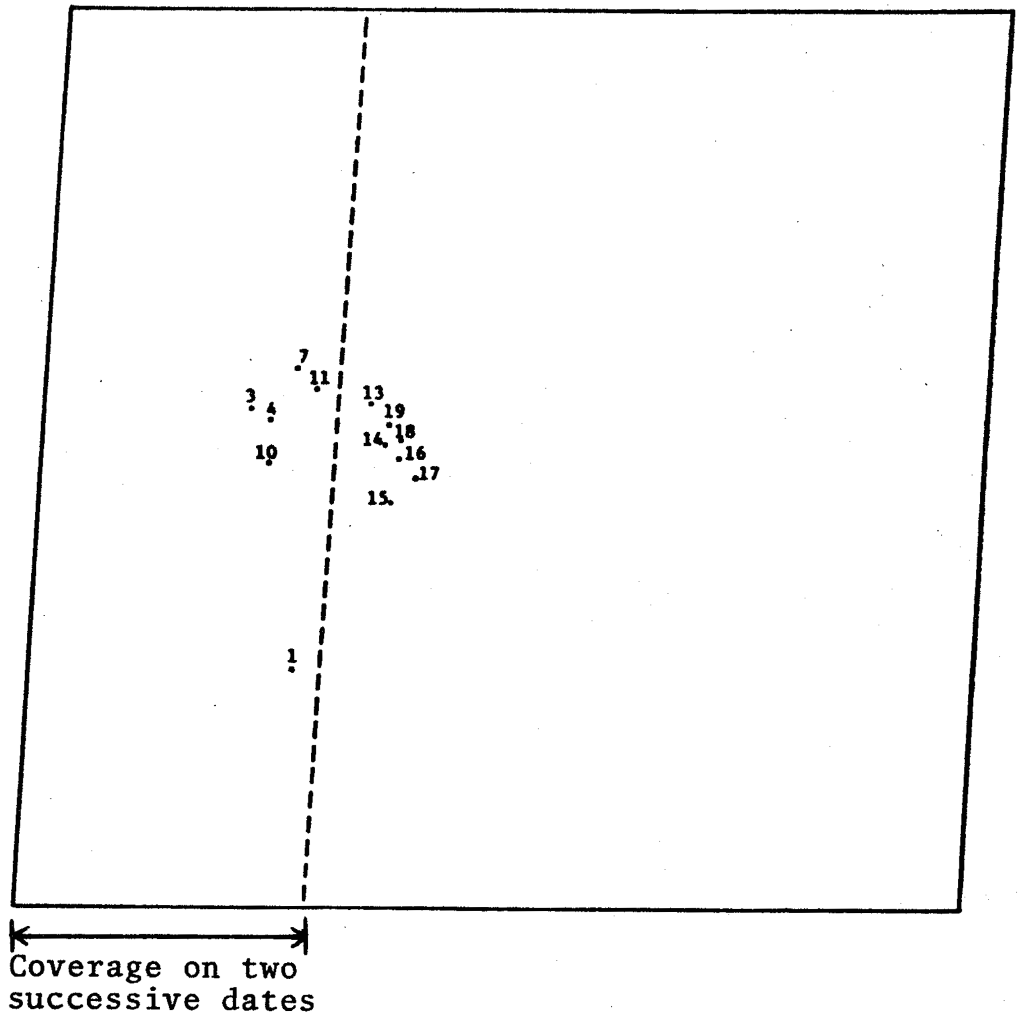


Figure 3-7. Position of the Throckmorton test site within ERTS-1 images for 13 cycles.

ERTS-1 provided abundant cloud-free coverage of the Great Plains Corridor test sites during the 22.5 months that ground truth data were taken. During this period, an average of 52% of the possible images from 39 ERTS-1 overpass cycles provided usable MSS data for the Corridor test sites (Figure 3-8). The Hays, Throckmorton and Sonora test sites had the highest percentages of usable ERTS-1 data with 64%, 62%, and 62%, respectively. Three other test sites, Chickasha, College Station, and Sand Hills, had greater than 50% (56%, 52%, and 52%, respectively). Of the remaining test sites, Weslaco, Cottonwood and Mandan had 49%, 46% and 46%, respectively. Woodward yielded the least number of good overpasses with only 36%. Even this percentage would be considered good coverage in many parts of the U.S.

The following ERTS-1 data products for the Great Plains Corridor test sites have been received from NASA/GSFC: 440 sets of four black-and-white standing order images, 203 color composite prints, 57 color composite transparencies, and 217 sets of computer compatible tapes (800 b.p.i.).

The procedures for processing the MSS data are described in Section 3.3.2 and Technical Report RSC-54. The "ultimate" product in the computer processing procedure is a site processing report for each subsite area within a test site (Figure 3-2). For the ten G.P.C. test sites, 148 ERTS

ERTS-1 DATA ACQUIRED

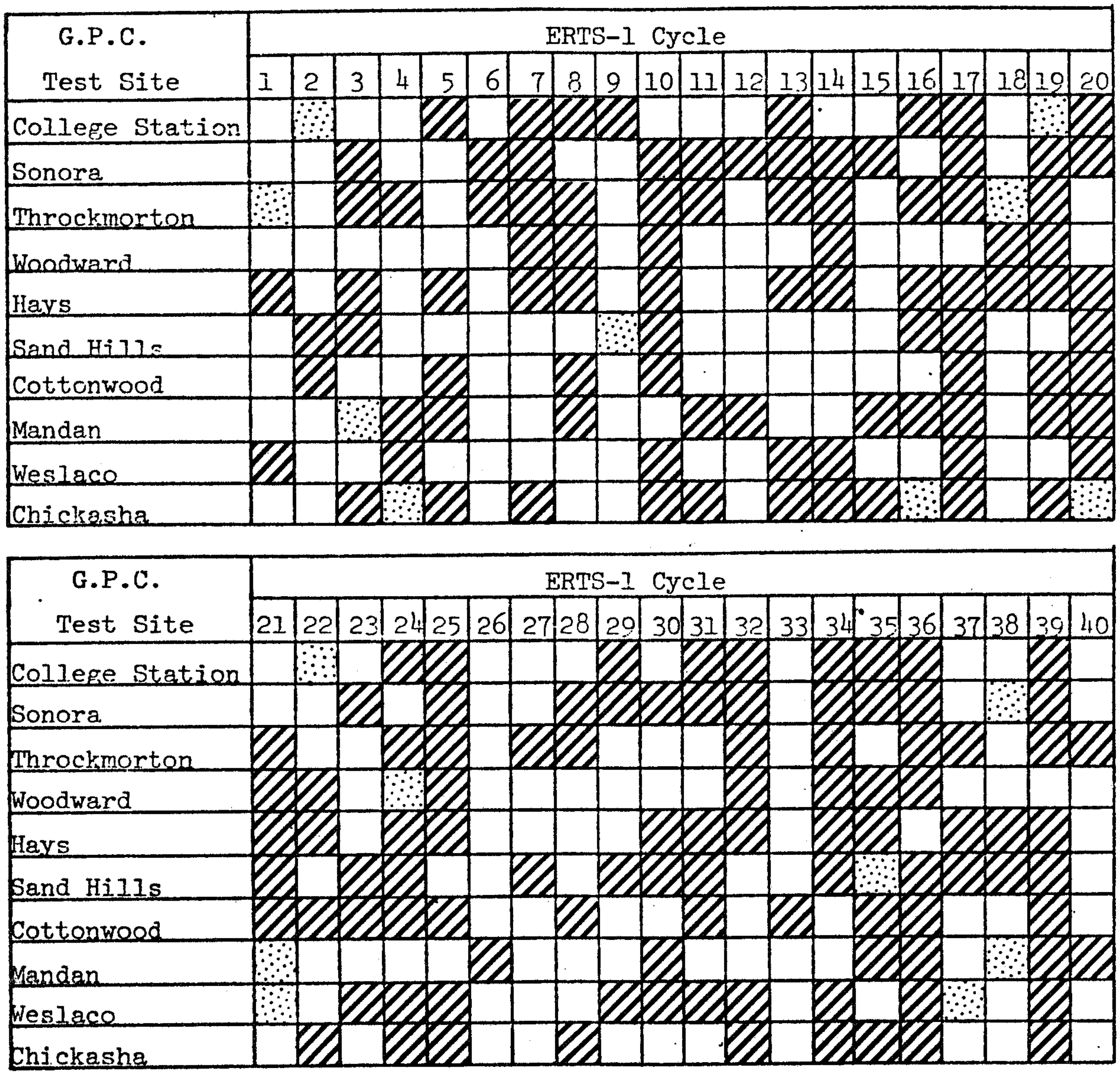


Figure 3-8. ERTS-1 imagery received for which 100% cloud-free conditions[1] existed (hatched blocks) over the test sites during cycles 1-40[2]. Stippled blocks indicate cycles that were not cloud-free but most of the site data are usable[3].

[1]Determined from the imagery
[2]Entire images not necessarily cloud-free
[3]Usually small cumulus clouds dotting the area with much clear or open area

MSS tapes were processed to this level. The maximum number processed to the subsite area level for a given test site was 25 at the Throckmorton test site. The minimum was eight at the Woodward and Mandan test sites.

3.4 Selection of Data Sets for Quantitative Analysis

Final analysis of ERTS-1 MSS data for quantitative relationships of reflectance parameters to ground data parameters required closely coordinated data collection and good data quality. Careful review was made of the potential 217 sets of satellite data and 220 ground truth data sets prior to the final data selection. In the final data selection, all satellite data sets were eliminated that did not have coordinated ground data and for which either ground or satellite data were suspect. These eliminations resulted in the final selection of 124 data sets for which both good ground and satellite data were available.

Attention was given to the selection of data sets which were representative of the several identifiable growth periods during the year. Growth response to weather in the Great Plains Corridor typically produces: (1) a period of rapidly increasing biomass production in the <u>spring</u>, (2) a period of diminished production due to <u>summer</u> drought, (3) a secondary period of biomass production in the <u>fall</u> and

(4) a period of little production or dormancy in the winter. These periods are shown diagrammatically in Figure 3-9.

Since the initiation and duration of each of the seasonal periods varies with latitude, they were defined for each test site. Figure 3-10 shows the defined duration of each period and the number of data sets for each seasonal period at each test site. The final selection included 124 data sets well distributed among test sites and seasons. All test sites were represented in all seasons, except the dormant winter seasons, where ground data were not collected at some sites.

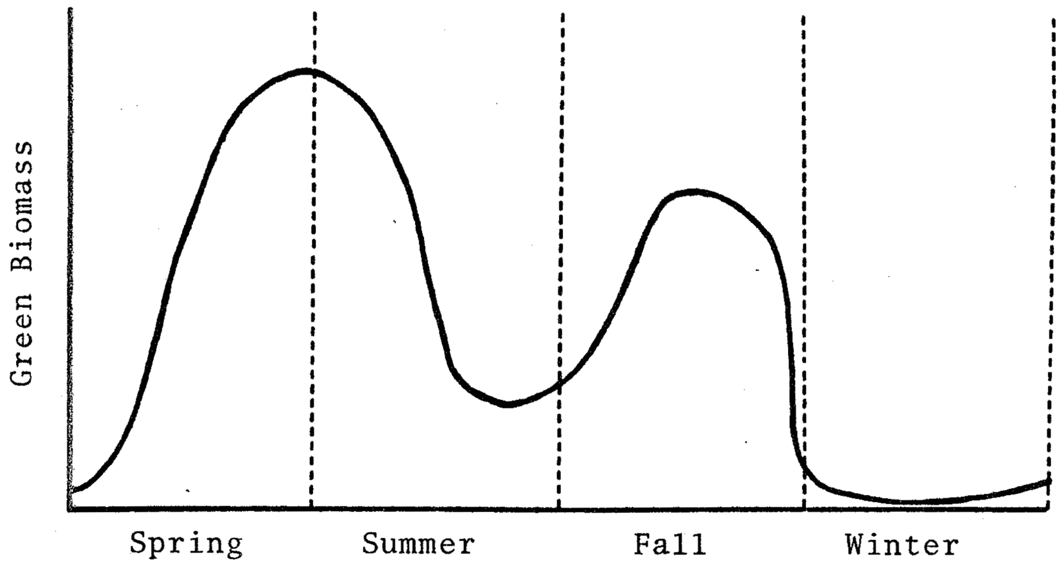


Figure 3-9. Hypothetical anticipated greenup-browndown response in the Great Plains Corridor and partition of seasons.

Test Site	Spring		Summer		Fall		Winter		Site Totals
1 N/S	Mar-May	4/4	June-Sept	3/2	Oct-Nov	3/3	Dec-Feb	1/1	11/10
2	Mar-June	7	July-Aug	2	Sept-Oct	2	Nov-Feb	3	14
3	Mar-May	6	June-Aug	3	Sept-Oct	4	Nov-Feb	5	18
4	Apr-June	2	July-Aug	3	Sept-Oct	1	Nov-Mar	1	7
5	Apr-June	4	July-Aug	4	Sept-Oct	4	Nov-Mar	0	12
6	May-June	4	July-Aug	5	Sept	1	Oct-Apr	0	10
7	May-June	4	July-Aug	4	Sept	4	Oct-Apr	1	13
8	May-June	3	July-Aug	1	Sept	1	Oct-Apr	2	7
9	Feb-May	4	June-Sept	2	Oct-Nov	3	Dec-Jan	0	9
10	Apr-June	5	July-Aug	2	Sept-Oct	4	Nov-Mar	2	13
Season Totals		47		31		30		16	124

Figure 3-10. Dates selected for seasons by test site as determined from ground data evaluations and the number of data sets selected for analysis for each test site and season.

4.0 DATA ANALYSIS AND RESULTS

4.1 Ground Observations

The kinds of ground truth data acquired at the GPC test sites concurrent with ERTS-1 overpass coverage were described in Section 3.1 and detailed in Technical Memorandum RSC-71 (Appendix B). Of primary interest in this study was the determination of the time of passage of the green wave in the early spring at each of the test sites as well as the detection of brownout of the grassland vegetation resulting from the summer drought stress typical of this region. It was logical then to measure some parameter of the vegetation reflecting the level of greenness in quantitative terms. Green biomass, or the quantity of aboveground herbaceous vegetation that is composed of live green plant material, was the parameter selected as the primary indicator of these conditions. Other vegetation parameters were also measured, including total aboveground biomass and moisture content of the vegetation, to access their degree of correlation with ERTS MSS data and to better understand the relationships between composite spectral reflectance of natural vegetation systems and components of these ecosystems. Other ground parameters were also measured or evaluated, such as precipitation, temperature, phenology, grazing utilization, etc., to further evaluate the MSS data and possibly explain anomalies that might exist at certain times of the year.

Ground photographs were also taken to serve as a permanent record of ground conditions and offer the possibility for use as an independent estimate of greenness.

4.1.1 Quantitative Vegetation Measurements

Of the parameters being measured to monitor vegetation condition, green biomass is probably the most sensitive for measuring significant changes. Green biomass, as used here, is the quantity of aboveground herbage (grasses and forbs) that is green and is expressed on a dry weight basis. In this investigation, the green biomass values are derived by integrating two independently determined factors--dry biomass (total standing herbage) and percentage green estimates.

Figure 4-1 reveals that maximum green biomass at the ten test sites varied widely; ranging from a low of 640 kg/ha at Weslaco to a high of 2900 kg/ha at Hays and Chickasha. The remaining test sites recorded maximum values close to 2000 kg/ha, with the exception of Sand Hills which never exceeded 1200 kg/ha.

In late April and early May 1973, green biomass for the Texas sites was relatively high, averaging 940

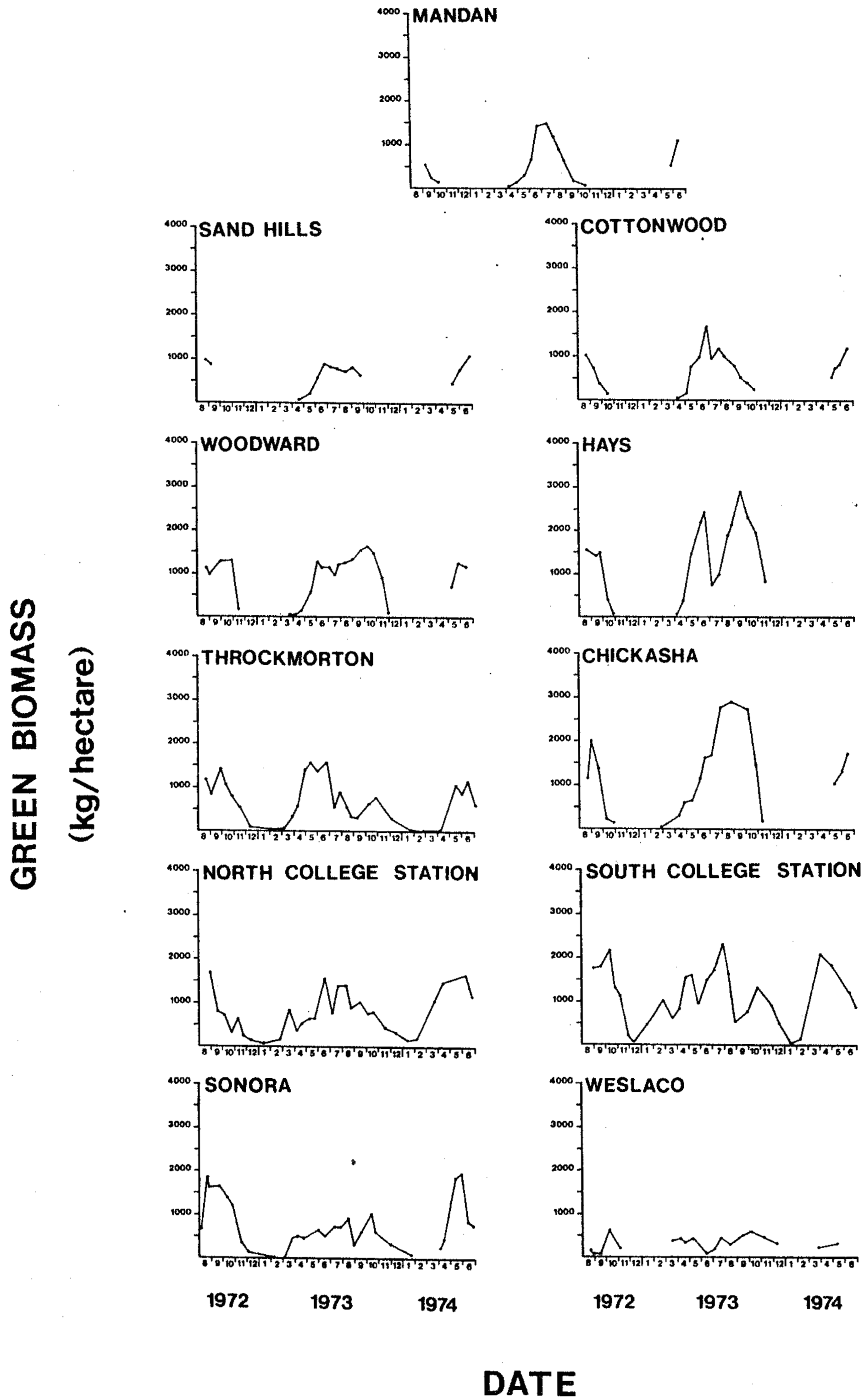


Figure 4-1. Green biomass at the eleven Great Plains Corridor test site areas as measured for 22 months of ERTS-1 coverage.

kg/ha. The Oklahoma and Kansas sites were just beginning to green-up and averaged 390 kg/ha. The northern sites had only 100 kg/ha, and this was due primarily to the growth of cool season species.

In late May and early June, the average green biomass for the Texas sites was somewhat lower (840 kg/ha) due to drier conditions at the Throckmorton and Weslaco sites. The Oklahoma and Kansas sites were in good condition at this time averaging 1460 kg/ha and the northern sites had begun to greenup quite well with an average of 730 kg/ha.

More favorable growing conditions in early July caused an increase in the average green biomass for the Texas sites (1230 kg/ha). The Oklahoma and Kansas sites averaged 1680 kg/ha at this time; an increase of 220 kg/ha over the early June period, even though the Kansas site showed a large reduction due to drought. The northern sites continued to show an increase in green biomass with an average of 1120 kg/ha.

All of the southern (Texas) and northern sites were experiencing summer drought by late August and, consequently showed a significant decline in green biomass (Figure 4-1). The southern sites averaged only 440 kg/ha and the northern sites had dropped to 780 kg/ha. All of the central Great Plains sites (Oklahoma and Kansas) had good moisture in July and August and continued to produce new green matter. Green biomass measurements showed an average of 2200 kg/ha at these three sites.

In late April and early May 1974, green biomass for the Texas sites averaged 1350 kg/ha, which was considerably higher than the same period in 1973. This difference is primarily due to the large increases at Sonora and the North College Station test site areas, since Throckmorton and Weslaco were slightly lower than in 1973. Green biomass was at or near its peak at this time. The Oklahoma test sites had reached about one-half their 1974 spring peak at 1000 kg/ha. The northern test sites had produced about 450 kg/ha green biomass. In early spring 1974, then, green biomass was approximately double that recorded during the same period in 1973 in the Great Plains Corridor.

By the end of June 1974, when the ground sampling was terminated, the southern test sites were experiencing early summer drought stress and had begun to brown down. The northern sites, however, had not yet reached their peak spring green biomass when the sampling period ended.

Although green biomass serves as an effective index for describing the amount of live plant material, it does not reveal the quantity of dry or total standing herbage. Total standing herbage, expressed on a dry weight basis, provides a measure of the amount of vegetation covering the ground surface and is called "dry biomass". The term "total biomass" is not used here, as it would cause ambiguity, since the term would include belowground biomass as well as the aerial parts of a plant. With this information and a knowledge of the type and growth habits of the vegetation that exists on a site, inferences can be made concerning the amount of vegetative ground cover, as well as height and density of the herbage.

Figure 4-2 shows the variations in dry biomass for the ten test sites for the 23 months of ground data collection. During the period of this study, the maximum dry biomass ranged from 3800 kg/ha at the Hays test site, where range fertilization is practiced, to 1000 kg/ha at Weslaco. Minimum dry biomass recorded ranged from 1600 kg/ha at Throckmorton and Mandan to 180 kg/ha at Weslaco.

Grazing treatment can cause a considerable influence on fluctuations in measured dry biomass. For example, green biomass at the Chickasha test site continued to increase from late April to late May 1973, due to the increase in percentage of the vegetation that was green matter. However, dry biomass decreased from late April to mid-May, since cattle were continuously grazing the pastures during this period. Following the mid-May sampling, five inches of rain stimulated growth such that by the late May sampling

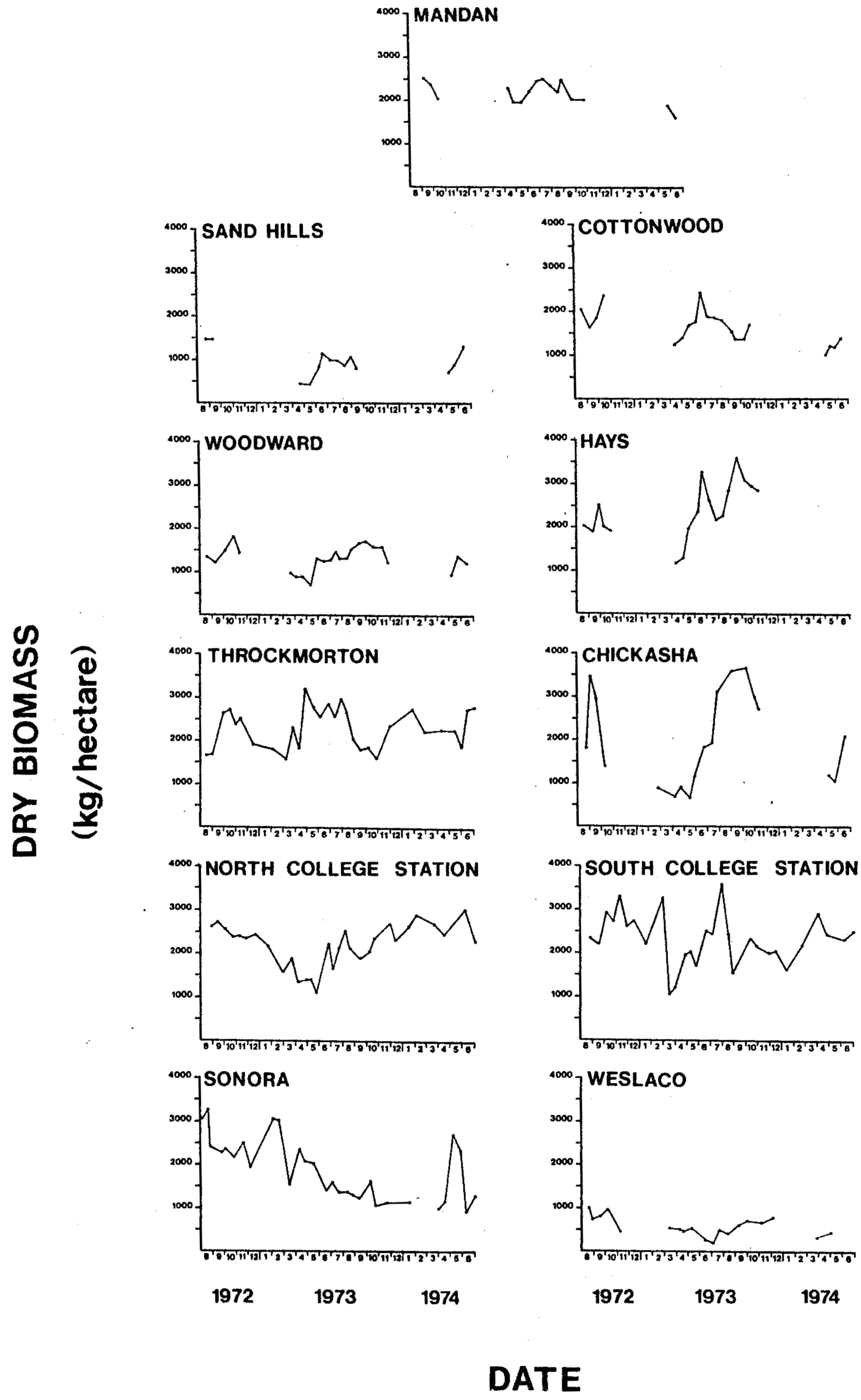


Figure 4-2. Dry biomass (total standing herbage expressed on a dry weight basis) at eleven Great Plains Corridor test site areas as measured for 22 months of ERTS-1 coverage.

dry biomass had increased about 40%. The percentage of the vegetation that was green matter was essentially unchanged on the two May dates.

Moisture content of the vegetation was measured at the ten Great Plains Corridor test sites at the time of each sampling, since moisture stress was expected to influence the spectral reflectance properties of plants (Figure 4-3). Moisture content of vegetation ranged from almost no moisture at Sonora (Feb. 3, 1973) and Throckmorton (Feb. 26, 1974) to 78% moisture at the South College Station test site (April 25, 1973).

Moisture content of the vegetation is generally indicative of growing conditions, with higher moisture contents indicating better growing conditions. Since the amount of moisture in the vegetation is greatly influenced by the quantity of green plant material, the graphs of these two vegetation condition indices are similar. However, weather factors such as high humidity and cool temperature can cause the moisture content to be relatively high, irrespective of the quantity of green plant material present. For example, at the Throckmorton test site, green biomass decreased approximately 20% between August 9, 1973 and August 24, 1973 (Figure 4-1), while the moisture content increased (Figure 4-3). This discrepancy can at least be

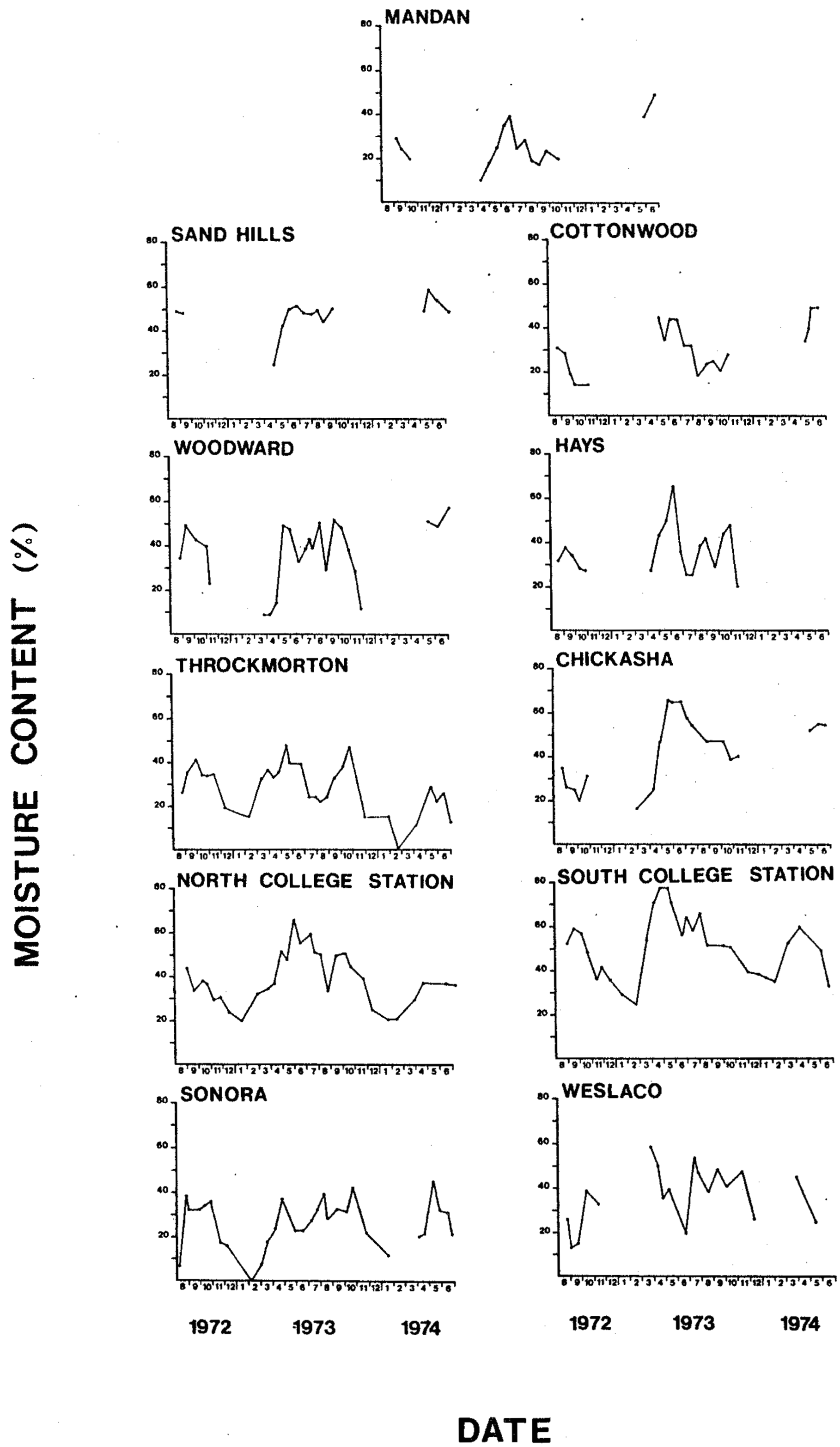


Figure 4-3. Percentage moisture content of the vegetation at the eleven Great Plains Corridor test site areas as measured for 22 months of ERTS-1 coverage.

partially attributed to the 3.8 cm of rainfall that fell between the two sample dates.

Due to the dependency of green biomass estimates on visual judgments of percentage green vegetation in sample plots, these estimates can be influenced by human bias or error. In an attempt to obtain an independent estimate of the "greenness" of a vegetative scene and to evaluate the likelihood that human bias or error in estimation may have been substantial, ground photographs were examined.

Oblique permanent photo point aspect photographs taken at all sampling sites at each test site as a part of the ground sampling procedure were digitized. Ten samples in each of the four filter positions of a Macbeth TD-504 transmission densitometer using a 3 mm aperture were taken from each 35 mm Ektachrome transparency. These values were averaged to obtain a single value for each filter position for each date at all test sites.

From a preliminary evaluation of the densitometer measurements in the four different filters and visual inspection of the transparencies from which the measurements were taken, it was determined that some technique for eliminating or reducing the effects of different exposures and lighting conditions was necessary. A ratio of the "visual" (V) filter density value to the "green" (G) filter density value was found to correct quite well for different exposures, as long as they did not approach severe over or under-exposure. An evaluation using vegetation greenness ratings from three interpreters based on pre-established standards and densitometer measurements from the same photographs showed very high correlation with the ratio V/G (R^2 = .86) and very low correlation with G (R^2 = .01). Subsequent regression analyses using ground truth estimates of percentage green vegetation show much better correlation with V/G than with G. This ratio was found far superior as an estimate of greenness to any of the four filter values alone.

The V/G ratio of film density data from the selected dates (Sec. 3.4) was used in simple linear regression analyses to assess the relationships between this independent estimate of greenness and the percentage green estimates from the ground truth data obtained by each test site cooperator. A high degree of correlation exists between these two estimates of green herbaceous vegetation at Throckmorton (R^2 = .8022), as revealed in Figure 4-4. The only other test site area showing good correlation is College Station-North (R^2 = .7742). Chickasha and Cottonwood are the only other sites that show a possible linear

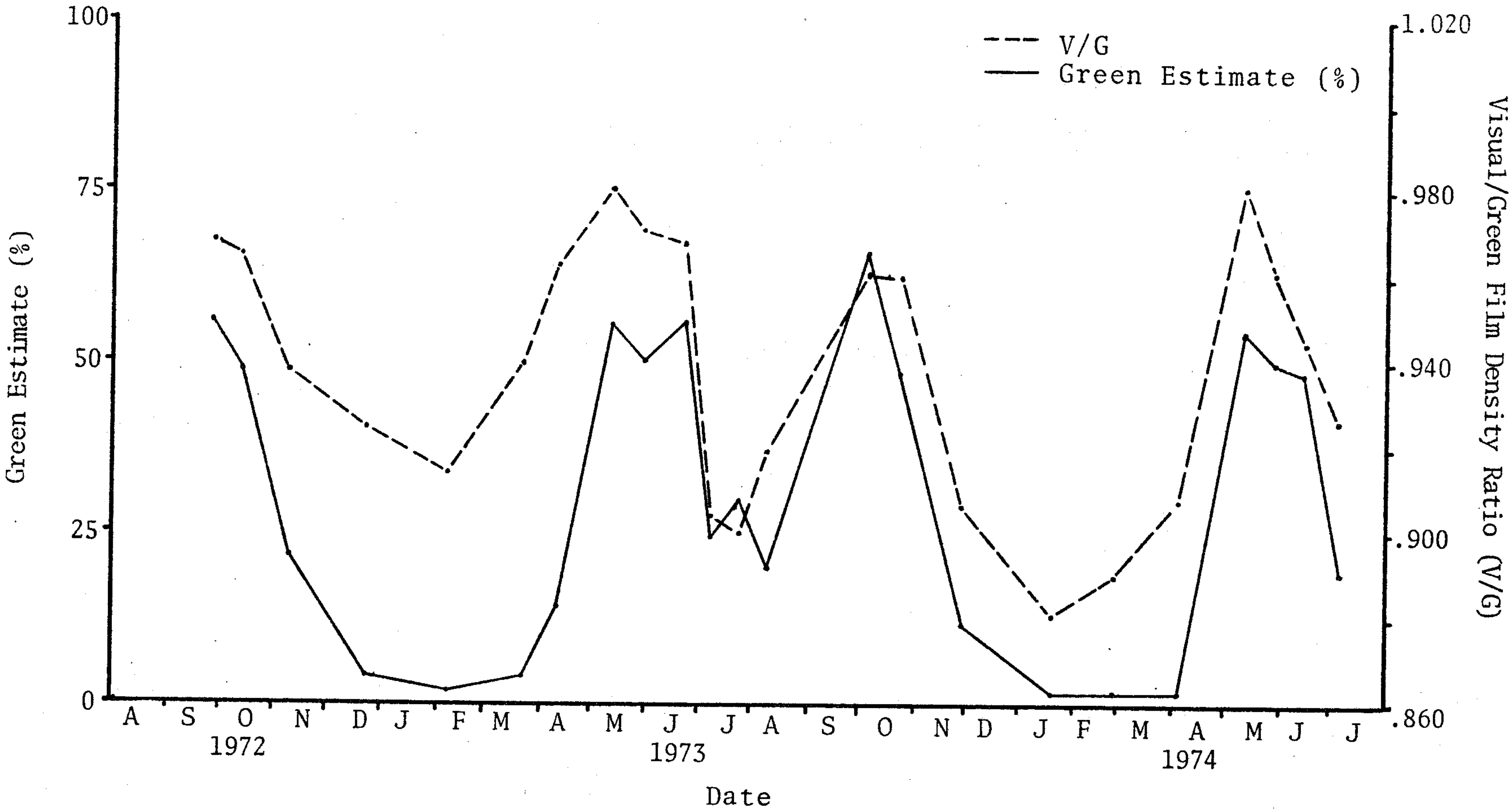


Figure 4-4. Graph showing the relationship of the V/G ratio (visual filter density value divided by the green filter density value) from ektachrome ground photograph densitometry to <u>in situ</u> estimates of percentage green herbaceous vegetation at the Throckmorton test site.

relationship (R^2 = .4823 and .3732, respectively). A poor relationship is evident at College Station-South (R^2 = .2828), Mandan (R^2 = .1430), Weslaco (R^2 = .1017), Sonora (R^2 = .0942), Hays (R^2 = .0710), Woodward (R^2 = .0142), and Sand Hills (R^2 = .0076). It seems evident that for the different vegetation types studied, the film density data ratio value is differentially acceptable for use as an estimator of the percentage of green herbaceous vegetation; or some field personnel are more capable of estimating percentage green vegetation with good accuracy and precision than others; or both explanations are applicable.

The V/G vegetation greenness estimates are also used in relating changes in ERTS-1 radiance measurements to vegetation changes, as reported in Section 4.4 of this report.

4.1.2 Green Wave Responses and Environmental Conditions

For the 1973 growing season, cooperators at each of the test sites were requested to begin collecting ground data corresponding with the ERTS-1 overpass immediately preceeding the expected date of spring greenup. They were then instructed to sample in conjunction with the satellite overpass immediately following the first spring flush of vegetation growth. Based on these data, and official weather records, Figure 4-5 reveals the chronological order of the onset of spring at each test site.

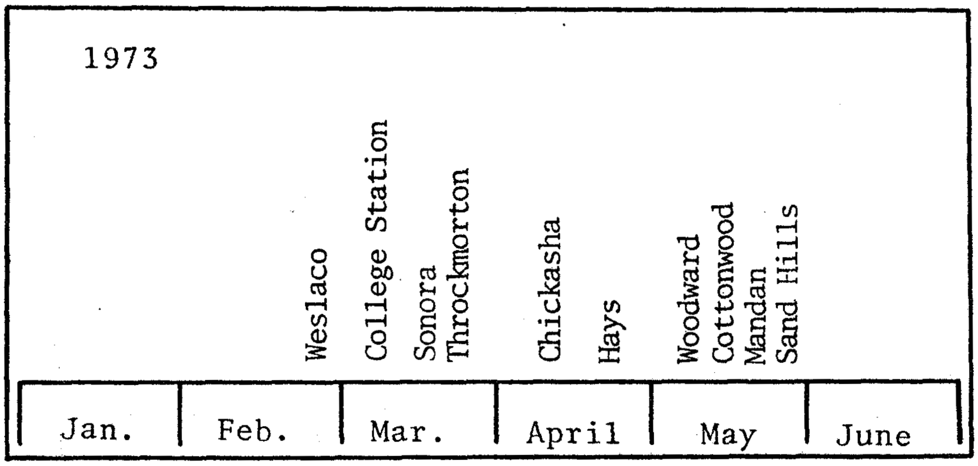


Figure 4-5. Time of occurrence of initial spring greenup at ten Great Plains Corridor test sites in 1973.

With respect to the advance of spring (vernal advancement) northward through the Great Plains Corridor, only two test sites, Woodward and Sand Hills, appear to be out of place. Both of these sites are dominated by sandy soils supporting primarily warm-season vegetation, whereas, the other eight G.P.C. sites are dominated by clayey or loamy soils supporting a mixture of warm and cool season species. Since sandy soils warm-up much more slowly than clayey or loamy soils due to poorer heat conductivity through the porous sandy soil mass, it is to be expected that these sites would experience a delayed greenup in the spring. In addition, the "absence" of cool season species, which respond more rapidly than warm season species with the onset of spring, is partly responsible for the delayed greenup at these sites. It should be noted also that the more southerly Woodward site greened up approximately one month before the northern Sand Hills site.

The expected progression of phenological events at the ten Great Plains Corridor test sites based on Hopkins "Bioclimatic Law" was presented in Figure 2-2. The actual vernal advancement as recorded by the ground measurements was presented in Figure 4-5, but is repeated in Figure 4-6 in relation to the expected progression. The "zero point" for the 1973 expected progression calculations of the green wave is about March 10. It is important to note, however, that at the College Station test site, green herbaceous vegetation was quite abundant in many areas before March 10. In fact, at the South College Station test site, green biomass totaled about 1000 kg/ha on March 1. This production was entirely the vigorous response of winter annual forbs to abundant moisture. The last severe frost occurred on February 10 at College Station, but cold weather was characteristic until near the end of the month. Warm season grasses were showing significant greenup response by mid-March. Below freezing temperatures were recorded on April 10,

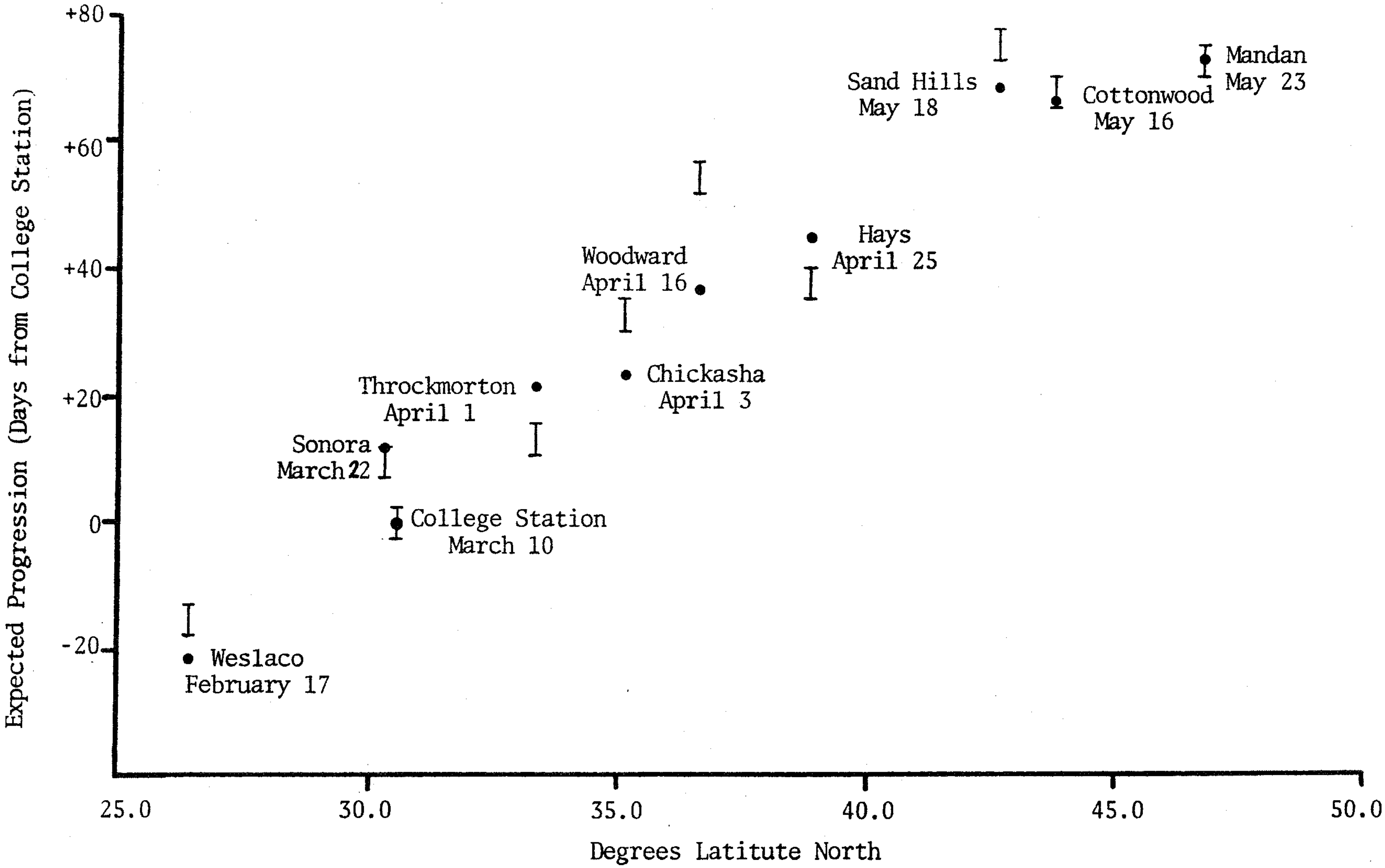


Figure 4-6. Expected progression of phenological events in 1973 (dots) at ERTS-1 G.P.C. test sites and actual progression of the green wave in 1973 (bars) as determined from ground observations.

but the perennial rangeland vegetation did not experience substantial injury. Total green biomass was reduced, however (Figure 4-1).

It is important at this point to clarify the meaning of spring greenup or the time of passage of the "green wave". The GPC cooperators were not requested to measure or record the date of spring greenup. It would be very difficult to impossible in most cases to denote a single day as the time when this occurred, even if the vegetation was observed daily. A range of 6 days (bars) is shown as the estimated period of greenup in Figure 4-6.

Throughout the Great Plains region, warm and cool season perennial grass species (such as blue grama, buffalograss, Texas wintergrass, and crested wheatgrass) begin to turn green at the base of the old culms during warm periods during late winter. At some test sites, such as Throckmorton and College Station, there is some green vegetation throughout the winter. There comes a time, however, when the soils warm up and the intermittent frosts and cool spells end and a period of rapid greenup takes place. Usually, this rather rapid greenup period will result in an obvious visual aspect change. This greenup is reflected in the green biomass measurements. For example, at the Woodward test site samples were taken on March 21, April 5, and April 23, all of which were estimated to have less than 100 kg/ha of green biomass. On May 11, 1973, the next sampling date, the green biomass estimate jumped to almost 500 kg/ha.

February 10 marked the end of "winter" at Weslaco and toward the end of the month spring greenup had occurred. Although the time of actual passage of the green wave was not observed at Weslaco, the period from February 20-25 is a reasonable estimate from the weather and ground data that are available.

The last killing freeze in 1973 at Sonora occurred in mid-February but continued cool weather delayed greenup until mid- to late-March. March 17-22 is the period representing this time of vegetative development.

At Throckmorton, a hard freeze occurred on February 16, 1973, followed by two weeks of cold, near freezing temperatures. Two weeks of unseasonably warm weather followed and by late March, the cool season species, primarily Texas wintergrass, were responding vigorously. March 20-25 is taken to be the period of initial spring greenup. The warm season species were somewhat slower in responding but by the first of April, the two major species had developed good leaves 4 to 8 cm long. On April 10, however, subfreezing temperatures destroyed the warm-season grasses. This is not reflected in the green biomass estimates (Figure 4-1), however, due to the dominance of the increasingly vigorous Texas wintergrass at this time of year.

At the time of ground sampling on April 6, 1973, the Chickasha test site supported almost no green herbaceous vegetation. A few isolated winter annual forbs could be observed. Spring greenup occurred around the April 10-15 and by April 23 very vigorous grass growth was observed.

At Woodward, cool season forbs were present in March and April and constituted the bulk of the green biomass recorded. Spring greenup occurred approximately during the first week in May (May 2-7).

Cool season grasses at Hays provided a small amount of green biomass in early April but spring greenup occurred in response to a warm spell that began on April 12. This vegetation greenup period was determined to be April 15-20. On April 25, green biomass at Hays had increased from 50 to 350 kg/ha while at Woodward, green biomass had only increased from 35 to 90 kg/ha.

The last hard freeze in the Sand Hills region occurred in mid-April but 31° to 33° minimum daily temperatures were common until mid-May. Beginning on May 15 maximum daily temperatures were commonly above 80%. This resulted in an initial spring greenup beginning about May 22-27.

Warm temperatures beginning the first week in May initiated the spring greenup period at Cottonwood and Mandan, but Mandan was about one week slower in developing. May 15 to 20 and 20 to 25 are taken as the greenup initiation periods.

Following the initial greenup in 1973 at the test sites, good moisture and warm weather enabled continued increase in green biomass production throughout most of the Great Plains as reported in the previous section.

Moderate drought stress was generally experienced beginning in early June and lasting through mid-July. College Station, Sonora, and Throckmorton experienced considerable drought stress in late August through September. Chickasha had adequate moisture throughout the summer and did not experience drought. A substantial secondary greenup occurred in September and October from Weslaco to Sand Hills. Figure 4-1 accurately depicts the time of brown down in the late fall and winter at each test site through the green biomass data.

Spring greenup in 1974 typically occurred about two weeks later than in 1973 at the southern test sites and about one to two weeks earlier at the northern test sites. The delay at the southern sites results from a very dry winter and killing freezes in late March. The earlier greenup at the northern sites probably resulted from a wetter winter and warmer weather in late April and early May.

4.2 Image Interpretations

The potential for making quantitative assessments from ERTS MSS data became apparent early in the investigation and has received primary emphasis. Therefore, developing potential ERTS imagery interpretation procedures was not emphasized. Yet during the course of the investigation, both aircraft and satellite imagery were routinely used. This section records observations about some of the potentials for, and limitations on, the use of ERTS and supportive aircraft imagery for regional resource analyses.

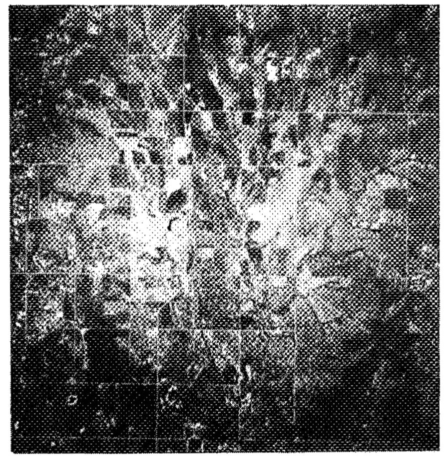
4.2.1 Seasonal Aerial Photography Evaluations of Test Site Vegetation Conditions

Both color and color IR aerial photography were requested for this investigation. They were to be used: (1) as an aid for test site characterizations, and (2) as a second stage data acquisition system for validating ERTS observations in conjunction with ground data acquisition. The initial plans for this investigation included the acquisition of aerial photography as underflights to satellite overpass at several critical periods during the growing season. Aircraft scheduling problems and cloud cover precluded fully assessing the planned procedures for multistage measurement of vegetation conditions throughout the Great Plains Corridor.

Color IR aerial photographs (1:60,000) were, however, found to be useful for documenting the stages of plant development, growth conditions, and features of rangeland resources. This capability is demonstrated in Figure 4-7. Aerial photographs (Color IR, 1:60,000) taken on May 2-3, 1974 show the status of rangeland vegetation development at the Throckmorton, Chickasha, Woodward, and Cottonwood test sites (Figure 4-7). At this time, initial spring greenup had already occurred at Throckmorton but due to the winter and spring droughts at this test site, there was less than 1000 kg/ha of green forage, and conditions at the site were deteriorating when the photos were taken. More than 1500 kg/ha were present on native rangeland in the Chickasha area. Initial growth of cool season annual vegetation was only beginning at the Cottonwood test site, where less than 700 kg/ha of green biomass was measured. Vegetation development at the Hays test site was intermediate to that at the Chickasha and Cottonwood test sites.

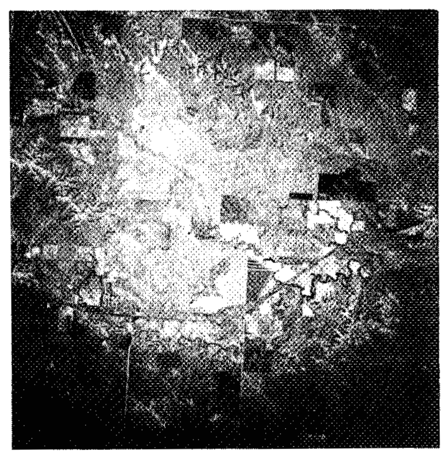
Procedures are being developed by the Remote Sensing Center for using spectral densitometer measurements as a means of documenting vegetation conditions from color IR aerial photography. Although they were not used in the current investigation, such procedures appear promising as an intermediate tool for calibrating and validating growth conditions at extended test sites.

Throckmorton
Texas



Chickasha
Oklahoma

Hays
Kansas



Cottonwood
South Dakota

Figure 4-7. Reproductions from NASA-obtained color IR aerial photography (1:60,000) showing status of rangeland vegetation development at four Great Plains Corridor test sites in the spring of 1974.

The extent of aerial photo coverage at the ten Great Plains Corridor test sites was reported in Section 3.2 of this report. Although the aerial photography was not used extensively in documenting growing conditions, they have been used extensively to characterize the test site areas and develop "masks" for digital data retrieval (Section 3.3.2).

4.2.2 ERTS-1 Image Evaluations of Vegetation Conditions

Manual interpretations of vegetation conditions have been attempted from ERTS-1 single band imagery and multiband color composite imagery. The results obtained early in the investigation are reported in Progress Report RSC 1978-1. Band 5 was shown to be the most useful single band; however, color composite imagery from MSS Bands 4, 5, 6 and Bands 4, 5, 7 provide greatly enhanced information about the status of natural vegetation systems.

Color balance and exposure control were serious problems for color composite imagery obtained from NASA/GSFC early in the study. Although the photographic reproductions were greatly improved during the course of the investigation, color balance and exposure control remain important problems for the manual assessment of vegetation conditions among different image dates. However, with careful color balancing, subtle vegetation differences can be detected among dates. Within a good image, the evaluation of vegetation conditions for areas of 10 to 20 picture elements or more, appear to be limited primarily by the amount and condition of bare surface soil exposed. The ability to detect temporal differences in herbaceous vegetation conditions is apparent from data presented in Section 4.4.1 and Figure 4-23.

In the general vicinity of the Throckmorton test site, a wide variety of rangeland conditions can be readily observed from a portion of an ERTS-1 image taken in February 1974, as shown in Figure 4-8a (Observation I.D. No. 1581-16424). The well managed ranch of the Swenson Land and Cattle Company, which lies immediately west and southwest of the Throckmorton test site (A; Texas Experimental Ranch) appears brighter than most adjacent properties because: (1) most woody vegetation has been controlled, and (2) good management has increased the amount of standing biomass on the area. Heavy stands of mesquite (*Prosopis glandulosa*) (B) appear dark in the dormant and early growing season but are not readily discriminated after the mesquite canopy has developed fully in the early summer. These areas are often seriously overgrazed and support an abundance of cool season herbaceous vegetation, giving them unique tonal characteristics in the spring. Areas occupied by heavy stands of the evergreen juniper (*Juniperus ashei*) (C) are best differentiated in the

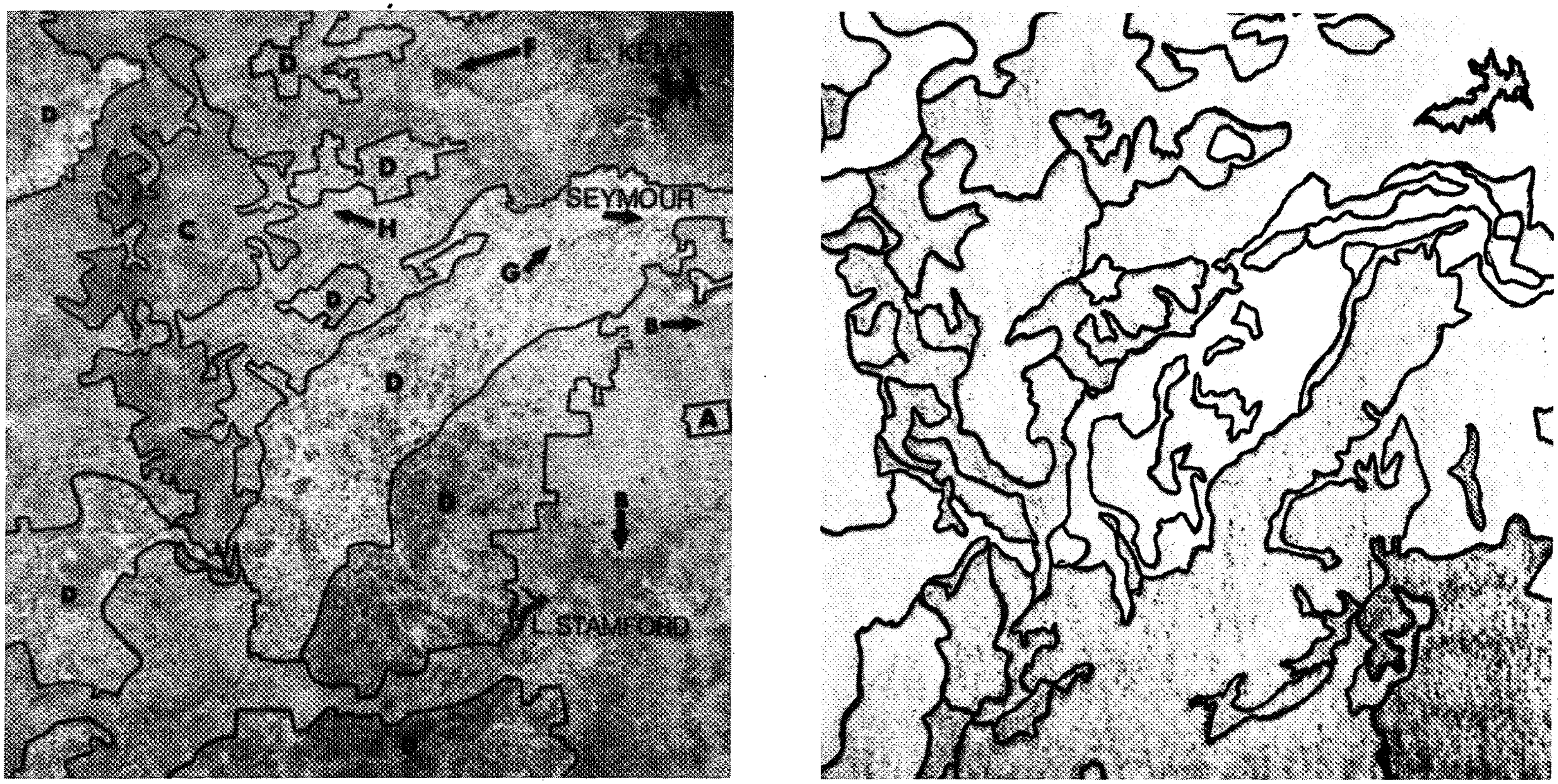


Figure 4-8a. A 15000 sq. km portion of ERTS image 1581-16424 (color composite of bands 4, 5, and 7) acquired on February 24, 1973. Resource delineations show selected landscape features in the vicinity of the Throckmorton test site. Letter code identifies items of interest: Throckmorton test site (A); heavy stands of mesquite (B); heavy stand of juniper (C); cropland (D); burned rangeland (F); Brazos River (G) near Seymour, Texas; and severely eroded areas(H).

b. Range site map developed from published county generalized soil maps for the area of adjacent ERTS image. Color code identifies these range sites: Shallow Redland (red); reddish to light brown Mixed Land (orange); dark brown Deep Hardlands (green); reddish or grayish brown Deep Hardlands (purple); Sandy Loams and Sandylands (yellow); dark brown to grayish Mixed Lands (yellow green); and Very Shallow range sites (brown).

dormant season when their live green plant material results in strong color and tonal contrast with the surrounding dormant vegetation. West of Lake Kemp a large area of burned rangeland (F) can be easily detected 10 weeks following a wildfire.

Observations similar to these used here to illustrate the potential for manual interpretation of range vegetation conditions have been made at all test sites throughout the Great Plains Corridor. This type of interpretive capability will prove invaluable for future evaluation and monitoring of rangeland resources on a regional basis from ERTS-type satellites.

4.2.3 Vegetation and Soil Delineation Capabilities from ERTS-1 Imagery

Land use and gross landscape features are readily observed from ERTS-1 MSS color composite imagery. Delineations shown in Figure 4-8a illustrate the possibilities for manual interpretation of: cultivated agricultural areas (D), contained water bodies such as Lake Kemp and Lake Stamford, and prominent terrain features such as rivers (G), and severely eroded rangelands (H). It can also be shown for this area that multidate imagery greatly enhances the probability of making correct interpretations.

Although it is easy to distinguish between fine and coarse textured soils and between soils with widely differing colors on most ERTS imagery, accurate soil boundary delineations must also employ the use of multidate imagery. Except on cultivated lands, the detection of soil differences is controlled to a great extent by differences in type of vegetation and amount of plant material the different soils support. Range sites are those areas which have the potential for producing similar amounts and kinds of vegetation. Major range sites, then may be more effectively mapped from ERTS imagery than soil associations, although the two are intrinsically interrelated.

Although testing the capability for mapping soils or range sites from ERTS imagery was not an objective of this study, a cursory comparison of Figures 4-8a and 4-8b reveals the potential. It can be seen that the croplands (D) follow very closely the Deep Hardlands, dominated by Abilene, Hollister, and Tillman clay loam and loam soils; dark brown to grayish Mixed Lands dominated by Abilene, Miles, and Yahola clay loam to loamy fine sand soils; and Sandy Loams and Sandylands, dominated by Brownfield, Miles, and Quinlan loamy fine sand to sand soils. Rangelands occupy most of the Shallow Redlands (Vernon and Valera clays and clay loams), reddish to light brown Mixed Lands (Carey and Woodward silts and very fine sandy loams), gravelly and stony Deep Hardlands (Ector, Cottonwood, and LaCasa clay loams and gravelly to stony clay loams), and Very Shallow range sites (Tarrant stony clays), as well as considerable acreages of the other three types that are often cultivated.

Each range site supports a fairly characteristic mixture of short, mid, and tall grass species with actual composition and production on an area determined by management practices. As an example, the Deep Hardland clay or loam range sites in fair to good condition generally support short and mid grasses, such as blue grama, sideoats grama, buffalograss, western wheatgrass and silver bluestem, with varying amounts of mesquite, lotebush, and prickly pear. The Sandyland range sites include the short grasses blue grama and sideoats grama, but are primarily composed of the tall grasses little bluestem, switchgrass, indiangrass, sand lovegrass, and Canada wildrye, with sand shin oak as the primary invading brush species.

Experience during the course of this investigation suggests that ERTS-1 imagery will be useful for delineating the broad, soil-associated vegetation types for future projects aimed at measuring rangeland feed conditions, wildlife habitat type mapping, land resource inventory and land use monitoring. Although intensive mapping may not be feasible with the resolution capabilities of ERTS-1, the synoptic view gained from the satellite imagery simplifies many aspects of regional resource mapping.

4.3 ERTS-1 Digital Data Analysis

In Section 3.3.4, the processes involved in extracting ERTS-1 digital data for test sites were described. Interpretations of the multispectral scanner data necessitate an understanding of the spectral reflectance characteristics of the objects being remotely measured. This enables optimum spectral band selection for interpreting the features under consideration. This section describes band ratioing techniques tested to evaluate the relationships between ERTS MSS data and vegetation parameters, and will present temporal ERTS spectral band measurements for selected natural vegetation systems and land uses.

4.3.1 Theoretical Vegetation Index Model

The vernal advancement (green wave effect) and its seasonal retrogradation occur as a function of local weather conditions and other environmental parameters favorable to plant growth. Although it seems probable that these phenological phenomena can be qualitatively interpreted from ERTS-1 MSS color composite imagery, it is desirable to document the seasonal vegetation changes quantitatively (e.g., for automated interpretation). Therefore, it was important to develop a theoretical model for using ERTS-1 MSS data to measure the relative "greenness" of natural vegetation scenes.

It is well established that the foliage of green plants differentially absorb and consequently, differentially reflect energy in the visible (0.5 - 0.7) and near infrared (0.7 - 1.1) regions of the spectra measured by ERTS-1. Since the red band (MSS Band 5) energy is strongly absorbed and the near-infrared band (MSS Bands 6 and 7) energy somewhat more reflected by dense green vegetation, a ratio of the red to near-infrared reflectance should provide a useful index of the greenness of a vegetation scene. This fundamental relationship suggests a hypothetically useful concept for monitoring natural vegetation changes.

Although a simple ratio of Band 5/Band 7 reflectance could be used as a measure of relative greenness, location-to-location, cycle-to-cycle, and location-within-cycle deviations would likely occur as a large source of error. Thus, the difference in Band 7 and Band 5 reflectance values, normalized over the sum of these values, is used as an index value and is called the "vegetation index" or "band ratio parameter".

$$\text{Vegetation Index (R)} = \frac{\text{Band 7} - \text{Band 5}}{\text{Band 7} + \text{Band 5}} \qquad (1)$$

To avoid working with negative ratio values and the possibility that the variance of the ratio would be proportional to the mean values, a square-root transformation is applied. The resulting "transformed vegetation index" or TVI is then

$$\text{Transformed Vegetation Index} = \sqrt{R + 0.5} \qquad (2)$$

where R is the vegetation index (1). Figure 4-9 shows the relationship of the original ratio (i.e., vegetation index) to the transformed vegetation index values (2) over the range of values obtained throughout the autumnal phase. The "transformed vegetation index" values will theoretically increase as the difference between Band 7 and Band 5 increases due to increased absorption of Band 5 energy by green plant material.

4.3.2 Ratio Analyses

As a tentative evaluation of the validity of the ratio analysis approach, autumnal phase ERTS1 MSS data from College Station and Throckmorton, Texas were used to calculate a limited number of band-to-band ratios. Although some other band-to-band ratios appeared to have some promise, the "transformed vegetation index" described above was calculated early in the study for all existing ERTS-1 data for the selected sites.

At College Station, four subsites were compared at three dates: August 30, October 23, and December 16, 1972 (Figure 4-10). At each of three subsites, designated X, Y, and Z, MSS data from 4100 ha (9840 pixels) scenes were used to calculate the mean radiance for Bands 5 and 7 for each

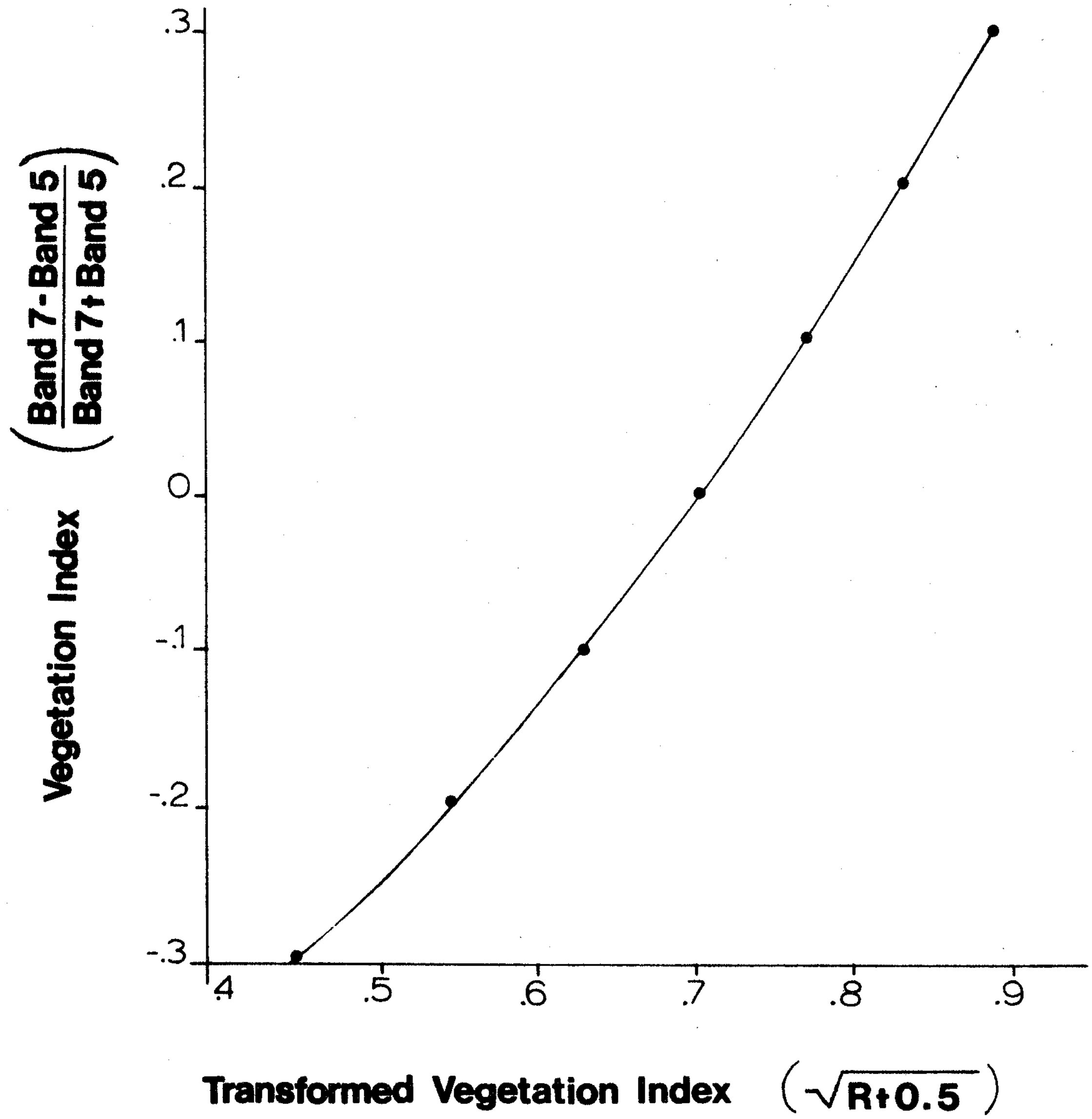


Figure 4-9 . Relationship of vegetation index to square-root transformations of the vegetation index.

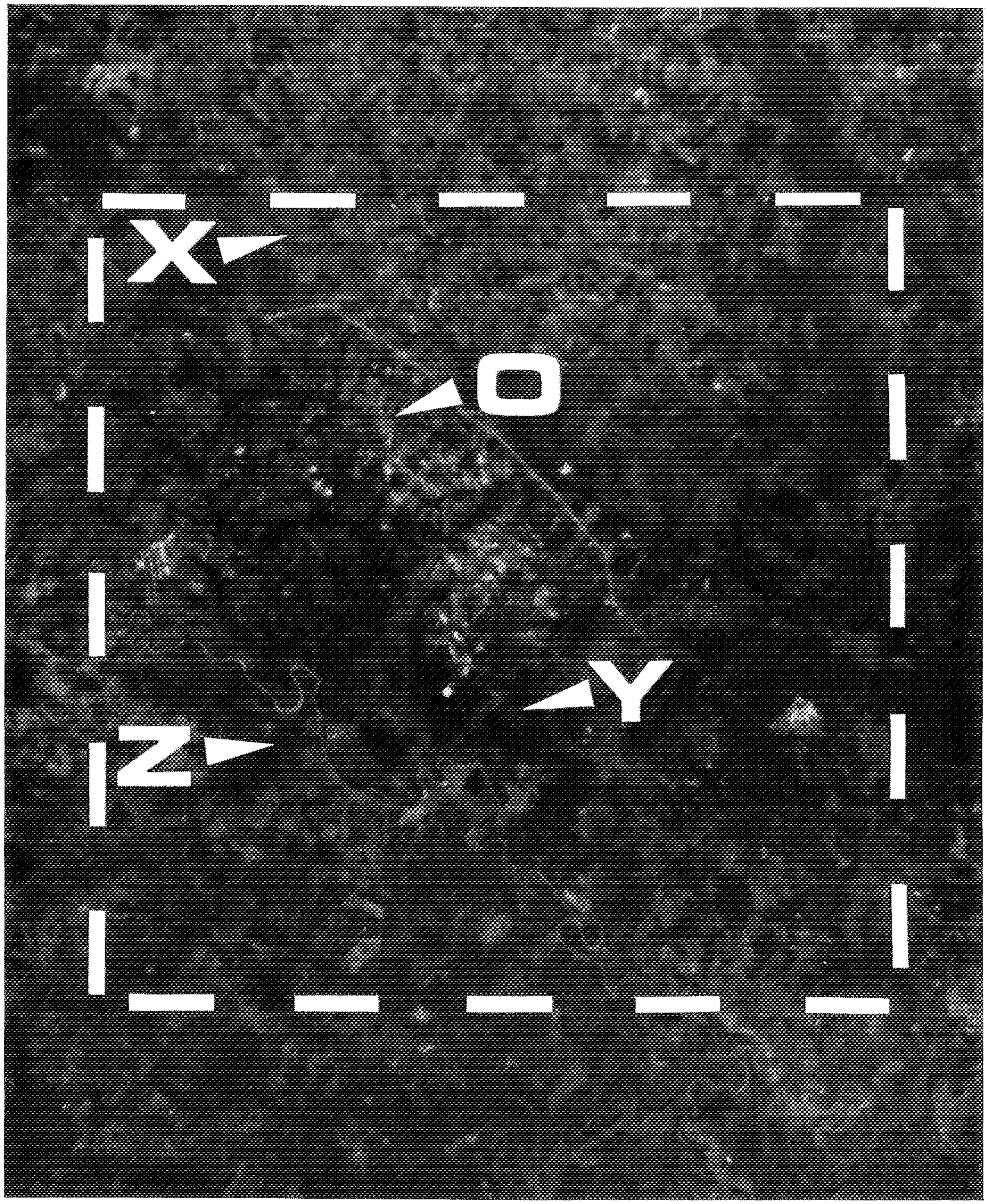


Figure 4-10. Photo enlargement of ERTS-1 image 1092-16305 showing sub-sites at Test Site No. 1: O) Downtown Bryan, Texas, X) north rangeland site, Y) south rangeland site, Z) Brazos River bottom site.

date. Sites X, Y, and Z can be designated mixed pasture and dryland farming, mixed woodland-grassland, and irrigated cropland, respectively. Site O is an urban scene (144 pixels) from downtown Bryan, Texas, which has little vegetation or bare soil. Asphalt, concrete and crowded buildings are the predominant features of Site O. Mean radiance values were used for calculating the transformed vegetation index values shown in Figure 4-11.

At Sites X and Y, the scenes were dominated by natural vegetation and the index value changes were small. The changes were, however, consistent with ground estimates of greenness. The increased index value at Site X in December is probably the result of winter pasture included in the 4100 ha scene. The dramatic shift between August 30 and October 23 at Site Z results from the harvest of irrigated crops from the Brazos River Valley. Ratio values obtained from the urban (Site O) scene were very low compared to rural scenes dominated by vegetation.

Further evaluation of the transformed vegetation index was made using data from the ERTS-1 Throckmorton test site. TVI values were calculated from mean radiances for each of four quadrants of a 4100 ha scene that is mostly native grassland. Transformed vegetation index values are compared with standing dry biomass, green biomass, and

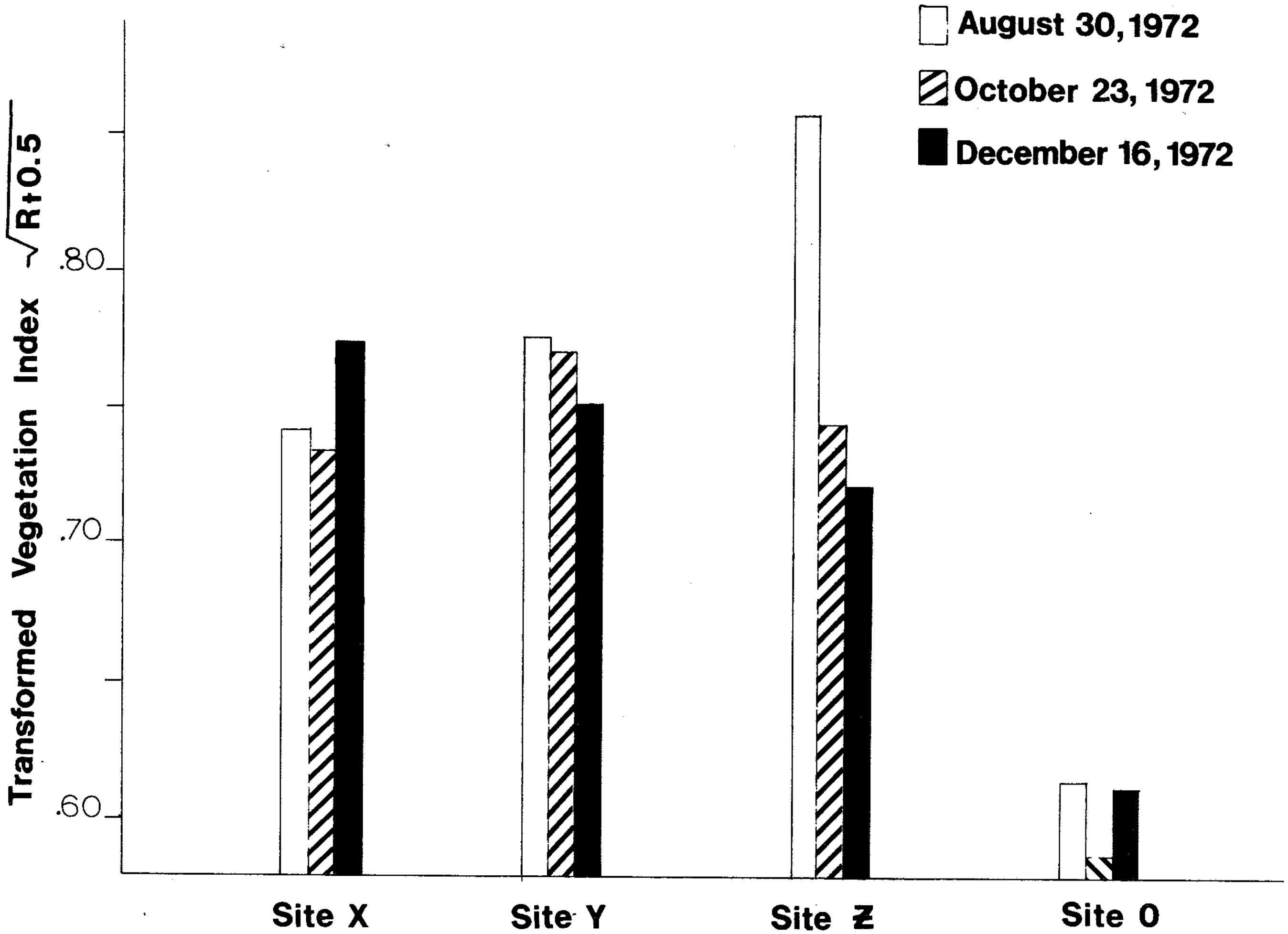


Figure 4-11. Transformed vegetation index values from four sub-sites at College Station.

percent green estimates taken at four dates during the 1972 autumnal phase (Figure 4-12).

These data show an excellent relationship between the index values and the gradual "brownout" of grassland vegetation during the fall of 1972. There is an obvious decline in percent green biomass following the first killing frost that occurred about Julian day 336. Although no ERTS-1 data were available for Julian day 335, it was expected that the index values would also reflect the sharp drop in green biomass.

Analysis of variance on these first-look data indicated that the differences among transformed vegetation index values were highly significant ($\rho = .001$) and that the differences among all dates were statistically significant. A least squares, multiple regression analysis indicated that 99% of the variation in the transformed vegetation index was accounted for by the mean percent green estimate and standing dry biomass measured at the time of the ERTS-1 overpass. These preliminary analyses for the Throckmorton site suggested that changes in the order of 200 kg/ha green biomass or 4 percent green estimate may be detectable from ERTS-1 data for sites having a uniform vegetation cover.

Following the receipt of ERTS-1 digital data corresponding with test site ground data collected during

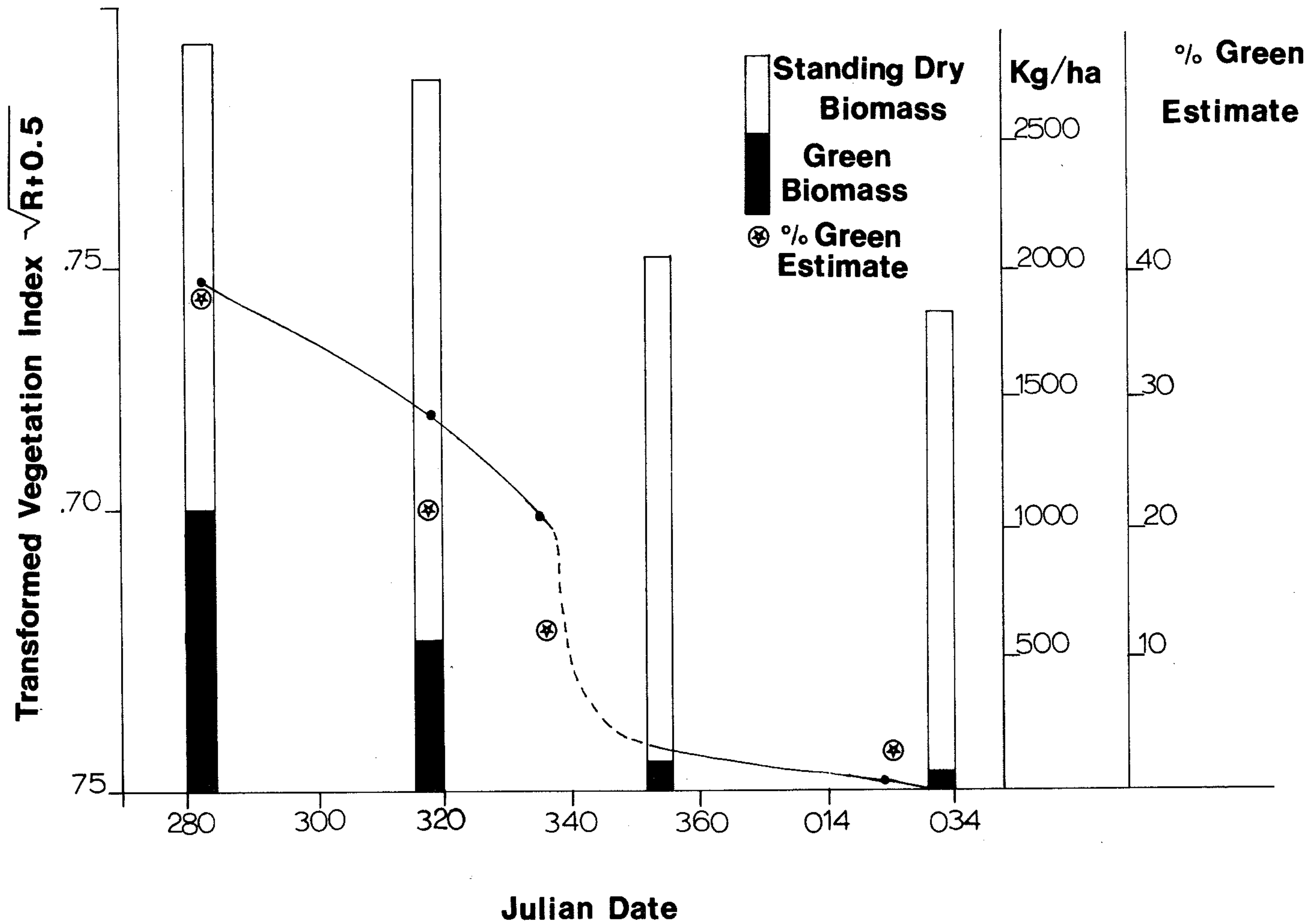


Figure 4-12. Transformed vegetation index values compared to autumnal phase biomass data from the Throckmorton test site.

the spring and early summer of 1973, additional ratios and individual band values were evaluated for their correlations with vegetation measurements.

Since Band 6 energy is in the near infrared region, it would seem reasonable to expect that a ratio of Band 5 to Band 6 or the difference between Band 5 and Band 6 would produce similar results. However, since Band 6 and Band 7 are spectrally different, their energies may be absorbed or reflected differently by green vegetation or by different types of vegetation. Also, any of the four band values or various ratios of these may be well correlated with green biomass, although it is expected that some will be better correlated than others. Therefore, it was deemed necessary to evaluate some of these possibilities and compare them with the results of the analyses using the TVI.

Eight analyses were performed for the College Station, Sonora and Throckmorton test sites. Green biomass data were regressed on TVI, the difference between Bands 7 and 5 divided by their sum (BRP7), the difference between Bands 6 and 5 divided by their sum (BRP6), the ratio of Band 5 to Band 7, and radiance values for each of the four ERTS bands. The correlations between these ERTS data and green biomass are presented in Table 4-1.

At the Throckmorton test site, the regression of TVI on green biomass was highly significant, but green

Table 4-1. R^2 values from regression analyses of green biomass and ERTS-1 spectral band radiance measurements and ratios of selected band values for three G.P.C. test sites.

ERTS-1 Band or Band Ratio Parameters	Test Site: College Station Area 1 (7 dates)	College Station Area 2 (6 dates)	Sonora (10 dates)	Throckmorton (14 dates)	All Three Sites (37 dates)
TVI	.342	.388	.082	.550**	.334**
BRP7	.322	.380	.072	.559**	.335**
BRP6	.456†	.467	.206	.686**	.459**
$\frac{\text{Band 5}}{\text{Band 7}}$	.340	.392	.085	.539**	.325**
Band 7	.697*	.575†	.043	.081	.027
Band 6	.816**	.633†	.103	.036	.024
Band 5	.018	.742*	.013	.465**	.291**
Band 4	.853**	.849**	.006	.262†	.323**

** regression significant at the 99% level of probability
* regression significant at the 95% level of probability
† regression significant at the 90% level of probability

biomass alone accounted for only 55% of the variation in TVI for these data. The square root transformation of BRP7 to produce the TVI had little effect on the correlation of the ERTS data and green biomass. At Throckmorton, the correlation was slightly better for BRP7, but at College Station and Sonora the TVI was slightly better.

The simple ratio of Band 5 to Band 7 was not as well correlated with green biomass at Throckmorton as any of the other ratioing techniques used. This was also the case when the data from all three test sites (thirty-seven data sets) were compared.

By substituting near-infrared Band 6 data for Band 7 data in the ratio of the difference between the near-infrared and red values divided by their sum, a substantial increase in R^2 values is realized at all three of the test sites considered. At Throckmorton, R^2 values increased from 55.0% to 68.6% when the BRP6 was substituted for TVI. BRP6 was the best "estimator" of green biomass. Band 5 was the only simple radiance band value well correlated with green biomass at Throckmorton.

At College Station and Sonora, BRP6 showed the best correlation with green biomass of the ratioing techniques used, but accountable variation was less than 50%. Bands 4, 5, 6, and 7 showed fair to very good correlation with green biomass at College Station, except Band 5 for the north area. Band 4 data showed very good correlation at both areas at College Station (R^2 = 0.853 and 0.849). However, an examination of the coefficient for green biomass reveals that the relationship may be a result of some factor that Band 4 wavelengths are sensitive to which varies seasonally at College Station, as does green biomass. A negative regression coefficient for green biomass indicates the opposite relationship that would be expected between green biomass and Band 4 data based on theoretical considerations. Further study with more data sets will be required to understand this phenomenon.

The preliminary analyses of the ERTS-1 and ground data, therefore, suggested that the transformed vegetation index or a similar ratio using Band 6 data instead of Band 7 data would be a practical approach for achieving the project objectives, as well as providing the potential for obtaining quantitative estimates of the condition of natural vegetation. Consideration of all three test sites included together reveals that BRP6 (or a square root transformation of BRP6) may be the best estimator of green biomass.

It was recognized that numerous factors might affect band to band reflectance shifts, including amount and kind of soil, surface soil moisture content, height and vigor of vegetation, and water and pigment content of plant materials. These and other factors were investigated in an attempt to ascertain how the component reflectance values of a vegetated scene integrate to give a scene reflectance value.

4.3.3 Characteristic Signatures from Natural Vegetation Systems

Characteristic signatures of vegetation/soil resource combinations are one of the keys to regional monitoring utilizing ERTS data. Knowledge of typical signatures can be utilized for such activities as setting threshold values for classification of vegetation/soil resource types within an ERTS image and for understanding the remotely sensed response of a vegetation/soil resource to phenological change. The approach taken here has been to delineate certain vegetation/soil resource combinations (as described below) and to group characteristic signature data by season for each of them. In this way, a fairly large data set is available for each vegetation/soil resource from which basic comparisons can be made with others. The TVI value is the parameter used in this compilation due to its proven appropriateness in this study. Another approach could have been the use of individual channel values or a different combination of channels than that in the TVI. ERTS channel radiance, BRP, and TVI values for each of the subsites are given by date and season in Appendix F for use by interested investigators.

In an attempt to compile seasonal characteristic signatures, vegetation/soil resource combinations were chosen in six general and 13 specific groupings as given in Table 4-2. Under these criteria, some specific groupings contain as few as one subsite from one of the ten Great Plains test sites. Some include as many as twelve subsites representing six of the test sites. Of the 13 specific groupings, two contained only one subsite. These are marked in the table and the figures as "small samples". They are included so that comparisons can be made by interested users.

TVI values from Appendix F were collected into the 13 specific groupings and were subsequently averaged by season. The means and extremes are shown in Figure 4-13 for 6 "open grassland" groupings, in Figure 4-14 for the three "grass-shrubland/deep upland" groupings, and in Figure 4-15 for two "woodland" groupings. Since the TVI value is correlated with green biomass (Section 4.4), the upper extreme values are probably controlled by vegetation cover and vigor. At the same time, the lower extreme values are

Table 4-2. Vegetation and soil resources in the Great Plains Corridor selected for evaluation of seasonal characteristic spectral signatures.

	Deep Upland	Shallow Upland	Bottomland
Open Grassland	clay loam/silty clay loam/silt loam ---- fine sandy loam/loam ---- clay	shallow stony clay	* fine sandy loam
Grass-Shrubland	fine sandy loam/loam ---- clay loam/silty clay loam/silt loam ---- clay		
Woodland	fine sandy loam		fine sandy loam/loamy & sandy ---- * clayey & loamy

* Small samples--data taken from one subsite only.

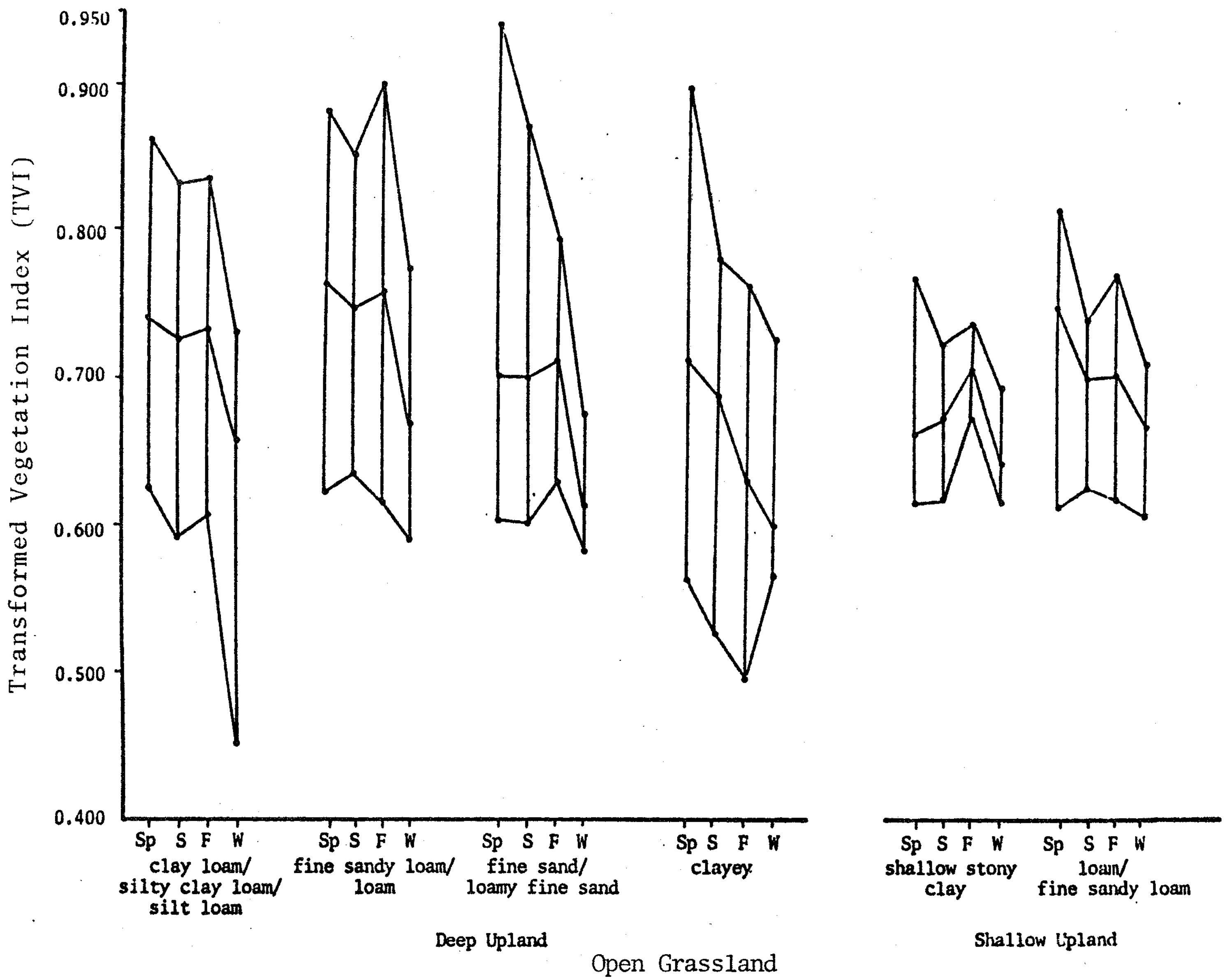


Figure 4-13. Seasonal maximum, minimum, and mean TVI values observed for open grasslands for selected range sites and corresponding soil types within the Great Plains Corridor.

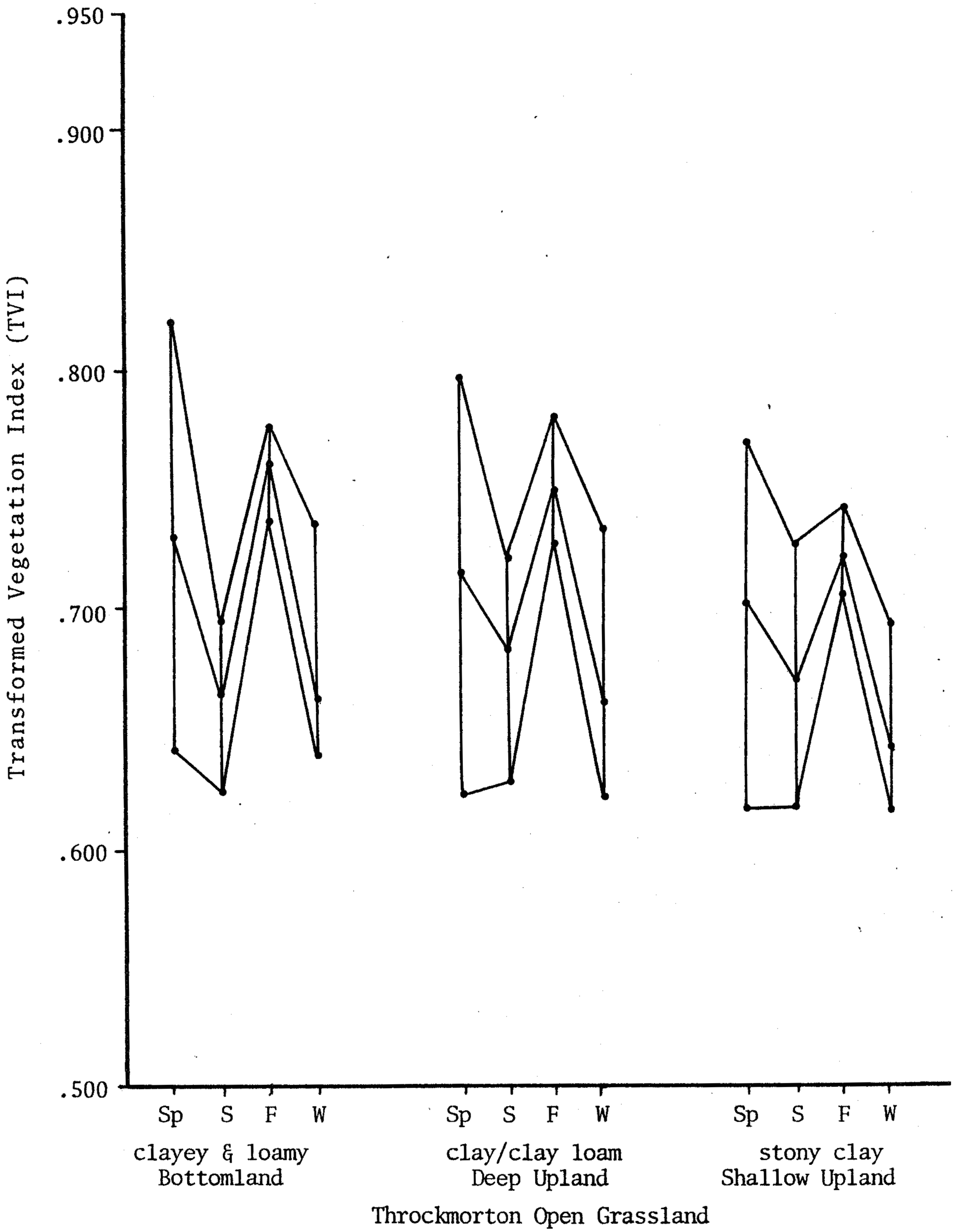


Figure 4-14. Seasonal maximum, minimum, and mean TVI values observed for the open grassland vegetation type at the Throckmorton test site for the three major range sites.

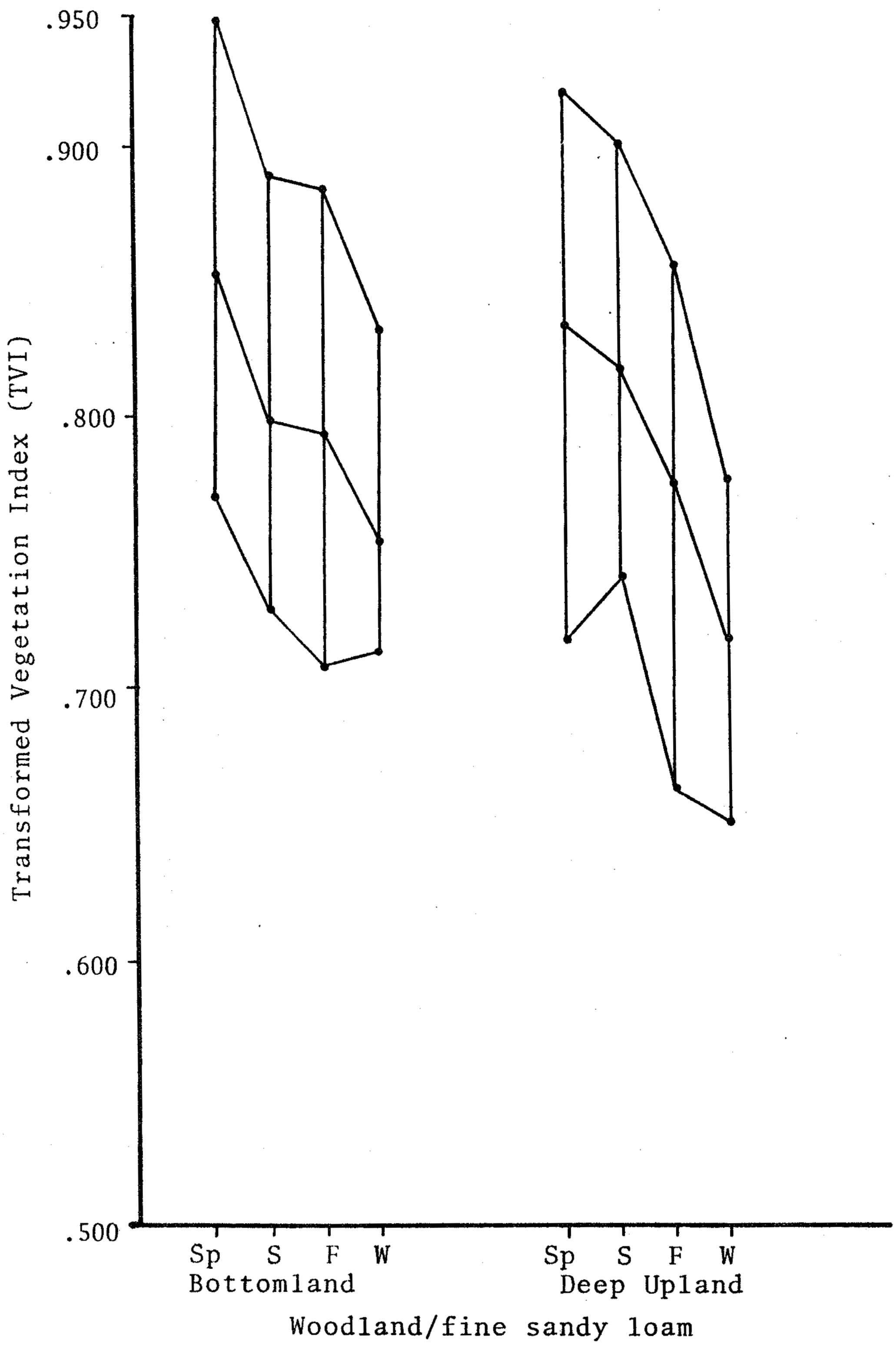


Figure 4-15. Seasonal maximum, minimum, and mean TVI values recorded for bottomland and deep upland woodlands in the Great Plains Corridor.

apparently controlled to a great extent by soil type, since the criteria for a low TVI value is poor vegetative vigor and/or poor ground cover. These parameters are highly dependent on the soil resource.

In using signatures from seasonal TVI value means and ranges, it is necessary to keep in mind how seasons were chosen (Section 3.4) and what phenological changes are included in each season. Ground based measurements of the vegetation in each subsite were examined and an ERTS over-pass date was said to occur during the season indicated by the corresponding ground measurements.

The seasonal range of TVI values is large, covering both green and brown periods during some seasons. For instance, "spring" covers the period from the beginning of greenup following the "winter" dormant period to the beginning of the brown-down caused by summer drought stress (Figure 3-6).

In order to adequately analyze and characterize signatures for the categories selected here, a multitude of parameters would have to be studied. Within each vegetation/soil resource such factors as soil color, soil moisture, soil texture, percentage ground cover, vegetation height, species composition, proportion of ground cover, green biomass, etc. would have to be evaluated. This type of analysis is beyond the scope of the work done under this contract. The intent, then, of the following characterizations of vegetation/soil resource groupings, and of their intercomparisons, is to provide reference guidelines for other investigators having an interest in this type of information. Seasonal extreme values are drawn rather than standard deviations to provide the all-inclusive range that was found in the Great Plains Corridor.

Six "open grassland" groupings are depicted in Figure 4-13 in terms of seasonal TVI value ranges. Four of the groupings are for deep uplands while two are for shallow uplands. No clear differences are noticeable between soil types within a range site classification when averaged in this way across these several locations. The expected range of values, indicated by the envelopes outlined by the high and low extremes, appears narrower for shallow uplands than for deep uplands. This is probably related to the amount of vegetative ground cover.

For a given location, as described below, a minimum range of values would be expected. This range of values would be a subset of the overall range found for that vegetation/soil resource throughout the Great Plains Corridor. For a particular location, then, soil type or range site differences might be detectable.

As an example, for the Throckmorton, Texas test site, Figures 4-14 and 4-16 depict the seasonal TVI values for bottomland, deep upland and shallow upland for open grassland. The shallow uplands at the Throckmorton test site are inherently the least productive of the major range sites. In contrast, the bottomlands are highly productive with deep relatively fertile soils, which receive more moisture than the other range sites, due to drainage. Lying intermediate in productivity between these two are the deep uplands and clayey uplands.

It can be seen (Figure 4-14) that, in general, the mean and extreme values decrease from bottomland to deep upland to shallow upland soils. This is probably due to the fact that the bottomland sites have a very high percentage of vegetative ground cover, whereas the deep uplands have somewhat less ground cover and the shallow uplands usually have a lighter colored (more reflective) soil with even less ground cover. The mean summer value for bottomland is lower, however, than that for deep uplands and shallow upland (Figure 4-16). Data for clayey uplands are essentially identical to deep upland values and, consequently, are not graphed. Cool season species (primarily Texas wintergrass) dominate in the bottomlands. These cool season species are more susceptible to drought stress and brown down more

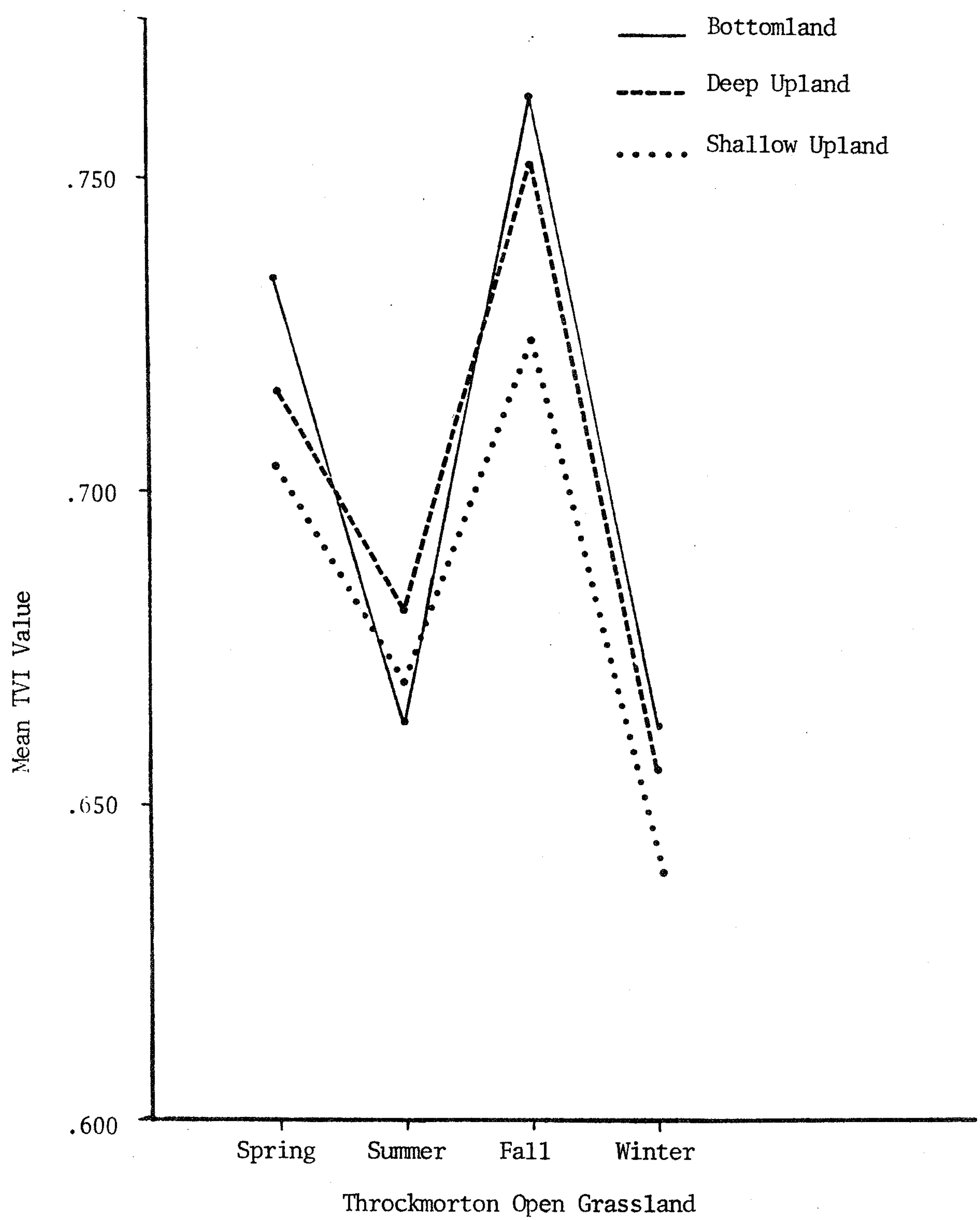


Figure 4-16. Seasonal mean TVI values for the open grassland vegetation type at the Throckmorton test site for the three major range sites.

rapidly and severely during the summer such that virtually no standing green vegetation is left. This effect is supported by the mean TVI value for summer equalling that for "winter" when very little green vegetation occurs, although there is still almost 100% ground cover. In winter, the upland sites demonstrate the effect of brown vegetation coupled with poorer ground cover than that in the bottomlands or deep uplands, as their mean TVI values are considerably lower.

The three specific groupings of the "grass-shrubland/deep upland" category (Figure 4-17) are different from each other in mean trend shape, envelope shape, and mean value within seasons. The width of the "clay" envelope is much wider as well, as it was for the clayey soils of open grasslands.

Figure 4-15 illustrates woodland categories and also gives a comparison of seasonal TVI values for two woodland groupings on the same soil type--fine sandy loam. One grouping (10) is for bottomlands while the other (11) is for deep upland. During all seasons except summer, the bottomlands exhibit higher mean and extreme TVI values than do the deep uplands, possibly indicating better moisture relations resulting in higher productivity and vigor. The lower summer value may result from bottomland species being

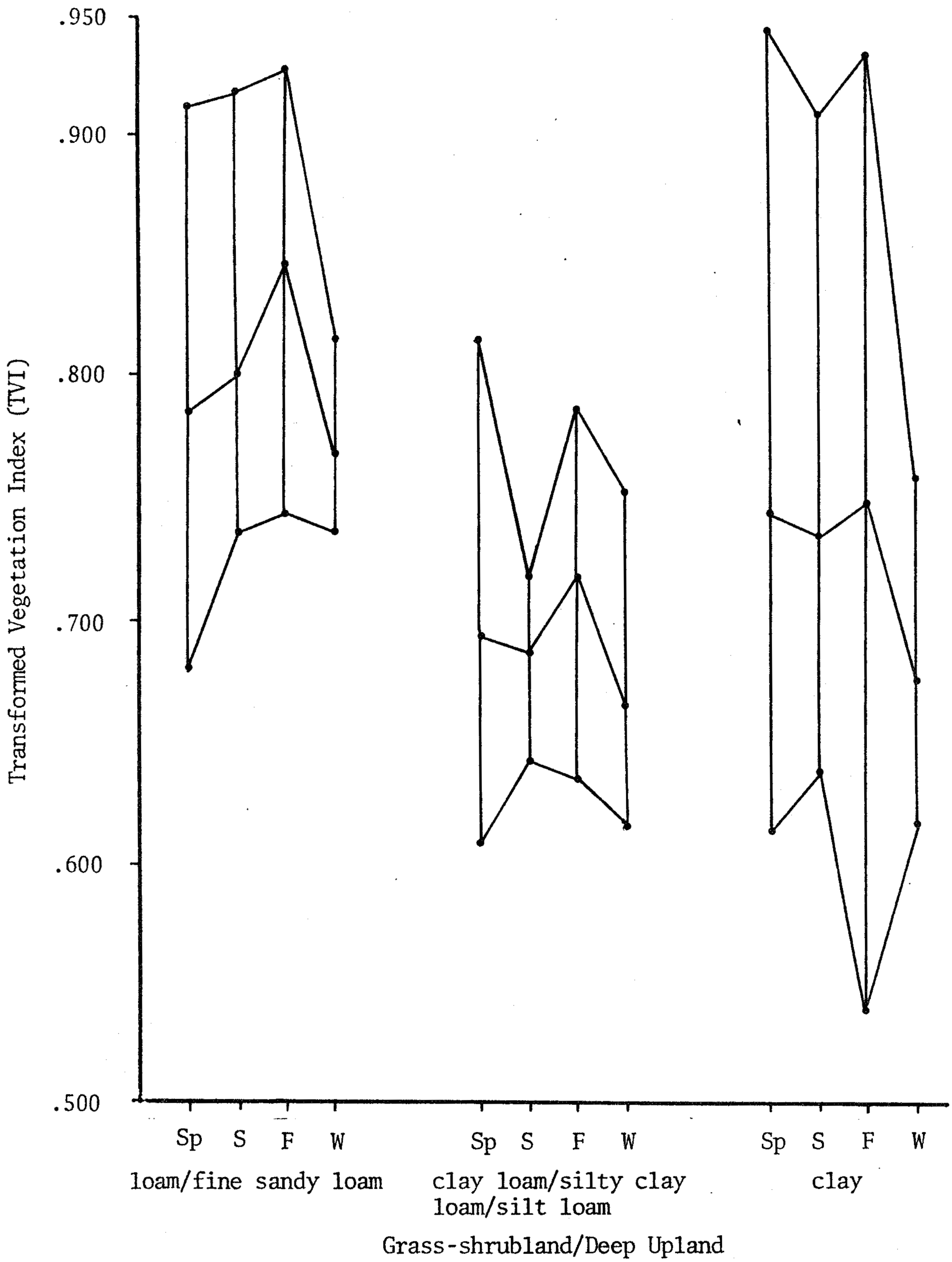


Figure 4-17. Seasonal maximum, minimum, and mean TVI values observed for selected soils corresponding to deep uplands of the grass-shrubland vegetation type in the Great Plains Corridor.

less adapted to withstand summer drought stress than deep upland species.

Figure 4-18 is a regrouping of curves to allow a comparison between vegetation resource types which occur on the same soil type and general soil category. For deep uplands, a comparison is shown for open grassland, grass-shrubland and woodland on fine sandy loam/loam soil. It is evident that mean trends and extremes are distinct for each resource type. Open grasslands provide the widest envelope and one with alternating peaks and valleys from season to season. Grass shrublands and woodlands have approximately the same range of extremes, but where grass-shrublands show an increase in TVI from spring to fall before the winter decrease, the woodlands exhibit a steady decrease from spring through winter. The high value of the lower extreme for grass-shrublands is undoubtedly due to the shrub component which maintains the greenness of the overall scene when grasses brownout.

Grazing treatment effects were previously reported (Progress Report 1978-3) for data acquired at the Texas Experimental Ranch (the Throckmorton test site). The two degrees of use being studied, moderate and heavy, were found to be distinguishable on ERTS data. Heavy grazing is not synonymous with severe grazing or over-use. Herbaceous

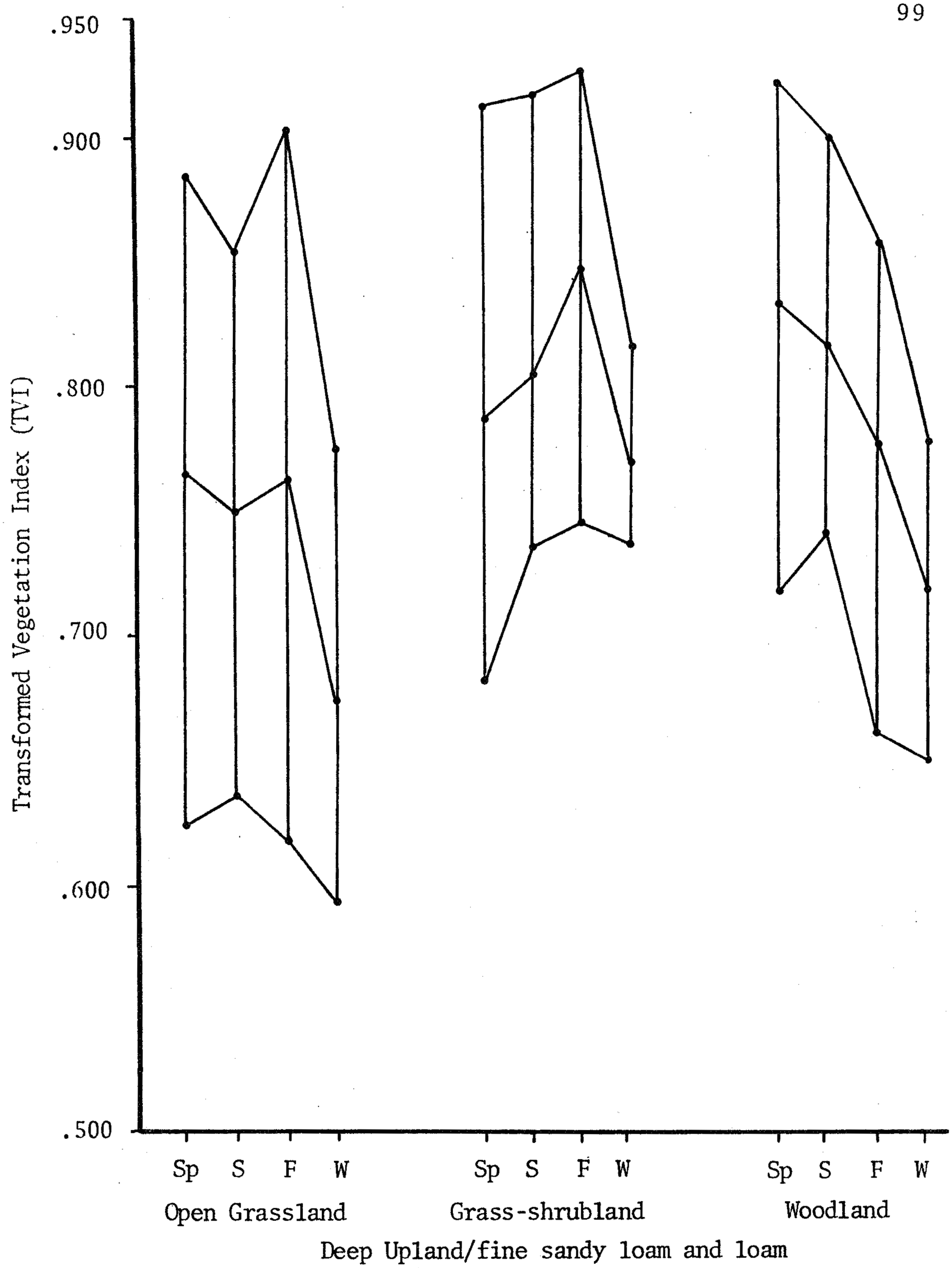


Figure 4-18. Seasonal maximum, minimum, and mean TVI values observed for three vegetation types on deep uplands in the Great Plains Corridor.

biomass differences between the two types of use, therefore, are not extreme.

TVI values for heavily grazed pastures and moderate, four pasture, deferred grazing system pastures are given in Figure 4-19. Data for January through June 1974 are shown here in addition to those given previously in the above mentioned report. TVI values for three overpasses previously recorded (June 16, July 22 and August 9, 1973) have been deleted from the figure due to the occurrence of heavy cirrus overcast on those dates. These cirrus conditions were found after the publication of the previous report upon receipt of ERTS color composite images which clearly showed the semi-transparent overcast. The effect of cirrus is greater on channel 5 than on channel 7 and, therefore, the resulting TVI values would have been distorted if included. TVI values from the overpass of July 4 (previously not included) have been inserted.

The TVI values for the moderately grazed pastures were lower than those on the heavily grazed pastures on only two dates--one early in April and one in early July. For the rest of the 21 month period, the moderately grazed pastures clearly show, through the TVI values, higher values of green biomass.

One of the two anomolous data points has previously been explained in Progress Report 1978-3 as probably

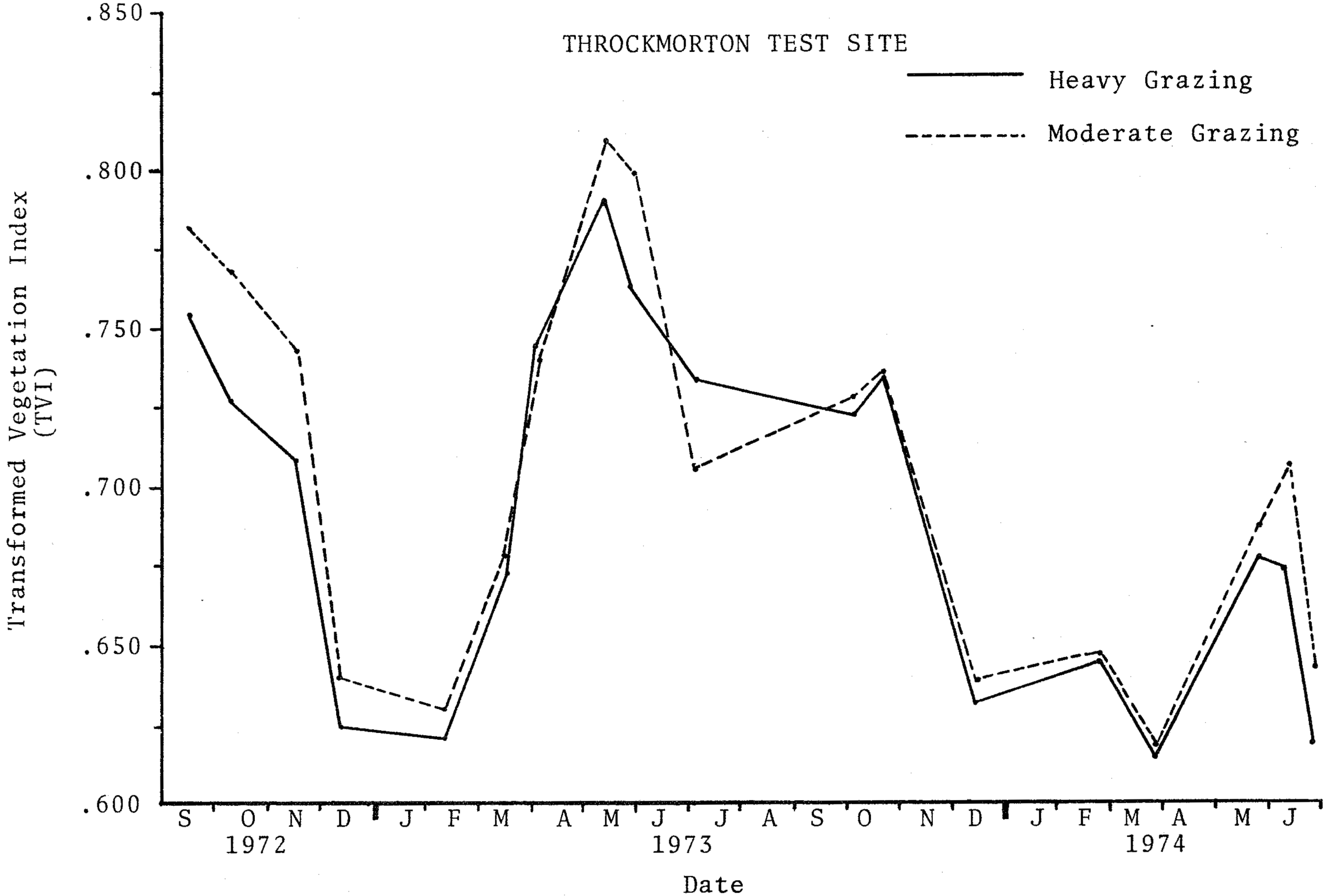


Figure 4-19. ERTS-1 radiance measurements expressed as the transformed vegetation index for the moderate four-pasture, deferred grazing system pastures and the heavy, continuous grazing pastures.

due to the obscuration of new, short green leaves by taller dry vegetation on the moderately grazed pastures. In the heavily grazed pastures, less dry vegetation was standing and, consequently, the new leaves were more visible to ERTS. The ground data for July 4 has been examined unsuccessfully for an explanation of the lower TVI value for moderate grazing on that date.

4.4 ERTS-1 MSS Data and Test Site Ground Measurements

The data presented in the previous section reveals that ERTS-1 MSS data is sensitive to differences in vegetation/soil resources and illustrates the potential for monitoring these differences through time. Evidence was presented which showed that dissimilarities between three range sites (Figure 4-16) and two grazing treatments (Figure 4-19) are detectable with ERTS-derived TVI data. This discrimination was ascribed to differences in amount of herbaceous biomass, although no ground validation data were presented.

This section will present tested relationships between ERTS-1 MSS data and quantitative ground measurements of vegetation. Seasonal influences and weather effects will also be evaluated. Emphasis will be given to evaluating these relationships at the Throckmorton test site where the greatest number of ERTS/ground truth data sets were obtained; the most extensive ground area was monitored with ERTS data; the most intensive ground data was collected by headquarters personnel; and all seasons were well represented in the final data sets used.

4.4.1 Relationships Between TVI and Vegetation Parameters

Quantitative ground measurements of vegetation conditions include measurements of the total standing herbaceous biomass, moisture content of the vegetation, and percentage green vegetation on a dry weight basis (Section 3.1.2). Indirectly, the important vegetation condition parameter, green biomass, is obtained from the measurements of dry biomass and percentage green estimate.

The inclusion of all 124 data sets (all test sites and all seasons) in a simple linear regression analysis with the ERTS measurement parameter TVI regressed on green biomass reveals a very low coefficient of determination (R^2 = .196), although the regression was highly significant (P > F = .0001). Figure 4-20 shows the amount of dispersion in this conglomerated data set as well as the regression line associated with these two parameters. The dissimilarities in data point distributions for individual test sites is apparent and accounts for some of the data dispersion. Weslaco is the extreme example showing all data points at less than 700 kg/hectare and spread over a range of TVI values from a relatively high 0.716 to a maximum of 0.906.

A similar plot using the 124 data sets and the regression of TVI on vegetation moisture content shows a significant regression (P > F = .001) and a substantially better coefficient of determination (R^2 = .519) between the ERTS and ground data (Figure 4-21). The scatter diagram indicates, however, that a curvilinear function (dashed

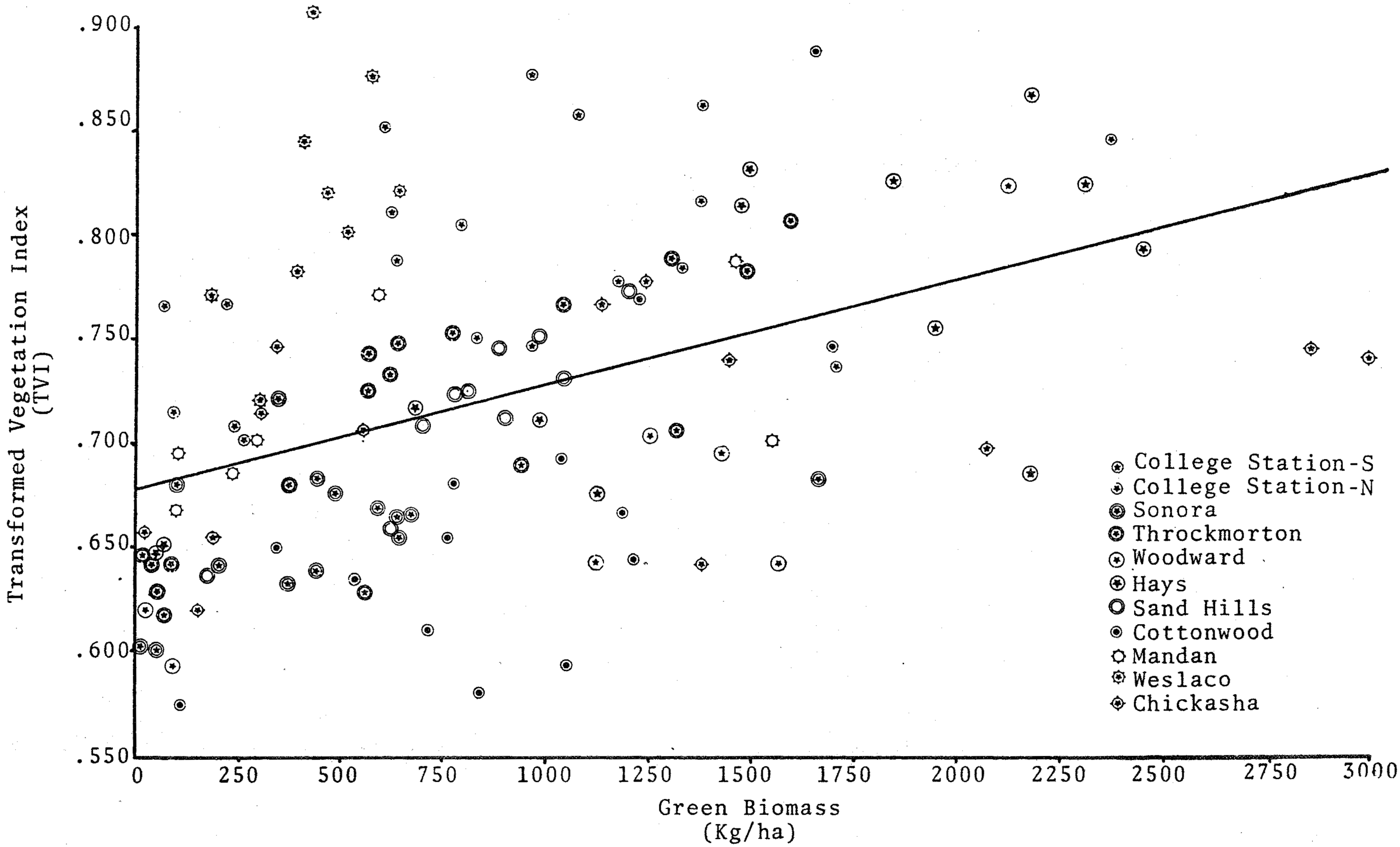


Figure 4-20. Least squares regression line for the correlation of green biomass with the transformed vegetation index for 124 observations at the ten G.P.C. test sites.

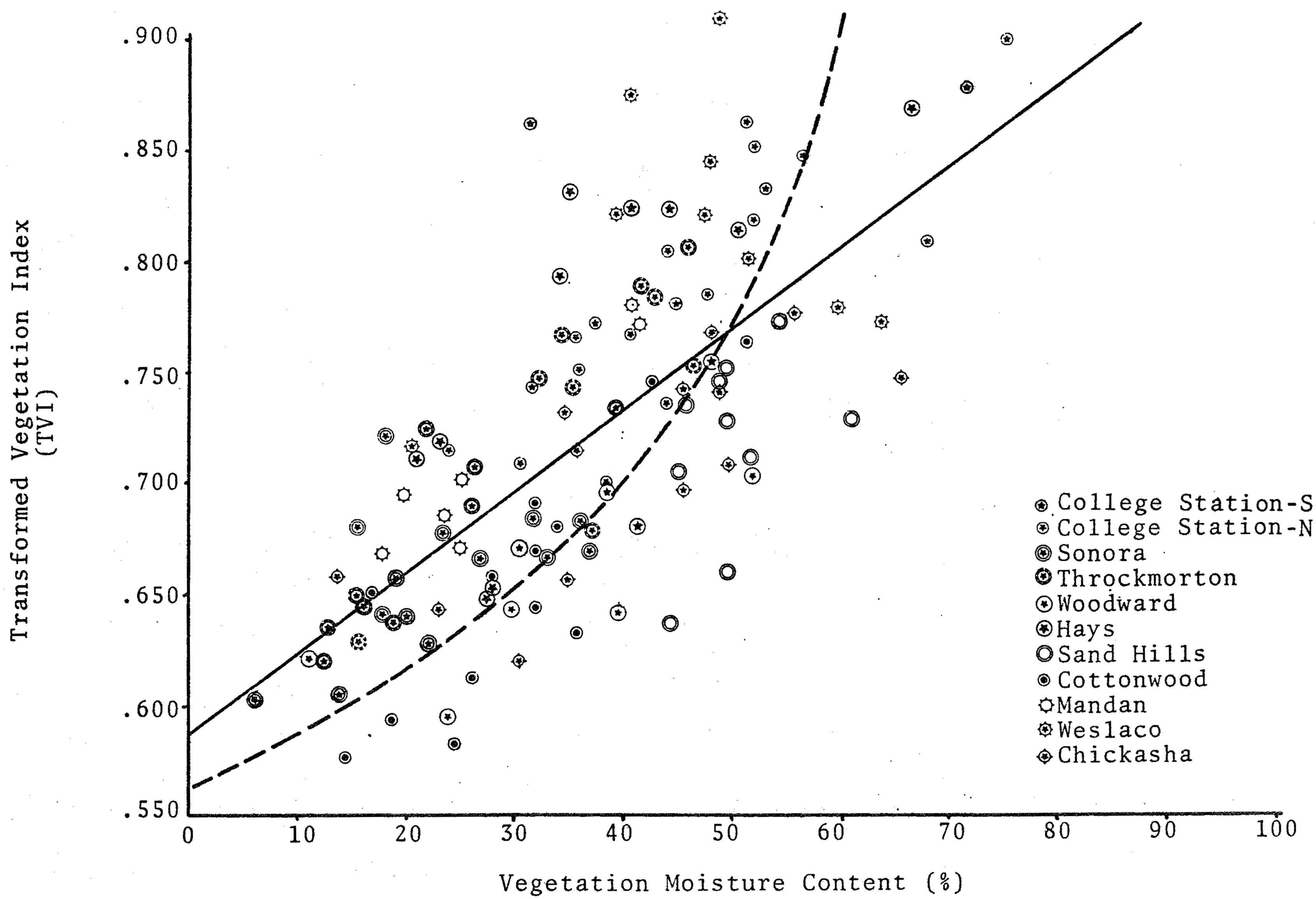


Figure 4-21. Least squares regression line (solid line) for the correlation of vegetation moisture content with the transformed vegetation index and possible curvilinear relationship between these parameters (dashed line) for 124 observations at the ten G.P.C. sites.

line) might better describe the relationship between moisture content and TVI.

The comparable regression of TVI on dry biomass for all data was found to be insignificant ($P > F = .4131$; $R^2 = .0055$).

It is of considerable importance to note that the green biomass values are dependent upon estimates of "percentage green vegetation" made by cooperating station personnel. It is assumed that these estimates of percentage green vegetation on a dry weight basis are reliable, reasonably accurate estimates. It is to be expected, however, that the different estimators at the various test sites do not estimate with the same accuracy or precision. Also, certain other aspects of the ground sampling procedures, such as permitting ground data collection ± 3 days of the concurrent satellite overpass, may have resulted in less than optimum data sets on some dates at some sites.

Vegetation moisture content is typically strongly related to green biomass when plants are actively growing. Consequently, it seems reasonable to assume that if green biomass estimates and vegetation moisture content measurements are made with good accuracy and precision they will be highly correlated. Likewise, if these two vegetation parameters are highly correlated and green biomass is responsible for a high degree of correlation with an ERTS measurement parameter (such as TVI), then it is expected that the moisture content will be similarly correlated with the ERTS parameter. If moisture content of the vegetation is responsible for a high degree of correlation with an ERTS parameter, green biomass may or may not be well correlated with the ERTS parameter. The situation where disagreement exists is not unlikely, especially when the time of day of ERTS overpass is considered. Moisture content of the vegetation is determined from the total clipped biomass (live and dead plant material). When a considerable amount of standing dead plant material is present, it can absorb much moisture. The vegetation moisture content at the time of sampling will depend heavily on the length of time since precipitation occurred, humidity, windspeed, time of day, etc. This effect would be expected to be greatest on the more moist (mesic) test sites and sites with a greater quantity of standing dead plant material. Likewise, many of the factors causing moisture content of the dead biomass to vary may also cause the surface soil to change colors resulting in a shift in reflectivity.

Green biomass and vegetation moisture content are well correlated at six G.P.C. test sites (Table 4-3). Tests of significance (H_o: $\rho=0$ vs. H_1: $\rho \neq 0$) for the correlation

Table 4-3. Correlation between green biomass and vegetation moisture content with level of significance from tests of correlation coefficients, and correlation between TVI and green biomass and vegetation moisture content for G.P.C. test sites.

Test Sites	Green Biomass vs. Moisture Content		TVI vs. Green Biomass	TVI vs. Moisture Content
	r	P>|r|	r	r
College Station North	.3151	.3452	.4770	.4298
College Station South	.4944	.1464	.5134	.9171
Sonora	.6354	.0146	.4274	.5686
Throckmorton	.7429	.0004	.8516	.8783
Woodward	.7246	.0655	.7761	.7701
Hays	.6603	.0194	.7118	.6833
Sand Hills	.3244	.3605	.9072	.4060
Cottonwood	.6881	.0093	.6530	.8592
Mandan	.8097	.0273	.8429	.9387
Weslaco	.0101	.9793	.4275	.3292
Chickasha	.3075	.3067	.4637	.7914

coefficients shown in Table 4-3 indicate that the correlation is greatest at the Throckmorton test site ($P>|r| = .0004$). A close relationship between these two vegetation parameters is also observed to exist at Sonora, Woodward, Hays, Cottonwood, and Mandan. The poorest correlation occurred at the Weslaco test site.

A comparison of the relationships of these two vegetation parameters with TVI (Table 4-3) reveals that where a poor association exists between the two ground parameters, a poor association also exists between TVI and green biomass or TVI and moisture content or both. It is interesting to note that at the more mesic College Station South test site area and the Chickasha test site area, moisture content was well correlated with TVI while green biomass was not. These two test sites have the highest annual precipitations (100 and 70 cm, respectively) of the ten G.P.C. test sites and both had abnormally high rainfall during most of this study (e.g., 150 and 90 cm, respectively, in 1973). Both sites also support large amounts of herbaceous biomass.

A knowledge of these effects suggests that the incorporation of weather measurements might enable adjustment of the data for some of these effects. This will be dealt with in Section 4.4.4. In addition, the data presented in

4.4.2 TVI versus TVI6

The transformed vegetation index (TVI), which was derived in Section 4.3.1, has been emphasized to this point in all analyses and evaluations of ERTS data relative to ground truth information. It was pointed out in Section 4.3.2, however, that for three of the Texas test sites and with the limited amount of data available early in the study that the band ratio parameter utilizing Band 6 data (BRP6 or TVI6) in place of Band 7 provides somewhat better correlations with green biomass. This relationship was not tested for the other test sites at that time due to incomplete data sets.

Following selection of the final data for analysis in the G.P.C. study, both TVI and TVI6 parameters were calculated (124 data sets) and are presented in Table 4-4. Graphs of TVI6 data by test site are presented in Appendix G. The obvious difference between the two parameters is the somewhat larger numerical value of TVI6. For example, during winter dormancy at Throckmorton, a TVI value of .642 was equivalent to a TVI6 value of .694, and during the spring the comparable values were .808 and .838, respectively. At Cottonwood in the summer period, a TVI value of .669 was recorded with a corresponding TVI6 value of .717; while at Mandan the summer period showed the same TVI value

Table 4-4. ERTS-1 MSS data expressed as TVI and TVI6 for G.P.C. test site areas by seasons.

	TEST SITE																					
	Coll. Sta. North		Coll. Sta. South		Sonora		Throck-morton		Woodward		Hays		Sand Hills		Cottonwood		Mandan		Weslaco		Chickasha	
	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6	TVI	TVI6
Spring	.751	.773	.851	.859	.603	.656	.680	.722	.620	.669	.649	.697	.649	.694	.680	.717	.702	.729	.781	.801	.715	.735
	.783	.807	.890	.896	.640	.685	.748	.769	.668	.717	.813	.823	.660	.712	.744	.781	.784	.804	.848	.856	.708	.746
	.809	.826	.877	.878	.676	.711	.808	.838			.868	.869	.723	.765	.635	.693	.770	.807	.766	.798	.747	.786
	.858	.865	.830	.836	.682	.716	.789	.810			.794	.812	.776	.799	.762	.801			.716	.767	.764	.788
					.657	.697	.622	.681													.775	.805
					.641	.689	.684	.743														
					.637	.693																
Summer	.737	.769	.847	.863	.666	.720	.721	.767	.641	.704	.718	.755	.751	.786	.690	.739	.669	.725	.820	.845	.740	.779
	.817	.835	.749	.771	.673	.723	.707	.758	.704	.745	.710	.765	.724	.760	.669	.717			.753	.794	.695	.746
	.771	.796					.636	.703	.644	.707	.821	.844	.711	.755	.645	.712						
											.686	.740	.706	.752	.597	.693						
													.737	.774								
Fall	.704	.729	.785	.793	.683	.723	.784	.811	.695	.734	.831	.831	.746	.734	.657	.645	.686	.736	.805	.837	.642	.702
	.709	.729	.766	.776	.670	.728	.767	.794			.652	.707			.651	.686			.869	.890	.621	.677
	.804	.825	.862	.855			.732	.767			.823	.829			.578	.664			.906	.909	.744	.777
							.753	.784			.751	.780			.613	.674					.738	.766
Winter	.714	.710	.765	.759	.721	.736	.743	.766	.595	.657					.576	.651	.695	.728			.658	.683
					.680	.705	.642	.694									.669	.702			.655	.699
					.604	.675	.629	.677														
							.645	.696														
							.648	.683														

(.669), but TVI6 was .725. Although both Band 6 and Band 7 measure radiation in the near infrared region and the theory for the development of TVI is valid for TVI6, it is apparent that they are recording somewhat different information about objects on the ground.

Regression analyses were performed to assess the degree of association between the ERTS parameters (TVI and TVI6) and quantitative ground measurements at each of the G.P.C. test site areas. In the previous section, it was shown that when the data for all eleven test site areas were included in the regression analysis, only 19.61% and 51.95% of the variation in TVI could be accounted for by estimates of green biomass and moisture content, respectively. The same analyses but with TVI6 showed only a slight improvement, (23.27% and 53.59%, respectively).

These regression analyses were also performed for individual test site areas. The coefficients of determination and significance tests of the regressions, presented in Table 4-5, show that the ERTS measurements are very closely related to one or both of these vegetation parameters at nine of the eleven test site areas. Weslaco showed the poorest correlation between ERTS data and measured ground parameters.

Table 4-5. R^2 values from regression analyses of ERTS-1 band ratio parameters and selected ground parameters for each G.P.C. test site and all sites combined.

Test Site	Green Biomass		Moisture Content		Green Biomass + Moisture Content	
	TVI	TVI6	TVI	TVI6	TVI	TVI6
College Station North	.2275	.3236†	.1847	.2579	.3142	.4434†
College Station South	.2636	.3340†	.8412**	.8467**	.8459**	.8668**
Sonora	.1827	.3084*	.3233*	.5907**	.3306	.5983**
Throckmorton	.7252**	.8254**	.7714**	.7685**	.8598**	.9117**
Woodward	.6024*	.7749**	.5931*	.6853*	.6932†	.8509*
Hays	.5066**	.5410**	.4670*	.4520*	.5873	.6028*
Sand Hills	.8231**	.8003**	.1648	.2038	.8370*	.8293**
Cottonwood	.4264*	.5583**	.7383**	.6825**	.7455**	.7431**
Mandan	.7105*	.6346*	.8812**	.9530**	.9011*	.9531**
Weslaco	.1828	.2513	.1084	.0521	.2883	.3012
Chickasha	.2150	.3170*	.6263**	.7283**	.6799**	.8280**
All Sites	.1961**	.2327**	.5195**	.5359**	.5299**	.5559**

** regression significant at the 99% level of probability
* regression significant at the 95% level of probability
† regression significant at the 90% level of probability

TVI6 is generally better correlated with green biomass and moisture content of the vegetation than TVI. Nine of the eleven test site areas showed substantially larger coefficients of determination (R^2) for the relationship between green biomass and TVI6 than with TVI (Table 4-5). The exceptions were Sand Hills and Mandan where a high degree of correlation was observed between TVI and green biomass (R^2 = .8231 and .7105, respectively) and TVI6 showed only slightly lower values of R^2 (.8003 and .6346, respectively). At these two sites, however, TVI6 showed higher R^2 values than TVI for the regression on vegetation moisture content. At only four of the eleven test site areas were coefficients of determination for TVI vs. moisture content and TVI6 vs. moisture content substantially different, and these four test sites (Sonora, Woodward, Mandan, and Chickasha) all showed better correlation with TVI6.

The regression of TVI6 on green biomass was significant at the 95% level of probability at eight of the ten test sites. Green biomass accounted for 82.54% of the variation in TVI6 at Throckmorton, 80.03% at Sand Hills, 77.49% at Woodward, 63.46% at Mandan, 55.83% at Cottonwood and 54.10% at Hays. At Sonora and Chickasha, green biomass was shown to account for only about 31% of the variation in TVI6. Both College Station test site areas were similar at about 33% with the regression significant at the 90% level of probability. The regression was not significant at Weslaco, which showed an R^2 of .2513.

Moisture content of the vegetation was best correlated with TVI6 at Mandan, College Station (South), Throckmorton, and Chickasha with respective R^2 values of .9530, .8467, .7685, and .7283. Woodward and Cottonwood also showed good correlation as moisture content accounted for 68% of the TVI6 variation. Sonora and Hays were somewhat lower at 59.07% and 45.20%, respectively. Almost no association was found between TVI6 and moisture content at the Weslaco (R^2 = .0521), Sand Hills (R^2 = .2038), and College Station (North) (R^2 = .2579) test site areas.

The regression of TVI6 on green biomass and moisture content in combination generally did not improve the R^2 over that of the best correlated parameter considered alone. Notable exceptions are College Station (North), Throckmorton, Woodward, and Chickasha where coefficients of determination were increased by 10% or more.

4.4.3 Seasonal and Individual Test Site Effects

The ERTS-1 MSS data expressed as the band ratio parameter TVI6 has been shown to vary considerably throughout the year in the Great Plains Corridor. Analysis of variance previously reported showed that these data varied significantly by season. Differences in spectral response were also found to be significant among test sites. The individual test site characteristics of vegetation, soil, and other factors cause the spectral response variations to be differentially correlated with the coincident measured ground parameters. Consequently, the inclusion of data from all sites in a single regression analysis with ERTS and ground data resulted in relatively low coefficients of determination. Since herbaceous vegetation in this region responds similarly in the vernal advancement phase of development, it was hypothesized that better correlation with ERTS data would be possible if the seasonal effects were removed. This would refine the capability to monitor the initial greenup period and follow the development of the herbaceous vegetation, particularly in the spring.

At most of the test sites (only College Station and Weslaco being excepted) a definite extended winter dormant period exists in which the herbaceous vegetation dies back and loses virtually all of its green plant material. The standing dead material is then generally reduced in height by grazing, decaying, and weather actions before new growth is initiated. It would be expected that prior to the initial spring flush of growth, all of these test sites would have a similar visual aspect. This includes a bleached brown cover of dead plant material having a low profile and varying amounts of exposed surface soil. These conditions should allow good detection of green biomass as it develops to a measurable level and increases in volume. It is expected that as the vegetation grows and develops through the spring, summer, and fall and is modified by grazing and other treatments, the G.P.C. test sites will develop progressively dissimilar vegetation situations. This is expected to result in a progressively poorer relationship between ERTS and ground parameters if all test sites are considered in a single regression model.

The linear regression of TVI6 on green biomass for all dates and all test sites shows that there is a relatively poor relationship (R^2 = .2327) among these two variables, similar to that shown in Figure 4-20 for TVI and green biomass. The same analysis performed on the data split out by seasons shows that the best relationship between the ERTS and ground data occurred in the spring (R^2 = .4027). The next highest coefficient of determination was observed (.3735) for the winter. As expected a very poor relationship was observed for the summer and fall seasons (.0451 and .0604, respectively).

At College Station and especially Weslaco, the extended winter dormant period does not fully develop. Both areas experience freezing weather which kills the herbaceous vegetation, but frequent intermittent periods of warm weather with adequate moisture results in growth of grasses and forbs. At College Station, cool season forbs usually become prominent on many of the range and pasture lands in late January and early February. By the time of the normal spring greenup (passage of the green wave), which causes the range grasses to respond vigorously, some areas already have an abundance of green vegetation composed primarily of the forbs. These broad-leaved species frequently provide almost total ground cover--often with very little green biomass (on a dry weight basis). These conditions were experienced on the College Station test site areas during the current study. The College Station South test site area was most dramatically affected. It is believed that this winter and early spring green forb component in the vegetative scene is in large part responsible for the failure of TVI6 values to drop to the normal winter dormant level experienced at most of the other test sites. It is important to note also that the TVI values for the winter period at College Station were larger than the TVI6 values (Table 4-4). At no other test site did this occur. Typically, the absolute values of TVI6 are larger than the TVI determinations. The basic spectral relationships resulting in this reversal are currently unexplained.

At Weslaco, the subsite area from which ERTS data was extracted and for which ground samples of herbaceous vegetation were taken has a woody brush component typified in Figure 3-1 and Appendix C. The brush canopy cover is approximately 20%. The ground photographic record reveals that this overstory, composed of many species, maintains a green appearance throughout the year, although some of the species do brown out completely in the winter. In addition to being drought tolerant, the brush species are deeply rooted and able to extract moisture from depths below that of the grasses. Consequently, this overstory is less sensitive to short-term fluctuations in soil moisture stress than the herbaceous vegetation. The brush overstory is probably responsible for the year-round relatively high TVI6 values shown in Table 4-4. Additionally, the poor relationship observed (Table 4-5) between the TVI6 values for the Weslaco test site and the measured ground parameters is probably a direct result of the "evergreen" brush component of the vegetative scene. Because of the relatively atypical situation at College Station and Weslaco, the investigators were imposed to exclude these data.

The College Station and Weslaco data were removed from the data set and the relationship between TVI6 and green biomass was greatly improved. The overall (all seasons) coefficient of determination does not show a good relationship but was increased to .4346. However, a highly significant regression was observed for TVI6 regressed on green biomass ($P > F = .0001$) during the spring growing period (Figure 4-22). Green biomass accounted for 70% of the variation in the ERTS radiance measurement parameter TVI6.

The resultant regression equation is as follows:

$$\hat{Y} = .686775 + .000759X$$

where

$\hat{Y}$ = TVI6

X = green biomass (kg/ha)

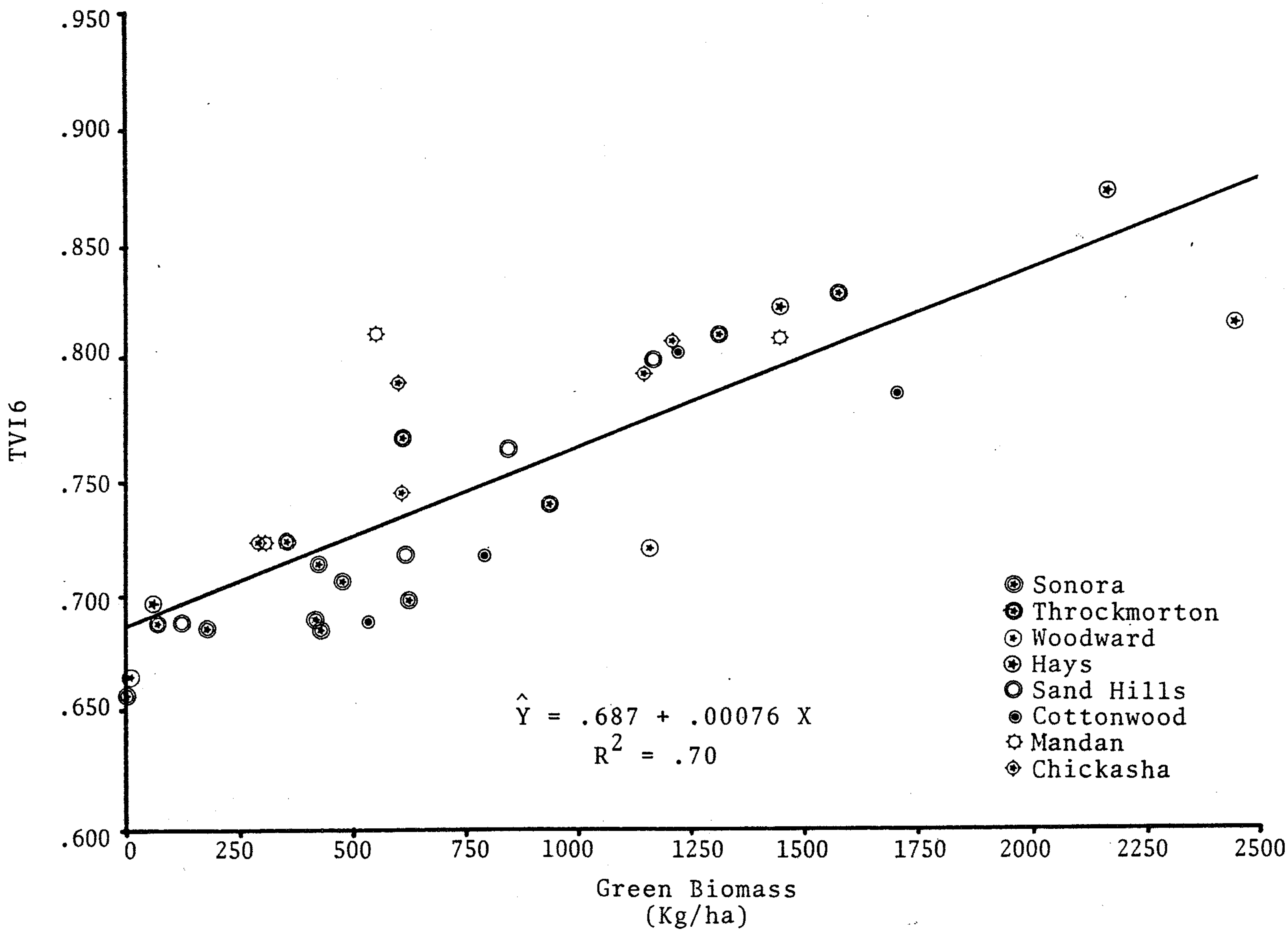


Figure 4-22. Least squares regression line for the correlation of green biomass with the ERTS-derived parameter TVI6 for spring data at eight G.P.C. test sites.

In other words, starting with a winter dormant base TVI6 value of .687, every 100 kg/ha increase in green biomass results in an average increase of .076 in the TVI6 response value. The coefficient of determination for the summer was still very low (R^2 = .0699) but R^2 increased to .3313 during the fall growing period.

For typical mixed prairie grassland vegetation in the Great Plains region, a reliable determination of the time of initiation of spring greenup is possible through observation of TVI6 response. Broad increments of green biomass can be estimated, which enable quantitative monitoring of the herbage production increases in the spring and early summer. However, accurate green biomass estimation and vegetation condition monitoring will probably involve the use of models developed for specific vegetation/soil types characteristic of broad land resourse regions within the Great Plains Corridor.

In addition to percent vegetation moisture content to the regression equation of TVI6 on green biomass for all ten test sites increased the amount of variation accounted for by the ground parameters from 23% to 56% (Table 4-6). The seasonal breakdown indicates that the closest relationship between the ERTS parameter and ground

Table 4-6. Coefficients from multiple regression of TVI6 on green biomass adjusted for vegetation moisture content (%) using all data for the eleven test areas for three groupings of the data.

Data Groupings and Number of Data Sets	β-coefficients			R^2
	β_0 Y-intercept	β_1 Green Biomass	β_2 Moisture Content	
I. All Data--124	.64652	.00015	.00266	.5559
II. Seasons				
Spring--47	.64775	.00038	.00219	.6739
Summer--31	.67496	.00001	.00220	.3589
Fall--30	.56897	-.00005	.00535	.5126
Winter--16	.66342	.00095	.00130	.4701
III. Growing and Dormant Periods				
Growing--77	.63814	.00021	.00279	.5432
Dormant--47	.65924	.00010	.00228	.5563

measurements occurs in the spring. The regression coefficients for green biomass indicate that the TVI6 parameter is most sensitive to changes in green biomass in the winter.

By excluding the College Station and Weslaco test sites, the regression analyses show that the sensitivity of TVI6 for detecting green biomass differences is increased considerably (Table 4-7). The sensitivity of the TVI6 parameter to moisture content was also shown to be substantially decreased. Regression analysis for the spring data shows that green biomass and vegetation moisture content account for 82% of the variation in the observed TVI6 values. These two ground measurements reflect the status of the herbaceous vegetation conditions both in terms of the quantity of photosynthetic plant material and the turgor of the plant tissues. The good relationship between these parameters and TVI6 indicates that the ERTS-1 MSS data has great potential for monitoring vegetation conditions within the Great Plains Corridor. It is believed that maximum utility will be achieved with models that account for site effects resulting from major differences in the vegetation/soil resource.

The differential degree of association between ERTS and ground measurements experienced at the various Great

Table 4-7. Coefficients from multiple regression of TVI6 on green biomass adjusted for vegetation moisture content (%) using data for all G.P.C. test sites except College Station and Weslaco (see eplanation in text).

Data Groupings and Number of Data Sets	β-coefficients			R^2
	β_0 Y-intercept	β_1 Green Biomass	β_2 Moisture Content	
I. All Data--94	.65578	.00028	.00173	.5953
II. Seasons				
Spring--35	.64882	.00054	.00146	.8197
Summer--24	.69446	.00007	.00119	.2192
Fall--21	.60878	.00020	.00314	.5270
Winter--14	.68147	.00178	-.00046	.6043
III. Growing and Dormant Periods				
Growing--46	.63920	.00037	.00197	.6704
Dormant--38	.67360	.00017	.00136	.4793

the two graphs suggest that the relationship between the ERTS and ground parameters may be different for the various test sites (i.e., different vegetation/soil types).

An analysis of variance for test site and seasonal effects on ground measured parameters (e.g., green biomass) revealed that there are significant test site differences. Also, as expected, there were highly significant seasonal effects ($P > F = .01$). No test site by season interactions were indicated.

A comparable analysis of variance for test site and seasonal effects on TVI values also revealed highly significant test site differences ($P > F = .0001$), as well as significant seasonal effects when adjusted for test sites. As with the ground data, there were no interactions between test sites and seasons for TVI data.

It is apparent from these analyses and the data presented in this section, that for the best fit of ERTS parameters to ground data it is necessary to evaluate the relationships between these parameters for similar vegetation/soil types. For example, although poor association exists between green biomass and TVI when all test sites are composited, Figure 4-23 demonstrates a good relationship between these two parameters at Throckmorton and other test sites (vegetation/soil type) taken individually. This relationship will be detailed in Section 4.4.4.

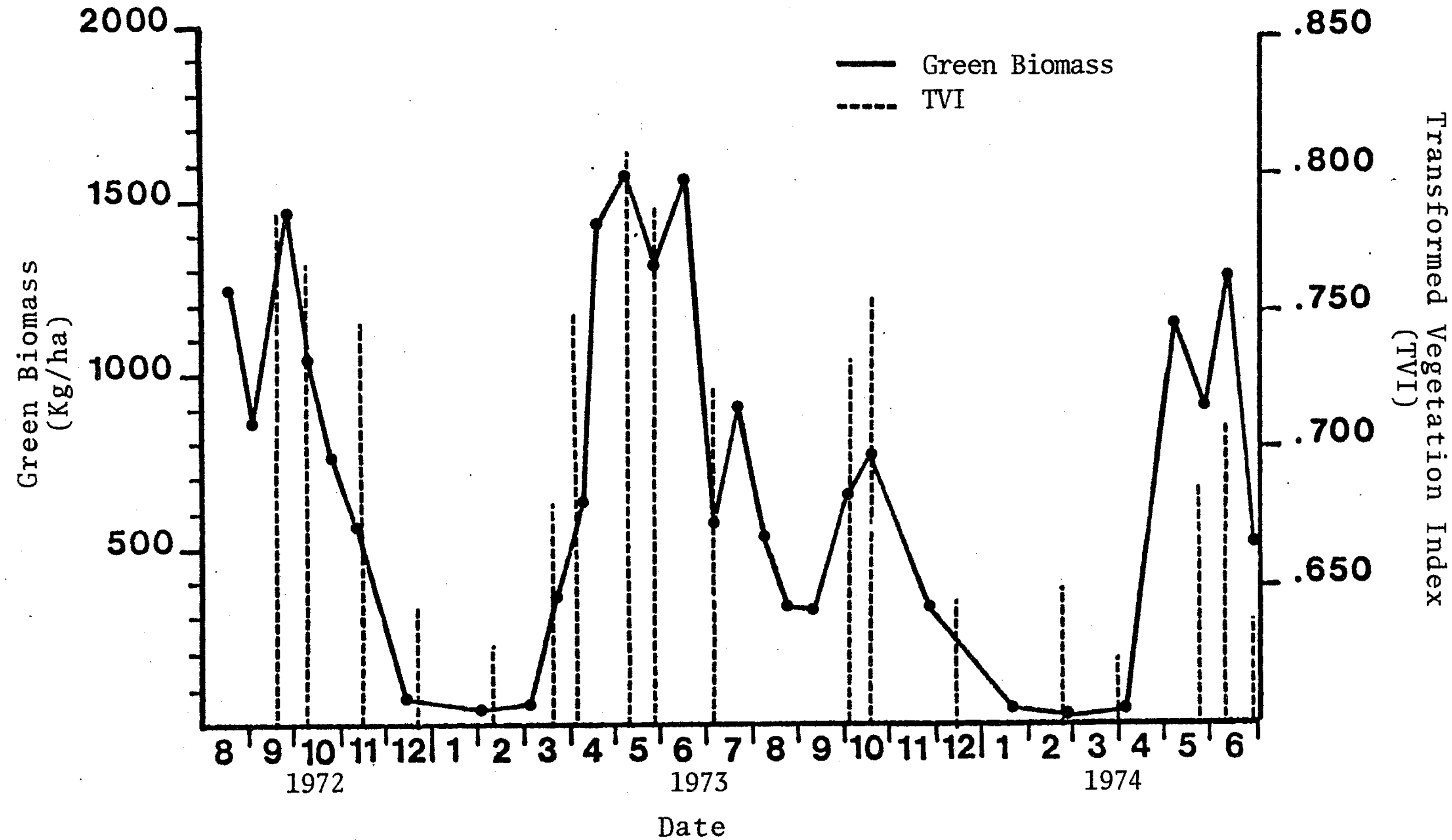


Figure 4-23. Graph showing the relationship of the transformed vegetation index (eighteen dates) and green biomass (all data) at the Throckmorton test site.

Plains Corridor test sites (Table 4-5) prompts consideration of reasons for these differences. A few of these have been discussed previously and will not be elaborated here. Obviously, characteristic vegetation and soil differences are important. Some concern was expressed in Section 4.4.1 about the accuracy of the green estimate values. There is also some concern about the heterogeneity of the subsite areas sampled at some locations. Undoubtedly, the ground samples were inadequate at the more heterogenious locations. At the Throckmorton test site, where a high degree of association is shown between TVI6 and green biomass (R^2=.8254, Table 4-5), twice as many ground samples were taken at each sampling date.

4.4.4 An Application Model for Measuring Green Biomass from TVI6 Data

The completeness of the Throckmorton data set, the larger ground data sample and the extensiveness of the test site provides good opportunity for evaluating the sensivity of ERTS MSS data to vegetation changes throughout the annual cycle for most of two years. TVI6 values presented in Figure 4-24 indicate the seasonal variations in the ERTS measurement parameter extracted for subsite area analysis.

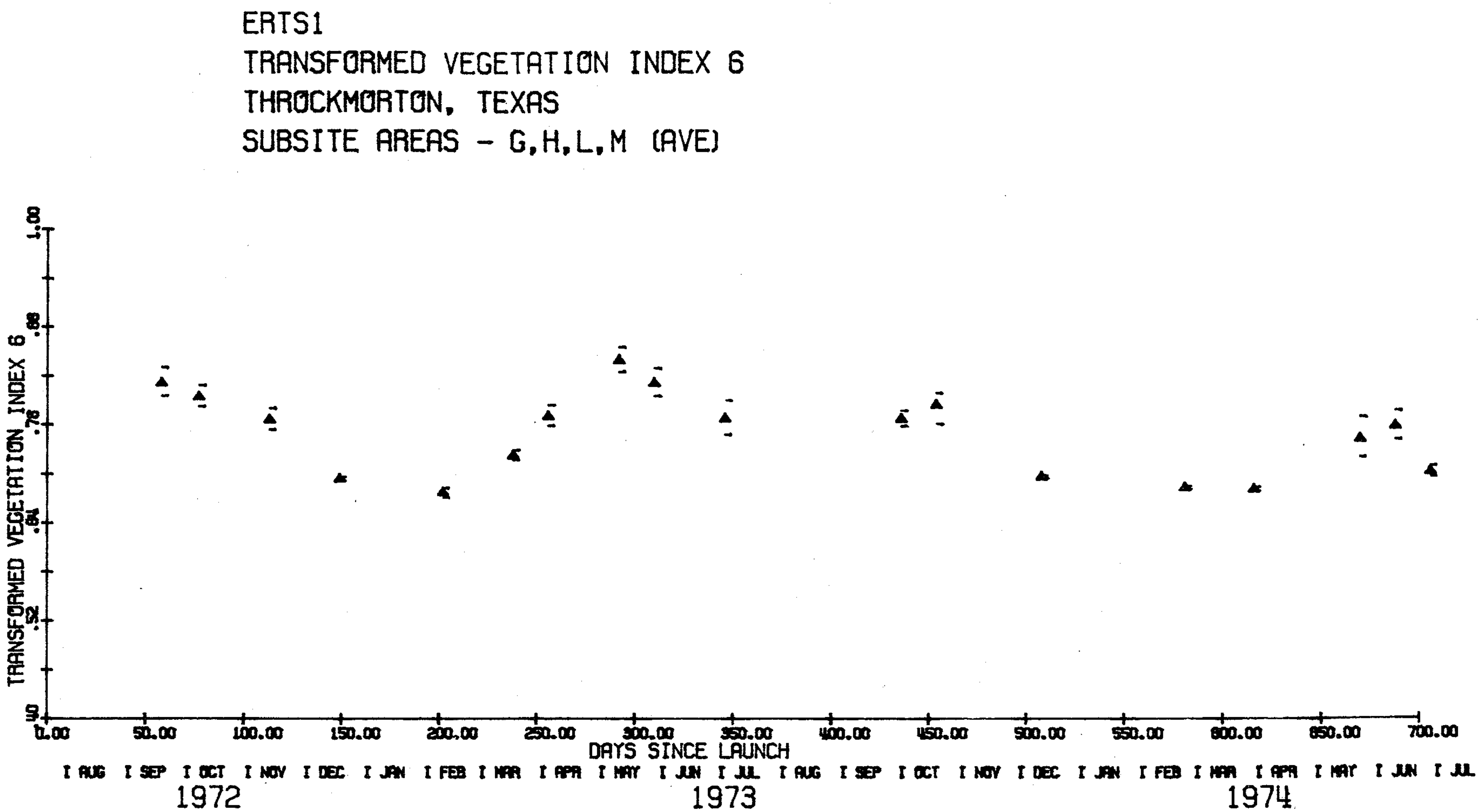


Figure 4-24. TVI6 values and associated standard deviations for eighteen dates at the Throckmorton test site.

(Similar graphs for TVI and individual ERTS band data for Throckmorton are presented in Appendix H). The low standard deviations for the plotted values attest to the validity of using the ERTS parameter for detecting and monitoring changes in ground scene reflectance.

The seasonal vegetation differences recorded by the TVI6 parameter are qualitatively manifest in the color composite imagery for the area (Figure 4-25). It can be seen that variations in color and tone of rangelands are also apparent from the digital data. The dull purplish character of the dormant rangeland vegetation on the February 1973 ERTS image changes to a bright red in May when the grasses are green and growing vigorously. The TVI6 values depict the change by increasing from .677 in February to .838 in May.

The ground photographic record (Figure 4-26) taken at the time of the ERTS coverage shown in Figure 4-25 reveals the vegetation conditions that were monitored by the ERTS MSS sensor. These photographs document the "brownout" that occurred from the Fall 1972 to mid-winter 1973, the subsequent greenup and maturation of the grasses in the spring, and the summer drought stress "browndown".

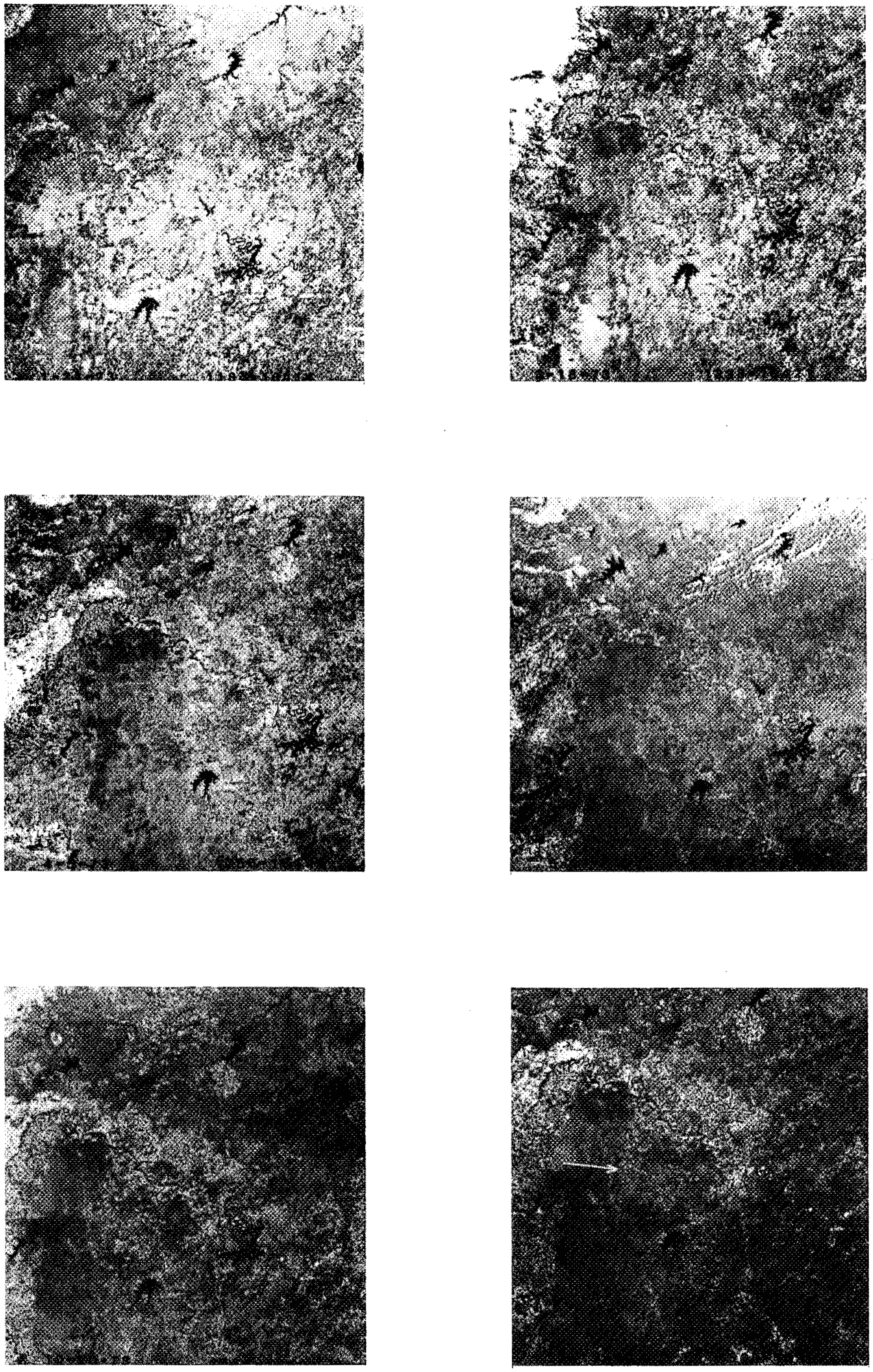


Figure 4-25. ERTS-1 color composite (Bands 4, 5, and 7) images of the Rolling Plains resource region including the Throckmorton test site (at arrow) for selected dates.

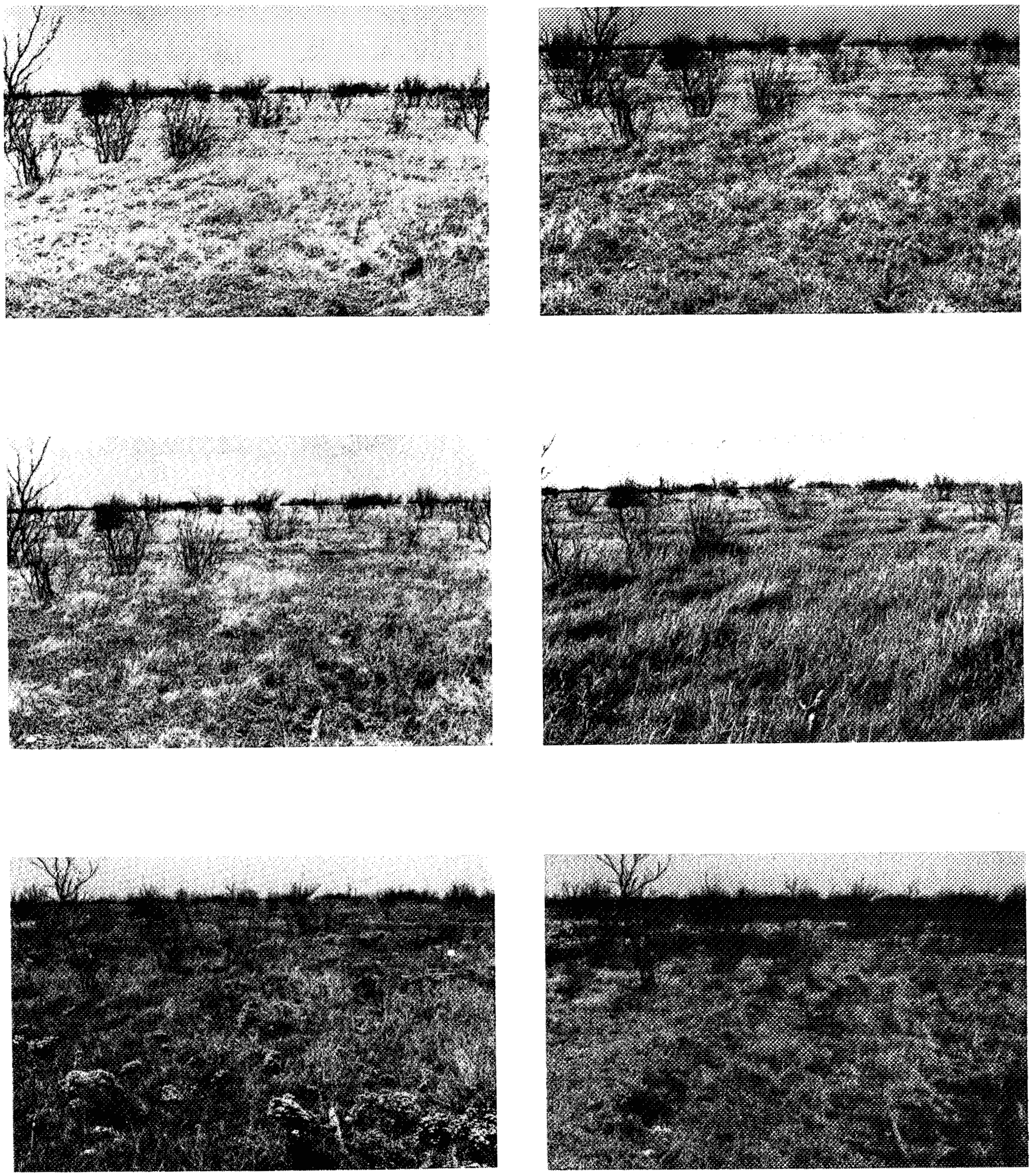


Figure 4-26. Photographic record of ground vegetation changes on selected dates at the Throckmorton test site.

The close relationship between the ERTS TVI6 data and the ground estimates of green biomass from vegetation clippings was reported in Section 4.4.2. The regression, which resulted in a coefficient of determination of .825 is diagrammed in Figure 4-27. At Throckmorton a sufficient number of ground samples were taken to adequately monitor the status of this vegetation type resulting in a high degree of correlation with the sentitive ERTS parameter.

Moisture content of the vegetation was also shown to be closely related to TVI6 (R^2 = .7685; Table 4-5; Figure 4-28). Moisture content typically ranged from 10% to 50%, although one winter sample recorded moisture content close to zero. It is important to note that the vegetation moisture content is drastically influenced by the amount of green biomass present. However, this association with moisture content confirms the hypothesis that the TVI or TVI6 values provide an indication of the status of the soil moisture relations. Weather influences, which are reflected in the vegetation through soil moisture relations, are, consequently, indirectly monitored.

Since vegetation systems are intrinsically related to environmental functions, weather parameters undoubtedly have an influence on the TVI6 parameter. Weather data can provide information about conditions such as soil moisture,

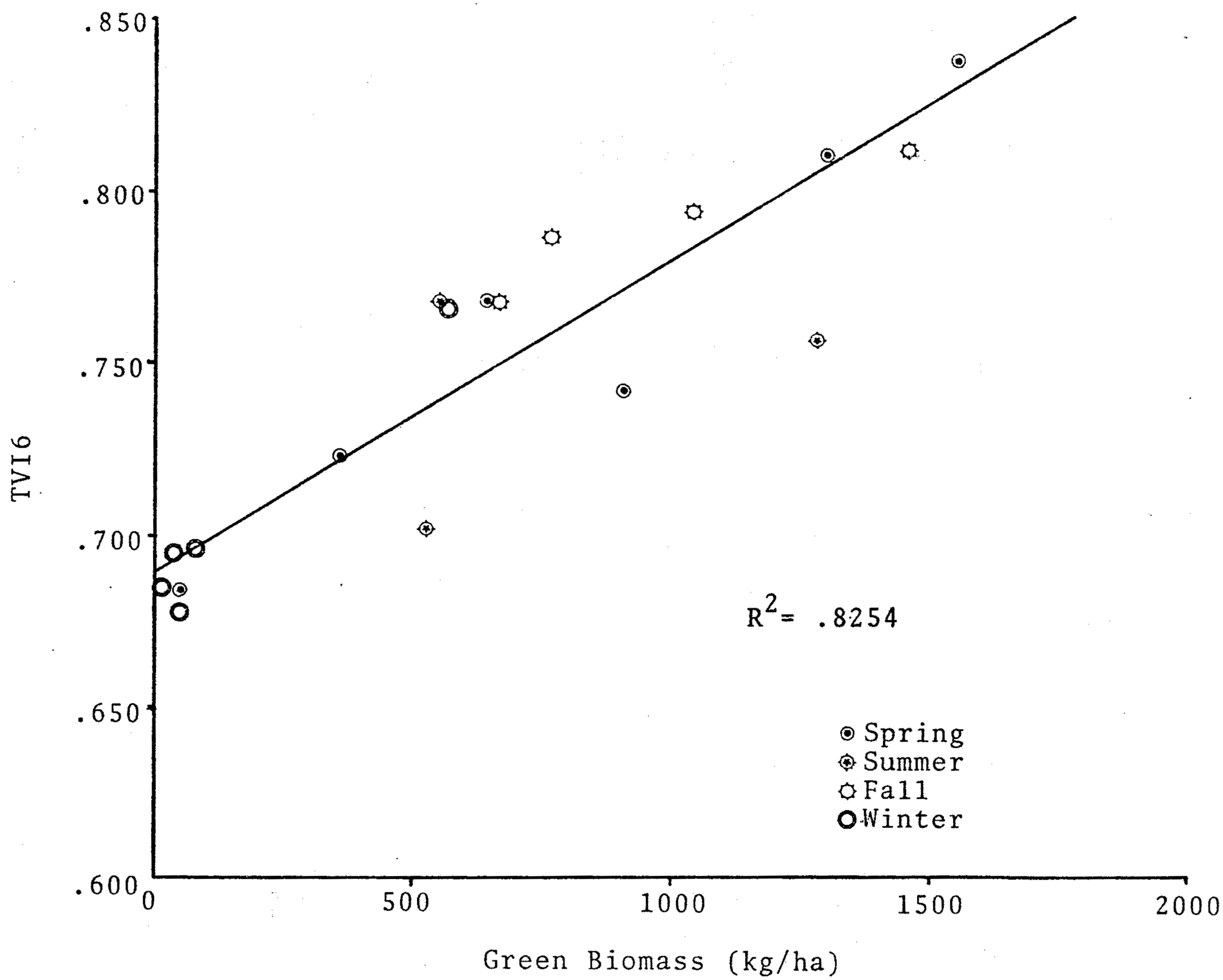


Figure 4-27. Linear regression of TVI6 on green biomass at the Throckmorton test site.

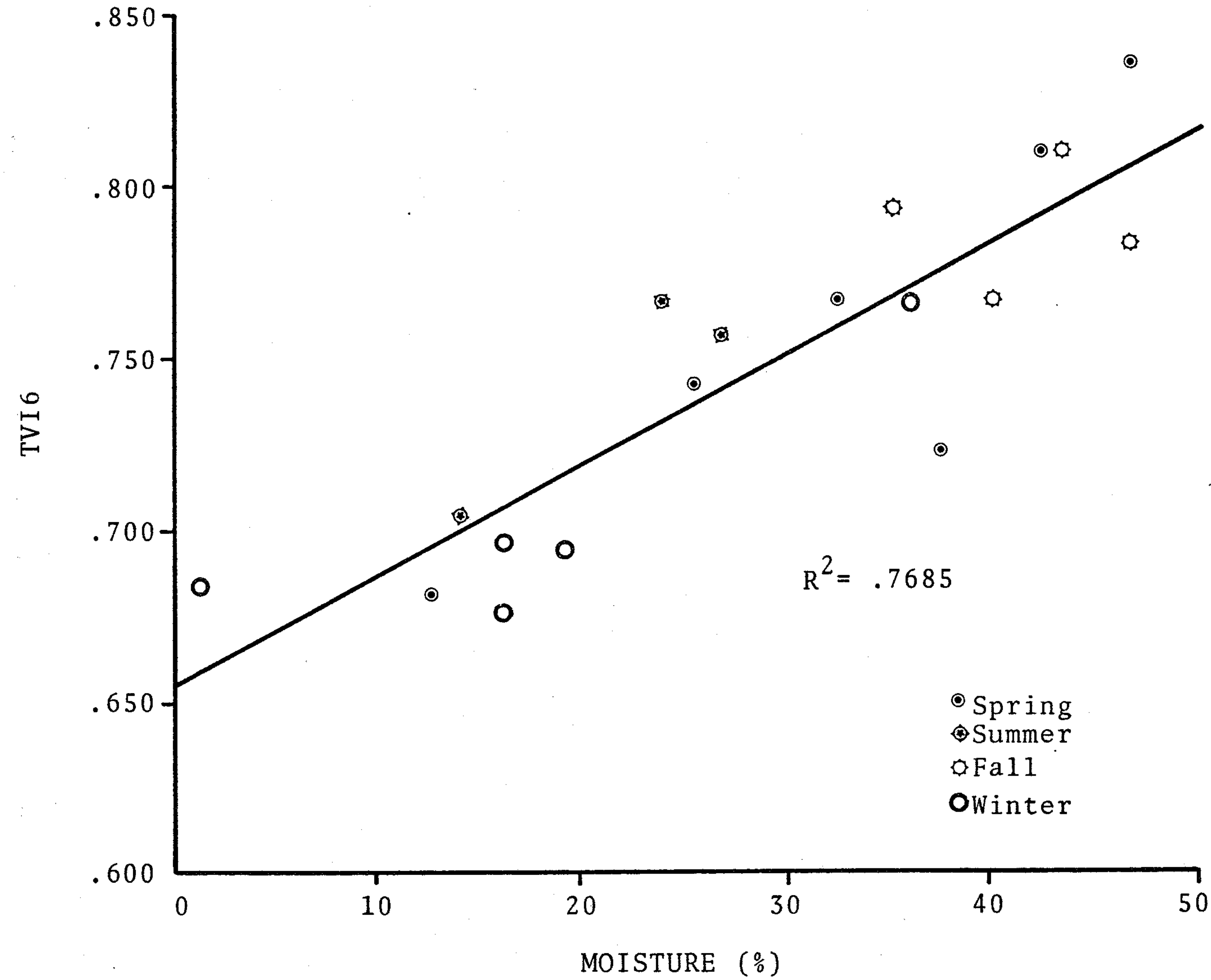


Figure 4-28. Linear regression of TVI6 on percentage moisture content at the Throckmorton test site.

atmospheric moistures, and plant stress without direct measurement. In addition to affecting growing conditions, weather can directly influence spectral reflectance of objects in a scene. Consequently, the length of time since the last precipitation, the amount of precipitation, and temperature (drying effect) are important in determining the color of the surface soil, dead vegetation, etc., and likewise their reflectance characteristics, on any given data.

Under certain moisture-temperature conditions, dew may be present on the leaf and soil surfaces at the time of satellite passes over. Although the skies may be clear, the free moisture on these surfaces may drastically affect the spectral response. In view of these influences, it is probable that some of the variation in ERTS-1 measurements can be accounted for by analyzing weather data. The good correlation (Figure 4-28) between vegetation moisture content and the ERTS parameter supports this hypothesis.

At the Throckmorton test site, where on-site daily weather data are available, the weather influence could be evaluated precisely. Table 4-8 presents selected weather parameters relative to the eighteen ERTS overpasses for which the data have been considered in this study. For three of the satellite overpasses, rain fell on the day prior to the ERTS data acquisition. In one instance

Table 4-8. Weather data corresponding with available ERTS data at the Throckmorton test site beginning September 1, 1972.

Satellite Coverage Date	Precipitation (inches)			Temperature (F°)					
	Since Previous Coverage Date	Last Ppt. Prior to ERTS Coverage Date		Date of ERTS Coverage			Since Previous Coverage Date		
		No. Days	Inches on Last Day	Mean	Max.	Min.	Mean	Max.	Min.
9-19-72	4.56	15	3.76	81	92	70	78	94	63
10-8-72	.89	17	0.09	71	89	53	73	89	42
11-13-72	6.40	1	0.23	46	54	38	58	95	38
12-19-72	1.86	7	0.90	54	67	40	42	76	13
2-10-73	4.18	3	0.83	35	50	20	41	78	11
3-18-73	1.91	1	0.90	60	74	46	50	76	26
4-5-73	1.74	2	0.40	49	64	34	53	74	34
5-11-73	1.31	22	0.50	80	92	68	62	92	28
5-29-73	0.70	6	0.70	68	84	52	71	98	48
7-4-73	4.15	1	0.19	76	84	68	80	109	52
10-3-73	13.54	7	1.21	77	88	68	78	100	52
10-20-73	1.74	8	0.59	63	80	46	65	90	46
12-13-73	0.79	20	0.70	47	59	35	55	84	22
2-24-74	0.75	3	0.55	31	42	19	42	82	0
3-31-74	1.58	10	0.80	80	96	64	60	96	20
5-24-74	4.37	18	1.24	78	90	66	67	96	32
6-11-74	3.08	7	1.43	75	89	60	76	98	52
6-29-74	0.01	5	0.01	78	93	63	77	100	51

twenty-two days had elapsed since the last rain. Temperatures ranged from 0°F to 109°F during this study.

Twelve weather information values were used in evaluating the weather influence at Throckmorton. These weather data include the following: number of days since last precipitation; amount of precipitation since last ERTS overpass (18 days); maximum temperature since last overpass; minimum temperature since last overpass, amount of precipitation on the day before the overpass; total precipitation for the two days prior to the overpass; accumulated precipitation since three days, six days, nine days, and twelve days prior to the overpass; and maximum, minimum, and mean temperatures on the day of the overpass.

Throckmorton test site green biomass measurements and the twelve weather values for the eighteen data sets were included as independent variables, with TVI6 as the dependent variable, in a stepwise multiple regression analysis. The "Maximum R^2 Improvement" procedure of North Carolina State University's Statistical Analysis System was implemented to select the variables that should most likely explain the variation observed in ERTS-1 measurements (TVI6) of rangeland at Throckmorton.

The best four variable model, including green biomass, included the following weather parameters: amount of precipitation since the last ERTS overpass (18 days), the amount of precipitation on the day before the overpass, and the maximum temperature on the day of the overpass. The addition of other variables resulted in only very small increases in the coefficient of determination. The resultant regression equation is as follows:

$$\hat{Y} = .7844 + .0015\, X_1 - .0094\, X_2 + .0866\, X_3 - .0017\, X_4$$

Where

$\hat{Y}$ = TVI6

X_1 = green biomass (kg/ha)

X_2 = preicipitation since last satellite overpass (18 days) (inches)

X_3 = precipitation on the day before the overpass (inches)

X_4 = maximum temperature on the day of the satellite overpass (°F)

These independent variables accounted for 91% of the variation in the TVI6 values. The relationship between TVI6 and green biomass after adjusting for these weather effects is shown in Figure 4-29.

A multiple regression analysis was performed using TVI6 and these weather parameters to estimate green biomass from the TVI6 data for Throckmorton. The predicted green biomass is plotted with the observed values in Figure 4-30.

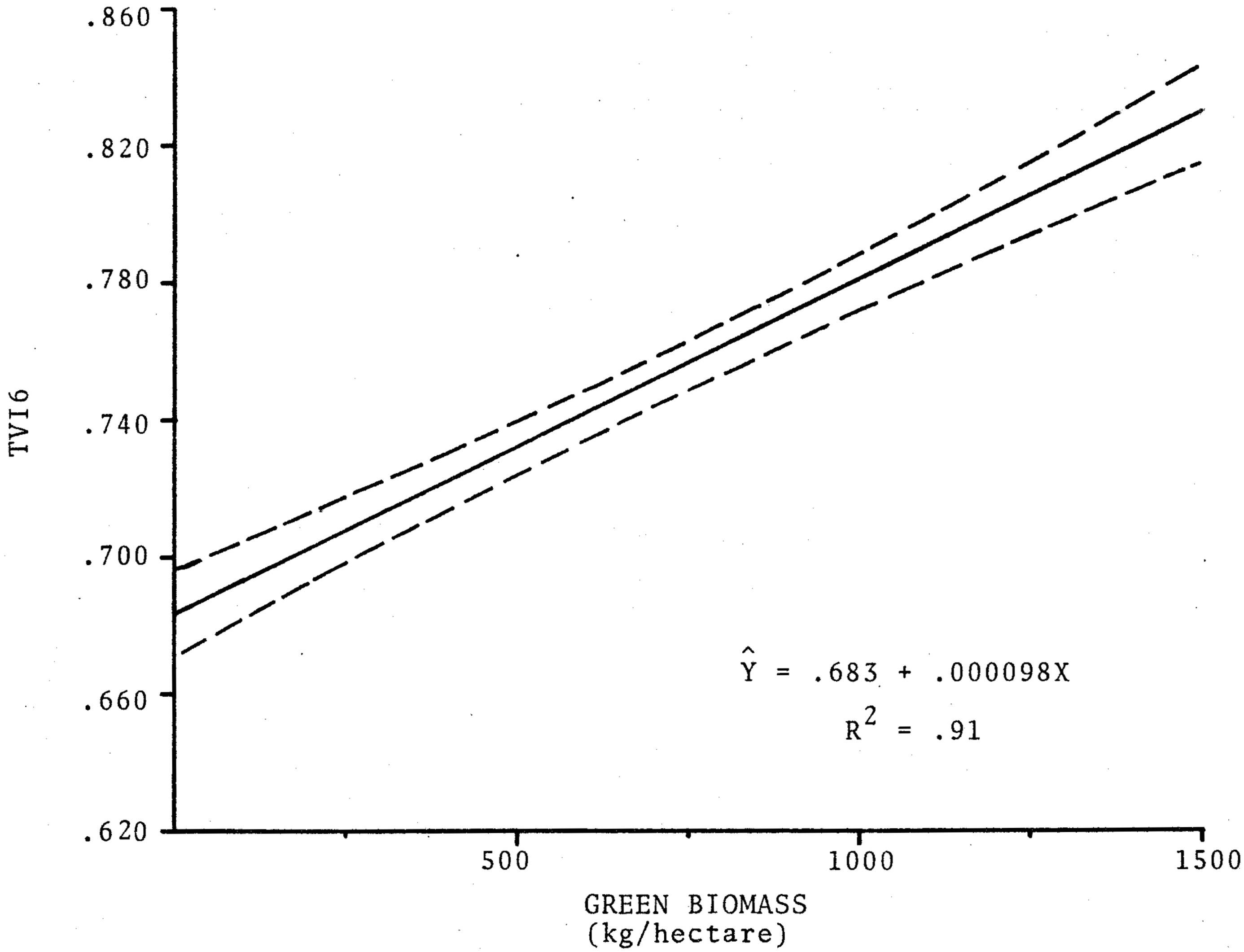


Figure 4-29. Regression line and 95% confidence limits for TVI6 with green biomass adjusted for weather parameters at the Throckmorton test site.

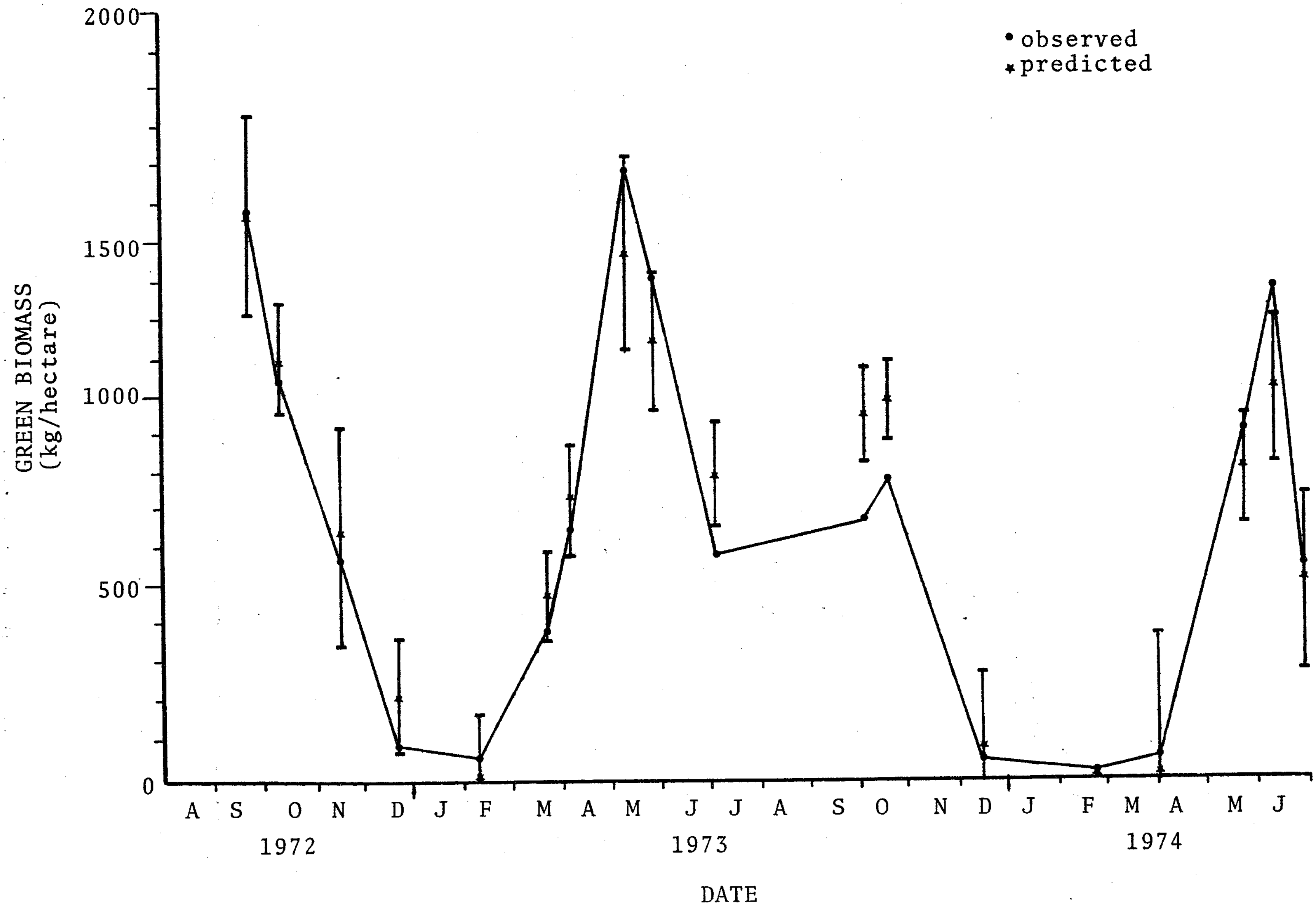


Figure 4-30. Measured green biomass and predicted values with 95% confidence limits from TVI6 adjusted for weather effects at Throckmorton.

The green biomass prediction model for the Throckmorton test site is as follows:

$$\hat{Y} = -508.89 + 648.89\ X_1 + 6.09\ X_2 - 56.15\ X_3 + 1.10\ X_4$$

Where

$\hat{Y}$ = green biomass (kg/ha)

X_1 = TVI6

X_2 = precipitation since last satellite overpass (18 days) (inches)

X_3 = precipitation on the day before the overpass (inches)

X_4 = maximum temperature on the day of the overpass (°F).

The ability to estimate green biomass in increments of 250 to 300 kg/ha with a 95% probability from TVI6 data and readily available weather data is indicated. The relationships tested at Throckmorton indicate that a very practical working model can be developed for estimating green biomass from ERTS MSS and weather data. The intricate network of official U.S. weather stations routinely collects the data necessary for this model.

4.5 Analysis Summary

First attempts to quantitatively relate the ERTS-derived TVI values to ground parameters recorded during the course of the investigation were disappointing. Although the correlation values relating TVI to green biomass were very highly significant, the coeffficents of determination (R^2) were low and indicated that only about 20% of the variation in TVI could be accounted for by ground measurements of green biomass. In some instances the TVI values appeared to be more closely associated with water content of the vegetation than with the amount of green biomass. It was noted, however, that the relationship of moisture content to TVI was a curvilinear function and largely inconsistent from test site to test site. The fact that green biomass and vegetation moisture content were found to be well correlated at some test sites and poorly related at others pointed to possible inadequacies of the ground data estimates at some test sites.

It has been shown in both this report and in previous reports that the normalized band difference based on Bands 5 and 6 is superior to Bands 5 and 7 for calculating a vegetation conditions index parameter. An extensive comparison of the relationship of TVI and TVI6 to green biomass measurements at all test sites confirmed this conclusion. From these analysis, however, it is apparent that the two parameters do record somewhat different information about the vegetation on the ground.

A detailed investigation of the seasonal and test site effects on the performance of TVI6 shows that there were differences in the performances of this ERTS-derived parameter at the several test sites. Several factors including the amount of evergreen shrubs, the amount of bare soil, the amount of tall weedy forbs and the adequacy of sampling are suspected to have contributed to the differencial detection capabilities at the several locations.

After two of the ten sites were excluded from the data set as being atypical, linear regression of TVI on green biomass accounted for 70% of the variation in the TVI6 values for spring data. This accountability could be increased to 82% when vegetation moisture content was taken into consideration. The poorest relationship between TVI6 and green biomass is during the summer when the standing dry biomass is the greatest.

A more detailed analysis of 18 data sets representing all seasons at the Throckmorton test site shows the sensitivity of the TVI6 parameter to changes in green biomass. After accounting for precipitation prior to overpass and temperature on the day of overpass, green biomass measurements accounted for 91% of the variation in TVI at this extensive test site area. This information indicates that for the typical mixed prairie grassland vegetation of the Great Plains region green biomass increments of 250 to 300 kg/ha can be measured routinely from MSS data of the quality obtained by ERTS.

The TVI6 parameter is most sensitive to the measurement of green biomass in the spring when obstructing dry matter is at a minimum. The relationship diminishes as the season progresses into the summer when only broad increments of green biomass can be estimated quantitatively. This in effect may impose some limitations on the use of ERTS data for detecting periodic summer drought. However, under a normal situation the obstructing natural vegetation will be removed by grazing animals in prolonged drought situations. This should allow monitoring the vegetation recovery period when moisture becomes available.

In summary it can be stated that the TVI6 parameter provides a quantitative measure of the green vegetation on any given site. Although the parameter was more sensitive for measuring vegetation change at some sites than others, it is adequate for measuring the spring green up throughout the Great Plains Corridor. Apparently there is some threshhold value of green biomass (approximately 500 kg/ha) below which the estimate is unreliable. There is evidence that conditions at the time of satellite overpass influence the scene reflectance and consequently the vegetation index parameter. Fortunately, it appears that this influence can be easily corrected in a regression model.

In view of the fact that prior to the launch of ERTS-1 it was hoped that ERTS data quality would be adequate to measure phenological changes, these results relative to an ERTS-derived parameter for quantitatively measuring green biomass are significant. It was totally unexpected that a parameter would be derived which would quantitatively measure useful increments of green plant material. These results represent a major breakthrough for the inventory and management of the nation's vast grazing resources. Possibly even more significantly, these results suggest that rangelands and other naturally vegetated areas can now be used as phenological indicators for timing and management of cropping systems.

4.6 Implications to the Needs of Agriculture

It has been the purpose of this project to explore the potential use of ERTS data for monitoring vegetation conditions throughout the Great Plains Corridor. Although ERTS-1 imagery are adequate for manual interpretation of broad landscape types, for observing critical growth periods, for distinguishing agricultural production types, and for general assessment of vegetation conditions, implications for making quantitative measurements from ERTS data need further consideration. Discrete increments of green biomass, measured by ERTS, could be employed to quantitatively assess the stage of crop development, the amount of native and tame pasture forages, the relative response of crops to environmental factors, and to index plant growth for yield estimates.

An obvious application of green biomass estimates obtained from ERTS, is to evaluate current production and accumulate seasonal yield data for forages to be used in livestock production. An understanding of ranch management systems is important to the development of this application.

Effective use of rangeland resources depends largely upon applying well designed plans geared to meet ranch operators' goals, while maintaining full considerations for conservation needs. Ranch management planning is dependent both upon having a satisfactory inventory of rangeland resources and knowing what capital assets are available (Figure 4-31). Four aspects of the rangeland resource inventory can be determined or aided by using remote sensing data: primary production potential for range sites,

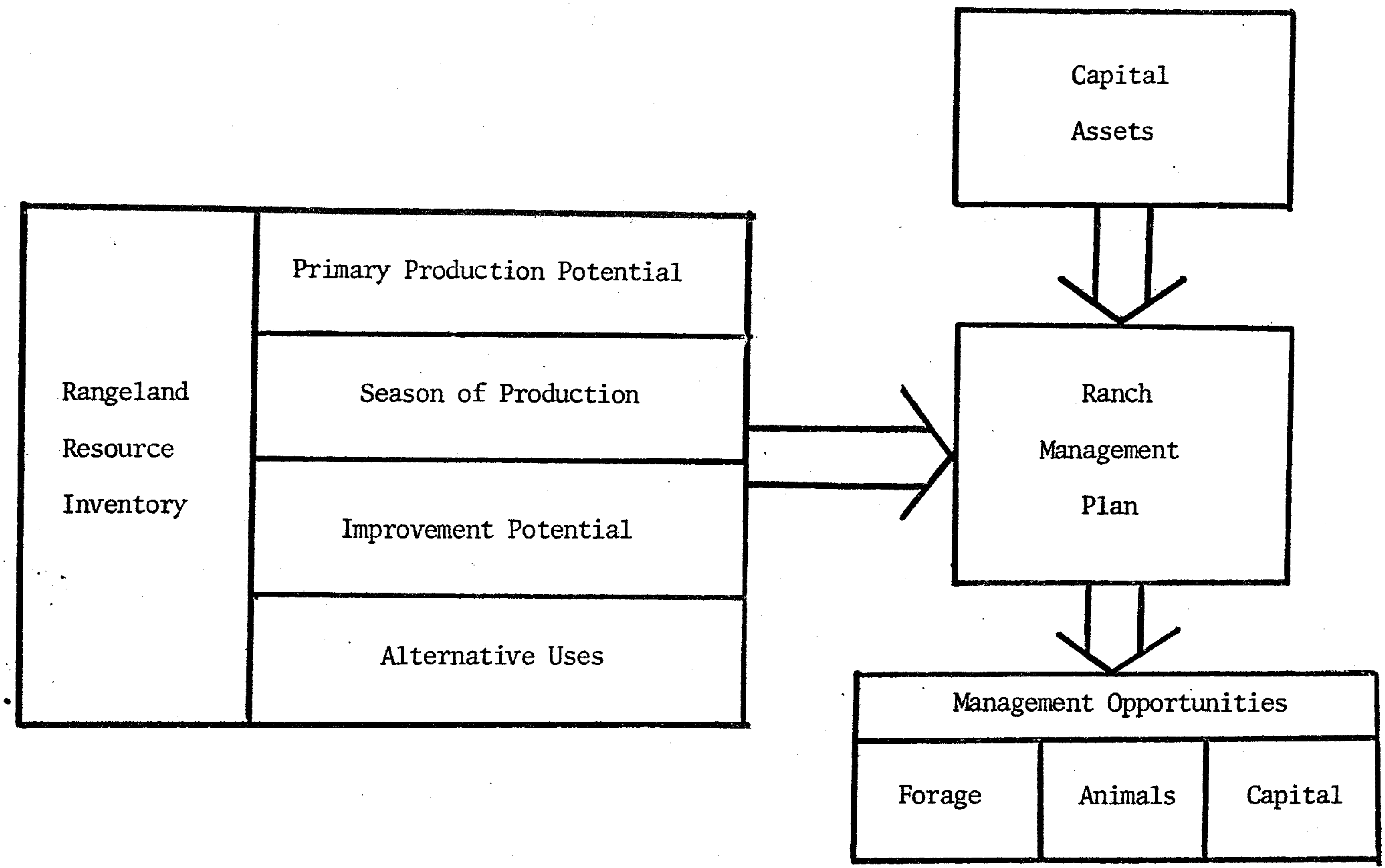


Figure 4-31. Diagram showing important products of the rangeland resource inventory and general aspects of ranch management planning.

seasonal production potential for management units, improvement potential for management units, and alternative uses for range sites. These are items of primary interest to be obtained from the resource inventory. For large ranches, covering thousands of hectares, ERTS-1 imagery may be well employed in delineating broad range sites and for determining potential alternative land uses. Monitoring seasonal production through multistage land inventory techniques could also be helpful in preparing resource maps for large ranching units. However, development of ranch management plans continues to require more detailed information than is feasible through use of ERTS data alone. ERTS data would be better employed by ranch operators in executing forage management plans.

In the past there have been no economically feasible means of monitoring vegetation conditions on a regional basis or of estimating the amount of forage available for livestock production. If the findings of this investigation are carried to the ultimate, it would become possible to monitor the amount of range forage available on a selected local basis or on a regional basis through sampling procedures. Resource monitoring for a forage management plan could be accomplished best by monitoring native range, tame pasture, and supplemental feeds independently (Figure 4-32).

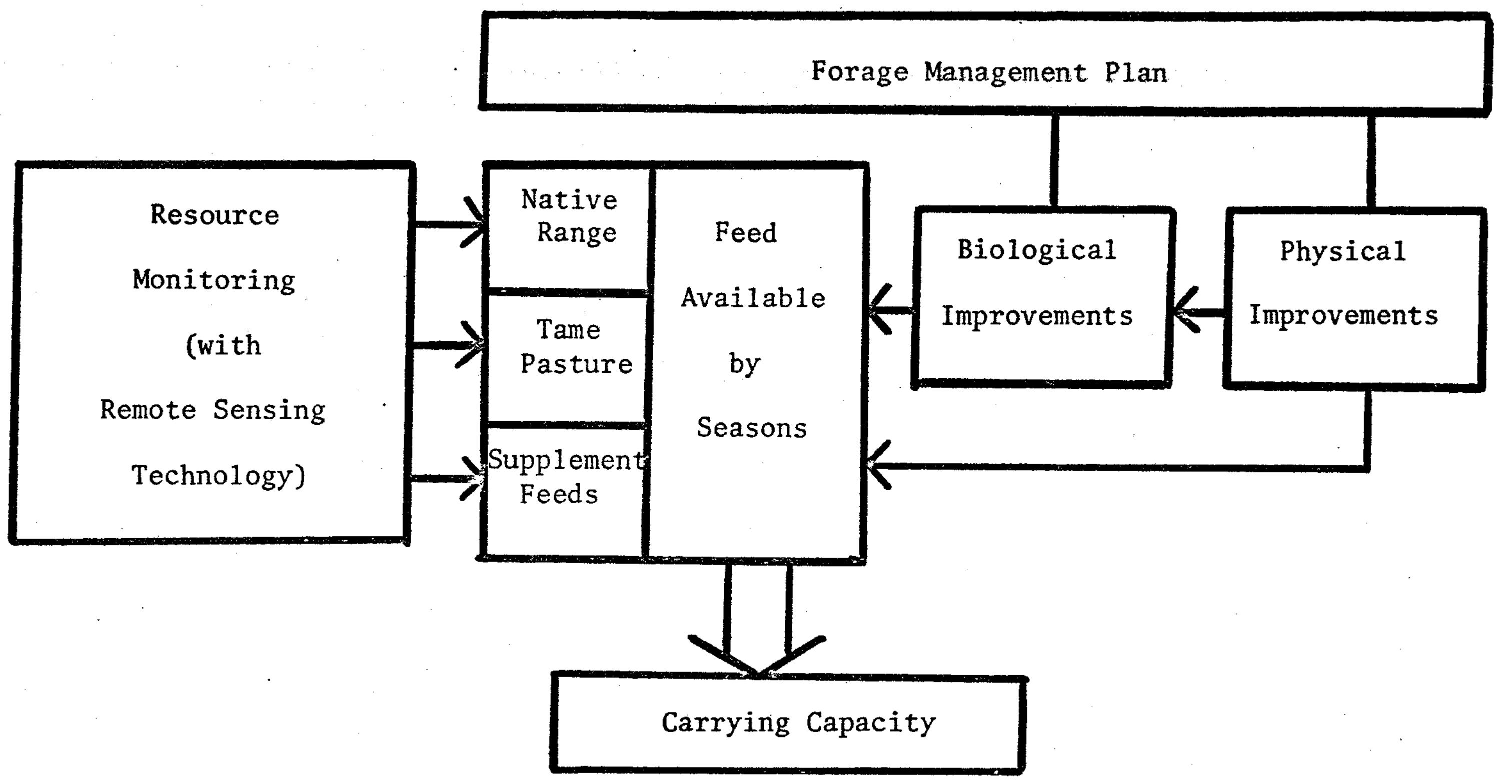


Figure 4-32. Diagram showing the place of entry for remote sensing data in forage management scheme.

It would be feasible to monitor both "range readiness" and "range feed condition" for native rangelands and tame pastures. The amount and status of supplemental feeds (i.e., hay crops, small grains, and other crops used as livestock feeds) could also be monitored from ERTS. Using the data from ERTS monitoring, measurements of feed available by seasons could thus be employed to establish the proper carrying capacity of the rangeland resource, either on a management unit or regional basis.

Criteria required for an operational monitoring system will depend upon the intended data user. For large ranch operators, quantitative information could be supplied on a subscription basis. In this case, the information would have to be specific for individual management units of approximately 100 hectares or more. A completely automated system for locating specific areas and providing information to the rancher in incremental levels of yield (i.e., lbs/acre or kg/ha) would have to be established. For direct input into forage management planning, the turn-around time from data acquisition and delivery would have to be less than one week. Cloud cover at the time of over-pass presents a most serious problem for this approach since the current 18 day cycle is only marginally adequate for reasonable assurance of cloud free data at critical seasons.

A more logical approach appears to be regional monitoring, using a network of sampling sites. For regional monitoring the following criteria are proposed: (1) an established network of test sites and alternate analogous sites identified by land resource types; (2) a system for automated data quality verification and site location; (3) on-line data processing that would provide an output to the regional user for each 18 day cycle during the growing season; (4) product turn-around of not more than one week following completion of the cycle for the region concerned; and (5) a data product in a format suitable for the needs of a broad array of users.

It is anticipated that information in an appropriate format on "range feed conditions" would be published by most local newspapers, farm journals, and many "house organs" in the Great Plains Corridor and throughout the western USA. If presented as an "index of vegetation conditions" it should also find broad applications to many situations found in dryland agriculture. If such an index were correlated and used in conjunction with existing climatological data, forage production forecasts could be performed by federal and state agricultural agencies.

The most devastating factor in dryland agriculture on the Great Plains is the reoccurrence of short and long-term droughts. Seasonal droughts often affect crop yield severely and cause rangeland to be abusively grazed. Long periods of below-normal precipitation can cause serious regional economic consequences. Currently, water-budget models are used to chart drought-stricken areas from weather data. ERTS type data appears to offer a more direct approach to regional monitoring of drought effects, especially for native perennial rangeland vegetation. This investigation has documented this feasibility of using ERTS MSS data for quantitative assessment of green biomass. Seasonal drought indexes, also derived from ERTS data, could be used to increase the reliability of current drought charting systems and lead to better understanding the impact of precipitation deficiencies on agricultural production.

5.0 CONCLUSIONS

The purpose of this project has been to observe natural vegetation systems as phenological indicators throughout the Great Plains Corridor Region. It was hypothesized that the vernal advancement and retrogradation of natural vegetation could be monitored using ERTS-1 imagery and data. It was further proposed that natural vegetation systems used as phenological indicators of seasonal development provide an important means of measuring bioclimitic effects on a regional basis. The Great Plains Corridor study has emphasized quantitative analysis of ERTS-1 MSS spectral reflectance as data quantitative indicators of the amount and seasonal condition of rangeland vegetation. The techniques used are viewed as a viable alternative to qualitative assessments made through image interpretation.

The Great Plains Corridor project has also been responsible for the development of related ERTS-1 activities in the Great Plains and especially in Texas. The spinoff projects have been user-generated; consequently the investigation is impacting on established application efforts.

5.1 Project Accomplishments

Specific accomplishments achieved towards the use of ERTS data for the quantitative assessment of natural vegetation are as follows:

A mathematical model was employed and tested for correcting MSS digital data for changes in solar intensity as a function of solar elevation angle. Changing atmospheric and illumination conditions are a serious problem for making temporal comparisons of digital data values and would have impeded progress towards the quantitative assessment of vegetation from ERTS-1 data had the solar angle correction not been developed. The successful application of the solar angle correction model made it possible to compare digital data from frame to frame, cycle to cycle and location to location throughout the duration of the investigation.

An effective test site network consisting of ten primary test sites was established for this rangeland oriented investigation throughout the Great Plains Corridor. More than 217 sets of satellite data and 220 sets of ground truth data were collected for the test sites involved in the study.

The theoretical derivation of the normalized band difference led to the development of the transformed vegetation index (TVI). Investigations early in the project led to development of the hypothesis that the normalized difference between the red and infrared bands was potentially useful for the quantitative measurement of green biomass. In the final analysis, it appears that the difference between Band 5 and Band 6 are most sensitive to the detection and quantitative evaluation of green biomass differences. The parameter is called TVI6.

Detailed statistical analyses show that the TVI6 parameter, along with limited weather data is adequate to quantitatively assess rangeland feed conditions. Using the most extensive data collected at any single test site, the Throckmorton test site, detailed statistical analyses show the potential for the use of the ERTS-derived parameter for the quantitative measurement of green biomass. Factors such as moisture content of the vegetation or the alternate use of precipitation and temperature data are necessary for modeling a predictive equation for estimating green biomass to the desired accuracy.

It was clearly demonstrated that the vernal advancement could be monitored through its northward movement in the Great Plains. Ground observation and satellite data collected in 1973 show that the vernal advancement progressed from the most southerly sites through the northern most sites according to an expected progression calculated from the generalization commonly known as Hopkins Bioclimatic Law. It is of interest that in 1973 four of the ten test sites were six days or more later than the expected progression and two test sites were more than six days early. Spring developed as much as 18-20 days from the expected progression. Observation from satellite data would be useful in monitoring the actual advancement of spring throughout this vast region.

The successful use of ERTS data for measuring green biomass has led to an approach for a follow-on investigation which will evaluate the use of ERTS data to monitor rangeland feed conditions on a regional basis.

Although emphasis has been given to quantitative evaluation of ERTS-derived data, experience with this investigation shows the feasibility of using man-aided interpretation of ERTS imagery of mapping the renewable natural resources. This potential use of ERTS data is especially applicable to the uncharted wildland areas of the world. The use of ERTS-derived maps will be especially applicable to natural resource management (range management, wildlife management) and for environmental impact analysis. Of special note in this regard is the fact that quantitative application of ERTS-data will be dependent upon knowing the resource type being monitored.

5.2 Potential Applications in Agriculture

Three general classes of activities are going on continually in the agricultural field: 1) assessing and updating the status of crop condition; 2) forecasting the status of crops with respect to potential yield; and 3) accounting for crop acreages and production for historical and economic analysis purposes. Remote sensing has been used most extensively in determining the status of the crop as it exists when viewed by the sensor. The use of remote sensing in the second activity, forecasting crop condition for estimating production, has been minimal to date. The third activity, compiling statistics on crop acreages and production by remote sensing has great potential and is closely associated with forecasting regional production.

The results from the Great Plains Corridor project, as well as those from the Phenology Satellite Experiment (also sponsored by NASA), and the NE69 regional project, have shown that phenological changes over large regions can be monitored from ERTS-type satellite data. These results, coupled with the aspirations of the NASA Large Area Crop Inventory Experiment sponsored by the Earth Observations Division of NASA/Johnson Space Center, are causing an important increase in the use of remotely sensed data for forecasting crop condition.

In Section 4.6 of this report, a few potential uses were listed for the ERTS-derived green biomass estimates on rangelands and associated crop areas. These include the quantitative assessment of the stage of crop development, the determination of amounts of native and tame pasture forages, the relative response of crops to environmental factors, and the indexing of plant growth for yield estimates. The potential exists for application of these same techniques in an even wider range of agricultural uses.

There are two avenues by which results of this study can initially be used effectively in the broad scope of agriculture. One approach is that of adapting specific quantitative assessment techniques from this rangeland investigation for monitoring specific crops. An example of this is the use of the TVI (Transformed Vegetation Index) in direct monitoring of wheat development throughout its crop calendar. The close relationship between green biomass and TVI will allow the investigator to follow crop development as ground cover and leaf area increases and to observe when heading and ripening begin. A system such as this, using only two of the four ERTS bands for calculating a simple parameter, is very cost effective when the resulting information content is so high.

The second approach would utilize the observations of the rangelands themselves to determine cropland conditions at critical times, such as the winter wheat planting period. In illustration, yields of dryland winter wheat are highly dependent upon the soil moisture condition at the time of planting. Soil moisture regimes can be inferred indirectly from measurements of the area's rangeland vegetation conditions. Use can be made of the fact that natural vegetation integrates the environmental conditions preceding the time of observation. In the case of perennial rangeland grasses, soil moisture is one of the most important factors in determining their growth status.

Determining the status of native grassland conditions preceding the wheat planting period, relative to that in a "normal" year, provides a useful indicator of the area's soil moisture conditions. This knowledge can be used as the starting point for prediction of wheat yield for that crop year. Other important conditions critical to crop development may likewise be determined indirectly from the quantitative measurement of rangeland condition.

The concept of utilizing rangeland as a phenological indicator for crops on a regional basis has the potential for wide application in the vast regions of the world where native rangeland and dryland farming co-exist. The usefulness of native grasslands as integrators of environmental conditions is enhanced by the fact that, in general, fertilization and irrigation are not used. Consequently, little confusion would arise due to imposed cultural practices if determination of cropland condition was made from satellite measurements of rangeland vegetation.

In the broader sense, remote sensing of phenological indicator plants may become one of the most valuable contributions of remote sensing to agriculture. According to results of the Phenology Satellite Experiment (Dethier et al., 1974) it is possible to monitor phenological changes by satellite over large regions. Phenological indicator plants have long been studied for correlation between weather factors and plant growth. Developments of this work will allow phenological observations of indicator plants from satellite to be utilized to develop crop calendars on a regional basis. The observation of indicator plants can also be used to determine the feasibility of introducing new plants to an area.

Recent research has been carried out to predict crop yields from phenological observations of that crop. The approach is to relate the stage of development observed against that which would occur in a "normal" season. In this way, the present crop season is evaluated relative to "normal" and crop yield predictions are adjusted correspondingly. In future years, the NASA crop survey will be able to utilize satellite data for this seasonal evaluation.

Through the NASA sponsored projects utilizing ERTS data, it has been shown that the technology exists for crop identifications and subsequent inventory. This is part of the justification for the Large Area Crop Inventory Experiment currently being carried out by NASA. The follow-on to this current project can logically include some of the possibilities discussed here for monitoring vegetation conditions on a regional basis. Furthermore, the applications discussed here are especially applicable to aiding crop production forecasting in uncharted regions of the world.

5.3 New Technology Statement

In accordance with New Technology clause of Contract NAS 5-21857, it is noted that no developments during the period of this report are considered applicable to the reporting requirements.

REFERENCES

1. R.F. Daubenmire. Plants and Environment. John Wiley and Sons, Inc. 1959. p. 185.

2. B.E. Dethier, W.W. Knapp, A.B. Pack, M.T. Vittum, and N.H. Peck. "NE-69. Atmospheric Influences on Ecosystems and Satellite Sensing." 1974 Annual Progress Report. N.Y. State Ag. Exp. Station. Cornell Univ. 2pp.

3. N. Robinson. Solar Radiation. N. Robinson, ed. Elsevier Publishing Company, Amsterdam. 1966. p.37.

4. J.W. Rouse, R.H. Haas, D.W. Deering and J.A. Schell. "Monitoring the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation." Progress Rept. 1978-2. Remote Sensing Center, Texas A&M Univ. 1973. pp.49-51.

5. J.W. Rouse, R.H. Haas, D.W. Deering and J.A. Schell. "Monitoring the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation." Progress Rept. 1978-3. Remote Sensing Center, Texas A&M Univ. 1974. pp. 22-26.

6. J. Service. A User's Guide to the Statistical Analysis System, Student Supply Stores, North Carolina State University. 1972.

APPENDIX A

TEXAS A&M UNIVERSITY
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COLLEGE STATION TEXAS 77843

College of Agriculture
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College of Geosciences
College of Science

TECHNICAL MEMORANDUM RSC-63

GREAT PLAINS CORRIDOR RANGELAND TEST SITES

BY

D. W. DEERING AND R. H. HAAS

SEPTEMBER 1972

INTERDISCIPLINARY TEACHING AND RESEARCH

Technical Memorandum RSC-63

Great Plains Corridor Rangeland Test Sites

By

D. W. Deering and R. H. Haas

Ten existing rangeland study sites have been selected to provide data in support of ERTS-1 Great Plains Corridor investigations. Each of the selected locations had an ongoing rangeland research program underway prior to the initiation of the current study. Photographs and vegetation data are collected periodically by cooperators at each of the locations to provide a data base for the Great Plains Corridor investigation.

The ten rangeland study sites range from southern Texas to North Dakota. Three primary sites and one secondary site are in Texas. Two of the primary sites in Texas and all primary sites in the other five Corridor states lie within the Mixed Prairie grassland association, which defines the Great Plains Corridor. An additional secondary site was established at Chickasha, Oklahoma.

Each of the study sites are herewith generally described with respect to location, climate, kind of vegetation and soils. Sampling sites within each study area are generally defined. Data collected periodically from these sampling sites will reveal the vegetational and climatic changes over time for each study site.

College Station (Study Site No. 1)

The College Station, Texas study site consists of two separate areas of privately owned rangelands; one in north central and one in south central Brazos county. Ten sampling sites were selected by Vegetation Systems Laboratory personnel of Texas A&M University's Remote Sensing Center after careful scrutiny of recent aerial photographs of rangeland surrounding College Station followed by ground reconnaisance. The sampling sites were selected to represent typical rangelands and grazing management found in the College Station area.

The study site lies within the Southwestern Prairies Cotton and Forage land resource region, the Texas Claypan land resource area and the Texas Post Oak Savannah vegetation area. Mean annual temperature is 66°F, and the average precipitation is 38.9 inches annually. The study site has an average frost-free season of 260 days with March 7 being the average date for the last killing frost and November 22 the first in the fall.

Five of the sampling sites are located on fine sandy loam and clay loam Blackland Prairie soils on a somewhat arbitrarily bounded study area of about 600 acres. The remaining five sampling sites are located on formerly forested Coastal Plain soils and represent a study area of about 500 acres. Most of the pastures have been artificially seeded to bermudagrass, native grasses, and mixtures and some are intensively managed. Five of the sampling sites are designated as primary sites and are sampled at the time of each satellite overpass. The other five are designated as secondary sites and are sampled when obvious vegetation changes occur coinciding with satellite overpass.

Sonora (Study Site No. 2)

The Texas A & M University Agricultural Research Station at Sonora is located approximately 20 miles SSE of Sonora, Texas. It contains 3400 acres of native rangeland in the Edwards Plateau vegetation area and lies within the Southwestern Plateaus and Plains Range and cotton land resource region and the Edwards Plateau land resource area. An average precipitation of 22.7 inches is received annually and mean annual temperature is 67°F. This study site has an average frost-free season of 205 days. The average date of the last killing frost is April 10 and the first in the fall is November 1.

Five sampling sites are located on the low stony hills range site, which is dominated by stony, clay, and silty clay soils. Dominant perennial species on these sampling sites are curlymesquite grass and sideoats grama. Herbage yield for this site ranges from about 1000 lb./acre when the range is in fair condition to about 2500 lb./acre in low excellent condition. The five sampling sites are representative of the area's rangeland from the standpoint of condition and grazing treatment.

Throckmorton (Study Site No. 3)

The Texas Experimental Ranch near Throckmorton, Texas is operated by the Texas Agricultural Experiment Station. The ranch encompasses 7200 acres of native rangeland in the Texas Rolling Plains vegetation area and is an integral component of the Mixed Prairie grassland association. It lies within the Central Rolling Red Prairies of the Central Great Plains Winter Wheat and Range land resource region. Annual precipitation is about 24.9 inches. Mean annual temperature is 65°F, and the frost-free season lasts about 211 days. April 12 is the average date of the last killing frost, and November 9 is the average date of the first fall frost.

Eleven sampling sites have been established throughout the ranch such that all grazing treatments, consisting of four grazing systems and two levels of use (moderate and heavy), and an ungrazed exclosure are sampled. All grazing treatments, including the exclosure, are represented by a sampling site on the same soil type of the rolling hills range site — one of the most abundant and important forage producing sites on the ranch. Texas wintergrass and side-oats grama are the dominant perennials on this range site, although buffalograss and three-awns are abundant as well. Forage production on the rolling hills range site is about 2000 lb/acre. Four additional sampling sites are located on range sites of greater and lesser productivity than the rolling hills range sites.

Five sampling sites, which were selected by Throckmorton Experimental Ranch personnel, are designated as primary sites and are sampled at the time of each satellite overpass. The remaining six sites were selected by Vegetation System Laboratory personnel, designated as secondary sites, and are sampled when there are obvious changes in the vegetation coinciding with satellite overpass.

Woodward (Study Site No. 4)

The U.S. Southern Great Plains Field Station at Woodward, Oklahoma is operated by the Agriculture Research Service, USDA. The grazing study pastures are located approximately 15 miles WNW of the main field station. The study site lies within the Central Great Plains Winter Wheat and Range land resource region in the Central Rolling Red Plains. Average annual precipitation is 23 inches and mean annual temperature is 60°F. The study site has a 198 day average frost-free season with April 12 being the average date of the last killing frost and November 17 the first in the fall.

The Woodward sampling sites are on hummocky and dunal loamy fine sands and fine sands and occur in native rangeland pastures totaling approximately 400 acres. The dominant perennials on these sites include sand sagebrush, sand dropseed, sand lovegrass, thin paspalum, little bluestem, and sand bluestem. On good condition ranges the herbage yield varies around 1300 to 1400 lb/acre. The five sampling sites will monitor vegetation changes for a continuous, moderate yearlong grazing treatment and a "rest renewal rotation" grazing system.

Hays (Study Site No. 5)

The Hays, Kansas study site consists of two separate areas, each with five sampling sites. Hays Area A is the Kansas Agricultural Experiment Station's Fort Hays Branch research pastures, and Hays Area B is the Fort Hays Kansas State College farm pastures. These areas are located about three miles WSW of Hays, Kansas. The study site lies within the Central Great Plains Winter Wheat and Rangeland resource region in the Rolling Plains and Breaks. The study areas receive an average annual precipitation of 22.9 inches and have a mean annual temperature of 55°F. The frost-free season lasts about 168 days. April 29 is the average date of the last killing frost, and October 14 is the first in the fall.

Hays Area A consists of 260 acres of native rangeland which is divided into eight contiguous pastures, each of which is approximately 30 acres in size. All eight pastures are in good or excellent condition and are being grazed continuously. Degree of use is moderate. All five sampling sites are located on clay uplands with silty clay loam soils. The dominant perennial species are bluegrama, buffalograss, and western wheatgrass. Herbage yield averages about 3000 to 4000 lb/acre.

Hays Area B consists of two pastures totaling 1200 acres which have been moderately grazed for about 35 years. The five sampling sites are located on limy uplands.

The two Hays study site sampling areas will enable a valid comparison of range site differences as expressed over time.

Sand Hills (Study Site No. 6)

Research is conducted at the Sand Hills study site by the Nebraska Agricultural Experiment Station. The study site is in the Nebraska Sand Hills within the Western Great Plains Range and Irrigated land resource region.

Precipitation is about 18 inches annually and mean annual temperature is 47°F. The frost-free season lasts an average of 152 days with May 4 the average date of the last killing frost and October 3 the first in the fall.

The five sampling sites are situated along U.S. Highway 83 between Valentine, Nebraska and an area 30 miles south of Valentine. They are located on fine sand and loamy fine sand soils, which produce 400 to 600 pounds of forage per acre. Two of the sites are on sub-irrigated rangelands which produce up to 2000 lb/acre. Dominant perennials vary from one site to another but include sand reedgrass, blue grama, needle-and-thread, sand bluestem, sand lovegrass, prairie cordgrass, switchgrass, and big bluestem.

Cottonwood (Study Site No. 7)

The Cottonwood Range and Livestock Experiment Station is operated by South Dakota State University's Agricultural Experiment Station. The study site lies within the Pierre Shale Plains and Badlands of the Western Great Plains Range and Irrigated land resource region. Average annual precipitation is 15.2 inches. Mean annual temperature for the study site is 45° and the frost-free season lasts about 136 days. The average date of the last killing frost is May 14, and the average date of the first killing frost in the fall is September 27.

The five sampling sites are located on clayey range sites with silty clay soils that are variously dominated by these perennial species: blue grama, buffalograss, western wheatgrass, and Texas wintergrass. Forage yield varies from about 900 lb/acre for ranges in low fair condition to over 2000 lb/acre for ranges in excellent condition. The sampling sites will enable detection of vegetation change differences over time between summer use and winter use pastures and between light, moderate, and heavy stocking rates.

Mandan (Study Site No. 8)

The Northern Great Plains Research Center at Mandan, North Dakota is operated by the Agricultural Research Service of the USDA. The 900 acre research area is in the Rolling Soft Shale Plain of the Northern Great Plains Spring Wheat land resource region. It receives about 15.9 inches of precipitation annually and has a 42°F mean annual temperature. The 138 day average frost-free period begins about May 11 and ends about September 26.

All five sampling sites are located on silt loam soils of the silty range site. These sites are dominated by the perennials western wheatgrass, blue grama, needle-and-thread, pinegrass, and scurfpea and yield about 2400 lb of forage per acre. These sampling sites are located within a 32 acre pasture which has received good management with moderate grazing. The range condition of this pasture is low excellent.

Weslaco (Study Site No. 9)

The Rio Grande Soil and Water Research Center at Weslaco, Texas is operated by the Agricultural Research Service of the USDA and is designated as a secondary study site. The study site is in the Rio Grande Plain area of the Southwestern Plateaus and Plains Range and Cotton land resource region. Average annual precipitation for this South Texas Plains vegetation area is 17.5 inches, and mean annual temperature is 74°F. The frost-free season lasts about 309 days with the average date of the last killing frost being February 7 and December 22 the first in the winter.

The five sampling sites are located on fine sandy loam soils of sandy loam range sites in fair range condition. The dominant perennial grass species include hooded windmillgrass, Texas grama, gummy lovegrass, and red threeawn. All five sites lie within a 600 acre continuously heavily grazed pasture.

Chickasha (Study Site No. 10)

The Southern Great Plains Watershed Research Center at Chickasha, Oklahoma is operated by the Agricultural

Research Service of the USDA and is designated as a secondary study site. It is in the Central Rolling Red Prairies of the Central Great Plains Winter Wheat and Range land resource region. Average annual precipitation for the 1500 acre watershed area is 27 inches. The mean annual temperature is 62°F and the average frost-free season is 216 days. The average date of the last killing frost is March 31, and the average date of the first killing frost is November 2.

The sampling sites are located on silt loam soils. These prairie range sites were subjected to contrasting grazing pressures in the past —— from severe to moderate, but they are currently considered to be in good or excellent range condtion. Herbage yield on these sites varies from 700 lb/acre to 6300 lb/acre. Dominant perennial species are little bluestem, Scribner's panicum, blue grama, sideoats grama, Indiangrass, silver bluestem, hooded windmillgrass, tall dropseed, and western ragweed.

APPENDIX B

TEXAS A&M UNIVERSITY
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TECHNICAL MEMORANDUM RSC-71

GROUND DATA COLLECTION AT THE ERTS-1 GREAT PLAINS CORRIDOR TEST SITES

BY

D. W. DEERING

APRIL 1973

VEGETATION SYSTEMS LABORATORY

Technical Memorandum RSC-71

GROUND DATA COLLECTION FOR THE ERTS-1 GREAT PLAINS CORRIDOR RANGELAND STUDY

by

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Remote Sensing Center
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INTRODUCTION

At each of ten established rangeland study sites within the Great Plains Corridor region (Figure 1), ground data is being collected to record temporal vegetation and climatic changes. These data are being used for evaluating the ability of the ERTS-1 satellite to measure and monitor these changes. Of particular interest is whether the ERTS-1 multispectral scanner (MSS) system is capable of detecting the onset and advance of spring from south to north through the Great Plains Corridor.

The ground truth data collection for the ERTS-1 project is performed by highly skilled field personnel experienced in sampling rangeland vegetation. The cooperating research stations and research personnel (Figure 2) are also providing background information

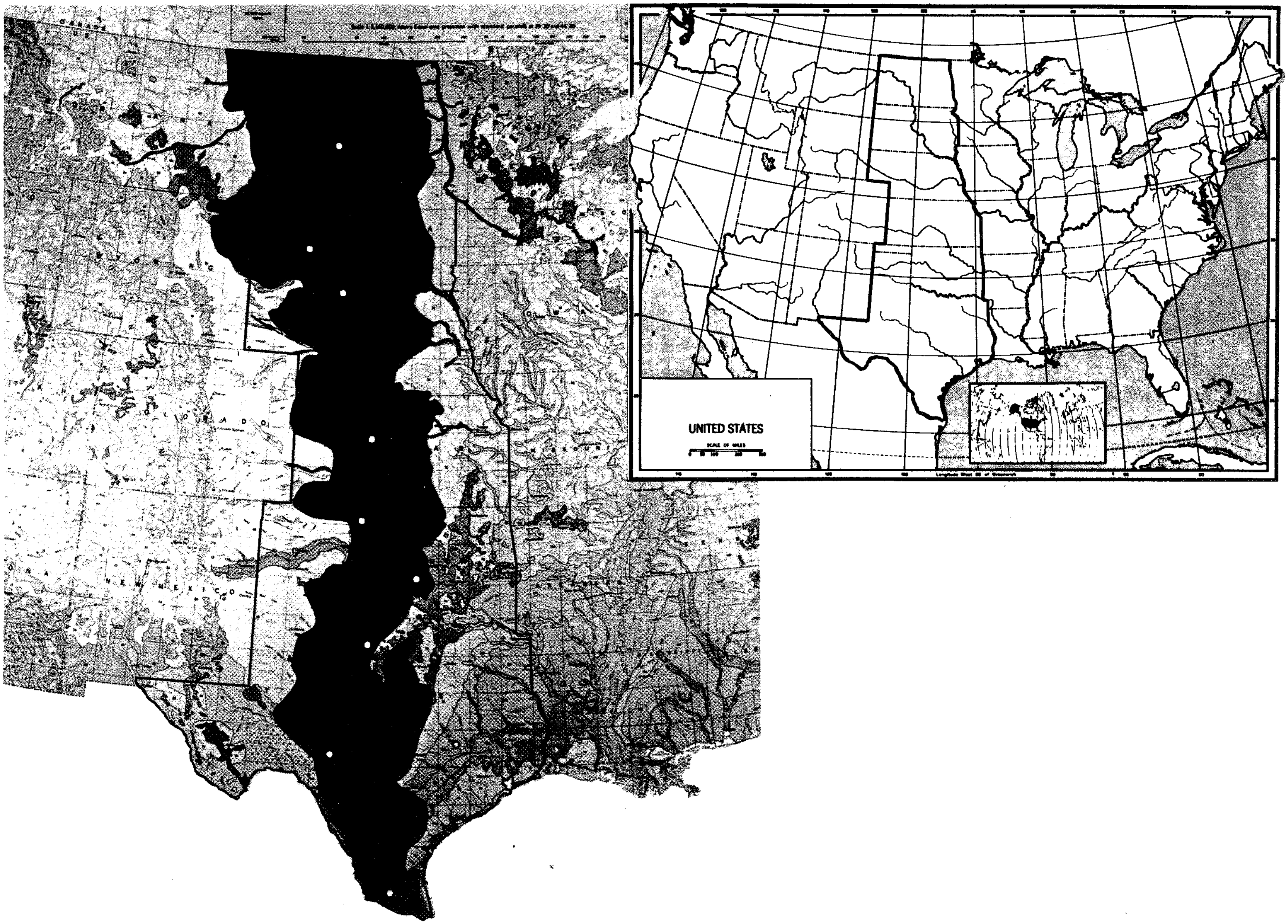

Figure 1. Great Plains Corridor and test site network.

Figure 2. Personnel and research stations associated with the ERTS-1 Great Plains Corridor Studies.

Mr. D. W. Deering, Remote Sensing Center, College Station, Texas.

Mr. C. Gonzalez, Remote Sensing Laboratory, Agricultural Research Service, USDA, Weslaco, Texas.

Dr. L. B. Merrill, Texas Range Station, Sonora, Texas.

Dr. M. M. Kothmann, Texas Experimental Ranch, Throckmorton, Texas.

Mr. B. Blanchard, Southern Great Plains Branch, Agricultural Research Service, USDA, Chickasha, Oklahoma.

Dr. E. H. McIlvain, Southern Great Plains Field Station, Agricultural Research Service, USDA, Woodward, Oklahoma.

Dr. J. L. Launchbaugh, Fort Hays Branch Station, Hays, Kansas.

Dr. P. Seevers, Department of Agronomy, Lincoln, Nebraska.

Dr. R. P. Gibbens, Animal Science Department, Range Field Station, Cottonwood, South Dakota.

Dr. G. Rogler, Northern Great Plains Field Station, Agricultural Research Service, USDA, Mandan, North Dakota.

established to monitor seasonal vegetation changes within this region. The test site locations are rangeland research stations of state agricultural experiment stations or the United States Department of Agriculture.

Several land use or resource classification systems have been proposed. The system proposed by Anderson, Hardy, and Roach [2] is land use biased. The landscapes included in the test site areas are made up of a complex of soils and vegetation types and strongly influenced by management history. The procedure that was developed for this project incorporates the use of soil surveys, vegetation resources, and land use information as independent parameters for identifying landscapes within the test sites. This procedure combined the Level II and Level III classification levels of Anderson, Hardy, and Roach [2]. They proposed four classification level. The four levels are as follows:

Classification Level	Source of Information
I	Satellite imagery with very little supplemental information.
II	High-altitude and satellite imagery combined with topographic maps.
III	Medium-altitude remote sensing (1:20,000) combined with detailed

the sampling sites, are marked with wooden or metal stakes driven in the ground at each sampling site. These photo point stakes are located on the sampling site such that when the photographs of the site are taken, while standing at this marker, the camera will be pointed in a northerly direction. This minimizes lighting problems that result from photographing the same scene or area at different times of the day or the various sampling dates and during the different seasons of the year. Work scheduling problems sometimes necessitates sampling at different times of the day. Offensive back-lighting, resulting in poor quality photographs, would be the result if the photographs were taken in other than the polar direction.

The photographs are taken with a 35mm format camera with a 50 or 55mm lens. Ektachrome-X color slide film is used, and all processing is handled through the use of film mailers and sent to the same Kodak processing plant. Four photographs are taken at each sampling site. The relative locations of these photo points are diagramatically presented in Figure 3.

Prior to taking the first photograph, a plot label and 1 m^2 plot frame are placed within the for activity.

6. The classification system should be suitable for use with imagery taken at different times of the year.

7. Effective use of sub-categories that can be obtained from ground surveys or from the use of larger-scale or enhanced imagery should be possible.

8. Collapse of categories must be possible.

9. Comparison with land-use information compiled in the past or to be collected in the future should be possible.

10. Multiple-use aspects of land use should be recognized when possible.

The system developed for the project was designed to meet the important aspects of the above criteria and also to be applicable to resource and land use classification - not strictly land use. Most classification systems have been resource or land use biased [1,11]. An attempt was made to develop a system that would characterize the soils and vegetation resources independent of their current use. Coding systems for the soils, vegetation, and management history on the ten test sites are contained in the appendix.

III. APPROACH

The procedure used in the characterization of the test sites employed NASA-obtained high-flight aerial photography, sampling site area established by the permanent photo point. It is located approximately 50 to 100 ft. or more to the north of the permanent photo point stake in an area that is representative of the vegetation of the site.

The first photograph at each sampling site is taken while standing at the permanent photo point stake (Figures 3 and 4). This is an oblique general aspect shot of the site that is re-photographed at each sampling. Color 3 1/2" X 5" prints carried in the field enable precise relocation of the same scene at each sampling interval. This photo provides a permanent record of the general condition of the vegetation at the time of sampling.

The camera shutter speed and f-stop settings used when taking this aspect photograph are recorded on the data collection form (Figure 8) at each of the sampling sites. This provides an aid to understanding exposure problems that sometimes arise and helps in recommending adjustments that can be made for future sampling.

The second photograph taken at each sampling site is located along an imaginary line between the plot and the permanent photo point stake. The photo is map by a computer, is distorted. A square area on the ground is a disproportional parallelogram on the grey-scale map, and vice versa. Consequently, to maintain rectangular site boundaries for extracting MSS data for digital tapes, the aerial photographs of the test sites are parallelograms instead of squares for the 7km by 7km test sites areas.

The following procedures were developed for characterizing the test sites and the developing of computer compatible classification data:

1) Determine the frame or frames of photography to be used in making the characterization of the sites.

All sites had 1:60,000 or 1:120,000 color-IR positive transparencies available for use in the characterization. The 1:60,000 color-IR positive transparencies were used in the actual characterization while the 1:120,000 color-IR positive transparencies were used for location of the site. Large-scale photography was used where available, to verify the interpretations made from the small scale photography.

2) Secure 7.5 minute series topographic maps of the sites.

These topographic maps were used with acetate overlays to record the resource and land use data at a photograph (Figüre 3).

VEGETATION MEASURES AND OBSERVATIONS

After all of the photographs have been taken at a sampling site, the percentage of green vegetation in the 1 m^2 plot is estimated (i.e., dry weight basis) and recorded on the data collection form (Figures 8 and 9). This value is the percentage of the total standing vegetation in the plot that is green matter, and when coupled with the dry biomass clipping weight provides an estimate of the quantity of green vegetation on the site.

Other vegetation field determinations are then made including condition of the vegetation (qualitative), current apparent intensity of utilization of the herbage on the site by livestock, and plant species currently dominating the visual aspect on the site and its (their) existing phenological stage. These determinations are entered on the data collection form (Figure 8).

The aboveground standing biomass contained within the 1 m^2 plot is clipped near the ground (to about 1/2 inch of the soil surface) and placed in a paper bag (Figure 10). This bag is then labeled by site number and date and placed in a larger plastic bag, which will also accommodate the other biomass samples. The plastic bag acts as a "seal" to retard the loss of moisture from the vegetation samples until they can be taken to the lab and weighed. The biomass samples are dried in an oven at 65 to 70^{o} C for 24 hours and re-weighed. These "fresh" and "dry" biomass weights are also recorded on the data collection form (Figure 8).

The biomass clipping data furnish an estimate of the total amount of herbage on the site, the amount of green vegetation on the site (when combined with the percentage green estimate), and the water content of the vegetation. All of these factors and their many implications (i.e., amount of ground cover, vegetation height and density, soil moisture, etc.) are expected to be very important site spectral signature determinants.

OTHER SIGNIFICANT DATA

Other "on site" data that is obtained at the time of each satellite overpass and sampling include the amount of precipitation since the last sampling, the number of days since the last measurable precipitation, and the maximum and minimum temperatures since the last sampling.

Information on the date that grazing was initiated on a site indicates the length of time that a site has been grazed. When related to previously supplied grazing treatment information these data enable a fuller understanding of the measured temporal change in vegetation biomass.

All study site photographs and sampling data are sent to the Vegetation Systems Laboratory of the Remote Sensing Center for interpretation, analysis, and archiving.

SUMMARY

The following is a step-by-step summary for the collection of ERTS-1 overpass correlated ground truth data. Steps 1-11 are repeated at each of the five sampling sites.

1. Locate the permanent photograph point (sampling site) stake.
2. Place the 1 m^2 (or similar) clipping plot frame in an area that is representative of the vegetation of the site and is within the sampling area established by the permanent photo point (approximately 50 to 100 ft. or more to the north of the

camera's location).

3. Affix the appropriate site and date labels to the aluminum plot marker stake and position the stake at the center of the far side (north) of the plot frame.
4. Return to the permanent photo point stake and take one oblique photo of the pre-selected scene that includes the clipping plot. Record on the data form the camera f-stop and shutter speed settings used.
5. Walk directly toward the plot frame. At approximately 15 ft. south of the plot take another photo, centering on the obliquely viewed plot.
6. Go to the clipping plot, pull up the aluminum marker and lay it down so that the label tag is within the plot frame and will be seen in the lower right or left hand corner of a photograph taken from the vertical. It should be taken at a 4-5 ft. height from the side of the plot that will provide the best detail of the vegetation in the plot under the existing light conditions.

7. The contents of the fourth photographs at the site is left up to the discretion of the photographer. Preferably, it will be a shot of some component of the vegetation that dominates the visual aspect.
8. After all four photographs have been taken, estimate the percentage of the standing vegetation the plot that is green matter (projected to a dry weight basis) and record the value in Item 6 on the data collection form.
9. Complete items 1,3,4, and 5 on the data collection form.
10. Clip the standing vegetation in the plot to within about 1/2 to 1 inch of the soil surface and place this sample in a paper sack.
11. Label the paper sack according to site and date and place it in the large plastic bag supplied by the VSL.
12. After all 5 sites have been sampled, return to headquarters and weigh each of the biomass samples.

13. Place the samples in a drying oven and dry the samples at 65 to 70° C for 24 hours and then re-weigh them. If air dry weights are used indicate this on the data collection form.
14. Mail the film in the film mailer supplied by the VSL.
15. Complete item 2 and the blanks at the top of the data collection form, attach the record stub from the film mailer to the form, and return the form in an envelope supplied by the VSL.
16. Repeat this procedure at the time of the next scheduled satellite overpass.

ERTS-1 OVERPASS CORRELATED GROUND TRUTH DATA

Test Site:________________ Sampling Date:________________

Number of days since last measurable precipitation:________________

Precipitation since last sampling:________ Sample Plot Size:________________

Maximum and minimum temperatures since last sampling: Max.________ Min.________

	Site 1	Site 2	Site 3	Site 4	Site 5
1. Condition[1] of Veg.: a. at time of satellite overpass					
b. at time of sampling					
2. Date Grazing Initiated					
3. Current Utilization[5]					
4. Species dominating the visual aspect a.					
b.					
c.					
5. Phenological stage[4] of dominant species a.					
b.					
c.					
6. Field estimate[2] of % green vegetation					
7. Above ground biomass[3] a. Fresh wt.					
b. Dry wt.					
8. Camera settings[6] for aspect photos	ss- ;f-	ss- ;f-	ss- ;f-	ss- ;f-	ss- ;f-
9. Remarks (use back side if necessary)					

[1] V = Vigorous, H = Healthy, Un = Unhealthy, D = Dry

[2] % of standing vegetation that is green matter; a dry-wt. percentage estimate.

[3] sample plot-clipped vegetation weight in grams.

[4] 1-Immature Vegetative, 2-Mature Vegetative, 3-Early Bloom, 4-Full Bloom, 5-Immature Seed, 6-Mature Seed, 7-Seed Shatter, 8-Dormant.

[5] O = None, L = Light, M = Moderate, H = Heavy

[6] SS-shutter speed; f-aperture setting

APPENDIX C

Technical Report RSC-54

Classifying Land Resource Types at ERTS-1 Test Site Areas

by

David R. Thompson and R. H. Haas

April 1974

supported by

National Aeronautics and Space Administration
Contract NAS5-21857

SUMMARY

A study was initiated to develop an approach to resource and land use classification that would identify and document uniform land partials in the vicinity of the Great Plains Corridor test site areas. This report describes the procedures used in isolating resource types and preparing "masks" that would aid in digital data retrieval from ERTS-1 satellite scenes at test site areas throughout the Central United States.

An approach was developed to characterize landscapes on the basis of soil, vegetation, and land use patterns. The approach was used to characterize the ten test sites in the Great Plains Corridor Project and to format the data so that differences in spectral characteristics of soil types, vegetation types, and kinds of land use could be evaluated.

The procedures developed for this study give accurate and repeatable results for soil, vegetation, and land use interaction. This accuracy is dependent upon the geometric fidelity of the computer grey-scale base map.

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Technical Report RSC-54

Classification and Formatting of Soils, Vegetation, and Land Use Patterns for the Great Plains Corridor Test Site Area

by

David R. Thompson and R. H. Haas

I. INTRODUCTION

Texas A&M University is conducting an ERTS-1 regional study in which the vernal advancement and retrogradation of natural vegetation (green wave effect) is monitored throughout the mixed prairies of the central United States. This study involves the use of multispectral scanner data from 7km X 7km scenes centered on the ten test site areas. Since each scene may include a variety of land resource features, average reflectance values for the 7km X 7km scenes would not be typical of sampling sites being monitored within test sites areas. Therefore, it was necessary to characterize soil, vegetation, and land use patterns at each test site.

A system for routine classification and formatting of the soil, vegetation or land use patterns has not been developed. The purpose of this study was to describe and implement an approach to resource and land use classification that would document the resource and land use patterns in the vicinity of the Great Plains Corridor test sites.

The study to characterize the ten test site areas in the Great Plains Corridor Project employed NASA-obtained high-flight aerial photography, existing large scale black-and-white photographs, RSC obtained color-IR aerial photographs, and ground survey data. The kind, quality, and extent of each land resource use was to be documented for each of the test site areas. This report describes the procedures used in isolating the resource types and in preparing "masks" that would aid in digital data retrieval from sampling site scenes.

II. BACKGROUND

The Great Plains Corridor project was established to monitor the vernal advancement and retrogradation of natural vegetation using Earth Resource Technological Satellite (ERTS) observations throughout the Great Plains Corridor. Particular emphasis is being given to detecting the south-north vernal advancement and ensuing retrogradation of vegetation with the onset of summer drought or first frost. A ten test site network (Mandan, North Dakota; Cottonwood, South Dakota; Sand Hills, Nebraska; Hays, Kansas; Woodward, Oklahoma; Chickasha, Oklahoma; Throckmorton, Texas; Sonora, Texas; College Station, Texas; and Weslaco, Texas) was concerning the climate, soils, vegetation and grazing management for their test site areas.

SAMPLING SITES

In the summer of 1972 a minimum of five sampling sites were selected at each of the ten study sites by the Great Plains Corridor cooperators with the assistance of Vegetation Systems Laboratory personnel of Texas A&M University's Remote Sensing Center. Seven of the study sites have five sampling sites. Of the remaining three the College Station and Hays study sites have ten sampling sites each and the Throckmorton study site has eleven. The individual sampling sites were selected as being representative of the overall study area.

The sampling sites are sampled by the cooperators at each time of the satellite overpass ± 3 days, except during the dormant seasons. The sampling procedure involves taking photographs at each site, clipping a one square meter (or similar) plot on each site, and recording other vegetation and climatic conditions.

PHOTOGRAPHY

Permanent photograph points, which establish

	topographic maps and substantial amounts of supplemental information.
IV	Low-altitude imagery with most of the information derived from supplemental sources.

They developed categories for only Levels I and II. Additional information such as soil surveys and vegetation types was necessary for completion of the correction project task. A system utilizing soils, vegetation, and land use management history were needed as independent parameters in this system. This resource-land use classification should also meet the criteria set up by Anderson [1]. These criteria are as follows:

1. The minimum level of accuracy in the interpretation of the imagery should be about 90 percent.

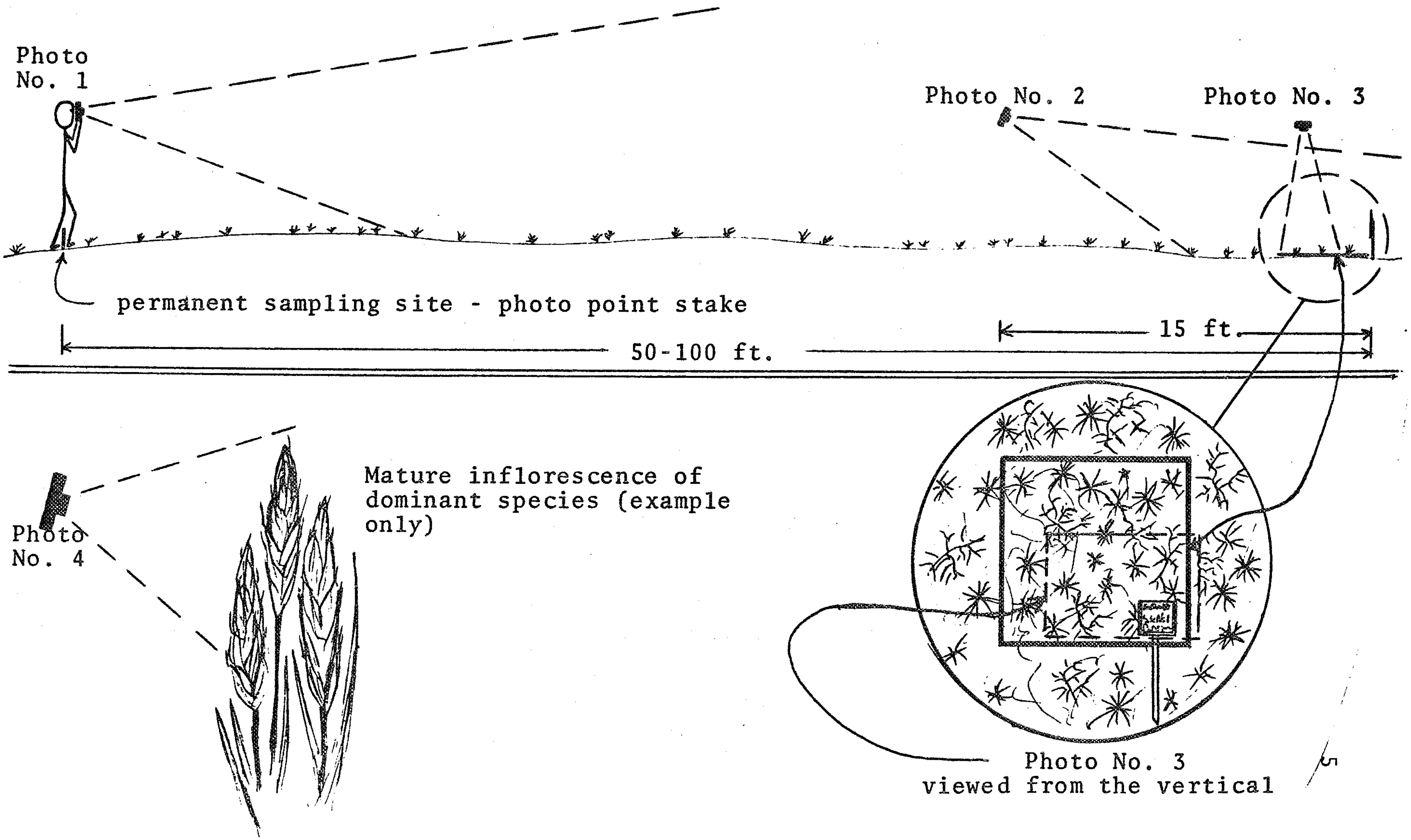
2. The accuracy of interpretation for the several categories should be about equal.

3. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.

4. The classification system should be usable or adaptable for use over an extensive area.

5. The categorization should permit vegetation and other types of land cover to be used as surrogates

Figure 3. DIAGRAM SHOWING PHOTOGRAPHS TO BE TAKEN AT EACH SITE



Remote Sensing Center obtained aerial photography, soil surveys developed by the Soil Conservation Service-USDA, and ground survey data to locate and document the kind and quality of land resource uses in the test site area. NASA obtained aerial photography was available in color-IR positive transparencies at scales of 1:120,000 and 1:60,000 for all sites. Color positive transparencies were available on all sites from NASA at a scale of 1:120,000. Remote Sensing Center photography was available at a scale of 1:8,000 for the College Station, Sonora, and Throckmorton sites as color-IR positive transparencies. Black-and-white prints were available for the College Station test site at a scale of 1:24,000.

Soil survey information varies from published surveys to copies of field sheets. Published soil surveys were available for College Station, Mandan, Sand Hills, Woodward, and Weslaco. Copies of field sheets were available for Chickasha, Hays, Sonora, and Throckmorton. A soil survey has not been made for the Cottonwood test site.

In order to characterize the small landscapes that occur within the test sites, a procedure had to be developed to transfer the data from the aerial photography, soil surveys, and ground truth to the computer-generated grey map. This was complicated in that the MSS data from the ERTS-1 satellite, when printed as a grey-scale a paced distance of 15 feet from the 1 m^2 plot frame (Figure 3 and 5). This photo is centered on the plot and, consequently, provides a good view of the entire plot that is to be clipped. It reveals the condition of the vegetation in the plot and adjacent area. Estimates of vegetation height, species composition, and homogeneity can be made from this photo.

The third photograph is a veritcal photograph of a "typical" portion of the 1 m^2 plot (Figures 3 and 6). This photo provides a record for estimating the amount of vegetative cover, percentage green vegetation vs. brown vegetation, bare ground, litter, species composition, and phenological stage of dominant species.

The subject included in the fourth photograph taken at each sampling site is a photograph of some aspect of the vegetation that dominates the visual aspect of the site at the time of sampling (Figure 7). Selection of this photo is left to the discretion of the photographer. For example, a dense stand of a grass or forb species with a fully mature infloresence may cause the vegetation over the landscape to look dry or dormant, when the leaves and stems are actually still green and succulent. A close-up of the infloresence of this species might be a good choice for this fourth scale of 1:24,000. This scale was roughly comparable to the computer generated grey-scale maps of Band 5 MSS data.

3) Determine the area to be characterized.

The test sites were located on the color-IR positive transparencies and the topographic map of the area. A 10km X 10km area was centered on the test site and outlined on the acetate which was secured to the topographic map (Fig. 1).

4) Characterize the site according to resource and land use.

The 10km X 10km areas were characterized with the use of color-IR positive transparencies of the site and recorded on the acetate overlay on the 7.5 minute topographic map for the site. The information was characterized according to the guidelines for coding resource and land use data in Appendix B. The soil information was assigned number codes for each site individually. These codes are included in Appendix A. Resource and land use data (Fig. 2) for each test site were developed as one overlay, and the soil data (Fig. 3) was developed as a separate overlay. The two overlays (Fig. 4) were then combined as the resource and land use data to be transferred to the computer generated grey-scale map.

5) Transfer the resources and land use data to the computer generated grey-scale map.

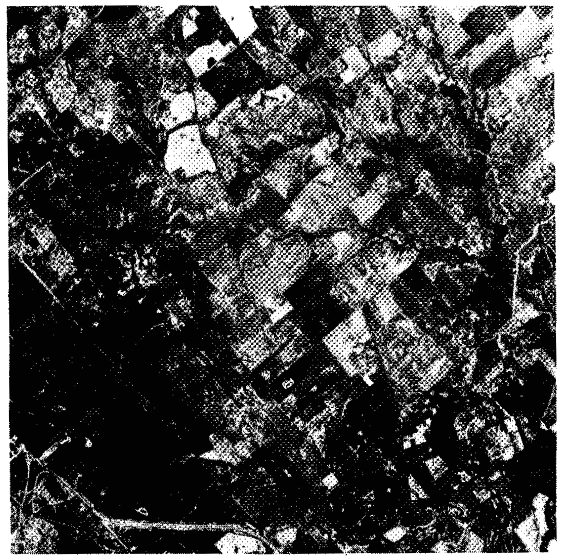


Fig. 1. Aerial photograph of a 10km X 10km area centered on the site to be characterized.

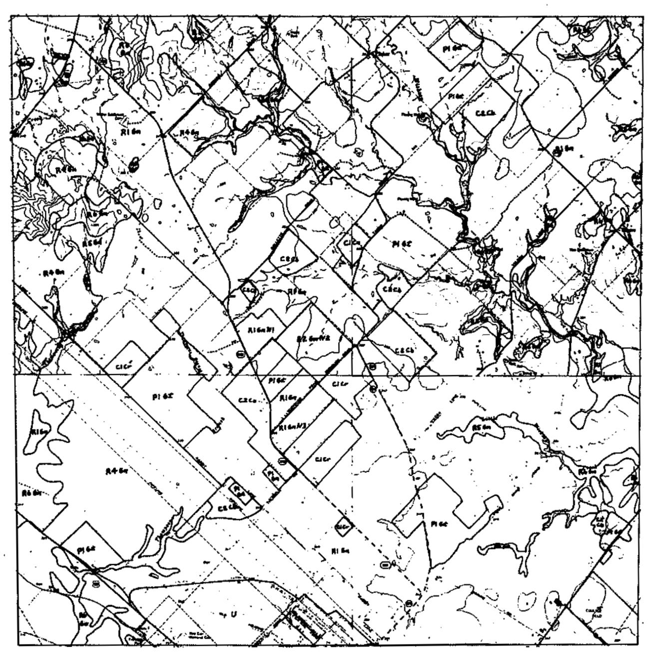


Fig. 2. Resources and land use data overlay of the test site on the topographic map.

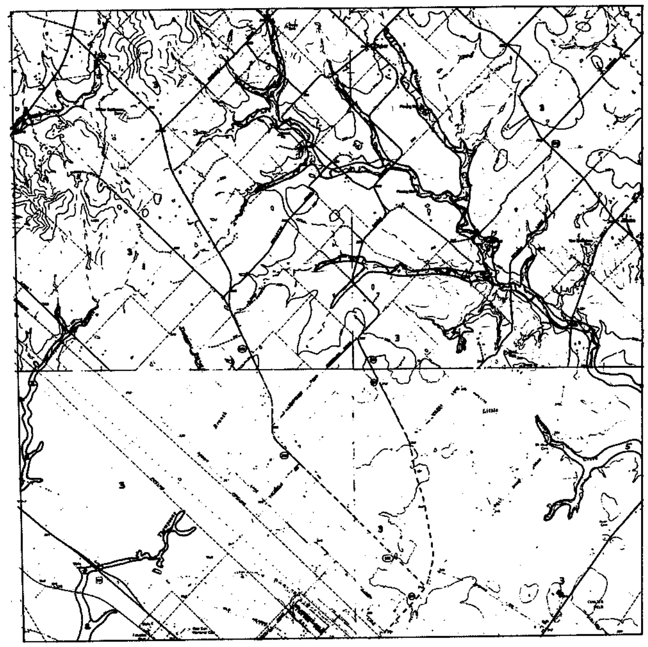


Fig. 3. Soils data overlay of the test site on the topographic map.

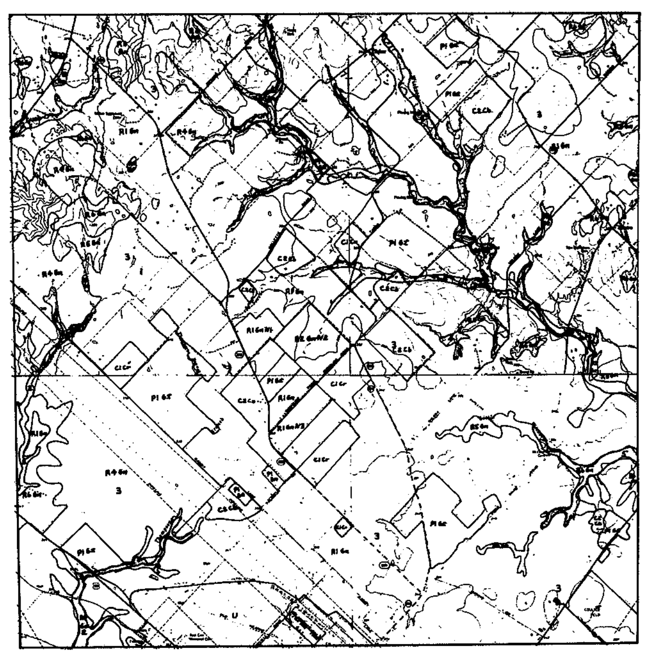


Fig. 4. Resource and land use data and soils data combined on the topographic map.

Band 5 MSS grey maps were used for the delineation of the resource, land use and soil type information. Within the 10km X 10km area, the central 7km X 7km area was "extracted" and the computer generated grey-scale maps were then blocked off into subsite areas corresponding to specific resource and land uses within this area. The border area within the 10km X 10km area and surrounding the 7km X 7km area enabled better interpretation of resource and land use types along the perimeter of the 7km X 7km area. It also provided the capability for easily expanding to computer process the greater area if desired in the future.

6) Store the resource and land use information in the computer.

The 7km X 7km areas that were recorded on the grey-scale map were stored in the computer as a "mask" (Fig. 5) for each test site. This data will provide base-line information for evaluating differences in spectral characteristics and changes in reflectance patterns from different soil types, vegetation types, or land use patterns.

IV. TEST SITE CHARACTERIZATION

Each of the test site areas (7km X 7km) that were characterized and stored in the computer are herewith generally described with respect to soils, principle

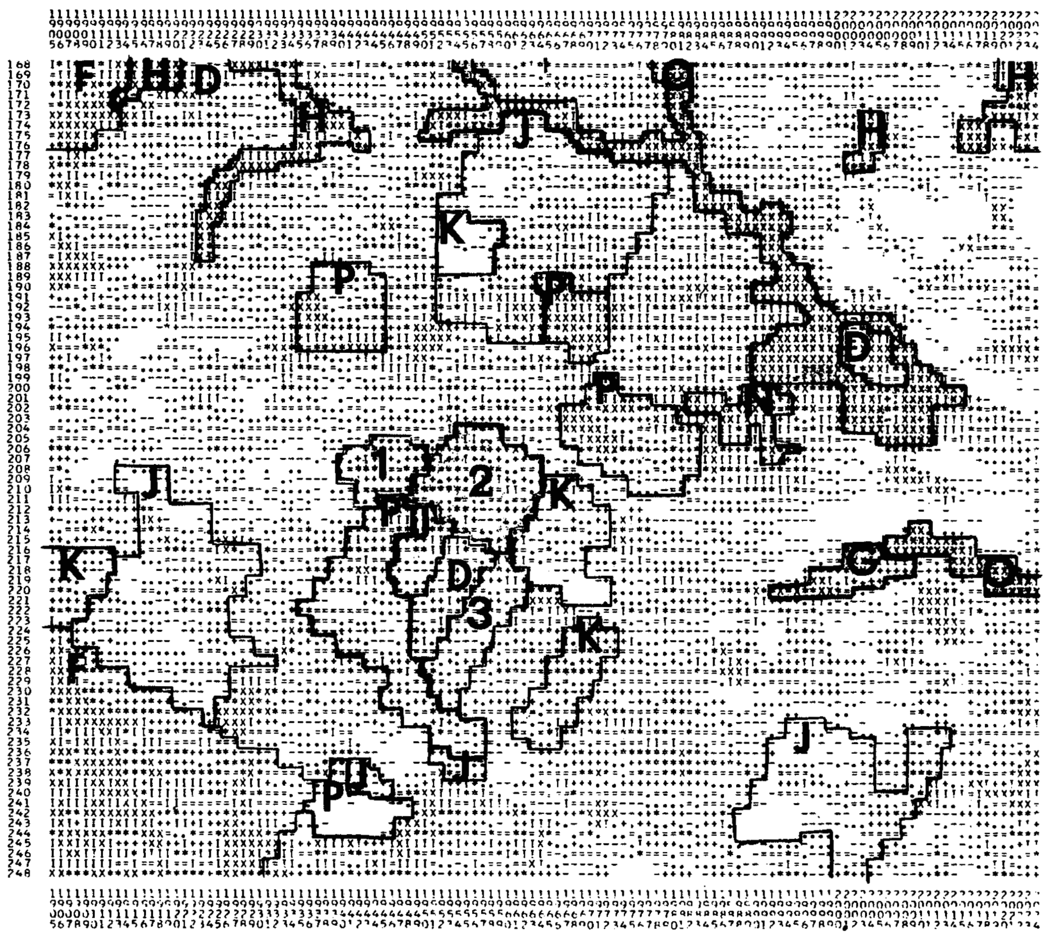


Fig. 5. Band 5 MSS grey map delineated with the resource, land use, and soil information.

vegetation resources, and land use. The key for the coding of the subsite areas and the procedures to be followed if more information is desired concerning a particular subsite will be discussed. Each of the ten test sites will be described and an aerial photograph of the test site with the "mask" that was produced using the procedures described in the approach section will be presented.

A. Key for Resource and Land Use Code

Each site has a brief description of the major soils, vegetation, and land use followed by an aerial photograph and the developed "mask" for the 7km X 7km area. These products for each site are shown on opposing pages with the computer generated "mask" and legend on the right page and aerial photograph on the left page. The key for the resource and land use code for each site is shown below.

Resource and Land Use Code:

Example: CS 1 R1 Gn N1

CS - Test site name (College Station)

1 = Soil group (Crockett-Lufkin Soils)

R1 = Vegetation Resource (Rangeland, open grassland)

Gn = Land Use (Grazing, Native grassland)

N1 = Subsite Area and Sampling Site or Pasture Number (north sampling site number 1)

With the use of this key, each symbol is explained and more information concerning each site can be located in the appendix. An example is the resource and land use code (CS 3 R1 Gn N1) for the College Station test site. The CS indicates that this is the College Station test site. The number 3 gives the soil group for this area. By turning to Appendix A, we find that the soil is a Crockett-Lufkin soil (Claypan). A brief description is given for the depth of the soil and how it lays in the landscape. The code R1 indicates the vegetation resource for this area. By checking Appendix B, it is shown that this is a rangeland vegetation resource with an open grassland subtype. The code Gn is indicated in Appendix B as a functional land use of grazing, native grassland. The code N indicates that this is the north (Subsite Area) sampling site number 1. The code is also used to indicate pasture numbers for the Sonora, Throckmorton, and Cottonwood test sites.

B. Test Site Descriptions

The network of ten test sites will be described in this section in relation to the large scene and to landscapes within the test site. Nine of the ten test sites lie within the Mixed Prairie grassland association. The College Station test site occurs within the True Prairie grassland association.

The test sites are essentially treeless, although the Weslaco and Sonora test sites have had an invasion of trees and shrubs which changed the prairie into a more brushland type. Climax dominant grasses have been replaced by less desirable species. The important grasses within the Great Plains Corridor include warm-season grasses (bluegrama, buffalograss, sideoats grama, and big and little bluestem) and cool season grasses (western wheatgrass, needle-and-thread, and Texas wintergrass).

The soils of the ten test sites are predominately loamy on most of the test sites. The Woodward and Sand Hills test sites are dominated by sandy soils. The Sonora, Throckmorton, and Cottonwood sites are dominated by clayey soils.

The ten test sites will be described according to soils, vegetation resources, and land use followed by an aerial photograph of the site and the developed "mask" of the site.

College Station Test Sites

The College Station test site is located in Brazos County, Texas. The site is divided into two different areas. One subsite area lies to the north of College Station (CS-1) and the other subsite area is southwest of College Station (CS-2). The north subsite (Fig. 6) is dominated by soils such as Crockett and Lufkin. These soils have fine sandy loam surfaces with heavy dense clay subsoils. The principle vegetation resource of this subsite is open grassland with grazing being the dominate land use. The subsite has a small area of grazed savannah in the southwest corner.

The south subsite (Fig. 7) is dominately Crockett and Lufkin soils with the southwest corner being Miller and Norwood soils of the Brazos River bottom. The subsite is divided equally into open grassland and woodland with grazing being the dominate land use. A considerable area was included into an "out" category because of large gullies, airport, heavy equipment training school, and small areas of various resources and land uses. This area will not be considered in the analysis of the site.

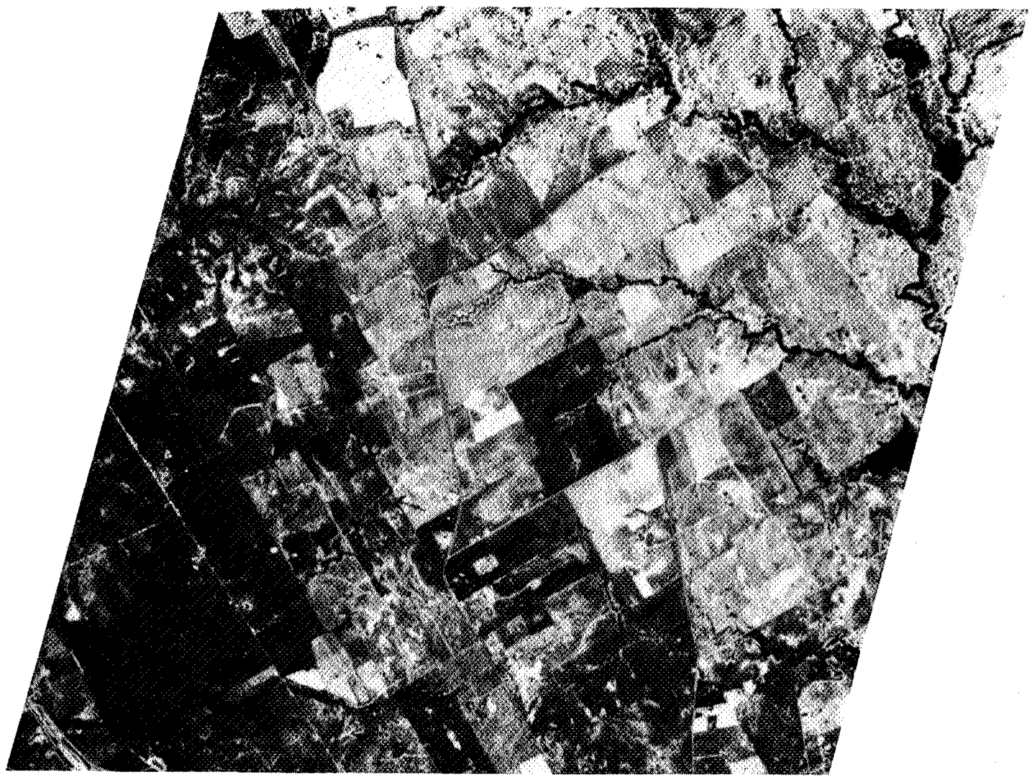
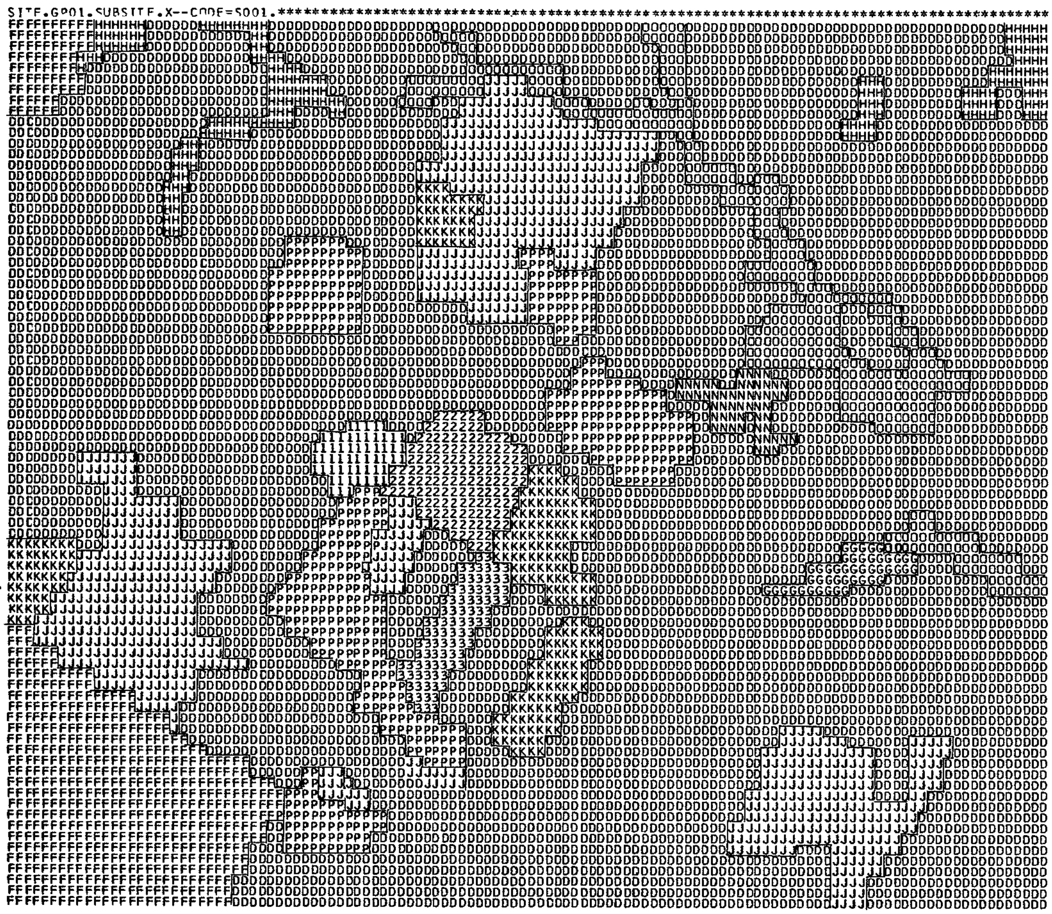


Fig. 6. Aerial photograph (above) and stratification of resources and land use (right) for the College Station test site (CS-1).



Resource and Land Use Legend

COLLEGE STATION - NORTH

Mask Symbol	Resource-Land Use			
C	Cs2	R6	Gn	
D	Cs3	R1	Gn	
1	Cs3	R1	Gn	N1
2	Cs3	R1	Gn	N2
3	Cs3	R1	Gn	N3
F	Cs3	R4	Gn	
G	Cs3	R5	Gn	
H	Cs3	R6	Gn	
N	Cs4	R1	Gn	
O	Cs5	R6	Gn	
J	Cs3	P1	Gt	
K	Cs3	C1	Cr	
P	Cs3	C2	Cb	

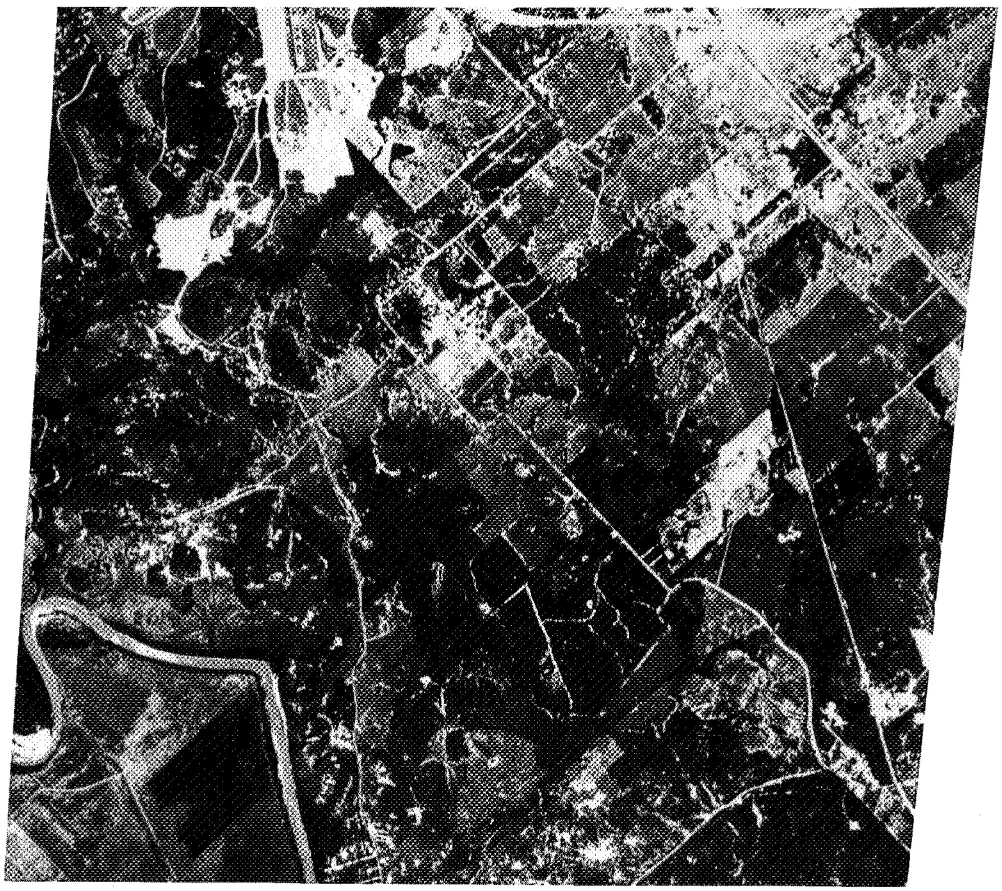
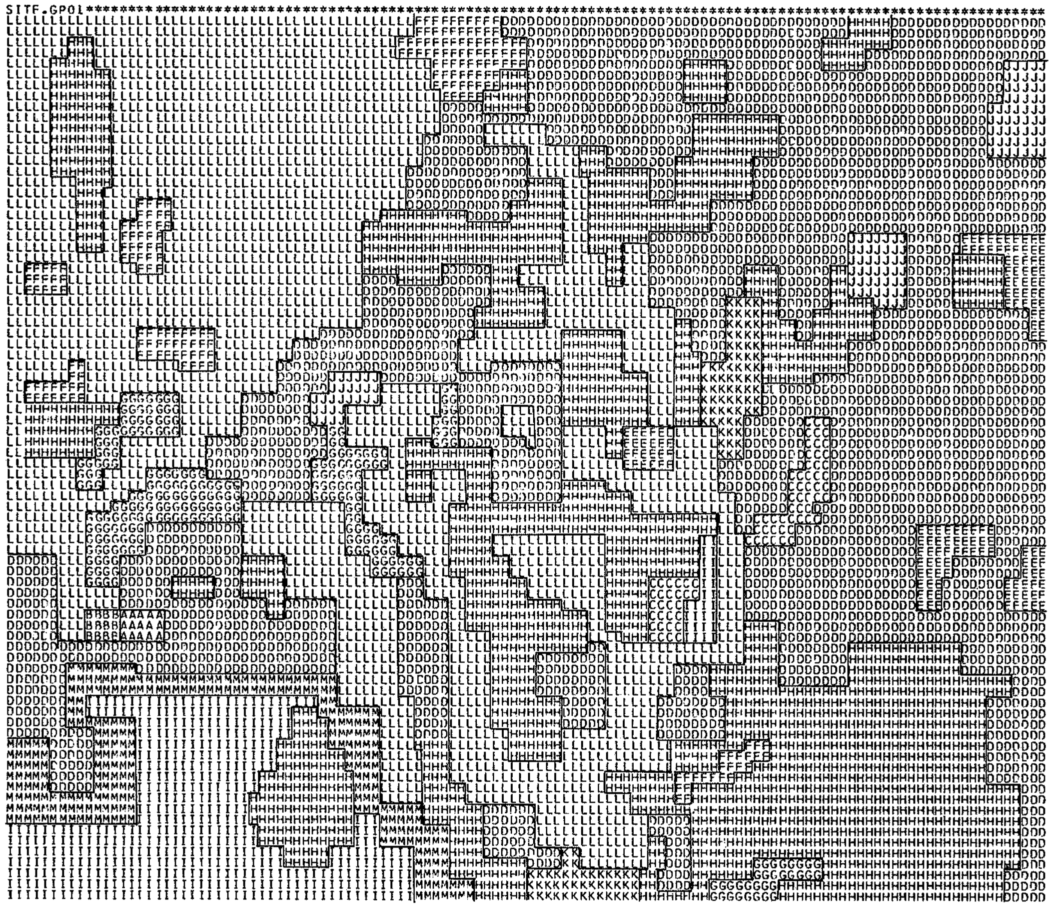


Fig. 7. Aerial photograph (above) and stratification of resources and land use (right) for the College Station south test site (CS-2).



Resource and Land Use Legend

COLLEGE STATION - SOUTH

Mask Symbol	Resource-Land Use		
A	Cs1	R2	Gn
B	Cs1	R5	Gn
C	Cs2	R6	Gn
D	Cs3	R1	Gn
E	Cs3	R2	Gn
F	Cs3	R4	Gn
G	Cs3	R5	Gn
H	Cs3	R6	Gn
I	Cs2	P1	Gt
J	Cs3	P1	Gt
K	Cs3	C1	Cr
L	Cs	Out	
M	CsW	4	

Sonora Test Site

The Sonora test site is located in Edwards County, Texas. The test site area (Fig. 8) includes the Texas A&M University Agricultural Research Station. The research station contains 3400 acres of native rangeland in the Edwards Plateau vegetation area. The research station is broken out on the computer printout according to the various pastures on the station. This will enable analysis to be made of the various treatments being conducted on the station.

The dominate soil on the test site area is the Tarrant series. This soil is a shallow stony clay soil occurring on nearly level to strongly sloping areas. The area outside the experiment station does not have a soil survey. Dominant perennial species on this test site area are curlymesquite grass and sideoats grama. Herbage yield for this site ranges from about 1120 kg/ha when the range is in fair condition to about 2800 kg/ha in low excellent condition. The principle vegetation resource of the test site is a grass-shrubland with grazing being the dominate land use.

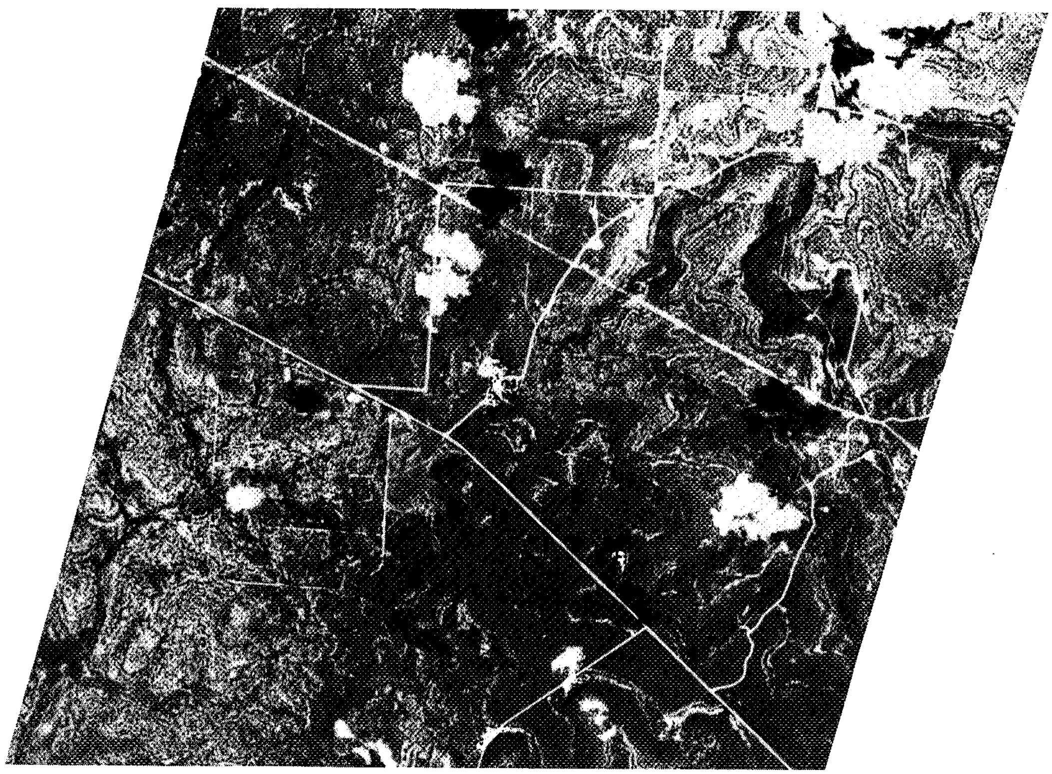
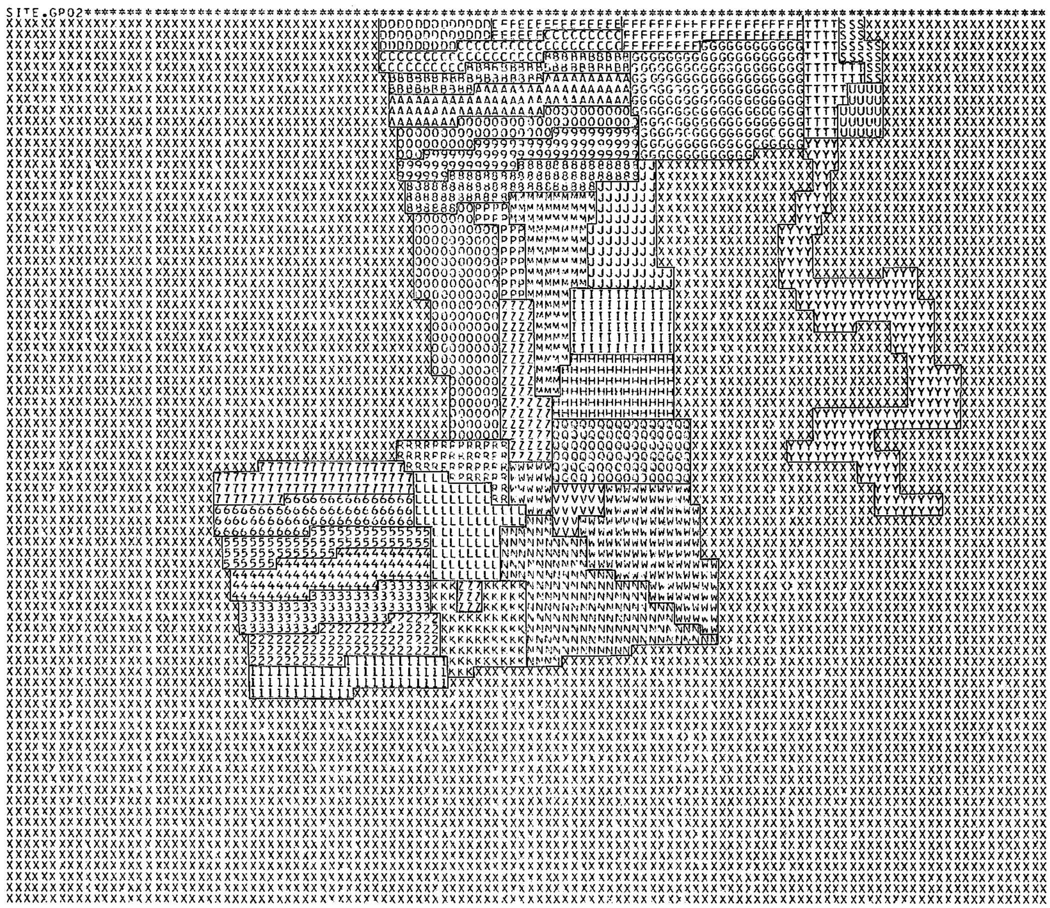


Fig. 8. Aerial photograph (above) and stratification of resources and land use (right) for the Sonora test site.



Resource and Land Use Legend

SONORA

Mask Symbol	Resource-Land Use	Mask Symbol	Resource-Land Use
1	So 4 R2 Gn1	I	So 4 R2 Gn24
2	So 4 R2 Gn2	J	So 4 R1 Gn25
3	So 4 R2 Gn3	K	So 4 R2 Gn26
4	So 4 R2 Gn4	L	So 4 R1 Gn27
5	So 4 R2 Gn5	M	So 4 R2 GnB
6	So 4 R2 Gn6	N	So 4 R2 GnC
7	So- 4 R2 Gn7	O	So 4 R2 GnD
8	So 4 R2 Gn8	P	So 4 R1 GnD
9	So 4 R2 Gn9	Q	So 4 R2 GnG
0	So 4 R2 Gn10	R	So 4 R2 GnH
A	So 4 R2 Gn11	S	So 4 R2 GnK
B	So 4 R2 Gn12	T	So 1 R2 GnK
C	So 4 R2 Gn13	U	So 5 R2 GnK
D	So 4 R2 Gn15	V	So 1 R2 GnN
E	So 4 R2 Gn17	W	So 4 R2 GnN
F	So 4 R2 Gn19	X	So 4 R2 Gn
G	So 4 R2 Gn22	Y	So 5 R2 Gn
H	So 4 R2 Gn23	Z	So Out

Throckmorton Test Site

The Throckmorton test site is located in Throckmorton County, Texas. The site includes most of the Texas Experimental Ranch. The site was characterized according to resources and land use (Fig. 9). The various pastures (Fig. 10) were also coded on the greymap and stored in the computer. This will enable the resources and land use to be studied separate and also enable each pasture to be studied separately.

The dominate soils on the site are divided into the deep upland soils, such as Abilene and Rowena, and the shallow upland soils, such as Owens and Tarrant. The Abilene and Rowena soils are deep clay loam soils occurring on nearly level to gently sloping areas. The Owens and Tarrant soils are shallow clayey soils occurring on sloping areas. A small area of Tabosa and Crawford soils, which are moderately deep clay soils on nearly level to gently sloping areas, occurs in the lower part of the test site. The principle vegetation resources are divided into open grassland and grass-shrubland, with grazing being the principle land use. Small areas of cropland occur to the south, east, and north of the ranch.

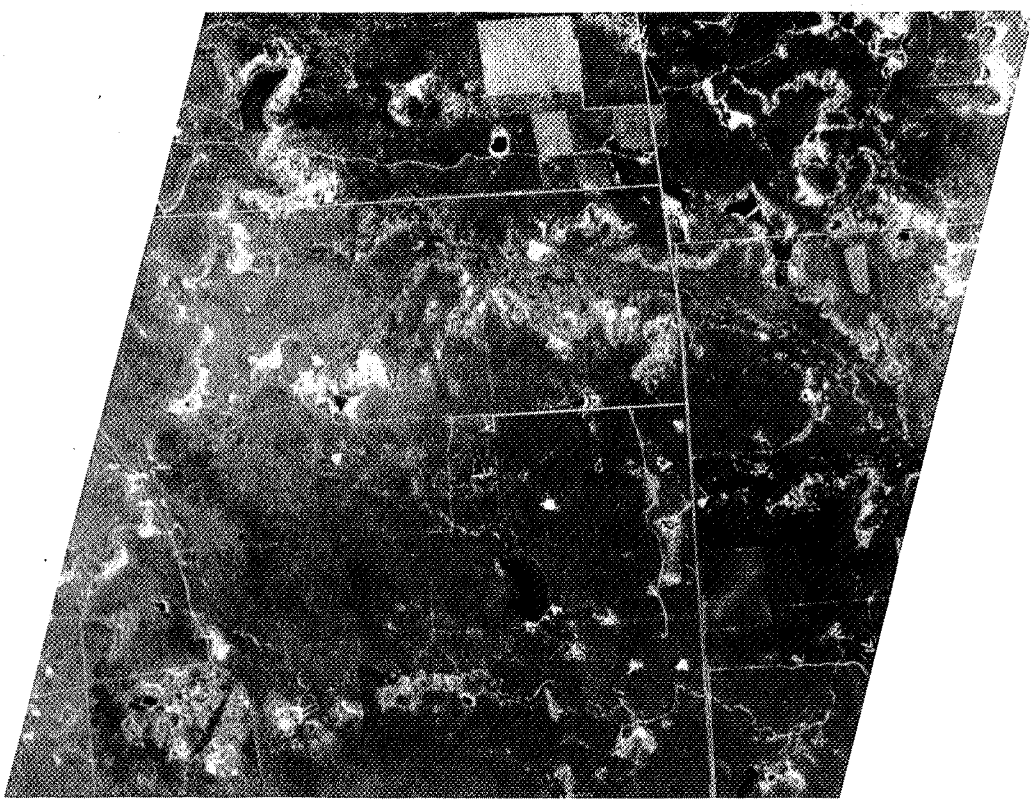
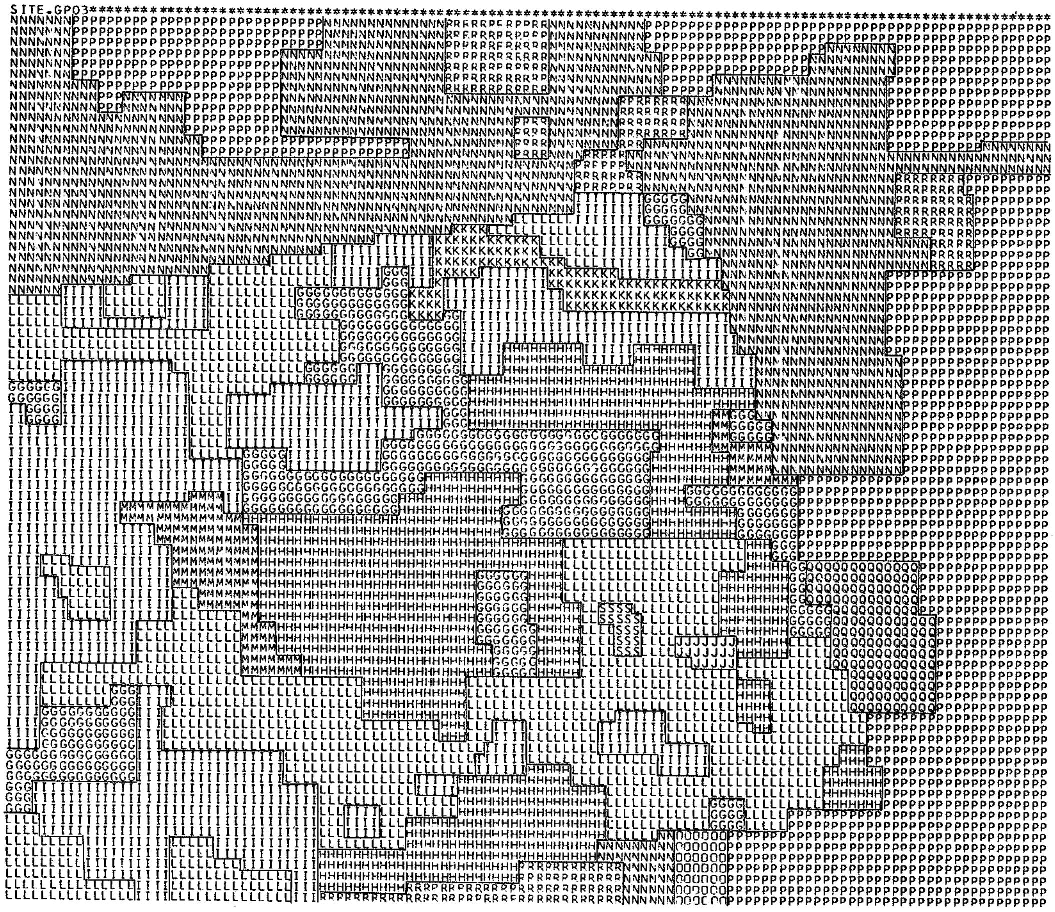


Fig. 9. Aerial photograph (above) and stratification of resources and land use (right) for the Throckmorton test site.



Resource and Land Use Legend

THROCKMORTON

Mask Symbol	Resource-Land Use		
G	Th1	R1	Gn
H	Th1	R2	Gn
I	Th2	R1	Gn
J	Th2	R2	Gn
K	Th3	R1	Gn
L	Th4	R1	Gn
M	Th4	R2	Gn
N	Th	R1	Gn
O	Th	R2	Gn
P	Th	R3	Gn
Q	Th	C1	Cr
R	Th	C2	Cb
S	Th	W1	

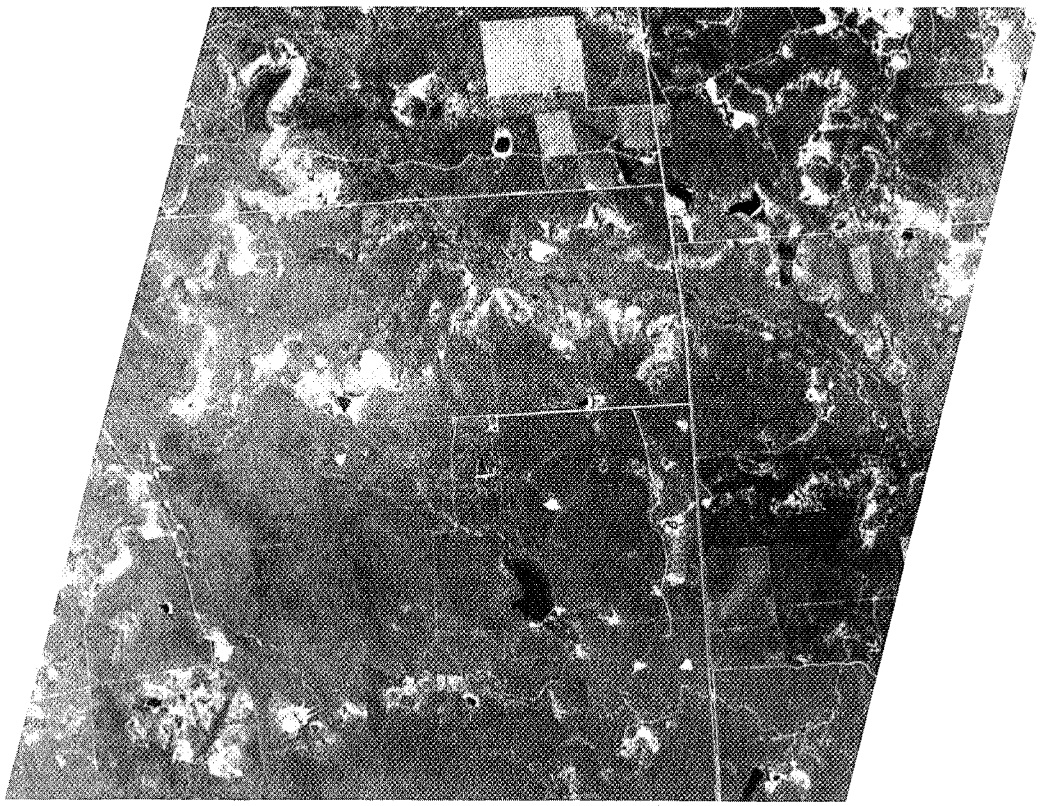
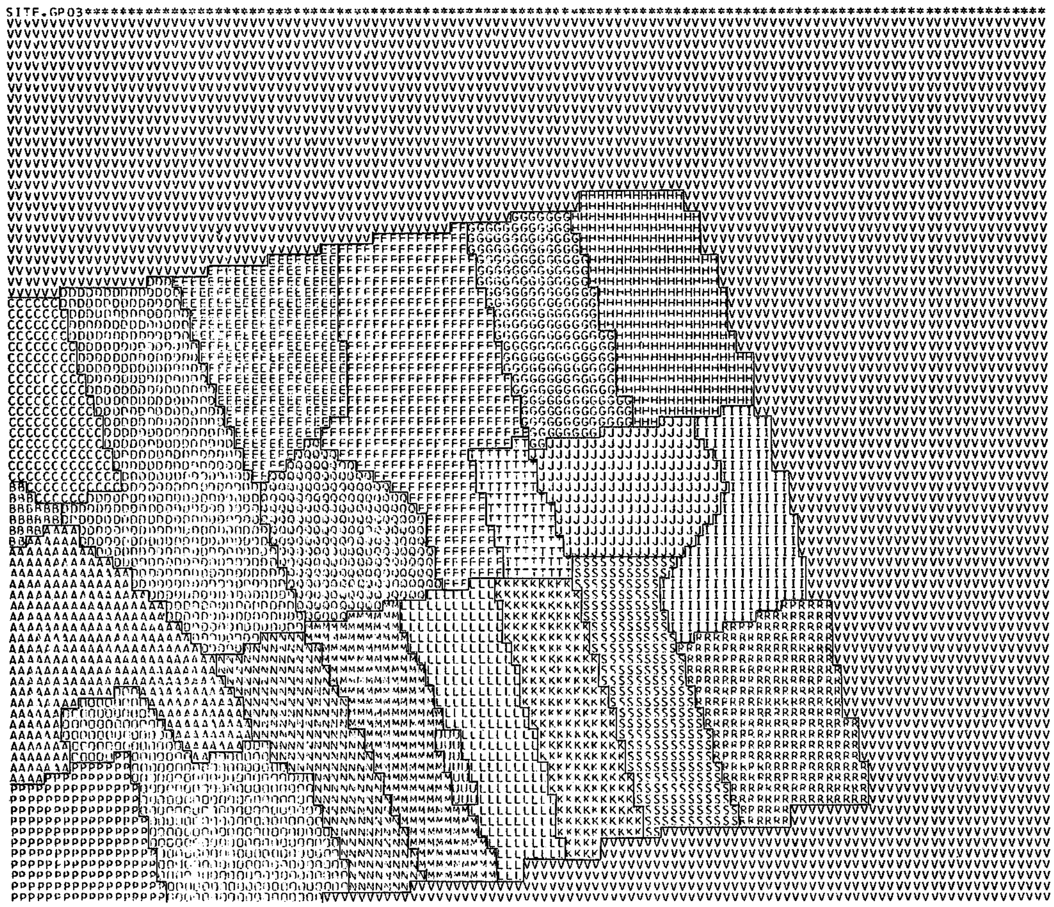


Fig. 10. Aerial photograph (above) and stratification of pastures for the Throckmorton test site.



Pastures Legend

THROCKMORTON

Mask Symbol	Pasture Number	Mask Symbol	Pasture Number
1	Th 1	A	Th 11
2	Th 2	B	Th 12
3	Th 3	C	Th 13
4	Th 4	D	Th 14
5	Th 5	E	Th 15
6	Th 6	F	Th 16
7	Th 7	G	Th 17
8	Th 8	H	Th 18
9	Th 9	I	Th 19
0	Th 10	J	Th Exclosure
		K	Th Other (outside ranch)

Woodward Test Site

The Woodward test site is located in Harper County, Oklahoma. The test site area takes in the grazing study pastures of the U. S. Southern Great Plains Field Station. The test site lies within the Central Great Plains Winter Wheat and Rangeland resource region in the Central Rolling Red Plains. The five sampling pastures for the Great Plains Corridor Project were coded separately from the rest of the experiment station. The dominate soils in the test site are Pratt and Tivoli. These soils are deep fine sandy loam and fine sandy soils that occur on hummocky and uneven, billowy areas and dune-like areas. The dominant perennials on this test site include sand sagebrush, sand dropseed, sand lovegrass, thin paspalum, little bluestem, and sand bluestem. On good condition range the herbage yield varies around 1456 to 1568 kg/ha. The principle vegetation resource of the site is open grassland with grazing being the land use. A small area of cropland occurs in the lower right of the test site. The bottom area of the site includes the Canadian River, which has changed its channel during the years. This area is principally composed of Lincoln soils.

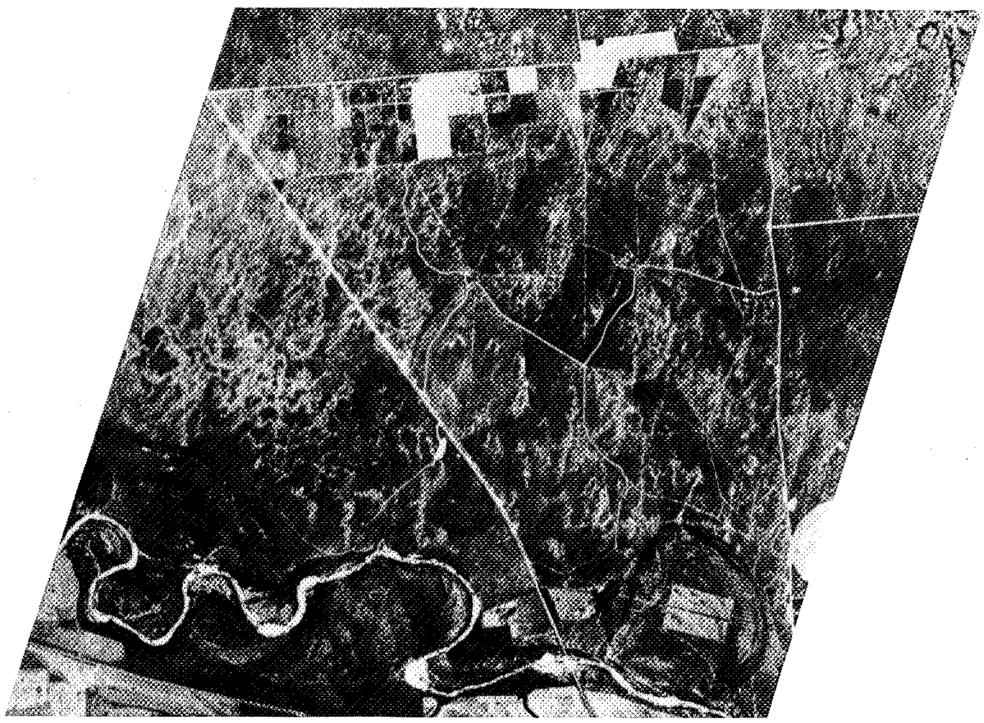
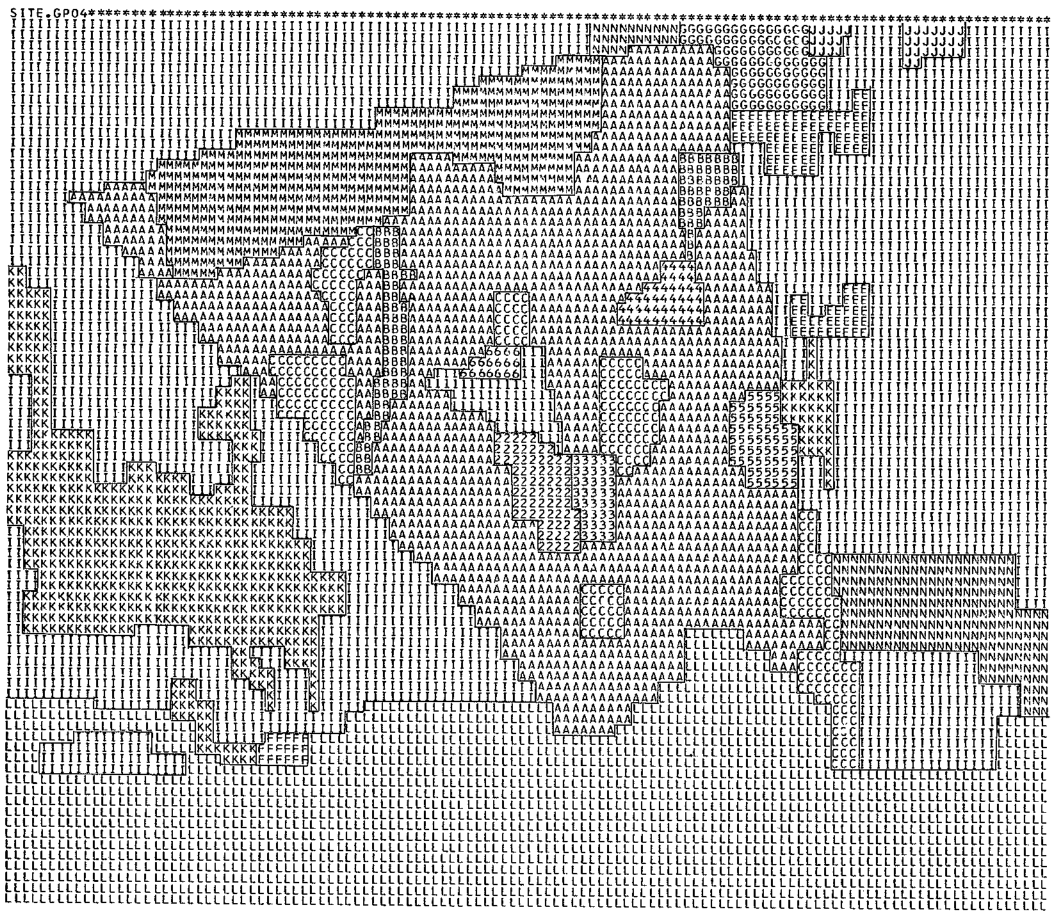


Fig. 11. Aerial photograph (above) and stratification of resources and land use (right) for the Woodward test site.



Resource and Land Use Legend

WOODWARD

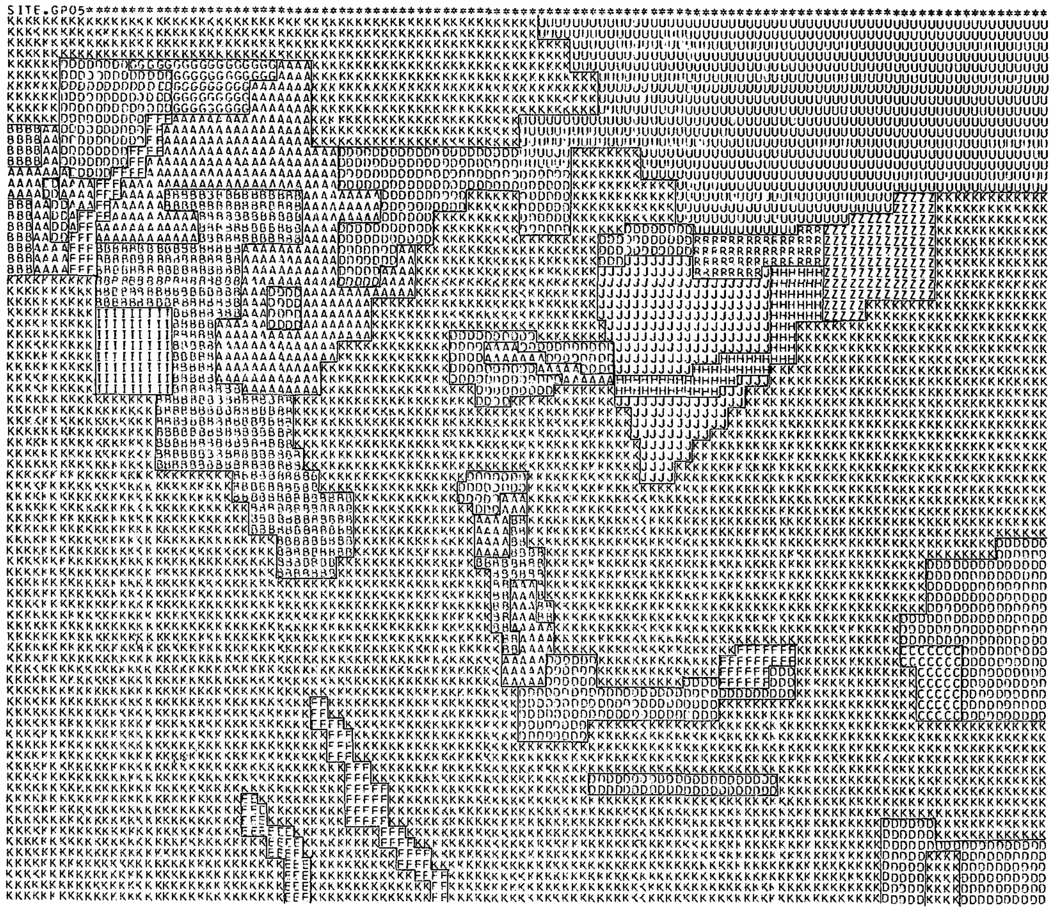
Mask Symbol	Resource-Land Use		
1	Wo6	R1	Gn1
6	Wo11	R1	Gn2
2	Wo6	R1	Gn2
3	Wo11	R1	Gn3
4	Wo6	R1	Gn4
5	Wo6	R1	Gn5
A	Wo6	R1	GnR
B	Wo7	R1	GnR
C	Wo11	R1	GnR
E	Wo2	R1	Gn
F	Wo3	R1	Gn
G	Wo4	R1	Gn
I	Wo6	R1	Gn
J	Wo8	R1	Gn
K	Wo11	R1	Gn
L	Wo3	R1	GnB
M	Wo	3P	
N	Wo	6C	

Hays Test Site

The Hays test site is located in Ellis County, Kansas. The test area includes the Kansas Agricultural Experiment Station's Fort Hays Branch research pastures, and the Fort Hays Kansas State College farm pastures. The test site lies within the Central Great Plains Winter Wheat and Rangeland resource region in the Rolling Plains and Breaks. The dominate soils on the non-cropland areas of the test site are Harney, Armo, and Brownell soils. These soils are deep loamy soils occurring on nearly level to sloping areas. The dominant perennial species are blue gramma, buffalograss, and western wheatgrass. The herbage yield averages about 3360 to 4480 kg/ha when in excellent condition. The principle vegetation resource on the non-cropland area of the test site is open grassland.

The majority of the area of the site is cropland with a large area of urban developement in the northeast corner of the 7km X 7km area. The cropland which dominates the total area of the site, will be excluded in the analysis of the site.

Fig. 12. Aerial photograph (above) and stratification of resources and land use (right) for the Hays test site.



Resource and Land Use Legend

HAYS

Mask Symbol	Resource-Land Use		
A	Ha2	R1	Gn
B	Ha3	R1	Gn
C	Ha6	R1	Gn
D	Ha9	R1	Gn
E	Ha10	R1	Gn
F	Ha13	R1	Gn
G	Ha7	R1	Gn
H	Ha2	R1	Gn1
J	Ha9	R1	Gn1
K	Ha	C1	Cr
I	Ha	I	
R	Ha	R	
U	Ha	U	
Z	Ha	Z	

Sand Hills Test Site

The Sand Hills test site is located in Cherry County, Nebraska. This test site is divided into four 2 mile X 2 mile subsite areas. These subsite areas occur along U. S. Highway 83 for a distance of 30 miles between subsite 1 and subsite 4. The test site is in the Nebraska Sand Hills within the Western Great Plains Range and Irrigated land resource region.

Subsite 1 is dominated by Valentine and Sarpy soils. These soils are deep, loamy fine sandy soils occurring on nearly level to undulating areas. The main vegetation resource on this subsite is open grassland with grazing being the main land use. The city of Valentine occurs in the northwest corner of the subsite. The Niobrara River is located in the bottom area of the subsite.

Subsite 2 is dominated by dune sand with subirrigated areas of Gannett soils. The dune sand occurs in rolling to hilly areas. The Gannett soils occur on nearly level areas. The vegetation resource for this subsite is open grassland with the land use being grazing. This subsite has two sampling areas located within the 2 mile X 2 mile area.

Subsite 3 is dominated by dune sand. A large area of Valentine and Sarpy soils occur in the center of the subsite. The dune sand area is rolling to hilly. The Valentine and Sarpy soils are deep, loamy fine sandy soils occurring on nearly level to undulating areas. The main vegetation resource of the subsite is open grassland. The dune sand areas are used for grazing as the main land use. Some of the other soil areas are used as hayland for a land use.

Subsite 4 is divided about equally into dune sand and other soils such as Valentine, Sarpy, and Gannett. The dune sand occurs in rolling to hilly areas while the other various soils occupy the more level and wet areas. This site also contains areas of water and muck. The main vegetation resource is open grassland with grazing being the dominant land use. A small area of hayland occurs on the subsite.

The subsite areas produce 448 to 672 kg/ha forage per acre for the fine sand and loamy fine sand soils while the sub-irrigated soils produce up to 2240 kg/ha. Dominant perennials vary from site to site but include sand reedgrass, blue grama, needle-and-thread, sand bluestem, sand lovegrass, prairie cordgrass, switchgrass, and big bluestem.

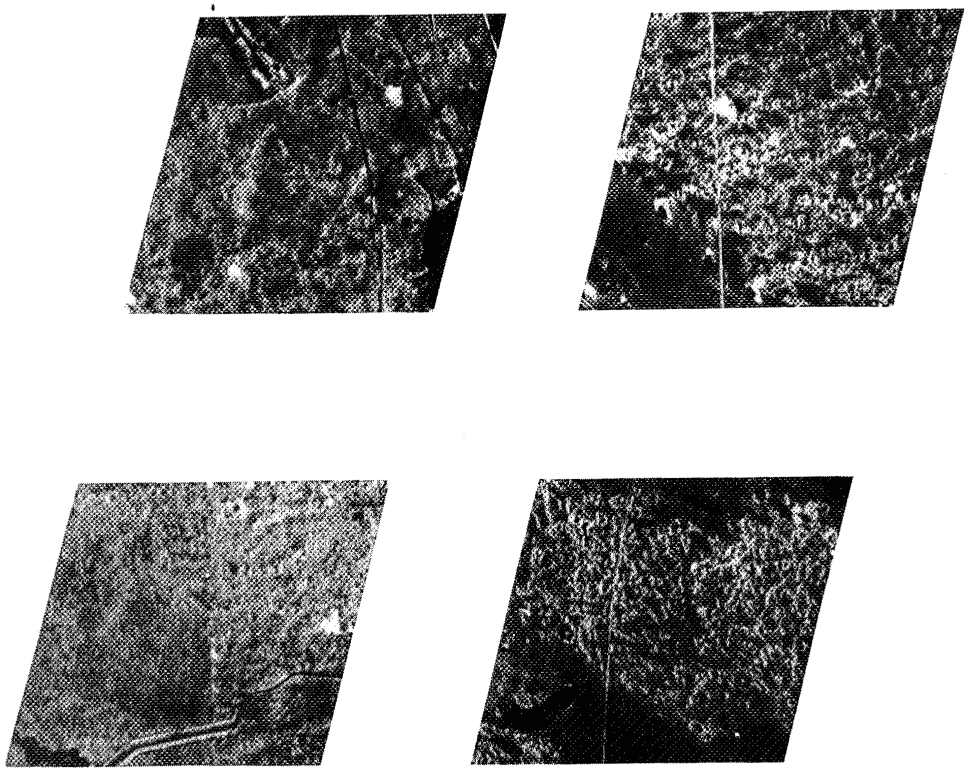
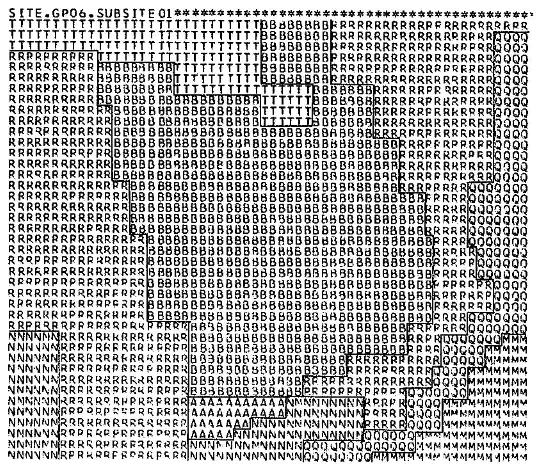
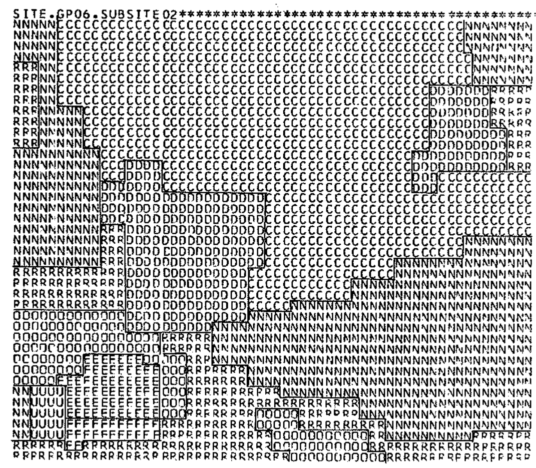
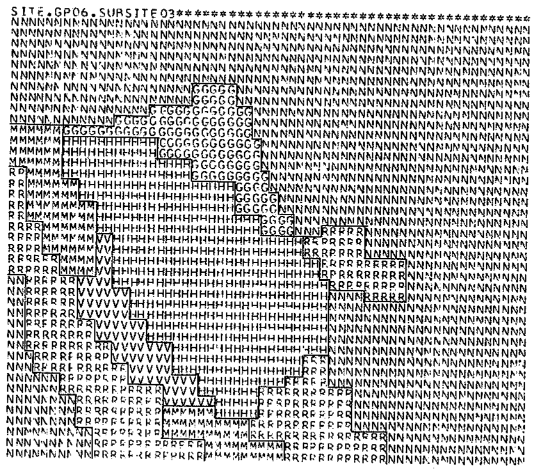
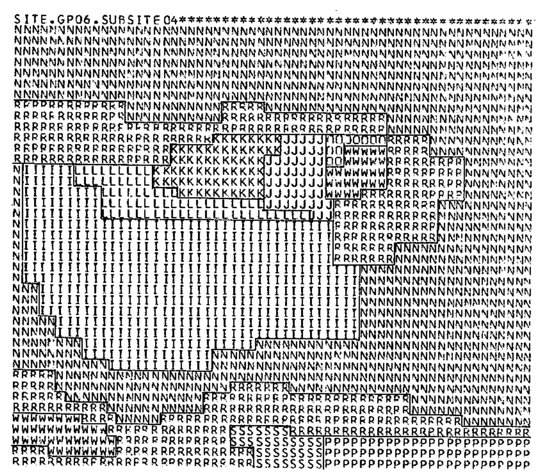


Fig. 13. Aerial photographs (above) and stratification of resources and land use (right) for the Sand Hills test sites.









Resource and Land Use Legend

SAND HILLS

Mask Symbol	Resource-Land Use	Mask Symbol	Resource-Land Use
A	Sh3 R1 Gn1	K	Sh5 R1 Gn5
B	Sh11 R1 Gn1	L	Sh11 R1 Gn5
C	Sh3 R1 Gn2	M	Sh2 R1 Gn
D	Sh11 R1 Gn2	N	Sh3 R1 Gn
E	Sh4 R1 Gn3	O	Sh4 R1 Gn
F	Sh11 R1 Gn3	P	Sh8 R1 Gn
G	Sh3 R1 Gn4	Q	Sh9 R1 Gn
V	Sh2 R1 H4	R	Sh11 R1 Gn
H	Sh11 R1 H4	S	Sh4 R1 H
I	Sh3 R1 Gn5	T	Sh T & U
J	Sh4 R1 Gn5	W	Sh1

Cottonwood Test Site

The Cottonwood test site is located in Jackson County, South Dakota. The test site lies within the Pierre Shale Plains and Badlands of the Western Great Plains Range and Irrigated land resource region. The Cottonwood Range and Livestock Experiment Station which is operated by South Dakota State University's Agricultural Experiment Station lies within the 7 km X 7 km area of the computer printout. A soil survey has not been made of this area. Based on observations at the station and a general soil map of the state, the dominate soils in the area are silty clays with Opal and Samsil the major series. The principle vegetation resource of the site is open grasslands with grazing being the land use. The dominate perennial species are blue gramma, buffalograss, western wheatgrass, and Texas wintergrass. Forage yields vary from 1008 kg/ha for fair condition to over 2240 kg/ha for excellent condition. The various pastures of the Cottonwood Station are shown on the computer printout. This will enable analyses to be made of the various treatments being conducted on the station.

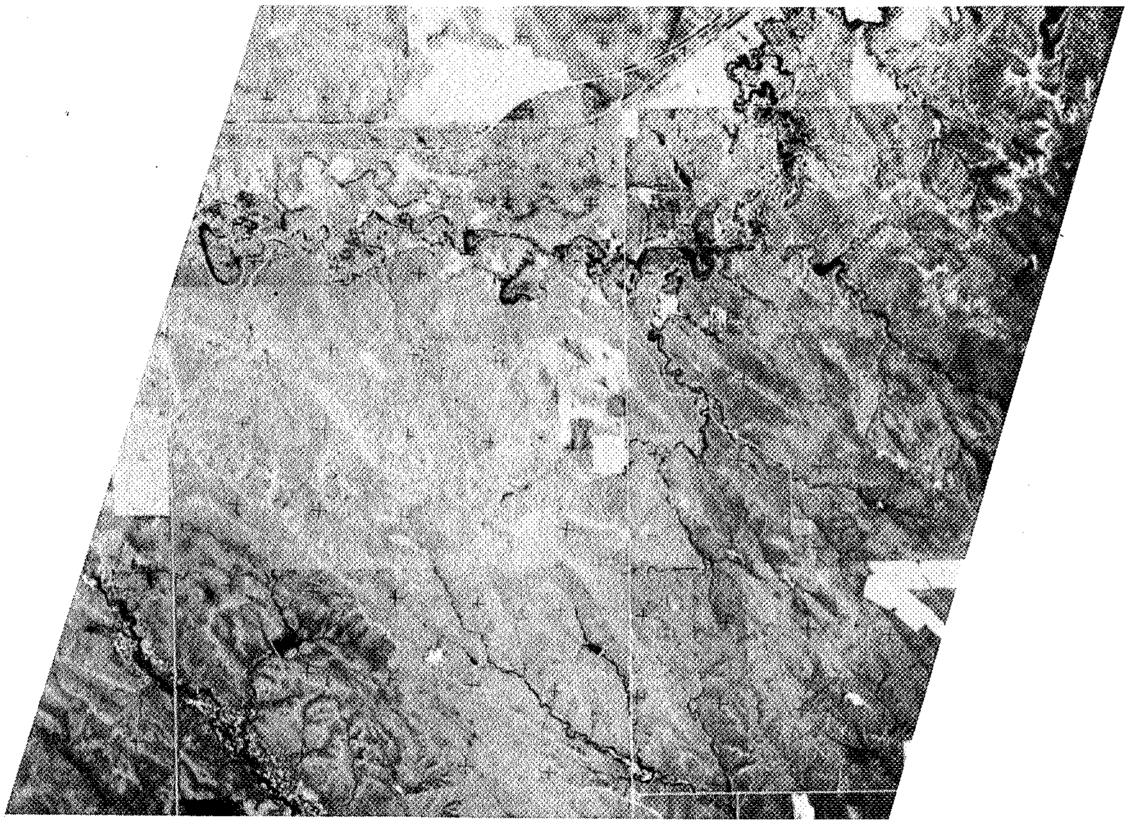
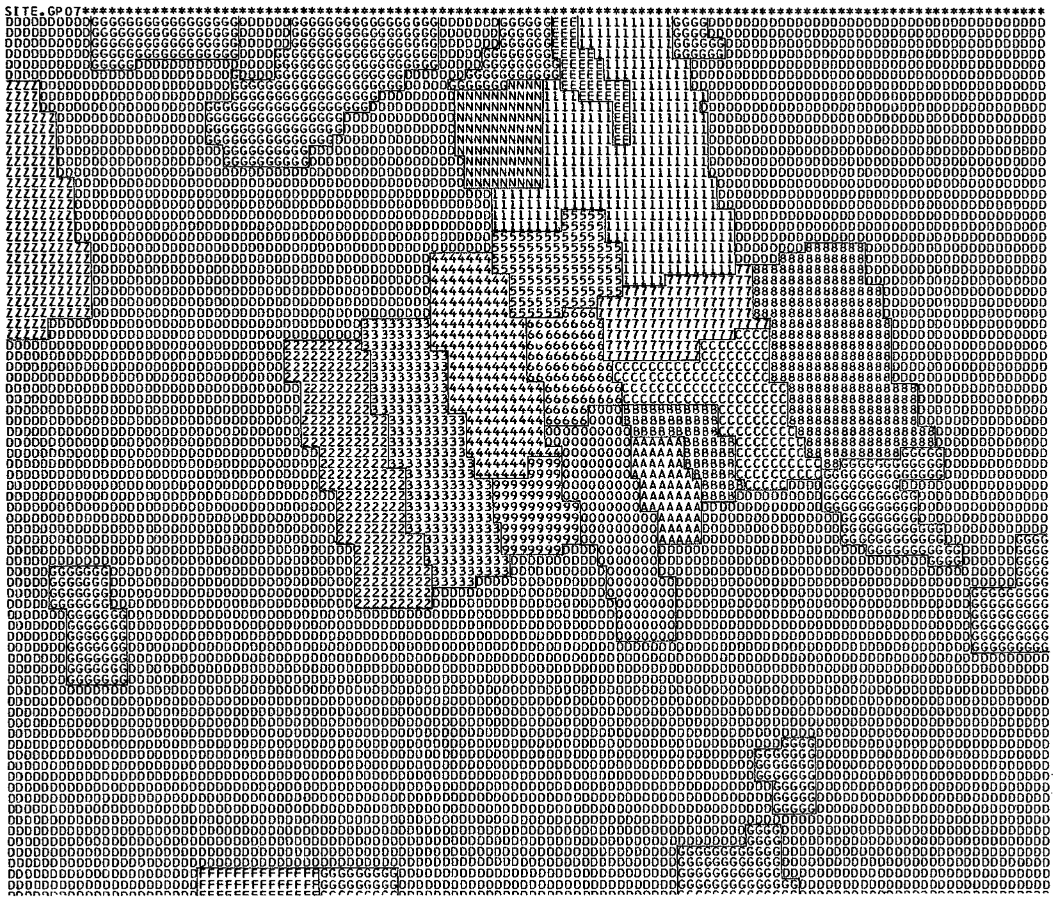


Fig. 14. Aerial photograph (above) and stratification of resources and land use (right) for the Cottonwood test site.



Resource and Land Use Legend

COTTONWOOD

Mask Symbol	Resource-Land Use
1	Cw R1 Gn 1
2	Cw R1 Gn 2
3	Cw R1 Gn 3
4	Cw R1 Gn 4
5	Cw R1 Gn 5
6	Cw R1 Gn 6
7	Cw R1 Gn 7
3	Cw R1 Gn 8
9	Cw R1 Gn 9
0	Cw R1 Gn 10
A	Cw R1 Gn 11
B	Cw R1 Gn 12
C	Cw R1 Gn 13
D	Cw R1 Gn
E	Cw R2 Gn
F	Cw R1 H
G	Cw C1 Cr
N	Cw T - airfield or station
Z	Cw Z - city of Cottonwood

Mandan Test Site

The Mandan test site is located in Morton County, North Dakota. The test site is located in the Rolling Soft Shale Plain of the Northern Great Plains Spring Wheat land resource region. The Northern Great Plains Research Center operated by the Agricultural Research Services of the USDA is located within the site. The principle soils of the site are Agar and Bainville. Agar soils are silt loam soils occurring on undulating to gently rolling areas. Bainville soils are loamy soils occurring on rolling to steep areas. These soils are dominated by the perennials western wheatgrass, blue grama, needle-and-thread, pinegrass, and scurfpea. The area yields about 2688 kg/ha of forage per acre. The principle vegetation resource for the site is open grassland with grazing being the land use. This resource occurs in the upper and eastern portion of the site. The lower left quarter of the site is in cropland. The cropland occurs on the level areas while the more sloping and rough areas are in native grasslands with small areas of hayland.

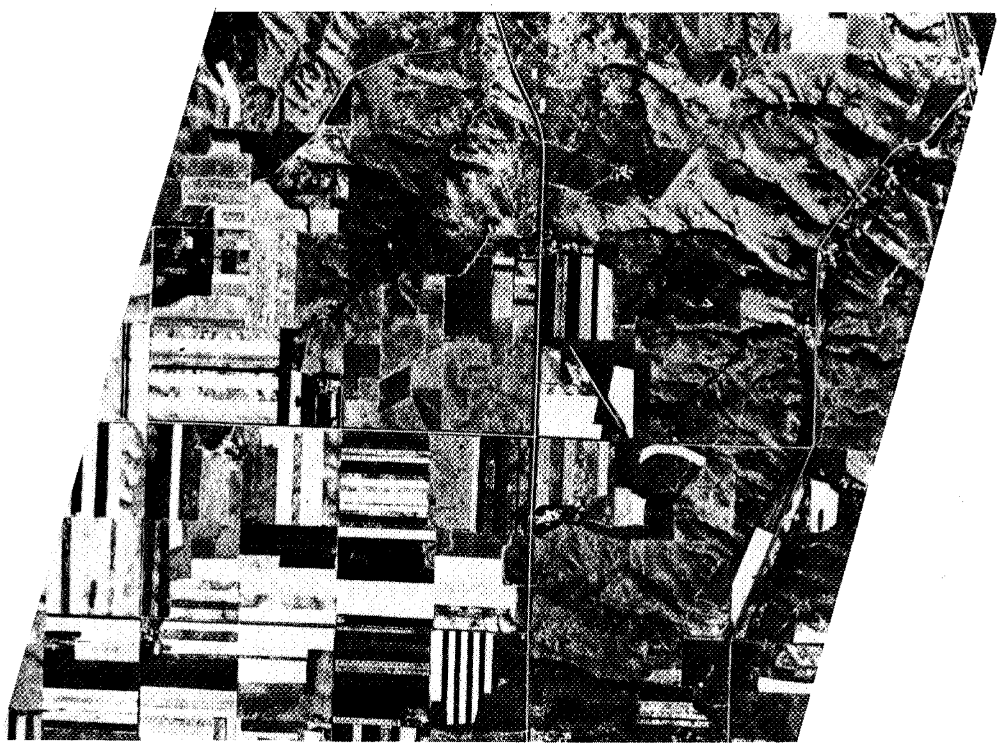
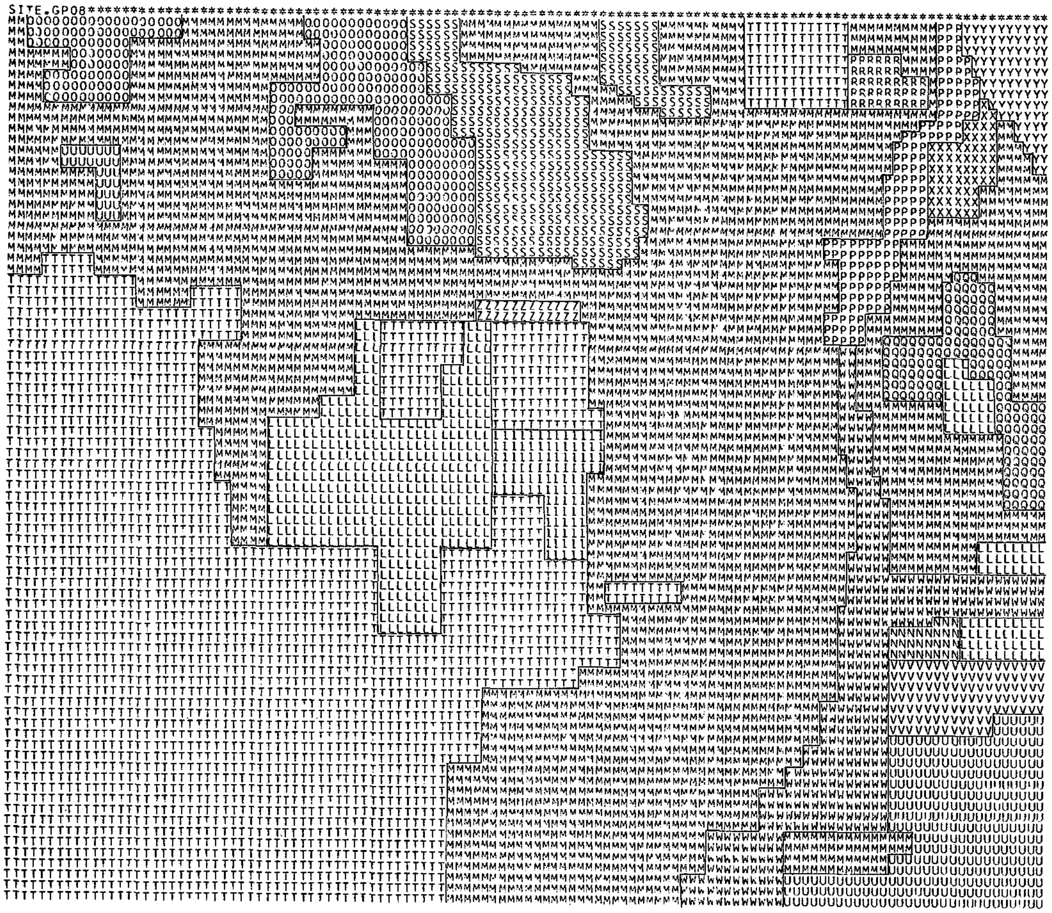


Fig. 15. Aerial photograph (above) and stratification of resources and land use (right) for the Mandan test site.



Resource and Land Use Legend

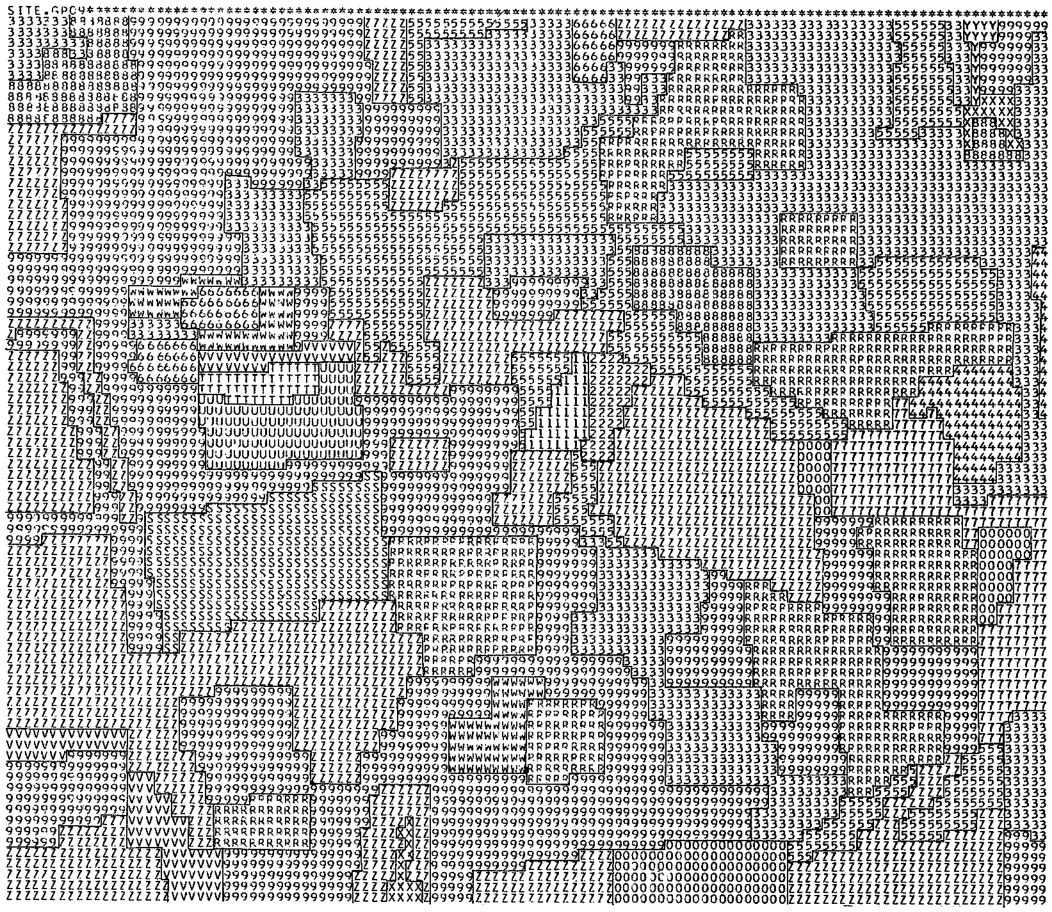
MANDAN

Mask Symbol	Resource-Land Use		
L	Ma1	R1	Gn
M	Ma2	R1	Gn
N	Ma4	R1	Gn
O	Ma5	R1	Gn
P	Ma6	R1	Gn
Q	Ma9	R1	Gn
R	Ma1	R1	H
S	Ma2	R1	H
T	Ma1	C1	Cr
U	Ma2	C1	Cr
V	Ma4	C1	Cr
W	Ma5	C1	Cr
X	Ma6	C1	Cr
Y	Ma7	C1	Cr
Z	Ma	Z	
1	Ma	T	

Weslaco Test Site

The Weslaco test site is located in Starr County, Texas. The test site is in the Rio Grande Plain area of the Southwestern Plateaus and Plains Range and Cotton land resource region. The dominate soils on the site are the Brennan and McAllen series. They are deep, fine sandy loam soils occurring on nearly level to gently sloping areas. The dominant perennial grass species include hooded windmillgrass, Texas grama, gummy lovegrass, and red threeawn. The vegetation resources of this test site are open grassland, grass-shrubland and wooded grassland. The test site is divided into many subsite areas because of the various vegetation and soil types that occur. Grazing is the main land use for the test site. A few small cropland fields occur in the site. These will be excluded in the analysis of the test site area.

Fig. 16. Aerial photograph (above) and stratification of resources and land use (right) for the Weslaco test site.



Resource and Land Use Legend

WESLACO

Mask Symbol	Resource-Land Use		
1	We1	R1	Gn1
2	We3	R1	Gn2
3	We1	R1	Gn
4	We1	R2	Gn
5	We1	R5	Gn
6	We2	R1	Gn
7	We2	R2	Gn
8	We2	R5	Gn
9	We3	R1	Gn
0	We3	R2	Gn
Z	We3	R5	Gn
Y	We4	R1	Gn
X	We4	R5	Gn
W	We6	R1	Gn
V	We6	R5	Gn
U	We3	P1	Gt
T	We6	P1	Gt
S	We3	P1	H
R	We3	C1	Cr

Chickasha Test Site

The Chickasha test site is located in Grady County, Oklahoma. The Southern Great Plains Watershed Research Center is operated by the Agricultural Research Service of the USDA. The test site is in the Central Great Plains Winter Wheat and Range land resource region.

The dominant soils on the test site are Lucien and Nash soils. Yahola and Port soils are found in the bottomland areas of the test site. These bottomland sites are usually in cultivation. The Lucien and Nash soils are deep loamy soils occurring on moderately sloping areas. Dominant perennial specien on little bluestem, Scribner's panicum, blue grama, sideoats grama, Indiangrass, silver bluestem, hooded windmillgrass, tall dropseed, and western ragweed. Herbage yield varies from 784 kg/ha to 9300 kg/ha. The main vegetation resource for the site is open grassland with grazing being the land use. Areas of woodland occur along the streams and draws.

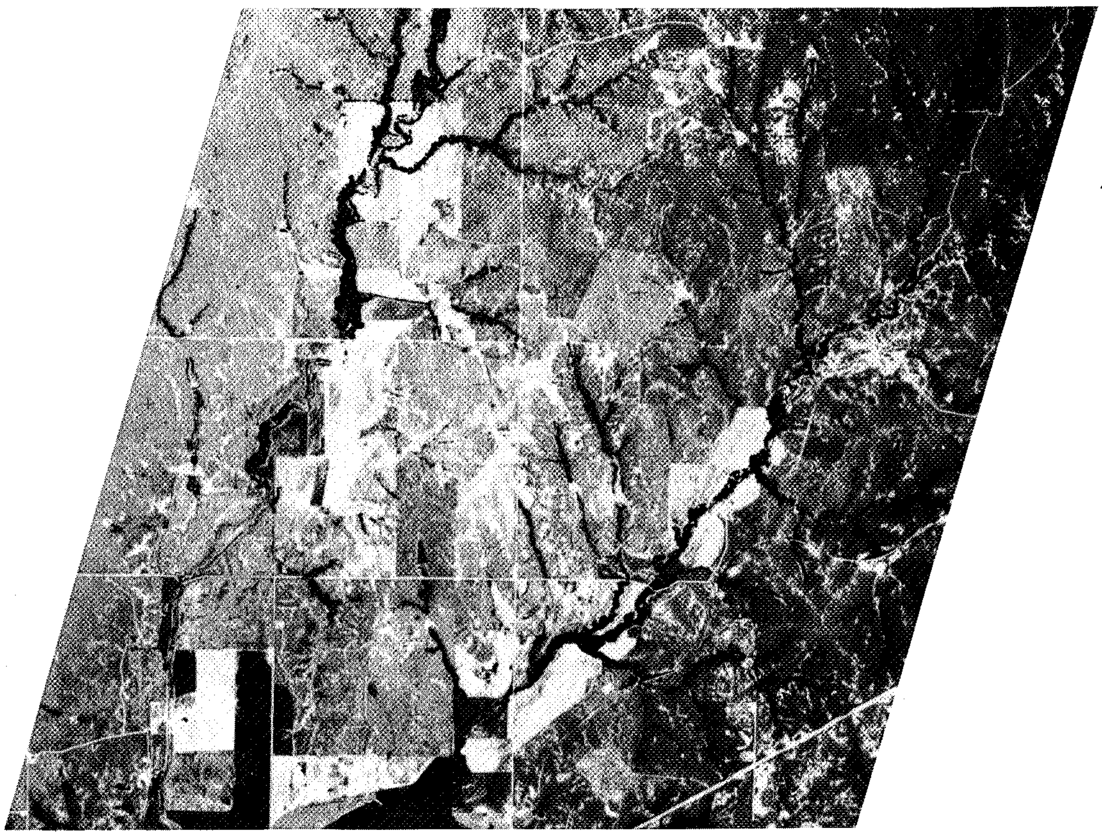
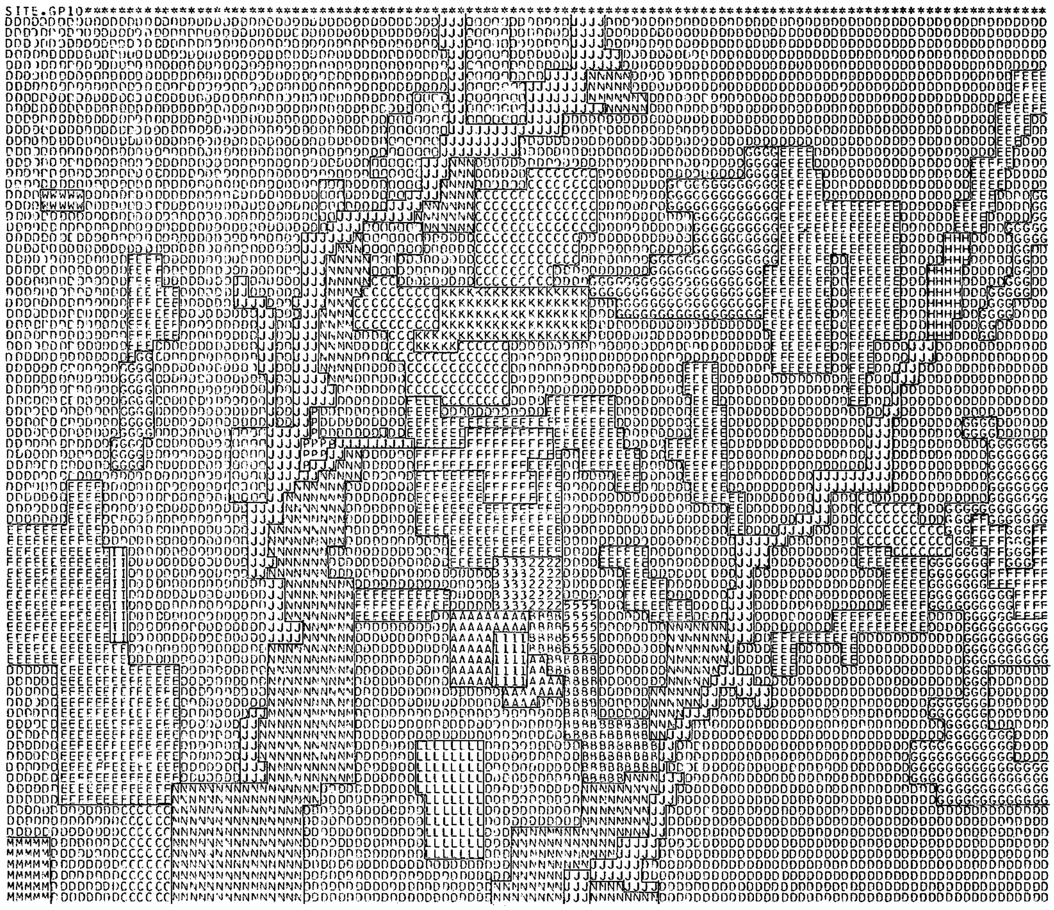


Fig. 17. Aerial photograph (above) and stratification of resources and land use (right) for the Chickasha test site.



Resource and Land Use Legend

CHICKASHA

Mask Symbol	Resource-Land Use			Mask Symbol	Resource-Land Use		
1	Ch1	R1	Gn1	H	Ch8	R1	Gn
2	Ch5	R1	Gn2	I	Ch5	R6	Gn
3	Ch5	R1	Gn34	J	Ch8	R6	Gn
5	Ch1	R1	Gn5	K	Ch4	P1	Gt
A	Ch1	R1	Gn	L	Ch5	P1	Gt
B	Ch2	R1	Gn	M	Ch4	C1	Cr
C	Ch3	R1	Gn	N	Ch8	C1	Cr
D	Ch4	R1	Gn	O	Ch8	C2	Cr
E	Ch5	R1	Gn	P	Ch8	P1	Gt
F	Ch6	R1	Gn	W	Ch	W1	
G	Ch7	R1	Gn				

V. Evaluation of Procedures

A system was developed to classify and format land resource information for ERTS-1 Great Plains Corridor test sites. The procedures include the use of aerial photography, map information and ground observations for isolating relative uniform land resources or land use types. ERTS-1 digital data were used to produce grey-maps for overlaying land-type information. These data are computer stored by coordinate locations and serve as a "mask" for extracting ERTS-1 digital data from relatively uniform landscapes.

The classification system was designed to treat resource types and land use as independent parameters. Land resources and land uses are mapped independently and used as overlays for delineating landscape types. This system agrees with criteria of Anderson [1] except it permits land use activities to be considered independent of identified resources. Thus, the system provides a means of land use classification that is not resource based.

It is possible to expand or collapse the system to attain the level of complexity desired. An example of the flexibility of the system is the Cottonwood test site where soil survey information was not available. Since the soil data were excluded, the ultimate stratification is land use based and reflects the grazing treatments by pastures. Since topographic maps of the area are available, slope could be used as another independent parameter.

Identifying and classifying of the resource and land use types was accomplished using 1:120,000 to 1:60,000 scale photography. However, any larger scale photography would have been equally adapted since everything is brought to a common scale with the use of 7.5 minute topographic maps. However, the color-IR photographs at a scale of 1:120,000 proved to be very suitable for characterizing the land resource types. Interpretation tests were not conducted on the interpreter classification since all areas were field verified.

The procedures for characterizing land resources and developing computer compatible classification data are designed use any map information, published data or information extracted from aerial photographs. The system lends flexibility to the kind and format of data utilized and to the degree of complexity of the final stratification. Further work is needed to determine the degree of correlation of natural vegetation with the strata used at the test sites and their relative uniformity.

SELECTED REFERENCES

1. Anderson, James. R., 1971, Land-Use Classification Schemes, Photogramm. Eng. U.37, No.4, p. 379-387.

2. Anderson, James R., Hardy, Ernest E., and Roach, John T. 1972. A Land-Use Classification System for Use with Remote-Sensor Data Geological Survey Circular 671. 16 p.

3. Austin, Morris E. 1965 Land Resource Regions and Major Land Resource Regions and Major U.S. Dept. of Agriculture, Agricultural Handbook 296 82 p.

4. Colwell, Robert N. 1968. Determining the Use-fullness of Space Photography for Natural Resource Inventory. Proceedings of the Fifth Symposium on Remote Sensing of Environment. The University of Michigan, Michigan. p. 249-289.

5. Colwell, Robert N. 1968. Remote Sensing of Natural Resources. Scientific America, 218 (1):54-69.

6. Deering, D. W., and Haas, R. H. 1972. Great Plains Corridor Rangeland Test sites, Technical Memorandum RSC-63, Remote Sensing Center, Texas A&M University, College Station, Texas. 11p.

7. Edwards, M. J., and Ableiter, J. K. 1951. Soil Survey of Morton County, North Dakota. U.S. Dept. of Agricultrue, Soil Conservation Service, Washington, D.C. 143 p.

8. Layton, M. H., Buzzard, C. R., and Hay, H. E. 1940 Soil Survey of Cherry County, Nebraska, U. S. Dept. of Agriculture, Soil Conservation Service. Washington, D.C. 91p.

9. Mowery, Irvin, et al. 1958. Soil Survey of Brazos County, Texas U.S. Dept. of Agriculture, Soil Conservation Service, Washington, D. C. 65p.

10. Nauce, Earl C., et al. 1960. Soil Survey of Harper County, Oklahoma U. S. Dept. of Agriculture, Soil Conservation Service. Washington, D. C. 59p.

11. Nunnally, Nelson R., and Witmer, Richard E. 1970. Remote sensing for land studies. Photogrammetric Eng. 36(5): p. 449-453.

12. Soil Survey Staff. 1966. Aerial Photo-Interpretation in Classifying and Mapping Soils. U. S. Dept. of Agriculture, Agricultural Handbook No. 294 89p.

13. Soil Survey Staff. Oct. 1970. Soil Taxomony (Preliminary Abridged Test) U. S. Dept. of Agriculture, Soil Conservation Service, Washington, D. C. 330p.

14. Thompson, Charles M., et al. 1972 Soil Survey of Starr County, Texas U. S. Dept. of Agriculture, Soil Conservation Service, Washington, D. C. 59p.

15. U. S. Dept. of Agriculture Soil Conservation Service, Soil Survey Field Sheets for Edwards County, Texas; Ellis County, Nebraska; Grady County, Oklahoma, and Throckmorton County, Texas.

16. U. S. Urban Renewal Administration, Housing and Home Finance Agency, and Bureau of Public Roads 1965 Standard Land Use Coding Manual, Washington, D. C., U. S. Government Printing Office, 111p.

APPENDIX A-1

Coding System for Soil Groups by Test Sites

Coding System for Soil Groups by Test Sites

Soils Code	Soil Groups
College Station Test Site (Test Site No. 1)	
Cs 1	Houston-Hunt soils (Blackland soils) - Deep clayey soils occurring on gently to sloping uplands.
Cs 2	Miller-Norwood soils (Flood plains of Brazos River) - Deep clay and loamy bottomland soils occurring on natural levees and large level areas.
Cs 3	Crockett-Lufkin soils (Claypan) - Deep fine sandy loam surface soils on nearly level to gently sloping areas.
Cs 4	Gullied areas - Areas severely cut by gullies. Only narrow remnants of original landscape remains between gullies.
Cs 5	Gowen-Ochlockonee soils (Flood plains of local streams) - Deep loamy and sandy bottomland soils occurring on nearly level areas.

Sonora Test Site (Test Site No. 2)

So 1	Abilene soils - Deep silty clay loam soils on nearly level areas.
So 4	Tarrant soils - Shallow stony clay soils on nearly level to strong sloping areas.
So 5	Valera soils - Moderately deep clay soils on nearly level areas.

Throckmorton Test Site (Test Site No. 3)

Th 1	Abilene-Throck-Rowena soils - Deep clay loam soils on nearly level to gently sloping areas.
Th 2	Owens-Tarrant soils - Shallow stony clay soils on sloping areas.
Th 3	Spur soils - Deep clay loam bottomland soils on nearly level areas.
Th 4	Tobosa-Crawford soils - Moderately deep clay soils on nearly level to gently sloping areas.

Woodward Test Site (Test Site No. 4)

Wo 2	Dalhart soils - Deep fine sandy loam soils occurring on uneven, concave-convex areas.

Wo 3	Lincoln soils - Deep loamy sand bottomlands occurring on nearly level to slightly hummocky areas.
Wo 6	Pratt soils - Deep loamy fine sand soils occurring on gently sloping, billowy areas.
Wo 7	Pratt soils - Deep fine sandy loam soils occurring on hummocky and uneven, billowy areas.
Wo 8	Pratt soils - Shallow loam soils occurring on moderately sloping to strongly sloping areas.
Wo 11	Tivoli soils - Deep fine sandy soils occurring on dune-like areas that are parallel to larger streams.

Hays Test Site (Test Site No. 5)

Ha 2	Armo soils - Deep loam soils occurring on gently sloping to moderately sloping areas.
Ha 3	Brownell soils - Deep gravelly loam soils occurring on gently sloping to sloping areas.
Ha 6	Crete soils - Deep silty clay loam soils occurring on nearly level areas.

Ha 7	Detroit soils - Deep silt loam soils occurring on nearly level areas.
Ha 9	Harney soils - Deep silt loam soils occurring on nearly level to gently sloping areas.
Ha 10	Hord soils - Deep silt loam soils occurring on nearly level areas.
Ha 13	Roxbury soils - Deep silt loam soils occurring on nearly level areas.

Sand Hills Test Site (Test Site No. 6)

Sh 2	Dwyer-Elsmere soils - Deep loamy fine sand soils occurring on nearly level to gently sloping areas.
Sh 3	Dune sand, stabilized - Sand dunes occurring on rolling to hilly areas.
Sh 4	Gannett soils - Deep, wet, fine, sandy loam soils occurring on nearly level areas.
Sh 5	Gannett-Valentine soils - Deep loamy fine sands occurring on nearly level to gently sloping areas.
Sh 8	Muck - A dark-colored mixture of rotted and partly rotted plant remains and fine sand occurring on level areas around the edges of lakes and ponds.

Sh 9	Rough broken land, Canyon soil material - Miscellaneous land type that occurs on steep or very steep areas adjacent to the Niobrara River.
Sh 11	Valentine-Sarpy soils - Deep loamy fine sand soils occurring on nearly level to undulating areas.

Cottonwood Test Site (Test Site No. 7)

No detail soil survey has been completed for the Cottonwood, South Dakota site.

Mandan Test Site (Test Site No. 8)

Ma 1	Agar soils - Deep silt loam soils occurring on nearly level areas.
Ma 2	Bainville soils - Shallow loam soils occurring on moderately steep areas.
Ma 4	Flasher soils - Deep loamy fine sand soils occurring on hilly areas.
Ma 5	Grail soils - Deep silt loam soils occurring on gently sloping areas.
Ma 6	Hall soils - Deep silt loam soils occurring on undulating areas.
Ma 7	Havre soils - Deep fine sandy loam soils occurring on nearly level areas.

Ma 9	William soils - Deep silt loam soils occurring on undulating to gently rolling areas.

Weslaco Test Site (Test Site No. 9)

We 1	Brennan soils - Deep fine sandy loam soils occurring on nearly level areas.
We 2	Delmita soils - Moderately deep fine sandy loam soils occurring on nearly level to gently sloping areas.
We 3	McAllen soils - Deep fine sandy loam soils occurring nearly level to gently sloping areas.
We 4	Ramadero soils - Deep loam soils occurring on nearly level drainageways.
We 6	Zapata soils - Very shallow gravelly loam soils occurring on gently sloping areas.

Chickasha Test Site (Test Site No. 10)

Ch1	Kingfisher soils - Deep loamy and clayey soils with many slickspot areas occurring on gently sloping to nearly level areas.

Ch 2	Konawa soils - Deep fine sandy loam soils occurring on gently sloping to moderately sloping areas that are moderately severely eroded.
Ch 3	Lucien soils - Shallow fine sandy loam soils occurring on moderately steep areas.
Ch 4	Lucien-Nash soils - Shallow and moderately deep loamy soils occurring on gently sloping to steeply rolling areas.
Ch 5	Minco-Grant soils - Deep fine sandy loam and silt loam soils occurring on rolling areas.
Ch 6	Prairie alluvium and broken land - Moderately deep to very shallow, loamy to clayey soils occurring on moderately sloping to steep areas.
Ch 7	Renfrow soils - Deep loamy soils occurring on sloping areas that are moderately eroded.
Ch 8	Yahola-Port soils - Deep fine sandy loam bottomland soils occurring on nearly level areas.

APPENDIX B-1

Coding System for Vegetation and Land Use Data

Guidelines for Coding Vegetation and Land Use Data at the Ten Great Plains Corridor Test Sites

In order to code the vegetation and land use data at the ten test sites, a resource and land use inventory was developed. This classification system was developed to provide a method to describe the vegetation and land use in a way that was not resource or land use biased. In this system land use was resource independent. The following tables contain only the vegetation resources and land uses that occurred on the sites.

Land Resources

Vegetation Resources

Code Symbol	
C1	Cropland, row crops
C2	Cropland, broadcast crops
P	Pastureland
P1	Pastureland, warm season, sod-forming forages
R1	Rangeland, open grassland
R2	Rangeland, grass-shrubland
R3	Rangeland, shrubland
R4	Rangeland, savannah
R5	Rangeland, wooded grassland
R6	Rangeland, woodland

Water Resources

W1	Ponds < 40 surface acres
W4	River

Land Use

C	Cropping
Cb	Cropping, broadcast crops
Cr	Cropping, row crops
G	Grazing
Gn	Grazing, native grassland
Gt	Grazing, tame pasture
H	Hayland
I	Industrial
R	Recreation
T	Transportation
U	Urban and built-up lands
Z	Other (farmsteads, rural business buildings)

Special Codes

Exclosure	Areas not grazed
Out	Areas to be excluded in analysis

APPENDIX D

Table E-1. Coverage Dates[1] and Relative Quality[2] of NASA 9 1/2" Aerial Photography Received

Great Plains Corridor Test Site	Color IR Positive Transparencies				Color Positive Transparencies	
	1:120,000 scale		1:60,000 scale		1:120,000 scale	
	Date	Quality	Date	Quality	Date	Quality
1. College Station	10-2-72	G	10-2-72	G	10-2-72	G
	8-15-73	P	8-15-73	P	8-15-73	P
	8-24-73	G	8-24-73	G	8-24-73	G
	6-14-74	P	6-14-74	P	6-14-74	P
2. Sonora	5-31-72	P	5-31-72	P	5-31-72	P
	8-21-72	G			8-21-72	G
	9-11-72	P	9-11-72	P	9-11-72	P
	8-5-73	P	8-5-73	G	8-5-73	P
	5-2-74	G	5-2-74	G	5-2-74	F
	6-14-74	G	6-14-74	G	6-14-74	G
3. Throckmorton	5-31-72	P	5-31-72	P	5-31-72	P
	9-11-72	F	9-11-72	F	9-11-72	F
	8-5-73	G	8-5-73	G	8-5-73	G
	5-2-74	G	5-2-74	G	5-2-74	F
	6-14-74	G	6-14-74	G	6-14-74	G
4. Woodward	5-31-72	G	5-31-72	F	5-31-72	F
	8-31-72	P	8-31-72	P		
	9-11-72	P	9-11-72	P	9-11-72	P
	8-5-73	G	8-5-73	P	8-5-73	G
	6-14-74	G	6-14-74	G	6-14-74	G
5. Hays	5-31-72	G	5-31-72	G	5-31-72	F
	8-18-72	G	8-18-72	G	8-18-72	G
	9-19-72	F	9-19-72	G	9-19-72	F
	8-5-73	G	8-5-73	G	8-5-73	G
	5-3-74	G	5-3-74	G	5-3-74	F
6. Sand Hills	5-31-72	F	5-31-72	F	5-31-72	F
	9-19-72	F			9-19-72	F
	8-10-73	G	8-10-73	G	8-10-73	G
	5-3-74	G	5-3-74	G	5-3-74	F
	6-14-74	G	6-14-74	G	6-14-74	G
7. Cottonwood	5-31-72	G	5-31-72	G	5-31-72	G
	9-14-72	G	9-14-72	G	9-14-72	G
	8-10-73	G	8-10-73	G	8-10-73	G
	5-3-74	G	5-3-74	G	5-3-74	F
8. Mandan	5-31-72	G	5-31-72	P	5-31-72	P
	9-14-72	G	9-14-72	G	9-14-72	G
9. Weslaco	8-31-72	G	8-31-72	P	8-31-72	G
	7-31-73	G	7-31-73	G	7-31-73	G
10. Chickasha	5-31-72	G	5-31-72	G	5-31-72	G
	8-18-72	F	8-18-72	F	8-18-72	F
			9-12-72	G	9-12-72	G
			8-5-73	G	8-5-73	G
			5-2-74	G		
	6-14-74	G	6-14-74	G	6-14-74	G

1 Dates are those shown on the duplicate photography.

2 See "Key" on page following

Table E-2. Coverage Dates[1] and Relative Quality[2] of NASA 70mm Aerial Photography Received

Great Plains Corridor Test Sites	Color Positive Transparencies								B & W Positive Transparencies							
	Type 1[2]		Type 2[2]		Type 3[2]		Type 4[2]		Type 1[2]		Type 2[2]		Type 3[2]		Type 4[2]	
	Date	Q[3]	Date	Q[3]	Date	Q[3]	Date	Q[3]	Date	Q[3]	Date	Q[3]	Date	Q[3]	Date	Q[3]
1. College Station			10-5-72 8-24-73 6-14-74	G F P			8-24-73 6-14-74	G P			8-24-73 6-14-74	G P	10-2-72 8-24-73 6-14-74	G G P	8-24-73 6-14-74	G P
2. Sonora	6-1-72	P	8-21-72 9-11-72 8-5-73 5-2-74 6-14-74	F P P G G	6-7-72 8-5-73	P P	9-11-72 8-5-73 5-2-74 6-14-74	P P G G	6-1-72 6-7-72	P P	7-23-72 8-21-72 9-11-72 8-5-74 5-2-74 6-14-74	G G P P G G	8-21-72 5-2-74 6-14-74	G G G	8-21-72 8-5-73 5-2-74 6-14-74	G P G G
3. Throckmorton			5-31-72 9-11-72 8-5-73 5-2-74 6-14-74	G P G G G	5-31-72 8-5-73	G G	9-11-72 8-5-73 5-2-74 6-14-74	P G G G			5-31-72 9-11-72 8-5-73 5-2-74 6-14-74	G P G G G	5-31-72 5-2-74 6-14-74	G G G	5-31-72 8-5-73 5-2-74 6-14-74	G G G G
4. Woodward			5-31-72 9-11-72 8-5-73 6-14-74	G P G G	5-31-72 8-5-73	G G	9-11-72 8-5-73 6-14-74	P G G			5-31-72 9-11-72 8-5-73 6-14-74	G P G G	5-31-72 6-14-74	G G	5-31-72 8-5-73 6-14-74	G G G
5. Hays			5-31-72 8-5-73 5-3-74 6-14-74	G G G G	5-31-72 8-5-73	G G	9-19-72 8-5-73 5-3-74 6-14-74	F G G G			5-31-72 8-18-72 9-19-72 8-5-73 5-3-74 6-14-74	G F F G G G	5-31-72 8-18-72 9-19-72 5-3-74 6-14-74	G G F G G	5-31-72 8-18-72 9-19-72 8-5-73 5-3-74 6-14-74	G G F G G G
6. Sand Hills			5-31-72 5-3-74 6-14-74	G G G	5-31-72	G	9-19-72 8-10-73 5-3-74 6-14-74	G G G G	8-10-73	G	5-31-72 9-19-72 8-10-73 5-3-74 6-14-74	G F G G G	5-31-72 9-19-72 5-3-74 6-14-74	G F G G	5-31-72 9-19-72 8-10-73 5-3-74 6-14-74	G F G G G
7. Cottonwood			5-31-72 5-3-74	G G	5-31-72	G	9-14-72 8-10-73 5-3-74	G G G	8-10-73	G	5-31-72 9-14-72 8-10-73 5-3-74	G G G G	5-31-72 9-14-72 5-3-74	G G G	5-31-72 9-19-72 8-10-73	G G G
8. Mandan			5-31-72	G	5-31-72	G	9-14-72	G			5-31-72 9-14-72	G G	5-31-72 9-14-72	G G	5-31-72	G
9. Weslaco			8-31-72 7-31-73	G G							8-31-72 7-31-73	G G	8-31-72 7-31-73	G G	8-31-72 7-31-73	G F
10. Chickasha			5-31-72 9-12-72 8-5-73 5-2-74 6-14-74	G G G G G	5-31-72 8-5-73	G G	9-12-72 8-5-73 6-14-74	G G G			5-31-72 9-12-72 8-5-73 5-2-74 6-14-74	G G G G G	5-31-72 9-12-72 5-2-74 6-14-74	G G G G	5-31-72 9-12-72 8-5-73 5-2-74 6-14-74	G P G G G

[1] Dates are those shown on the duplicate photography.

[2] See "Key" on following page.

[3] "Quality"

SYMBOLS USED FOR AERIAL PHOTOGRAPHY RECEIPT AND QUALITY DETERMINATION TABLES

AERIAL PHOTOGRAPHIC PRODUCTS

Relative quality determinations include these three categories:

G - good, the image includes the test site and is of high quality with little or no cloud cover

F - fair, the image includes the study site but the photography is of low quality or contains excessive cloud cover

P - poor, the image is of little or no use due to "missing" the study site partially or completely, or is poor quality photography, or contains excessive cloud cover

70mm aerial photographic products

Color Positive Transparencies

Type 1 - 2443 with no filter

Type 2 - 2443 with filter(s)

Type 3 - SO-356 with no filter

Type 4 - SO-356 with filter(s)

B & W Positive Transparencies

Type 1 - 2402 with no filter

Type 2 - 2402 with filter 25A

Type 3 - 2402 with filter 57

Type 4 - 2424 with filter 89B

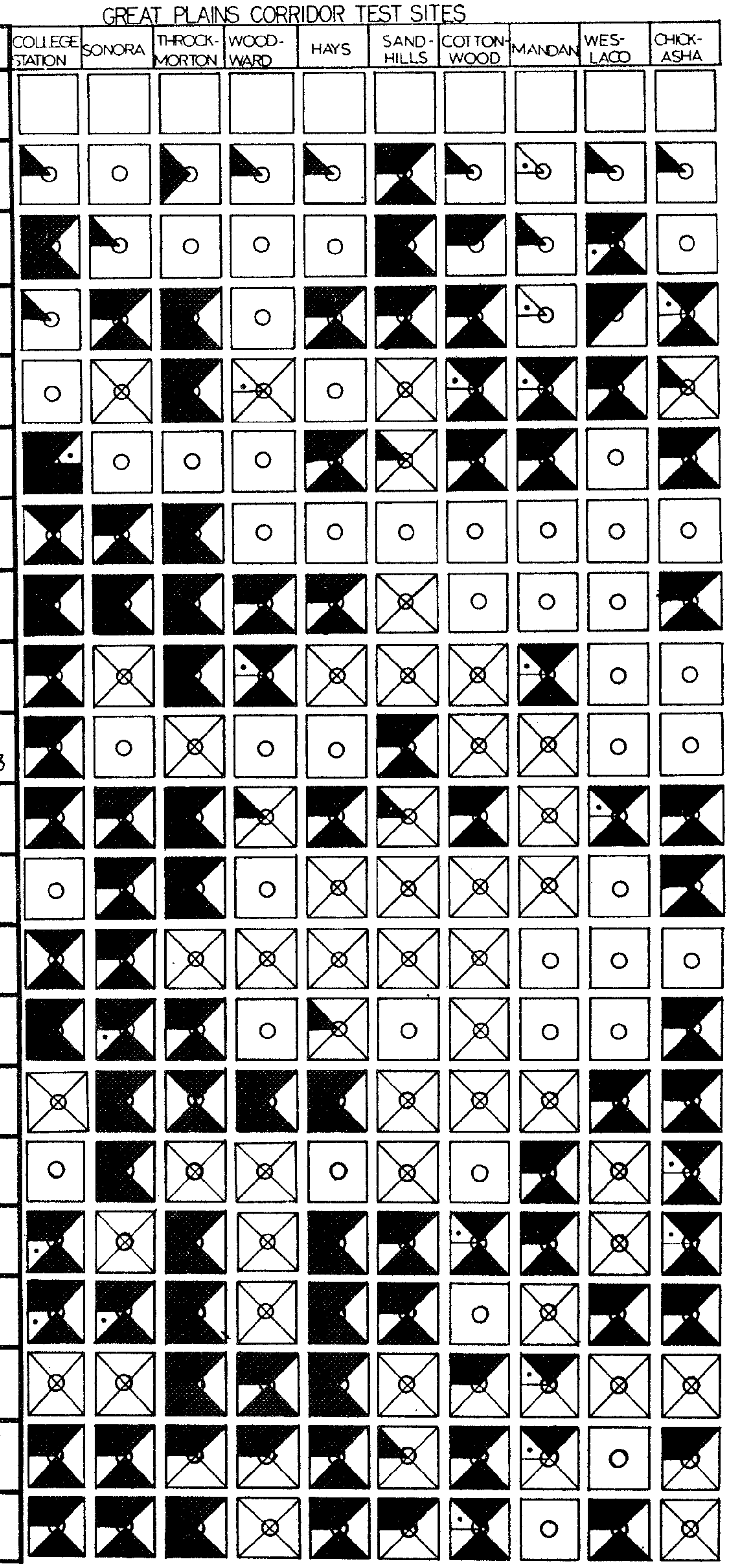
APPENDIX E

ERTS-1 IMAGERY AND TAPE

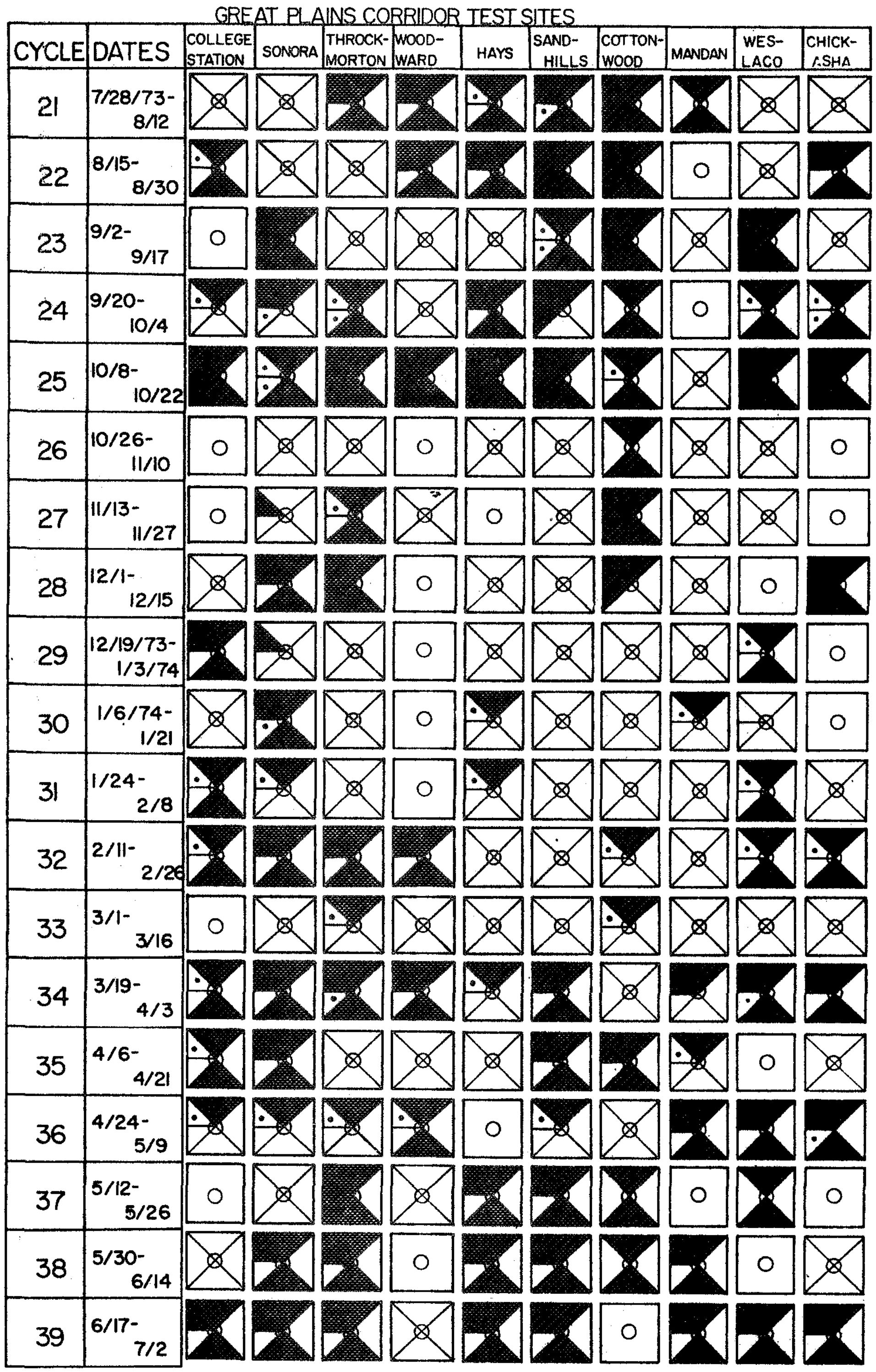
RECEIPTS AND ORDERS

GREAT PLAINS CORRIDOR TEST SITES

CYCLE	DATES
0	7/25/72 7/30
1	8/1 - 8/17
2	8/19 - 9/4
3	9/6 - 9/22
4	9/24 - 10/10
5	10/12 - 10/28
6	10/30 - 11/15
7	11/17 - 12/3
8	12/5 - 12/21
9	12/23 - 1/8/73
10	1/10 - 1/26
11	1/28 - 2/13
12	2/15 - 3/3
13	3/5 - 3/21
14	3/23 - 4/8
15	4/11 - 4/26
16	4/29 - 5/14
17	5/17 - 6/2
18	6/4 - 6/19
19	6/22 - 7/7
20	7/10 - 7/25

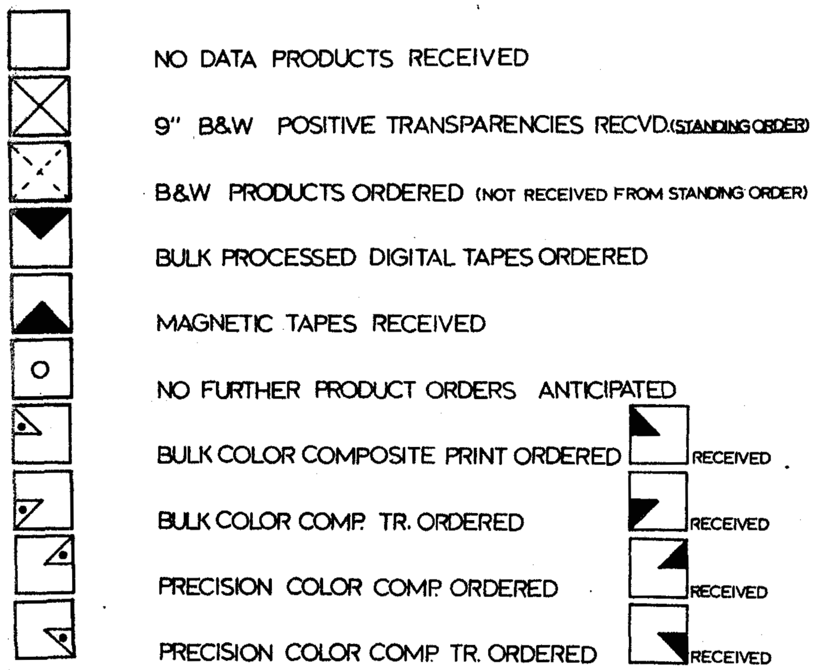


ERTS-I IMAGERY AND TAPE RECEIPTS AND ORDERS



Symbols Used for ERTS-1 Imagery and Tape

Receipts and Orders Quick-Look Chart



APPENDIX F

In this Appendix, the successful ERTS pass dates for each site are assigned to one of the four seasons--Spring, Summer, Fall, or Winter. They were assigned according to an evaluation made of ground truth data on the vegetation status at that date. Following the tables of sites/seasons, the ERTS channel radiances, calculated Band Ratio Parameter and Transformed Vegetation Index for each range site/date are tabulated. Each range site was classified under the scheme described in Appendix C above.

College Station (CS)

Spring	Summer	Fall	Winter
Mar 16 73	Jul 20 73	Oct 23 72	Dec 16 72
May 9 73	Jun 27 74	Nov 28 72	
May 27 73		Oct 18 73	
Mar 29 74			

Sonora (SO)

Mar 1 73	Jul 4 73	Sep 20 72	Dec 1 72
Mar 18 73	Jul 23 73	Nov 13 72	Jan 19 74
Apr 5 73		Sep 14 73	
Apr 24 73			
May 29 73			
Mar 31 74			
Apr 19 74			

Throckmorton (TH)

Spring	Summer	Fall	Winter
Mar 18 73	Jul 4 73	Sep 19 72	Nov 13 72
Apr 5 73	Jun 11 74	Oct 8 72	Dec 19 72
May 11 73	Jun 29 74	Oct 2 73	Feb 10 72
May 29 73		Oct 20 73	Dec 13 73
Mar 31 74			Feb 24 74
May 24 74			

Chickasha (CH)

Apr 5 73	Aug 27 73	Sep 19 72	Feb 10 73
Apr 23 73	Jun 29 74	Oct 25 72	Dec 13 73
May 11 73		Oct 2 73	
May 29 73		Oct 20 73	
May 6 74			

Woodward (WO)

Apr 6 73	Jul 5 73	Oct 21 73	Dec 1 72
Jun 17 73	Aug 10 73		
	Aug 28 73		

Hays (HA)

Spring	Summer	Fall	Winter
Apr 6 73	Jul 6 73	Sep 21 72	
May 13 73	Jul 23 73	Oct 26 72	
May 31 73	Aug 10 73	Oct 4 73	
Jun 17 73	Aug 29 73	Oct 21 73	

Sand Hills (SH)

May 15 73	Aug 17 72	Sep 4 72	
Jun 1 73	Jul 26 73		
May 28 74	Aug 12 73		
Jun 15 74	Aug 30 73		
	Jul 2 74		

Cottonwood (CW)

May 15 73	Aug 19 72	Sep 6 72	Oct 12 72
Jun 21 73	Jul 9 73	Sep 24 72	
Apr 22 74	Jul 26 73	Sep 1 73	
Jun 15 74	Aug 14 73	Sep 18 73	

Mandan (MA)

Spring	Summer	Fall	Winter
May 15 73	Jul 9 73	Sep 24 72	Oct 12 72
Jun 21 73			Apr 27 73
May 29 74			

Weslaco (WE)

Mar 16 73	Jul 20 73	Oct 6 72	
Apr 3 73	Sep 12 73	Sep 30 73	
Mar 29 74		Oct 18 73	
May 4 74			

COLLEGE STATION (NORTH), TEXAS

OPEN GRASSLAND--DEEP FINE SANDY LOAM (CS3 R1 GN)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
AUG 30 72	8.596	6.188	7.333	6.637	0.035	0.731
OCT 23 72	8.173	5.774	6.737	6.411	0.052	0.743
NOV 28 72	8.499	6.059	7.505	7.243	0.089	0.767
DEC 16 72	8.478	6.029	7.010	7.349	0.099	0.774
MAR 16 73	7.425	4.657	7.623	7.411	0.228	0.853
MAY 9 73	6.393	4.243	7.793	7.595	0.283	0.885
MAY 27 73	6.347	4.486	7.987	7.913	0.276	0.881
JUL 20 73	6.925	4.567	7.557	7.275	0.229	0.854
OCT 18 73	6.921	4.573	7.467	7.379	0.235	0.857
MAR 29 74	7.301	4.359	7.452	7.221	0.196	0.834
JUN 27 74	8.003	5.734	8.412	8.039	0.167	0.817

*OPEN GRASSLAND--DEEP FINE SANDY LOAM (CS3 R1 GN N1)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
AUG 30 72	8.633	6.169	7.598	7.026	0.065	0.752
OCT 23 72	7.324	5.577	5.945	5.599	0.002	0.709
NOV 28 72	8.130	6.066	6.403	6.073	0.001	0.707
DEC 16 72	7.930	5.861	5.776	5.916	0.005	0.710
MAR 16 73	7.231	5.184	6.034	5.698	0.047	0.740
MAY 9 73	7.436	5.164	7.031	6.540	0.118	0.786
MAY 27 73	7.531	5.448	7.966	7.564	0.163	0.814
JUL 20 73	6.596	4.436	6.921	6.495	0.188	0.830
OCT 18 73	6.739	4.779	6.598	6.514	0.154	0.808
MAR 29 74	6.917	4.207	6.939	6.543	0.225	0.851
JUN 27 74	8.114	6.086	7.933	7.387	0.097	0.772

*OPEN GRASSLAND--DEEP FINE SANDY LOAM (CS3 R1 GN N2)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
AUG 30 72	8.453	5.757	7.094	6.449	0.057	0.746
OCT 23 72	7.059	5.744	6.070	5.582	-0.014	0.697
NOV 28 72	8.242	6.078	6.436	6.014	-0.005	0.703
DEC 16 72	7.954	5.789	5.878	5.989	0.017	0.719
MAR 16 73	7.429	5.082	6.385	5.942	0.078	0.760
MAY 9 73	7.469	5.284	7.110	6.563	0.108	0.780
MAY 27 73	7.043	4.982	7.309	6.923	0.163	0.814
JUL 20 73	6.720	4.455	7.031	6.767	0.206	0.840
OCT 18 73	6.631	4.669	6.776	6.010	0.126	0.791
MAR 29 74	6.905	4.251	7.389	7.248	0.261	0.872
JUN 27 74	8.176	6.105	8.088	7.444	0.099	0.774

COLLEGE STATION (NORTH), TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP FINE SANDY LOAM (CS3 R1 GN N3)						
AUG 30 72	10.219	7.245	8.336	7.358	0.008	0.713
OCT 23 72	7.929	5.769	6.222	5.763	-0.001	0.707
NOV 28 72	8.258	6.160	6.696	6.333	0.014	0.717
DEC 16 72	8.032	5.927	6.082	6.061	0.011	0.715
MAR 16 73	7.423	5.145	6.347	5.886	0.067	0.753
MAY 9 73	7.125	4.901	6.680	6.141	0.112	0.783
MAY 27 73	6.986	4.901	6.897	6.483	0.139	0.799
JUL 20 73	7.395	5.325	7.274	6.667	0.112	0.782
OCT 18 73	6.812	4.774	7.117	6.599	0.160	0.813
MAR 29 74	7.022	4.591	7.408	7.211	0.222	0.850
JUN 27 74	7.928	5.821	7.549	6.954	0.089	0.767
SAVANNAH--DEEP FINE SANDY LOAM (CS3 R4 GN)						
AUG 30 72	8.069	5.333	6.917	6.659	0.111	0.781
OCT 23 72	7.649	5.057	6.033	5.745	0.064	0.751
NOV 28 72	7.301	5.364	6.249	6.003	0.056	0.746
DEC 16 72	7.841	5.235	5.702	6.085	0.075	0.758
MAR 16 73	7.224	4.668	6.594	6.418	0.158	0.811
MAY 9 73	6.631	3.895	7.656	7.477	0.315	0.903
MAY 27 73	6.439	3.751	8.264	8.324	0.379	0.937
JUL 20 73	7.153	4.951	7.679	7.320	0.203	0.838
OCT 18 73	6.342	3.935	6.359	6.296	0.231	0.855
MAR 29 74	7.629	5.306	7.874	7.590	0.177	0.823
JUN 27 74	7.309	4.859	7.665	7.492	0.213	0.845
WOODED GRASSLAND--DEEP FINE SANDY LOAM (CS3 R5 GN)						
AUG 30 72	8.100	5.780	6.764	6.130	0.029	0.728
OCT 23 72	7.597	5.072	6.259	6.020	0.085	0.765
NOV 28 72	8.019	5.563	6.476	6.167	0.052	0.743
DEC 16 72	7.761	5.273	5.971	6.104	0.073	0.757
MAR 16 73	7.112	4.755	6.320	5.960	0.112	0.783
MAY 9 73	6.592	3.969	7.348	7.190	0.289	0.888
MAY 27 73	6.427	4.054	7.753	7.798	0.316	0.903
JUL 20 73	6.265	3.724	7.647	7.645	0.345	0.919
OCT 18 73	6.205	3.802	7.029	6.462	0.259	0.871
MAR 29 74	7.253	4.931	7.301	7.108	0.181	0.825
JUN 27 74	7.706	5.499	8.231	7.968	0.183	0.827

COLLEGE STATION (NORTH), TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
WOODLAND--DEEP FINE SANDY LOAM (CS3 R6 GN)						
AUG 30 72	8.099	5.672	7.062	6.446	0.064	0.751
OCT 23 72	7.757	5.236	6.474	6.192	0.084	0.764
NOV 28 72	7.976	5.385	6.860	6.593	0.101	0.775
DEC 16 72	8.335	4.964	6.025	6.312	0.120	0.787
MAR 16 73	7.291	4.587	7.215	7.018	0.209	0.842
MAY 9 73	6.590	3.857	7.753	7.679	0.331	0.912
MAY 27 73	6.550	4.012	8.073	8.066	0.336	0.914
JUL 20 73	6.318	3.750	7.321	7.179	0.314	0.902
OCT 18 73	6.509	4.079	6.739	6.621	0.238	0.859
MAR 29 74	7.650	5.240	7.896	7.683	0.189	0.830
JUN 27 74	7.711	5.257	8.367	8.190	0.218	0.847
OPEN GRASSLAND--GULLIED AREAS (CS4 R1 GN)						
AUG 30 72	7.958	5.509	6.506	5.994	0.042	0.736
OCT 23 72	7.723	5.080	6.414	6.145	0.095	0.771
NOV 28 72	7.313	5.139	6.790	6.716	0.133	0.796
DEC 16 72	7.783	5.051	6.254	6.544	0.129	0.793
MAR 16 73	7.256	4.411	7.381	7.145	0.237	0.858
MAY 9 73	6.523	3.637	7.877	7.775	0.363	0.929
MAY 27 73	6.555	3.956	8.043	8.192	0.349	0.921
JUL 20 73	6.654	4.278	7.300	7.098	0.248	0.865
OCT 18 73	6.548	4.091	7.212	6.896	0.255	0.869
MAR 29 74	7.904	5.763	7.993	7.612	0.138	0.799
JUN 27 74	9.627	7.178	9.430	8.760	0.099	0.774
WOODLAND--DEEP LOAMY AND SANDY BOTTOMLANDS (CS5 R6 GN)						
AUG 30 72	8.440	5.921	7.102	6.471	0.044	0.738
OCT 23 72	7.536	4.883	6.590	6.439	0.137	0.798
NOV 28 72	7.745	5.125	6.926	6.859	0.145	0.803
DEC 16 72	7.313	4.703	6.309	6.945	0.193	0.832
MAR 16 73	7.226	4.311	7.720	7.603	0.276	0.881
MAY 9 73	6.297	3.496	7.976	8.128	0.398	0.948
MAY 27 73	6.305	3.747	8.232	8.466	0.386	0.941
JUL 20 73	6.592	4.132	7.629	7.531	0.291	0.890
OCT 18 73	6.450	4.001	7.015	7.203	0.286	0.886
MAR 29 74	7.359	4.992	7.431	7.209	0.182	0.826
JUN 27 74	7.549	5.219	8.678	8.649	0.247	0.865

COLLEGE STATION (NORTH), TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
PASTURELAND--DEEP FINE SANDY LOAM (CS3 P1 GT)						
AUG 30 72	9.917	7.167	7.969	7.166	-0.000	0.707
OCT 23 72	8.272	5.910	6.895	6.507	0.048	0.740
NOV 28 72	8.618	6.148	7.604	7.276	0.084	0.764
DEC 16 72	8.428	6.155	7.054	7.387	0.091	0.769
MAR 16 73	7.419	4.689	7.541	7.336	0.220	0.849
MAY 9 73	6.946	4.272	7.874	7.676	0.285	0.886
MAY 27 73	6.934	4.537	8.122	8.045	0.279	0.883
JUL 20 73	7.214	4.847	7.686	7.318	0.203	0.838
OCT 18 73	7.030	4.665	7.436	7.478	0.232	0.855
MAR 29 74	7.243	4.796	7.424	7.209	0.201	0.837
JUN 27 74	8.079	5.761	8.499	8.087	0.168	0.817

COLLEGE STATION (SOUTH), TEXAS

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--DEEP CLAYEY (CS1 R2 GN)						
OCT 23 72	7.977	5.313	6.591	6.343	0.088	0.767
NOV 28 72	8.476	5.865	7.462	7.303	0.109	0.781
DEC 16 72	7.603	4.683	5.451	5.440	0.075	0.758
MAR 16 73	7.710	4.291	9.055	8.891	0.349	0.921
MAY 9 73	6.392	3.865	8.863	8.849	0.392	0.944
MAY 27 73	6.730	4.489	7.850	7.850	0.272	0.879
JUL 20 73	7.031	4.195	8.556	8.189	0.323	0.907
OCT 18 73	6.927	3.954	8.119	8.614	0.371	0.933
MAR 29 74	7.590	5.495	6.978	6.565	0.089	0.767
JUN 27 74	8.629	7.092	7.980	7.404	0.021	0.722
WOODED GRASSLAND--DEEP CLAYEY (CS1 R5 GN)						
OCT 23 72	7.466	5.001	5.968	5.831	0.077	0.759
NOV 28 72	7.830	4.929	6.538	6.302	0.122	0.789
DEC 16 72	7.454	5.013	5.474	5.667	0.061	0.749
MAR 16 73	7.624	4.817	7.514	7.118	0.193	0.832
MAY 9 73	6.550	3.871	7.606	7.659	0.329	0.910
MAY 27 73	6.393	4.183	7.310	7.496	0.284	0.885
JUL 20 73	7.347	4.819	7.695	7.198	0.198	0.835
OCT 18 73	6.299	3.550	6.352	6.745	0.310	0.900
MAR 29 74	7.257	4.921	7.391	7.026	0.176	0.822
JUN 27 74	8.331	6.653	8.015	7.525	0.062	0.749
WOODLAND--DEEP CLAY AND LOAMY BOTTOMLANDS (CS2 R6 GN)						
OCT 23 72	6.924	4.312	5.984	5.919	0.157	0.811
NOV 28 72	7.707	5.142	6.179	6.044	0.081	0.762
DEC 16 72	8.329	6.032	6.095	6.157	0.010	0.714
MAR 16 73	7.377	4.652	6.498	6.242	0.146	0.804
MAY 9 73	6.380	3.658	7.509	7.341	0.335	0.914
MAY 27 73	6.208	3.606	7.686	7.751	0.365	0.930
JUL 20 73	5.341	2.832	5.503	5.230	0.297	0.893
OCT 18 73	6.366	3.957	6.685	6.393	0.235	0.858
MAR 29 74	7.177	4.494	8.415	8.596	0.313	0.902
JUN 27 74	7.329	5.037	7.303	7.085	0.169	0.818
*OPEN GRASSLAND--DEEP FINE SANDY LOAM (CS3 R1 GN)						
OCT 23 72	7.613	5.094	6.416	6.233	0.101	0.775
NOV 28 72	8.215	5.719	6.844	6.585	0.070	0.755
DEC 16 72	8.740	6.118	6.952	6.999	0.067	0.753
MAR 16 73	7.576	4.862	7.285	7.000	0.180	0.825
MAY 9 73	6.771	4.158	7.728	7.507	0.287	0.887
MAY 27 73	6.713	4.383	7.744	7.695	0.274	0.880
JUL 20 73	6.203	3.865	6.216	5.799	0.200	0.837
OCT 18 73	6.796	4.381	6.929	6.946	0.226	0.852
MAR 29 74	7.362	4.975	7.867	7.755	0.218	0.848
JUN 27 74	8.058	6.131	7.737	7.312	0.088	0.767

COLLEGE STATION (SOUTH), TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--DEEP FINE SANDY LOAM (CS3 R2 GN)						
OCT 23 72	7.652	5.075	6.662	6.498	0.123	0.789
NOV 28 72	8.247	5.734	7.111	6.888	0.091	0.769
DEC 16 72	8.694	6.090	6.695	6.624	0.042	0.736
MAR 16 73	7.655	5.130	6.929	6.566	0.123	0.789
MAY 9 73	6.678	4.094	7.586	7.441	0.290	0.889
MAY 27 73	6.560	4.085	7.873	8.034	0.326	0.909
JUL 20 73	5.830	3.453	5.649	5.222	0.204	0.839
OCT 18 73	6.715	4.232	6.712	6.962	0.244	0.863
MAR 29 74	7.285	4.811	7.796	7.660	0.228	0.853
JUN 27 74	7.921	5.754	7.647	7.158	0.109	0.780
SAVANNAH--DEEP FINE SANDY LOAM (CS3 R4 GN)						
OCT 23 72	7.543	5.072	5.924	5.612	0.051	0.742
NOV 28 72	7.894	5.451	6.026	5.695	0.022	0.722
DEC 16 72	8.655	6.011	6.976	7.082	0.082	0.763
MAR 16 73	7.440	5.030	5.954	5.486	0.043	0.737
MAY 9 73	6.890	4.478	7.135	6.754	0.203	0.838
MAY 27 73	6.790	4.601	7.280	7.052	0.210	0.843
JUL 20 73	6.370	4.149	6.118	5.713	0.159	0.812
OCT 18 73	6.533	4.228	6.088	6.023	0.175	0.822
MAR 29 74	7.491	5.184	7.806	7.674	0.194	0.833
JUN 27 74	7.626	5.498	7.218	6.761	0.103	0.777
WOODED GRASSLAND--DEEP FINE SANDY LOAM (CS3 R5 GN)						
OCT 23 72	6.796	4.136	5.385	5.260	0.120	0.787
NOV 28 72	7.407	4.780	5.679	5.454	0.066	0.752
DEC 16 72	8.435	5.650	7.505	7.872	0.164	0.815
MAR 16 73	7.421	4.823	6.473	6.144	0.120	0.788
MAY 9 73	6.271	3.699	7.298	7.295	0.327	0.909
MAY 27 73	6.127	3.750	7.328	7.483	0.332	0.912
JUL 20 73	6.013	3.581	6.375	6.175	0.266	0.875
OCT 18 73	6.112	3.615	6.199	5.943	0.244	0.862
MAR 29 74	7.564	5.461	7.236	6.892	0.116	0.785
JUN 27 74	7.234	4.854	7.180	7.032	0.183	0.827
WOODLAND--DEEP FINE SANDY LOAM (CS6 R6 GN)						
OCT 23 72	6.915	4.240	5.722	5.575	0.136	0.798
NOV 28 72	7.506	4.875	5.864	5.634	0.072	0.756
DEC 16 72	8.546	5.909	6.679	6.721	0.064	0.751
MAR 16 73	7.356	4.713	6.463	6.149	0.132	0.795
MAY 9 73	6.151	3.500	7.280	7.301	0.352	0.923
MAY 27 73	6.019	3.584	7.286	7.458	0.351	0.922
JUL 20 73	5.341	3.387	6.099	5.399	0.270	0.878
OCT 18 73	6.047	3.587	5.639	5.831	0.238	0.859
MAR 29 74	7.516	5.235	7.771	7.587	0.183	0.827
JUN 27 74	7.075	4.661	7.339	7.257	0.218	0.847

COLLEGE STATION (SOUTH), TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
PASTURELAND--DEEP CLAY AND LOAMY BOTTOMLANDS (CS2 P1 GT)						
OCT 23 72	8.499	6.132	7.618	7.231	0.082	0.763
NOV 28 72	9.169	6.686	8.108	7.743	0.073	0.757
DEC 16 72	7.650	5.063	5.544	5.699	0.059	0.748
MAR 16 73	7.671	4.747	8.238	7.905	0.250	0.866
MAY 9 73	6.738	3.944	8.447	8.470	0.365	0.930
MAY 27 73	6.892	4.489	8.526	8.697	0.319	0.905
JUL 20 73	6.942	4.113	8.787	8.610	0.353	0.924
OCT 18 73	7.284	4.823	8.021	8.218	0.260	0.872
MAR 29 74	7.270	4.814	7.841	7.718	0.232	0.855
JUN 27 74	8.246	5.920	9.276	9.121	0.213	0.844
***PASTURELAND--DEEP FINE SANDY LOAM (CS3 P1 GT)**						
OCT 23 72	7.652	5.129	6.863	6.689	0.132	0.795
NOV 28 72	8.522	5.988	7.564	7.386	0.105	0.778
DEC 16 72	8.587	5.963	7.119	7.365	0.105	0.778
MAR 16 73	7.094	4.167	7.414	7.250	0.270	0.878
MAY 9 73	6.704	4.059	7.649	7.452	0.295	0.891
MAY 27 73	6.709	4.394	7.591	7.567	0.265	0.875
JUL 20 73	6.150	3.784	6.405	6.096	0.234	0.857
OCT 18 73	6.937	4.481	7.402	7.636	0.260	0.872
MAR 29 74	7.576	5.387	7.687	7.451	0.161	0.813
JUN 27 74	8.375	6.669	7.751	7.124	0.033	0.730

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DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN1)						
SEP 20 72	8.992	6.626	7.319	6.441	-0.014	0.697
NOV 13 72	8.178	5.631	6.423	6.351	0.060	0.748
DEC 1 72	8.155	5.643	6.191	5.997	0.030	0.728
MAR 1 73	8.182	5.936	5.565	5.167	-0.069	0.656
MAR 18 73	9.693	7.072	7.014	6.495	-0.043	0.676
APR 5 73	9.030	6.637	7.040	6.629	-0.001	0.707
APR 24 73	8.102	6.006	6.308	5.855	-0.013	0.698
MAY 29 73	9.102	7.264	7.166	6.686	-0.041	0.677
JUL 4 73	8.503	6.398	6.823	5.957	-0.036	0.681
JUL 23 73	8.021	5.988	6.335	5.617	-0.032	0.684
SEP 14 73	8.568	6.118	6.600	5.733	-0.033	0.684
JAN 19 74	8.537	6.304	6.110	5.204	-0.096	0.636
MAR 31 74	8.784	6.793	6.632	6.010	-0.061	0.662
APR 19 74	8.403	6.537	6.620	5.771	-0.062	0.662
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN2)						
SEP 20 72	9.606	7.335	7.533	6.595	-0.053	0.668
NOV 13 72	8.107	5.584	6.291	6.159	0.049	0.741
DEC 1 72	8.707	6.154	6.469	6.190	0.003	0.709
MAR 1 73	8.295	6.129	5.718	5.257	-0.077	0.651
MAR 18 73	7.242	7.675	7.562	6.828	-0.058	0.665
APR 5 73	9.100	6.763	7.110	6.532	-0.017	0.695
APR 24 73	8.103	6.054	6.352	5.831	-0.019	0.694
MAY 29 73	9.173	7.466	7.379	6.676	-0.056	0.666
JUL 4 73	8.605	6.478	6.892	6.106	-0.030	0.686
JUL 23 73	8.241	6.273	6.591	5.885	-0.032	0.684
SEP 14 73	8.618	6.172	6.531	5.712	-0.039	0.679
JAN 19 74	8.301	5.976	5.817	5.259	-0.064	0.660
MAR 31 74	9.004	7.026	6.892	6.184	-0.064	0.661
APR 19 74	8.738	6.981	7.012	6.254	-0.055	0.667
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN3)						
SEP 20 72	9.713	7.350	7.716	6.630	-0.051	0.670
NOV 13 72	8.492	5.981	6.817	6.666	0.054	0.744
DEC 1 72	9.099	6.477	6.831	6.612	0.010	0.714
MAR 1 73	8.434	6.376	5.865	5.477	-0.076	0.651
MAR 18 73	9.525	8.151	7.875	7.267	-0.057	0.665
APR 5 73	9.335	7.079	7.498	7.075	-0.000	0.707
APR 24 73	8.305	6.421	6.676	6.279	-0.011	0.699
MAY 29 73	9.450	7.845	7.491	6.346	-0.068	0.657
JUL 4 73	8.035	6.946	7.153	6.351	-0.045	0.675
JUL 23 73	8.320	6.365	6.771	6.005	-0.029	0.686
SEP 14 73	8.753	6.366	6.911	6.044	-0.026	0.684
JAN 19 74	8.903	6.629	6.542	5.515	-0.092	0.639
MAR 31 74	9.106	7.289	7.173	6.518	-0.056	0.666
APR 19 74	8.930	7.224	7.245	6.307	-0.068	0.657

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GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN4)						
SEP 20 72	8.985	6.521	7.988	6.512	-0.001	0.707
NOV 13 72	8.733	6.235	6.789	6.543	0.032	0.729
DEC 1 72	9.156	6.676	6.864	6.505	-0.013	0.698
MAR 1 73	8.597	6.583	6.010	5.581	-0.082	0.646
MAR 18 73	8.261	8.194	7.857	7.038	-0.076	0.651
APR 5 73	9.505	7.276	7.549	7.022	-0.018	0.694
APR 24 73	8.355	6.321	6.671	6.205	-0.009	0.701
MAY 29 73	9.514	7.897	7.614	6.972	-0.062	0.662
JUL 4 73	8.930	6.897	7.112	6.305	-0.045	0.675
JUL 23 73	8.416	6.355	6.824	6.159	-0.016	0.696
SEP 14 73	9.039	6.631	7.078	6.125	-0.040	0.678
JAN 19 74	9.093	6.938	6.528	5.810	-0.088	0.642
MAR 31 74	9.432	7.467	7.316	6.552	-0.065	0.659
APR 19 74	8.969	7.306	7.214	6.295	-0.074	0.652
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN5)						
SEP 20 72	8.909	6.535	7.481	6.580	0.003	0.710
NOV 13 72	8.370	6.045	6.689	6.473	0.034	0.731
DEC 1 72	9.026	6.674	6.694	6.248	-0.033	0.683
MAR 1 73	8.601	6.557	5.841	5.326	-0.104	0.630
MAR 18 73	10.303	8.470	7.916	6.980	-0.096	0.635
APR 5 73	9.326	7.120	7.404	6.797	-0.023	0.691
APR 24 73	8.334	6.340	6.494	5.899	-0.036	0.681
MAY 29 73	9.397	7.638	7.379	6.762	-0.061	0.663
JUL 4 73	8.742	6.873	7.116	6.172	-0.054	0.668
JUL 23 73	8.217	6.263	6.817	5.919	-0.028	0.687
SEP 14 73	8.674	6.273	6.749	5.813	-0.038	0.680
JAN 19 74	8.908	6.775	6.584	5.428	-0.110	0.624
MAR 31 74	9.235	7.304	6.875	6.230	-0.079	0.649
APR 19 74	8.959	7.422	7.115	6.024	-0.104	0.629
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN6)						
SEP 20 72	9.259	6.873	7.689	6.790	-0.006	0.703
NOV 13 72	8.657	6.334	6.910	6.714	0.029	0.727
DEC 1 72	9.402	6.951	7.134	6.607	-0.025	0.689
MAR 1 73	8.947	6.885	6.189	5.512	-0.111	0.624
MAR 18 73	7.328	8.476	8.101	7.172	-0.083	0.646
APR 5 73	9.761	7.633	7.804	6.944	-0.047	0.673
APR 24 73	8.616	6.752	6.895	6.169	-0.045	0.674
MAY 29 73	9.314	8.271	7.814	6.879	-0.092	0.639
JUL 4 73	9.216	7.149	7.477	6.430	-0.053	0.669
JUL 23 73	8.722	6.706	7.232	6.263	-0.034	0.683
SEP 14 73	9.070	6.715	7.230	6.087	-0.049	0.672
JAN 19 74	8.952	7.074	6.514	5.681	-0.109	0.625
MAR 31 74	9.504	7.915	7.463	6.429	-0.104	0.630
APR 19 74	9.416	7.918	7.636	6.563	-0.094	0.638

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GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN7)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
SEP 20 72	9.220	6.926	7.609	6.703	-0.016	0.695
NOV 13 72	8.236	5.827	6.675	6.489	0.054	0.744
DEC 1 72	8.355	6.430	6.815	6.352	-0.006	0.703
MAR 1 73	8.536	6.525	5.977	5.355	-0.099	0.634
MAR 18 73	10.456	8.062	7.860	6.978	-0.072	0.654
APR 5 73	9.295	7.027	7.459	6.763	-0.019	0.693
APR 24 73	8.248	6.338	6.491	5.946	-0.032	0.684
MAY 29 73	9.239	7.583	7.225	6.477	-0.079	0.649
JUL 4 73	8.545	6.486	6.950	5.974	-0.041	0.677
JUL 23 73	7.905	5.855	6.534	5.727	-0.011	0.699
SEP 14 73	8.792	6.409	6.886	5.869	-0.044	0.675
JAN 19 74	9.214	7.098	6.828	5.590	-0.119	0.617
MAR 31 74	9.317	7.410	6.977	6.068	-0.100	0.633
APR 19 74	8.842	7.280	7.172	6.111	-0.087	0.642

*GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN8)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
SEP 20 72	8.795	6.565	7.108	6.391	-0.013	0.698
NOV 13 72	8.000	5.838	6.354	6.203	0.030	0.728
DEC 1 72	8.359	6.636	6.621	6.211	-0.033	0.683
MAR 1 73	9.934	7.919	6.757	5.801	-0.154	0.588
MAR 18 73	8.527	7.908	7.468	6.580	-0.092	0.639
APR 5 73	9.259	7.154	7.211	6.426	-0.054	0.668
APR 24 73	8.199	6.221	6.533	5.848	-0.031	0.685
MAY 29 73	9.355	7.772	7.482	6.585	-0.083	0.646
JUL 4 73	8.701	6.607	7.150	6.153	-0.036	0.681
JUL 23 73	8.423	6.403	6.925	6.015	-0.031	0.685
SEP 14 73	8.392	6.472	7.174	6.018	-0.036	0.681
JAN 19 74	8.927	7.071	6.350	5.420	-0.132	0.607
MAR 31 74	9.191	7.342	6.996	6.003	-0.100	0.632
APR 19 74	9.159	7.694	7.364	6.279	-0.101	0.631

*GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN9)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
SEP 20 72	8.738	8.401	7.303	6.367	-0.138	0.602
NOV 13 72	8.095	5.587	6.526	6.366	0.065	0.752
DEC 1 72	9.009	6.522	6.726	6.286	-0.018	0.694
MAR 1 73	9.315	7.601	6.623	5.833	-0.132	0.607
MAR 18 73	8.575	7.554	7.349	6.606	-0.067	0.658
APR 5 73	9.123	6.755	7.277	6.711	-0.003	0.705
APR 24 73	8.069	6.048	6.437	5.929	-0.010	0.700
MAY 29 73	9.424	7.686	7.552	6.855	-0.057	0.665
JUL 4 73	8.432	6.289	6.881	6.029	-0.021	0.692
JUL 23 73	8.151	6.075	6.637	5.806	-0.023	0.691
SEP 14 73	8.391	6.495	7.044	6.043	-0.036	0.681
JAN 19 74	8.399	7.070	6.529	5.422	-0.132	0.607
MAR 31 74	9.234	7.279	7.117	6.375	-0.066	0.659
APR 19 74	8.977	7.339	7.202	6.275	-0.078	0.649

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GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN10)						
SEP 20 72	8.738	7.625	7.183	6.363	-0.090	0.640
NOV 13 72	8.375	5.917	6.524	6.419	0.041	0.735
DEC 1 72	8.734	6.362	6.583	6.124	-0.019	0.694
MAR 1 73	8.722	6.587	5.993	5.368	-0.102	0.631
MAR 18 73	8.538	7.992	7.586	6.667	-0.090	0.640
APR 5 73	9.300	6.971	7.241	6.558	-0.031	0.685
APR 24 73	8.014	6.112	6.233	5.696	-0.035	0.682
MAY 29 73	9.029	7.267	7.245	6.492	-0.056	0.666
JUL 4 73	8.752	6.648	7.044	6.089	-0.044	0.675
JUL 23 73	7.935	5.879	6.493	5.676	-0.018	0.695
SEP 14 73	8.702	6.263	6.856	5.897	-0.030	0.686
JAN 19 74	8.746	6.721	6.362	5.391	-0.110	0.625
MAR 31 74	9.155	7.251	6.996	6.177	-0.080	0.648
APR 19 74	8.979	7.251	7.267	6.250	-0.074	0.653
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN11)						
SEP 20 72	8.922	6.835	7.212	6.341	-0.037	0.680
NOV 13 72	8.436	5.963	6.444	6.274	0.025	0.725
DEC 1 72	8.854	6.440	6.628	6.176	-0.021	0.692
MAR 1 73	8.314	6.689	5.974	5.436	-0.103	0.630
MAR 18 73	10.033	7.526	7.134	6.435	-0.078	0.649
APR 5 73	9.138	6.856	7.164	6.609	-0.018	0.694
APR 24 73	8.032	6.054	6.288	5.892	-0.014	0.697
MAY 29 73	9.130	7.262	7.297	6.705	-0.040	0.678
JUL 4 73	8.559	6.486	6.812	5.951	-0.043	0.676
JUL 23 73	8.173	6.145	6.563	5.684	-0.039	0.679
SEP 14 73	8.740	6.308	6.810	5.837	-0.039	0.679
JAN 19 74	8.702	6.599	6.274	5.171	-0.121	0.615
MAR 31 74	8.950	6.942	6.804	6.005	-0.072	0.654
APR 19 74	8.316	7.056	7.033	6.031	-0.078	0.649
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN12)						
SEP 20 72	8.302	6.658	7.249	6.263	-0.031	0.685
NOV 13 72	8.598	6.233	6.722	6.553	0.025	0.725
DEC 1 72	9.478	6.856	6.924	6.457	-0.030	0.686
MAR 1 73	9.337	7.197	6.308	5.650	-0.120	0.616
MAR 18 73	6.727	7.646	7.267	6.403	-0.089	0.641
APR 5 73	9.494	7.165	7.599	6.968	-0.014	0.697
APR 24 73	8.351	6.408	6.543	6.089	-0.026	0.689
MAY 29 73	9.636	7.876	7.701	7.058	-0.055	0.657
JUL 4 73	8.905	6.856	7.036	6.148	-0.054	0.667
JUL 23 73	8.502	6.486	6.876	6.032	-0.036	0.681
SEP 14 73	9.113	6.648	7.029	6.067	-0.046	0.674
JAN 19 74	8.702	6.791	6.171	5.301	-0.123	0.614
MAR 31 74	9.517	7.513	7.268	6.541	-0.069	0.656
APR 19 74	9.173	7.529	7.367	6.481	-0.075	0.652

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GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN13)						
SEP 20 72	8.964	6.662	7.002	6.207	-0.035	0.682
NOV 13 72	8.463	5.843	6.482	6.299	0.038	0.733
DEC 1 72	8.987	6.570	6.763	6.264	-0.024	0.690
MAR 1 73	8.742	6.503	5.804	5.209	-0.110	0.624
MAR 18 73	8.123	7.424	7.008	6.205	-0.089	0.641
APR 5 73	9.266	6.975	7.252	6.594	-0.028	0.687
APR 24 73	8.233	6.145	6.250	5.909	-0.020	0.693
MAY 29 73	9.159	7.371	7.368	6.695	-0.048	0.672
JUL 4 73	8.707	6.515	6.994	6.143	-0.029	0.686
JUL 23 73	8.205	6.078	6.657	5.389	-0.016	0.696
SEP 14 73	9.126	6.718	7.115	6.094	-0.049	0.672
JAN 19 74	9.100	7.189	6.458	5.590	-0.125	0.612
MAR 31 74	9.136	7.163	7.068	6.135	-0.077	0.650
APR 19 74	8.930	7.195	7.185	6.301	-0.066	0.659
GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN15)						
SEP 20 72	9.454	7.395	7.454	6.377	-0.074	0.653
NOV 13 72	8.629	6.163	7.013	6.599	0.034	0.731
DEC 1 72	9.037	6.725	6.904	6.430	-0.022	0.691
MAR 1 73	7.671	5.343	4.702	3.956	-0.149	0.592
MAR 18 73	10.391	8.146	7.493	6.708	-0.097	0.635
APR 5 73	9.557	7.386	7.541	6.855	-0.037	0.680
APR 24 73	8.520	6.595	6.532	6.071	-0.041	0.677
MAY 29 73	9.437	7.711	7.546	6.846	-0.059	0.664
JUL 4 73	9.308	7.359	7.391	6.311	-0.077	0.651
JUL 23 73	8.330	6.308	6.945	6.114	-0.016	0.696
SEP 14 73	9.014	6.572	7.291	6.199	-0.029	0.686
JAN 19 74	9.173	7.038	6.637	5.482	-0.124	0.613
MAR 31 74	9.498	7.683	7.180	6.178	-0.109	0.626
APR 19 74	9.332	7.778	7.370	6.169	-0.115	0.620
***GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GN17)**						
SEP 20 72	8.133	6.079	6.840	6.039	-0.003	0.705
NOV 13 72	7.947	5.537	6.321	5.903	0.032	0.729
DEC 1 72	8.652	6.255	6.526	6.002	-0.021	0.692
MAR 1 73	8.717	6.676	6.005	5.271	-0.118	0.618
MAR 18 73	9.994	7.588	7.084	6.246	-0.097	0.635
APR 5 73	8.943	6.836	6.834	6.270	-0.043	0.676
APR 24 73	8.114	6.164	6.023	5.537	-0.054	0.668
MAY 29 73	9.049	7.036	7.303	6.620	-0.031	0.685
JUL 4 73	8.457	6.285	6.899	5.920	-0.030	0.686
JUL 23 73	7.978	5.958	6.371	5.555	-0.035	0.682
SEP 14 73	8.636	6.253	6.759	5.783	-0.039	0.679
JAN 19 74	8.797	6.705	6.296	5.112	-0.135	0.604
MAR 31 74	8.745	6.755	6.444	5.752	-0.080	0.648
APR 19 74	8.659	6.929	6.822	5.887	-0.081	0.647

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*GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN19)						
SEP 20 72	8.538	6.309	6.864	6.223	-0.007	0.702
NOV 13 72	8.392	6.698	6.875	6.498	-0.015	0.696
DEC 1 72	9.589	7.354	7.026	6.569	-0.056	0.666
MAR 1 73	9.339	7.258	6.209	5.466	-0.141	0.599
MAR 18 73	10.299	8.035	7.350	6.583	-0.099	0.633
APR 5 73	9.661	7.563	7.533	6.804	-0.053	0.669
APR 24 73	8.556	6.653	6.960	6.368	-0.022	0.691
MAY 29 73	9.777	8.023	7.631	6.911	-0.074	0.652
JUL 4 73	9.224	7.278	6.999	5.949	-0.100	0.632
JUL 23 73	8.573	6.686	6.702	5.768	-0.074	0.653
SEP 14 73	9.231	6.932	7.111	6.025	-0.070	0.656
JAN 19 74	9.412	7.442	6.886	5.600	-0.141	0.599
MAR 31 74	9.552	7.599	7.183	6.310	-0.093	0.638
APR 19 74	9.390	7.856	7.460	6.347	-0.106	0.628
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN22)						
SEP 20 72	8.594	7.599	7.069	6.324	-0.092	0.639
NOV 13 72	9.235	6.889	7.151	6.765	-0.009	0.701
DEC 1 72	9.859	7.459	7.244	6.766	-0.049	0.672
MAR 1 73	9.354	7.711	6.709	5.958	-0.128	0.610
MAR 18 73	8.505	8.302	7.799	6.864	-0.095	0.637
APR 5 73	9.320	7.636	7.913	7.214	-0.028	0.687
APR 24 73	8.548	6.616	6.992	6.397	-0.017	0.695
MAY 29 73	9.923	8.270	7.929	7.160	-0.072	0.654
JUL 4 73	9.144	7.185	7.074	6.064	-0.085	0.644
JUL 23 73	8.794	6.992	6.880	5.927	-0.082	0.646
SEP 14 73	9.135	6.774	7.200	6.195	-0.045	0.675
JAN 19 74	9.579	7.753	6.956	5.976	-0.129	0.609
MAR 31 74	9.737	7.919	7.609	6.744	-0.080	0.648
APR 19 74	9.538	7.988	7.789	6.707	-0.087	0.643
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN23)						
SEP 20 72	9.097	6.925	7.566	6.578	-0.026	0.689
NOV 13 72	8.474	5.949	6.724	6.491	0.044	0.737
DEC 1 72	8.335	6.316	6.691	6.353	0.003	0.709
MAR 1 73	8.551	6.488	5.955	5.483	-0.084	0.645
MAR 18 73	8.957	8.376	8.110	7.247	-0.072	0.654
APR 5 73	9.314	7.037	7.556	6.964	-0.009	0.701
APR 24 73	8.124	6.194	6.473	5.974	-0.018	0.694
MAY 29 73	9.219	7.518	7.468	6.738	-0.055	0.667
JUL 4 73	8.771	6.785	7.101	6.152	-0.049	0.672
JUL 23 73	8.135	6.146	6.527	5.747	-0.034	0.683
SEP 14 73	8.523	5.912	6.806	5.977	0.005	0.711
JAN 19 74	8.731	6.650	6.428	5.429	-0.101	0.632
MAR 31 74	9.235	7.232	6.960	6.245	-0.073	0.653
APR 19 74	9.011	7.385	7.235	6.260	-0.082	0.646

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GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN24)						
SEP 20 72	8.498	6.279	7.114	6.389	0.009	0.713
NOV 13 72	9.404	7.246	7.431	8.069	0.054	0.744
DEC 1 72	10.073	7.826	7.454	6.837	-0.067	0.658
MAR 1 73	9.443	7.508	6.601	5.733	-0.134	0.605
MAR 18 73	9.401	9.319	8.506	7.334	-0.119	0.617
APR 5 73	10.250	8.181	8.033	7.155	-0.067	0.658
APR 24 73	9.201	7.431	7.268	6.364	-0.077	0.650
MAY 29 73	10.164	8.376	8.054	7.026	-0.088	0.642
JUL 4 73	9.553	7.694	7.741	6.498	-0.084	0.645
JUL 23 73	9.048	7.165	7.346	6.259	-0.067	0.658
SEP 14 73	9.235	6.837	7.323	6.224	-0.047	0.673
JAN 19 74	9.379	7.481	6.937	5.863	-0.121	0.615
MAR 31 74	9.868	8.038	7.556	6.513	-0.105	0.629
APR 19 74	9.772	8.295	7.936	6.624	-0.112	0.623
***OPEN GRASSLAND--SHALLOW STONY CLAY (S04 R1 GN25)**						
SEP 20 72	8.425	6.177	7.079	6.269	0.007	0.712
NOV 13 72	9.176	6.785	7.093	6.665	-0.009	0.701
DEC 1 72	9.915	7.540	7.289	6.738	-0.056	0.666
MAR 1 73	10.291	8.142	7.152	6.183	-0.137	0.603
MAR 18 73	8.904	8.616	8.094	7.081	-0.098	0.634
APR 5 73	10.221	8.123	8.042	7.262	-0.056	0.666
APR 24 73	8.846	7.019	6.984	6.321	-0.052	0.669
MAY 29 73	10.431	8.726	8.223	7.227	-0.094	0.637
JUL 4 73	9.645	7.736	7.629	6.435	-0.092	0.639
JUL 23 73	9.079	7.177	7.207	6.220	-0.071	0.655
SEP 14 73	9.438	7.169	7.393	6.212	-0.072	0.655
JAN 19 74	9.653	7.796	7.035	5.927	-0.136	0.603
MAR 31 74	10.106	8.341	7.751	6.741	-0.106	0.628
APR 19 74	9.309	8.327	7.913	6.752	-0.104	0.629
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN26)						
SEP 20 72	9.137	6.782	7.563	6.645	-0.010	0.700
NOV 13 72	8.507	6.085	6.751	6.492	0.032	0.730
DEC 1 72	9.208	6.914	7.003	6.531	-0.028	0.687
MAR 1 73	8.722	6.671	6.012	5.241	-0.120	0.616
MAR 18 73	8.302	8.356	8.109	7.105	-0.081	0.647
APR 5 73	9.269	7.128	7.606	6.946	-0.013	0.698
APR 24 73	8.193	6.145	6.685	6.029	-0.010	0.700
MAY 29 73	9.233	7.645	7.509	6.786	-0.060	0.664
JUL 4 73	8.654	6.592	7.142	6.193	-0.031	0.685
JUL 23 73	7.934	6.006	6.521	5.679	-0.028	0.687
SEP 14 73	8.501	6.177	6.702	5.811	-0.031	0.685
JAN 19 74	8.835	7.008	6.569	5.548	-0.116	0.619
MAR 31 74	9.228	7.288	7.053	6.220	-0.079	0.649
APR 19 74	9.010	7.449	7.408	6.345	-0.080	0.648

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OPEN GRASSLAND--SHALLOW STONY CLAY (SO4 R1 GN27)						
SEP 20 72	8.637	6.249	7.477	6.438	0.015	0.718
NOV 13 72	8.729	6.290	6.974	6.550	0.020	0.721
DEC 1 72	9.201	6.842	7.008	6.437	-0.030	0.685
MAR 1 73	8.829	6.757	6.131	5.376	-0.114	0.621
MAR 18 73	9.124	8.442	8.080	7.079	-0.088	0.642
APR 5 73	9.578	7.415	7.671	6.860	-0.039	0.679
APR 24 73	8.329	6.363	6.633	5.956	-0.033	0.683
MAY 29 73	9.479	7.853	7.567	6.691	-0.080	0.648
JUL 4 73	8.877	6.818	7.295	6.301	-0.039	0.679
JUL 23 73	8.092	6.090	6.770	5.899	-0.016	0.696
SEP 14 73	8.724	6.330	6.913	5.803	-0.043	0.676
JAN 19 74	9.028	7.159	6.646	5.619	-0.120	0.616
MAR 31 74	9.369	7.448	7.167	6.197	-0.092	0.639
APR 19 74	9.125	7.534	7.488	6.398	-0.082	0.647
GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GNB)						
SEP 20 72	8.644	6.375	7.168	6.410	0.003	0.709
NOV 13 72	8.077	5.797	6.308	6.179	0.032	0.729
DEC 1 72	8.734	6.336	6.517	5.967	-0.030	0.686
MAR 1 73	8.838	6.772	6.095	5.317	-0.120	0.616
MAR 18 73	8.038	8.001	7.602	6.678	-0.090	0.640
APR 5 73	9.235	6.932	7.284	6.591	-0.025	0.689
APR 24 73	8.269	6.317	6.587	5.985	-0.027	0.688
MAY 29 73	9.377	7.710	7.622	6.780	-0.064	0.660
JUL 4 73	8.531	6.515	7.052	6.084	-0.034	0.682
JUL 23 73	8.468	6.560	7.005	6.060	-0.040	0.679
SEP 14 73	9.032	6.588	7.259	6.209	-0.030	0.686
JAN 19 74	8.614	6.563	6.204	5.189	-0.117	0.619
MAR 31 74	9.066	7.083	6.923	6.116	-0.073	0.653
APR 19 74	8.741	7.153	7.181	6.141	-0.076	0.651
GRASS-SHRUBLAND--SHALLOW STONY CLAY (SO4 R2 GNC)						
SEP 20 72	9.413	7.300	7.629	6.606	-0.050	0.671
NOV 13 72	7.742	5.418	6.273	6.059	0.056	0.746
DEC 1 72	8.393	5.987	6.557	6.121	0.011	0.715
MAR 1 73	8.400	6.306	5.959	5.348	-0.082	0.646
MAR 18 73	8.778	8.175	7.852	6.924	-0.083	0.646
APR 5 73	9.035	6.846	7.270	6.625	-0.016	0.695
APR 24 73	7.832	5.934	6.224	5.653	-0.024	0.690
MAY 29 73	8.745	6.923	7.248	6.542	-0.028	0.687
JUL 4 73	8.192	6.121	6.811	5.939	-0.015	0.696
JUL 23 73	7.308	5.828	6.306	5.591	-0.021	0.692
SEP 14 73	8.276	5.845	6.560	5.679	-0.014	0.697
JAN 19 74	8.345	6.214	6.063	5.256	-0.084	0.645
MAR 31 74	8.359	6.937	6.744	5.921	-0.079	0.649
APR 19 74	8.554	6.806	7.179	6.227	-0.044	0.675

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OPEN GRASSLAND--SHALLOW STONY CLAY (S04 R1 GND)						
SEP 20 72	8.799	6.536	7.274	6.363	-0.013	0.698
NOV 13 72	7.974	5.738	6.293	5.970	0.020	0.721
DEC 1 72	8.730	6.354	6.430	5.911	-0.036	0.681
MAR 1 73	8.653	6.548	5.806	5.132	-0.121	0.615
MAR 18 73	9.134	7.953	7.482	6.573	-0.095	0.636
APR 5 73	9.106	6.888	7.103	6.355	-0.040	0.678
APR 24 73	7.853	5.738	6.131	5.580	-0.014	0.697
MAY 29 73	8.888	7.149	7.268	6.485	-0.049	0.672
JUL 4 73	8.588	6.526	7.020	6.032	-0.039	0.679
JUL 23 73	7.335	5.788	6.462	5.647	-0.012	0.698
SEP 14 73	8.588	6.134	6.999	5.909	-0.019	0.694
JAN 19 74	8.714	6.506	6.289	5.159	-0.115	0.620
MAR 31 74	8.870	7.025	6.719	5.980	-0.080	0.648
APR 19 74	8.732	7.035	7.102	5.960	-0.083	0.646
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GNG)						
SEP 20 72	9.515	7.453	7.706	6.737	-0.050	0.671
NOV 13 72	8.202	5.777	6.663	6.478	0.057	0.746
DEC 1 72	8.822	6.436	6.781	6.388	-0.004	0.704
MAR 1 73	8.555	6.481	6.040	5.457	-0.086	0.644
MAR 18 73	8.931	8.472	8.346	7.465	-0.063	0.661
APR 5 73	9.195	6.888	7.682	7.086	0.014	0.717
APR 24 73	8.105	6.041	6.549	6.050	0.001	0.708
MAY 29 73	9.203	7.505	7.447	6.732	-0.054	0.668
JUL 4 73	8.826	6.839	7.508	6.613	-0.017	0.695
JUL 23 73	8.080	6.083	6.549	5.740	-0.029	0.686
SEP 14 73	8.539	6.002	6.841	5.821	-0.015	0.696
JAN 19 74	8.304	6.867	6.589	5.622	-0.100	0.633
MAR 31 74	9.196	7.266	7.148	6.357	-0.067	0.658
APR 19 74	9.022	7.411	7.591	6.585	-0.059	0.664
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GNH)						
SEP 20 72	8.233	6.029	7.244	6.457	0.034	0.731
NOV 13 72	7.954	5.577	6.477	6.426	0.071	0.755
DEC 1 72	8.529	5.986	6.656	6.314	0.027	0.726
MAR 1 73	8.493	6.339	6.053	5.462	-0.074	0.652
MAR 18 73	7.732	8.033	8.017	7.042	-0.066	0.659
APR 5 73	9.372	7.172	7.674	7.013	-0.011	0.699
APR 24 73	8.140	6.280	6.527	6.026	-0.021	0.692
MAY 29 73	9.231	7.644	7.564	6.781	-0.060	0.663
JUL 4 73	8.355	6.323	6.926	6.102	-0.018	0.694
JUL 23 73	8.122	6.086	6.849	6.055	-0.003	0.705
SEP 14 73	8.533	6.257	6.974	5.982	-0.022	0.691
JAN 19 74	8.324	6.865	6.494	5.502	-0.110	0.624
MAR 31 74	9.251	7.410	7.135	6.360	-0.076	0.651
APR 19 74	8.355	7.250	7.407	6.559	-0.050	0.671

SONORA, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--SHALLOW STONY CLAY (SC4 R2 GNK)						
SEP 20 72	8.617	6.517	7.409	6.452	-0.005	0.704
NOV 13 72	8.321	6.645	6.956	6.487	-0.012	0.699
DEC 1 72	9.213	7.044	6.957	6.394	-0.048	0.672
MAR 1 73	8.781	6.758	6.263	5.608	-0.093	0.638
MAR 18 73	9.346	8.064	8.082	7.223	-0.055	0.667
APR 5 73	9.231	7.079	8.382	7.861	0.052	0.743
APR 24 73	7.968	5.961	6.308	5.871	-0.008	0.702
MAY 29 73	8.856	7.167	7.590	6.869	-0.021	0.692
JUL 4 73	8.946	6.956	7.291	6.271	-0.052	0.670
JUL 23 73	7.949	5.883	6.329	5.623	-0.023	0.691
SEP 14 73	8.057	5.586	5.619	4.531	-0.104	0.629
JAN 19 74	8.738	6.898	6.555	5.780	-0.088	0.642
MAR 31 74	9.534	8.234	7.490	6.357	-0.129	0.609
APR 19 74	9.622	8.358	7.740	6.445	-0.129	0.609
GRASS-SHRUBLAND--DEEP SILY CLAY LOAM (SO1 R2 GNN)						
SEP 20 72	8.672	7.528	7.271	6.524	-0.071	0.655
NOV 13 72	9.328	7.239	7.377	6.921	-0.022	0.691
DEC 1 72	9.929	7.841	7.454	6.716	-0.077	0.650
MAR 1 73	9.457	7.737	6.931	5.959	-0.130	0.608
MAR 18 73	8.529	8.879	8.597	7.529	-0.082	0.646
APR 5 73	10.256	8.267	8.877	8.053	-0.013	0.698
APR 24 73	7.936	5.789	7.087	6.609	0.066	0.752
MAY 29 73	9.569	8.141	8.393	7.538	-0.038	0.679
JUL 4 73	9.328	7.522	7.887	6.654	-0.061	0.662
JUL 23 73	8.239	6.452	6.743	5.787	-0.054	0.668
SEP 14 73	8.941	6.791	7.140	6.075	-0.056	0.667
JAN 19 74	9.577	7.784	7.217	6.072	-0.124	0.614
MAR 31 74	10.177	8.682	8.169	7.085	-0.101	0.631
APR 19 74	10.038	8.684	8.375	6.963	-0.110	0.625
GRASS-SHRUBLAND--MODERATELY DEEP CLAY (SO5 R2 GNK)						
SEP 20 72	9.299	10.333	7.677	6.754	-0.209	0.539
NOV 13 72	8.046	5.662	6.130	5.982	0.028	0.726
DEC 1 72	8.396	5.983	6.093	5.639	-0.030	0.686
MAR 1 73	8.454	6.367	5.869	5.199	-0.101	0.632
MAR 18 73	7.395	7.677	7.633	6.945	-0.050	0.671
APR 5 73	9.047	6.756	7.122	6.624	-0.010	0.700
APR 24 73	7.329	5.692	6.196	5.939	0.021	0.722
MAY 29 73	8.353	7.116	7.371	6.743	-0.027	0.688
JUL 4 73	8.337	6.685	7.056	6.303	-0.029	0.686
JUL 23 73	8.177	6.159	6.686	5.938	-0.018	0.694
SEP 14 73	8.501	5.874	6.324	5.441	-0.038	0.679
JAN 19 74	8.202	5.834	5.652	4.921	-0.085	0.644
MAR 31 74	8.039	7.026	6.899	6.189	-0.063	0.661
APR 19 74	8.450	6.632	6.745	5.961	-0.053	0.668

SONORA, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--DEEP SILT CLAY LOAM (S01 R2 GNN)						
SEP 20 72	10.431	8.566	8.119	7.028	-0.099	0.634
NOV 13 72	8.043	5.370	6.671	6.508	0.096	0.772
DEC 1 72	8.215	5.709	6.822	6.436	0.060	0.748
MAR 1 73	8.136	5.741	6.276	5.861	0.010	0.714
MAR 18 73	9.090	7.636	8.764	8.095	0.029	0.727
APR 5 73	8.303	6.655	7.216	6.652	-0.000	0.707
APR 24 73	7.810	5.927	6.591	5.990	0.005	0.711
MAY 29 73	8.931	7.512	7.479	6.655	-0.060	0.663
JUL 4 73	7.308	5.306	5.873	5.157	-0.014	0.697
JUL 23 73	7.996	6.031	6.661	5.772	-0.022	0.691
SEP 14 73	8.231	5.854	6.844	5.907	0.005	0.710
JAN 19 74	8.349	6.168	6.052	5.202	-0.085	0.644
MAR 31 74	8.604	6.707	6.784	5.865	-0.067	0.658
APR 19 74	8.490	6.752	7.286	6.372	-0.029	0.686
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GNN)						
SEP 20 72	9.712	7.676	7.997	6.730	-0.066	0.659
NOV 13 72	7.772	5.411	6.237	6.102	0.060	0.748
DEC 1 72	8.356	5.975	6.476	6.068	0.008	0.713
MAR 1 73	8.304	6.231	5.857	5.262	-0.084	0.645
MAR 18 73	9.200	8.236	8.025	7.065	-0.076	0.651
APR 5 73	9.023	6.705	7.390	6.750	0.003	0.709
APR 24 73	7.798	5.821	6.410	5.898	0.007	0.712
MAY 29 73	8.682	6.847	7.330	6.706	-0.010	0.700
JUL 4 73	7.950	5.658	6.193	5.270	-0.036	0.682
JUL 23 73	7.595	5.601	6.380	5.638	0.003	0.709
SEP 14 73	8.239	5.786	6.695	5.775	-0.001	0.706
JAN 19 74	8.423	6.247	6.127	5.203	-0.091	0.639
MAR 31 74	8.962	7.035	6.910	6.051	-0.075	0.652
APR 19 74	8.733	7.066	7.340	6.281	-0.059	0.664
GRASS-SHRUBLAND--SHALLOW STONY CLAY (S04 R2 GN)						
SEP 20 72	8.758	6.529	7.271	6.441	-0.007	0.702
NOV 13 72	8.104	5.718	6.557	6.679	0.078	0.760
DEC 1 72	8.907	6.373	6.869	6.335	-0.003	0.705
MAR 1 73	8.639	6.627	6.118	5.389	-0.103	0.630
MAR 18 73	8.409	8.267	8.014	7.066	-0.078	0.649
APR 5 73	9.233	7.069	7.616	6.910	-0.011	0.699
APR 24 73	8.339	6.481	6.810	6.141	-0.027	0.688
MAY 29 73	9.300	7.596	7.622	6.839	-0.052	0.669
JUL 4 73	8.637	6.570	7.288	6.320	-0.019	0.693
JUL 23 73	8.432	6.482	7.035	6.095	-0.031	0.685
SEP 14 73	8.793	6.411	7.189	6.180	-0.018	0.694
JAN 19 74	8.320	6.822	6.691	5.644	-0.094	0.637
MAR 31 74	9.252	7.318	7.177	6.297	-0.075	0.652
APR 19 74	9.070	7.433	7.563	6.508	-0.066	0.659

SONORA, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--MODERATELY DEEP CLAY (S05 R2 GN)						
SEP 20 72	9.334	7.181	7.532	6.561	-0.045	0.674
NOV 13 72	8.110	5.745	6.345	6.433	0.057	0.746
DEC 1 72	8.328	6.570	6.663	6.121	-0.035	0.682
MAR 1 73	8.673	6.676	5.887	5.186	-0.126	0.612
MAR 18 73	8.915	8.169	7.557	6.710	-0.098	0.634
APR 5 73	9.230	6.988	7.106	6.400	-0.044	0.675
APR 24 73	7.932	5.934	6.071	5.445	-0.043	0.676
MAY 29 73	8.535	6.541	7.159	6.495	-0.004	0.705
JUL 4 73	8.220	6.032	6.919	6.122	0.007	0.712
JUL 23 73	7.812	5.774	6.436	5.648	-0.011	0.699
SEP 14 73	8.120	5.636	6.251	5.372	-0.024	0.690
JAN 19 74	8.583	6.596	6.146	5.194	-0.119	0.617
MAR 31 74	8.874	6.958	6.687	5.905	-0.082	0.647
APR 19 74	8.794	7.159	7.015	6.024	-0.086	0.643

THROCKMORTON, TEXAS

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP CLAY LOAMS (TH1 R1 GN)						
SEP 19 72	7.704	5.103	6.995	6.365	0.110	0.781
OCT 8 72	7.842	5.465	6.978	6.367	0.076	0.759
NOV 13 72	7.930	5.760	6.652	6.152	0.033	0.730
DEC 19 72	9.655	7.713	7.326	6.337	-0.098	0.634
FEB 10 73	9.749	7.931	7.226	6.323	-0.113	0.622
MAR 18 73	7.758	7.414	7.562	6.697	-0.051	0.670
APR 5 73	8.537	6.298	7.453	6.938	0.048	0.741
MAY 11 73	7.750	5.089	7.509	6.702	0.137	0.798
MAY 29 73	7.772	5.504	7.342	6.769	0.103	0.777
JUL 4 73	7.863	5.925	7.096	6.172	0.020	0.721
OCT 2 73	7.691	5.487	6.555	5.871	0.034	0.731
OCT 20 73	7.743	5.506	6.791	6.214	0.060	0.749
DEC 13 73	8.809	6.900	6.654	5.726	-0.093	0.638
FEB 24 74	9.374	8.293	7.727	7.032	-0.082	0.646
MAR 31 74	9.576	8.343	7.802	6.716	-0.108	0.626
MAY 24 74	8.958	6.992	7.731	6.500	-0.036	0.681
JUN 11 74	8.615	6.981	7.989	6.807	-0.013	0.698
JUN 29 74	9.729	8.495	8.330	6.896	-0.104	0.629
*GRASS-SHRUBLAND--DEEP CLAY LOAMS (TH1 R2 GN)						
SEP 19 72	7.507	4.916	6.808	6.267	0.121	0.788
OCT 8 72	7.509	5.040	6.698	6.246	0.107	0.779
NOV 13 72	7.666	5.341	6.496	6.108	0.067	0.753
DEC 19 72	9.202	7.268	7.058	6.189	-0.080	0.648
FEB 10 73	9.673	7.823	7.235	6.446	-0.097	0.635
MAR 18 73	7.505	7.113	7.471	6.673	-0.032	0.684
APR 5 73	8.449	6.222	7.543	7.111	0.067	0.753
MAY 11 73	7.539	4.793	7.449	6.772	0.171	0.819
MAY 29 73	7.502	5.142	7.307	6.858	0.143	0.802
JUL 4 73	7.326	5.932	7.035	6.115	0.015	0.718
OCT 2 73	7.473	5.258	6.267	5.684	0.039	0.734
OCT 20 73	7.713	5.477	6.790	6.155	0.058	0.747
DEC 13 73	8.566	6.608	6.520	5.738	-0.070	0.655
FEB 24 74	9.144	7.989	7.513	6.863	-0.076	0.651
MAR 31 74	9.407	8.122	7.579	6.512	-0.110	0.624
MAY 24 74	8.948	6.973	7.856	6.604	-0.027	0.688
JUN 11 74	8.303	6.487	7.716	6.689	0.015	0.718
JUN 29 74	9.337	8.065	8.041	6.769	-0.087	0.642

THROCKMORTON, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--SHALLOW STONY CLAY (TH2 R1 GN)						
SEP 19 72	8.414	5.959	7.286	6.400	0.036	0.732
OCT 8 72	8.316	6.451	7.445	6.509	0.005	0.710
NOV 13 72	8.541	6.377	6.855	6.128	-0.020	0.693
DEC 19 72	10.071	8.035	7.428	6.298	-0.121	0.615
FEB 10 73	9.719	7.866	7.084	6.158	-0.122	0.615
MAR 18 73	7.367	7.809	7.840	6.852	-0.065	0.659
APR 5 73	8.630	6.501	7.762	7.268	0.056	0.745
MAY 11 73	8.174	5.660	7.771	6.824	0.093	0.770
MAY 29 73	8.244	6.171	7.635	6.891	0.055	0.745
JUL 4 73	7.321	5.834	7.072	6.164	0.027	0.726
OCT 2 73	8.156	6.043	6.902	6.049	0.000	0.707
OCT 20 73	7.814	5.631	6.926	6.207	0.049	0.741
DEC 13 73	8.921	7.015	6.679	5.706	-0.103	0.630
FEB 24 74	9.464	8.327	7.743	6.978	-0.088	0.642
MAR 31 74	9.753	8.564	7.888	6.727	-0.120	0.616
MAY 24 74	8.969	7.076	7.935	6.695	-0.028	0.687
JUN 11 74	9.330	7.807	8.359	6.986	-0.056	0.667
JUN 29 74	10.175	8.996	8.695	7.102	-0.118	0.618
GRASS-SHRUBLAND--SHALLOW STONY CLAY (TH2 R2 GN)						
SEP 19 72	7.385	5.228	6.910	6.284	0.092	0.769
OCT 8 72	8.123	5.847	7.035	6.404	0.045	0.739
NOV 13 72	8.322	5.875	6.817	6.196	0.027	0.726
DEC 19 72	9.713	7.760	7.166	6.194	-0.112	0.623
FEB 10 73	9.738	7.792	7.179	6.337	-0.103	0.630
MAR 18 73	6.948	7.631	7.592	6.689	-0.066	0.659
APR 5 73	8.530	6.367	7.227	6.826	0.035	0.731
MAY 11 73	8.052	5.449	7.489	6.591	0.095	0.771
MAY 29 73	7.935	5.717	7.575	6.992	0.100	0.775
JUL 4 73	7.556	5.717	6.741	5.733	0.001	0.708
OCT 2 73	7.936	5.638	6.757	5.966	0.028	0.727
OCT 20 73	7.499	5.235	6.536	5.347	0.055	0.745
DEC 13 73	8.603	6.555	6.925	6.054	-0.040	0.678
FEB 24 74	9.479	8.388	8.048	7.243	-0.073	0.653
MAR 31 74	9.778	8.545	8.041	6.944	-0.103	0.630
MAY 24 74	8.402	6.378	7.614	6.533	0.012	0.716
JUN 11 74	8.720	6.947	8.023	6.942	-0.000	0.707
JUN 29 74	9.625	8.317	8.246	6.790	-0.101	0.632

THROCKMORTON, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX

OPEN GRASSLAND--DEEP CLAY LOAM BOTTOMLAND (TH3 R1 GN)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
SEP 19 72	7.865	5.214	7.120	6.477	0.108	0.780
OCT 8 72	7.770	5.364	7.091	6.489	0.095	0.771
NOV 13 72	8.035	5.808	6.788	6.275	0.039	0.734
DEC 19 72	9.741	7.744	7.553	6.571	-0.082	0.647
FEB 10 73	9.839	7.951	7.580	6.608	-0.092	0.639
MAR 18 73	8.100	7.134	7.875	7.072	-0.004	0.704
APR 5 73	8.605	6.261	7.653	7.107	0.063	0.750
MAY 11 73	7.737	4.962	7.840	7.058	0.174	0.821
MAY 29 73	7.678	5.442	7.427	6.887	0.117	0.786
JUL 4 73	8.479	6.730	7.246	6.129	-0.047	0.673
OCT 2 73	7.707	5.601	6.778	6.101	0.043	0.737
OCT 20 73	7.504	5.193	6.419	6.132	0.083	0.763
DEC 13 73	9.020	7.083	6.880	5.881	-0.093	0.638
FEB 24 74	9.428	8.337	7.891	7.299	-0.066	0.658
MAR 31 74	9.576	8.289	7.916	6.912	-0.091	0.640
MAY 24 74	8.943	6.876	7.946	6.723	-0.011	0.699
JUN 11 74	9.276	6.946	7.922	6.706	-0.018	0.695
JUN 29 74	9.991	8.757	8.419	6.982	-0.113	0.622

*OPEN GRASSLAND--MODERATELY DEEP CLAY (TH4 R1 GN)

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
SEP 19 72	7.764	5.181	6.922	6.240	0.093	0.770
OCT 8 72	7.849	5.480	6.992	6.348	0.073	0.757
NOV 13 72	8.020	5.747	6.689	6.171	0.036	0.732
DEC 19 72	9.633	7.640	7.308	6.287	-0.097	0.635
FEB 10 73	9.764	7.881	7.206	6.331	-0.109	0.625
MAR 18 73	7.991	7.415	7.650	6.757	-0.046	0.673
APR 5 73	8.597	6.383	7.611	7.116	0.054	0.745
MAY 11 73	7.327	5.186	7.576	6.775	0.133	0.795
MAY 29 73	7.738	5.518	7.456	6.890	0.111	0.781
JUL 4 73	7.363	6.016	6.990	6.049	0.003	0.709
OCT 2 73	7.761	5.574	6.607	5.915	0.030	0.728
OCT 20 73	7.775	5.577	6.924	6.160	0.050	0.741
DEC 13 73	8.300	6.939	6.651	5.702	-0.098	0.634
FEB 24 74	9.401	8.278	7.756	7.075	-0.078	0.649
MAR 31 74	9.664	8.458	7.832	6.723	-0.114	0.621
MAY 24 74	8.931	7.101	7.962	6.727	-0.027	0.688
JUN 11 74	8.603	6.910	7.891	6.731	-0.013	0.698
JUN 29 74	9.720	8.409	8.310	6.934	-0.096	0.635

THROCKMORTON, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*GRASS-SHRUBLAND--MODERATELY DEEP CLAY (TH4 R2 GN)						
SEP 19 72	7.223	4.600	6.526	6.035	0.135	0.797
OCT 8 72	7.424	4.948	6.567	6.071	0.102	0.776
NOV 13 72	7.515	5.101	6.285	5.949	0.077	0.759
DEC 19 72	9.028	7.013	6.882	6.026	-0.076	0.651
FEB 10 73	9.449	7.549	7.040	6.254	-0.094	0.637
MAR 18 73	7.138	6.764	7.312	6.544	-0.017	0.695
APR 5 73	8.729	6.514	7.996	7.493	0.070	0.755
MAY 11 73	7.463	4.676	7.324	6.648	0.174	0.821
MAY 29 73	7.417	5.086	7.086	6.661	0.134	0.796
JUL 4 73	7.571	5.712	7.050	6.213	0.042	0.736
OCT 2 73	7.420	5.173	6.228	5.594	0.039	0.734
OCT 20 73	7.239	4.868	6.492	6.023	0.106	0.778
DEC 13 73	8.840	6.894	6.745	5.949	-0.074	0.653
FEB 24 74	9.236	8.117	7.603	6.882	-0.082	0.646
MAR 31 74	9.434	8.245	7.673	6.482	-0.120	0.617
MAY 24 74	9.045	7.416	8.099	6.872	-0.038	0.680
JUN 11 74	8.200	6.319	7.491	6.470	0.012	0.715
JUN 29 74	9.329	7.891	7.862	6.566	-0.092	0.639
OPEN GRASSLAND--(UNCLASSIFIED) (TH R1 GN)						
SEP 19 72	8.001	5.458	7.219	6.442	0.083	0.763
OCT 8 72	8.077	5.719	7.187	6.436	0.059	0.748
NOV 13 72	8.148	5.880	6.580	6.023	0.012	0.716
DEC 19 72	9.457	7.418	6.974	6.011	-0.105	0.629
FEB 10 73	9.425	7.539	6.852	6.000	-0.114	0.622
MAR 18 73	7.640	7.184	7.483	6.676	-0.037	0.681
APR 5 73	8.506	6.321	7.736	7.277	0.070	0.755
MAY 11 73	8.262	5.314	7.668	6.866	0.127	0.792
MAY 29 73	8.041	5.925	7.515	6.357	0.073	0.757
JUL 4 73	7.323	5.906	7.060	6.150	0.020	0.721
OCT 2 73	7.734	5.527	6.761	6.067	0.047	0.739
OCT 20 73	7.692	5.376	6.703	6.117	0.064	0.751
DEC 13 73	8.837	6.992	6.705	5.762	-0.096	0.635
FEB 24 74	9.379	8.259	7.751	7.060	-0.078	0.649
MAR 31 74	9.482	8.158	7.816	6.779	-0.092	0.638
MAY 24 74	9.108	7.184	7.753	6.431	-0.055	0.667
JUN 11 74	8.636	6.875	8.032	6.340	-0.003	0.705
JUN 29 74	9.713	8.406	8.349	6.937	-0.096	0.636

THROCKMORTON, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
GRASS-SHRUBLAND--(UNCLASSIFIED) (TH R2 GN)						
SEP 19 72	7.713	5.113	7.070	6.467	0.117	0.785
OCT 8 72	8.099	5.603	6.551	5.769	0.015	0.717
NOV 13 72	7.901	5.591	6.156	5.372	-0.020	0.693
DEC 19 72	9.064	6.897	6.033	4.980	-0.161	0.582
FEB 10 73	9.178	7.222	6.156	5.245	-0.159	0.584
MAR 18 73	7.707	7.010	6.645	5.667	-0.106	0.628
APR 5 73	7.886	5.587	7.176	6.927	0.107	0.779
MAY 11 73	7.857	5.252	6.972	6.083	0.073	0.757
MAY 29 73	7.831	5.512	7.123	6.503	0.082	0.763
JUL 4 73	8.631	7.411	7.377	6.137	-0.094	0.637
OCT 2 73	7.647	5.319	6.249	5.422	0.010	0.714
OCT 20 73	7.653	5.589	6.828	6.414	0.069	0.754
DEC 13 73	8.562	6.500	6.520	5.668	-0.068	0.657
FEB 24 74	9.070	7.726	7.029	6.323	-0.100	0.633
MAR 31 74	9.457	8.029	7.494	6.451	-0.109	0.625
MAY 24 74	9.022	7.113	7.455	6.096	-0.077	0.650
JUN 11 74	8.703	7.155	7.810	6.493	-0.049	0.672
JUN 29 74	9.691	8.227	8.238	6.938	-0.085	0.644
SHRUBLAND--(UNCLASSIFIED) (TH R3 GN)						
SEP 19 72	7.708	5.081	7.100	6.428	0.117	0.786
OCT 8 72	7.366	5.455	6.997	6.305	0.072	0.757
NOV 13 72	7.371	5.492	6.331	5.802	0.027	0.726
DEC 19 72	9.101	7.010	6.584	5.753	-0.098	0.634
FEB 10 73	9.218	7.267	6.627	5.837	-0.109	0.625
MAR 18 73	7.536	6.934	7.169	6.393	-0.041	0.678
APR 5 73	8.575	6.408	7.559	7.065	0.049	0.741
MAY 11 73	8.230	5.132	7.526	6.753	0.136	0.798
MAY 29 73	7.774	5.434	7.520	6.983	0.125	0.790
JUL 4 73	7.697	5.742	6.985	6.084	0.029	0.727
OCT 2 73	7.659	5.315	6.473	5.807	0.044	0.738
OCT 20 73	7.676	5.288	6.762	6.100	0.071	0.756
DEC 13 73	8.712	6.741	6.546	5.702	-0.083	0.645
FEB 24 74	9.249	8.033	7.586	6.951	-0.072	0.654
MAR 31 74	9.404	8.041	7.688	6.667	-0.093	0.638
MAY 24 74	9.079	7.007	7.864	6.591	-0.031	0.685
JUN 11 74	8.571	6.769	7.827	6.699	-0.005	0.703
JUN 29 74	9.664	8.131	8.169	6.851	-0.085	0.644

WOODWARD, OKLAHOMA

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (W06 R1 GN1)						
DEC 1 72	8.966	6.893	5.853	4.983	-0.161	0.582
APR 6 73	8.995	7.457	6.704	5.852	-0.121	0.616
JUN 17 73	8.642	7.277	7.370	6.385	-0.065	0.659
JUL 5 73	8.548	7.218	6.877	5.792	-0.110	0.625
AUG 10 73	7.723	6.103	6.713	5.359	-0.020	0.693
AUG 28 73	8.730	6.891	6.914	5.717	-0.093	0.638
OCT 21 73	8.330	6.299	6.685	6.002	-0.024	0.690
OPEN GRASSLAND--DEEP FINE SANDY (W011 R1 GN2)						
DEC 1 72	9.059	6.816	5.890	5.035	-0.150	0.591
APR 6 73	9.387	8.151	7.290	6.434	-0.118	0.618
JUN 17 73	8.574	7.313	7.322	6.326	-0.072	0.654
JUL 5 73	8.511	7.192	6.935	5.815	-0.106	0.628
AUG 10 73	8.452	6.749	7.434	6.497	-0.019	0.693
AUG 28 73	9.033	7.354	7.237	5.993	-0.102	0.631
OCT 21 73	11.224	6.388	6.854	6.243	-0.011	0.699
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (W06 R1 GN2)						
DEC 1 72	9.493	7.251	6.237	5.327	-0.153	0.589
APR 6 73	8.937	7.216	6.390	5.592	-0.127	0.611
JUN 17 73	8.832	7.533	7.604	6.609	-0.065	0.659
JUL 5 73	8.779	7.518	7.179	6.032	-0.110	0.625
AUG 10 73	7.692	5.762	6.506	5.765	0.000	0.707
AUG 28 73	8.996	7.189	6.985	5.803	-0.107	0.627
OCT 21 73	8.063	6.331	6.784	6.042	-0.023	0.690
*OPEN GRASSLAND--DEEP FINE SANDY (W011 R1 GN3)						
DEC 1 72	9.033	6.901	6.039	5.089	-0.151	0.591
APR 6 73	9.157	7.557	6.831	5.998	-0.115	0.620
JUN 17 73	8.697	7.380	7.543	6.564	-0.059	0.664
JUL 5 73	8.593	7.237	7.169	5.936	-0.099	0.633
AUG 10 73	7.933	6.217	6.926	6.207	-0.001	0.707
AUG 28 73	9.160	7.563	7.335	6.156	-0.103	0.630
OCT 21 73	11.770	6.075	6.479	5.781	-0.025	0.689
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (W06 R1 GN4)						
DEC 1 72	8.916	6.607	5.877	5.021	-0.136	0.603
APR 6 73	9.015	7.476	6.995	6.118	-0.100	0.633
JUN 17 73	8.455	6.867	7.663	6.739	-0.009	0.700
JUL 5 73	8.338	6.707	7.217	6.311	-0.030	0.685
AUG 10 73	7.923	6.010	7.089	6.279	0.022	0.722
AUG 28 73	9.054	7.153	7.355	6.324	-0.062	0.662
OCT 21 73	9.691	5.870	6.568	5.352	-0.002	0.706

WOODWARD, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (W06 R1 GN5)						
DEC 1 72	9.399	7.291	6.477	5.662	-0.126	0.612
APR 6 73	9.156	7.720	6.929	6.161	-0.112	0.623
JUN 17 73	8.906	7.899	7.940	6.890	-0.068	0.657
JUL 5 73	8.346	7.752	7.685	6.456	-0.091	0.639
AUG 10 73	7.942	6.728	7.183	6.425	-0.023	0.691
AUG 28 73	8.982	7.267	7.523	6.452	-0.059	0.664
OCT 21 73	8.826	6.564	7.189	6.444	-0.009	0.701
OPEN GRASSLAND--DEEP LOAMY FINE SAND (W06 R1 GNR)						
DEC 1 72	9.127	6.893	6.038	5.115	-0.148	0.593
APR 6 73	9.029	7.447	6.893	6.079	-0.101	0.632
JUN 17 73	8.611	7.172	7.607	6.659	-0.037	0.680
JUL 5 73	8.544	7.066	7.169	6.064	-0.076	0.651
AUG 10 73	7.950	6.091	6.931	6.091	-0.000	0.707
AUG 28 73	8.939	7.183	7.158	6.000	-0.090	0.641
OCT 21 73	9.225	6.076	6.690	6.409	0.027	0.726
OPEN GRASSLAND--DEEP FINE SANDY LOAM (W07 R1 GNR)						
DEC 1 72	9.201	6.981	6.149	5.141	-0.152	0.590
APR 6 73	8.340	7.182	6.573	5.840	-0.103	0.630
JUN 17 73	8.708	7.304	7.658	6.672	-0.045	0.674
JUL 5 73	8.535	7.127	7.275	6.146	-0.074	0.653
AUG 10 73	7.827	5.941	6.883	6.119	0.015	0.717
AUG 28 73	8.973	7.150	7.146	6.039	-0.084	0.645
OCT 21 73	8.832	6.196	6.268	6.772	0.044	0.738
OPEN GRASSLAND--DEEP FINE SANDY (W011 R1 GNR)						
DEC 1 72	9.150	6.984	6.062	5.158	-0.150	0.591
APR 6 73	9.090	7.530	6.884	6.023	-0.111	0.624
JUN 17 73	8.907	7.483	7.978	7.012	-0.032	0.684
JUL 5 73	8.374	7.584	7.539	6.324	-0.091	0.640
AUG 10 73	8.072	6.446	7.007	6.125	-0.025	0.689
AUG 28 73	9.128	7.453	7.322	6.151	-0.096	0.636
OCT 21 73	9.574	6.316	7.112	6.385	0.005	0.711
OPEN GRASSLAND--DEEP FINE SANDY LOAM (W02 R1 GN)						
DEC 1 72	9.418	7.110	6.344	5.487	-0.129	0.609
APR 6 73	9.239	7.632	7.132	6.256	-0.099	0.633
JUN 17 73	8.723	7.233	7.903	6.963	-0.019	0.694
JUL 5 73	8.561	6.695	7.659	6.680	-0.001	0.706
AUG 10 73	7.924	5.912	7.255	6.384	0.038	0.734
AUG 28 73	9.050	7.092	7.548	6.398	-0.051	0.670
OCT 21 73	8.334	5.934	6.448	6.015	0.007	0.712

WOODWARD, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP LOAMY SAND BOTTOMLANDS (WO3 R1 GN)						
DEC 1 72	8.578	5.897	5.262	4.500	-0.134	0.605
APR 6 73	8.317	7.329	6.747	5.371	-0.154	0.538
JUN 17 73	7.949	6.043	7.756	6.990	0.073	0.757
JUL 5 73	8.553	7.065	7.606	6.501	-0.042	0.677
AUG 10 73	8.466	6.693	7.621	6.548	-0.011	0.699
AUG 28 73	8.904	6.913	6.962	5.742	-0.093	0.638
OCT 21 73	11.357	5.726	6.556	6.030	0.026	0.725
OPEN GRASSLAND--(UNCLASSIFIED) (WO4 R1 GN)						
DEC 1 72	9.472	7.239	6.339	5.514	-0.135	0.604
APR 6 73	9.138	7.506	6.927	6.095	-0.104	0.629
JUN 17 73	8.725	7.138	7.992	7.056	-0.006	0.703
JUL 5 73	8.539	6.594	7.832	6.837	0.018	0.720
AUG 10 73	7.939	6.449	7.388	6.370	-0.006	0.703
AUG 28 73	8.950	7.117	7.453	6.271	-0.063	0.661
OCT 21 73	8.755	6.150	6.873	6.243	0.008	0.712
OPEN GRASSLAND--DEEP LOAMY FINE SAND (WO6 R1 GN)						
DEC 1 72	9.254	6.995	6.201	5.304	-0.138	0.602
APR 6 73	9.065	7.458	6.972	6.165	-0.095	0.636
JUN 17 73	8.696	7.269	7.907	6.964	-0.021	0.692
JUL 5 73	8.536	7.200	7.563	6.480	-0.053	0.669
AUG 10 73	7.929	6.150	7.112	6.265	0.009	0.714
AUG 28 73	9.025	7.145	7.399	6.236	-0.068	0.657
OCT 21 73	9.458	6.150	7.017	6.667	0.040	0.735
OPEN GRASSLAND--SHALLOW LOAM (WO8 R1 GN)						
DEC 1 72	9.031	6.822	6.038	5.231	-0.132	0.607
APR 6 73	8.330	7.675	6.900	5.953	-0.126	0.611
JUN 17 73	8.570	6.941	7.691	6.686	-0.019	0.694
JUL 5 73	8.416	6.447	7.575	6.688	0.018	0.720
AUG 10 73	7.370	7.926	7.365	6.355	-0.110	0.625
AUG 28 73	8.650	6.836	7.279	6.158	-0.052	0.669
OCT 21 73	9.275	5.910	6.787	6.087	0.015	0.717
OPEN GRASSLAND--DEEP FINE SANDY (WO11 R1 GN)						
DEC 1 72	9.027	6.773	5.866	4.985	-0.152	0.590
APR 6 73	9.156	7.575	6.784	5.945	-0.121	0.616
JUN 17 73	8.436	6.740	7.604	6.738	-0.000	0.707
JUL 5 73	8.520	6.915	7.075	6.009	-0.070	0.656
AUG 10 73	7.007	6.158	6.799	5.915	-0.020	0.693
AUG 28 73	8.073	7.127	7.034	5.374	-0.096	0.635
OCT 21 73	9.744	6.081	6.749	6.029	-0.004	0.704

WOODWARD, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP LOAMY SAND BOTTOMLANDS (WO3 R1 GNB)						
DEC 1 72	8.927	6.282	6.827	6.072	-0.017	0.695
APR 6 73	8.315	7.072	7.280	6.513	-0.041	0.677
JUN 17 73	8.353	7.946	8.337	7.323	-0.041	0.678
JUL 5 73	9.039	8.084	7.955	6.645	-0.098	0.634
AUG 10 73	8.146	6.417	7.199	6.245	-0.014	0.697
AUG 28 73	9.109	7.369	7.489	6.278	-0.080	0.648
OCT 21 73	9.743	6.934	8.326	7.456	0.036	0.732

HAYS, KANSAS

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP LOAM (HA2 R1 GN)						
SEP 21 72	7.467	5.146	6.996	6.957	0.150	0.806
OCT 26 72	9.622	7.810	7.666	6.680	-0.078	0.650
APR 6 73	9.976	8.329	7.676	6.659	-0.111	0.623
MAY 13 73	8.629	6.518	7.913	7.311	0.057	0.747
MAY 31 73	7.950	5.746	7.982	7.532	0.134	0.797
JUN 17 73	8.531	6.336	8.576	7.880	0.109	0.780
JUL 6 73	8.448	6.762	7.914	7.047	0.021	0.722
JUL 23 73	7.732	5.618	7.183	6.136	0.048	0.740
AUG 10 73	7.555	5.100	7.747	7.107	0.164	0.815
AUG 29 73	9.230	7.084	7.631	6.586	-0.036	0.681
OCT 4 73	7.040	4.694	6.709	6.490	0.161	0.813
OCT 21 73	9.945	6.192	7.260	6.656	0.036	0.732
OPEN GRASSLAND--DEEP GRAVELLY LOAM (HA3 R1 GN)						
SEP 21 72	7.512	5.274	7.012	6.837	0.129	0.793
OCT 26 72	9.392	8.048	8.001	6.944	-0.074	0.653
APR 6 73	10.238	8.803	8.033	6.399	-0.121	0.615
MAY 13 73	8.426	6.212	8.099	7.648	0.104	0.777
MAY 31 73	8.249	6.365	8.028	7.463	0.079	0.761
JUN 17 73	8.994	6.977	8.693	7.344	0.058	0.747
JUL 6 73	8.737	7.270	8.066	7.077	-0.013	0.698
JUL 23 73	7.793	5.667	7.078	5.981	0.027	0.726
AUG 10 73	7.905	5.530	8.008	7.285	0.137	0.798
AUG 29 73	8.632	6.454	7.867	6.951	0.037	0.733
OCT 4 73	7.255	4.962	6.571	6.278	0.117	0.786
OCT 21 73	9.650	6.487	7.268	6.553	0.005	0.711
OPEN GRASSLAND--DEEP SILTY CLAY LOAM (HA6 R1 GN)						
SEP 21 72	7.096	4.814	6.679	6.861	0.175	0.822
OCT 26 72	10.074	8.695	8.433	7.317	-0.086	0.643
APR 6 73	9.859	8.229	7.585	6.642	-0.107	0.627
MAY 13 73	9.206	7.373	8.221	7.490	0.008	0.713
MAY 31 73	7.820	5.951	6.529	5.903	-0.004	0.704
JUN 17 73	9.017	7.400	7.655	6.672	-0.052	0.670
JUL 6 73	8.317	7.466	6.940	5.789	-0.127	0.611
JUL 23 73	8.774	6.700	6.935	5.786	-0.073	0.653
AUG 10 73	8.741	6.995	7.210	6.295	-0.053	0.669
AUG 29 73	10.451	6.932	7.883	6.980	0.003	0.710
OCT 4 73	7.091	4.924	4.810	4.262	-0.072	0.654
OCT 21 73	11.192	7.583	7.652	6.710	-0.061	0.663

HAYS, KANSAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP SILT LOAM (HA9 R1 GN)						
SEP 21 72	7.433	5.159	7.222	7.154	0.162	0.814
OCT 26 72	9.928	8.237	8.015	6.860	-0.091	0.639
APR 6 73	9.342	8.217	7.849	6.884	-0.088	0.642
MAY 13 73	9.113	7.182	8.477	7.818	0.042	0.736
MAY 31 73	7.535	5.360	7.701	7.442	0.163	0.814
JUN 17 73	8.431	6.424	8.421	7.772	0.095	0.771
JUL 6 73	8.730	7.369	8.079	7.074	-0.020	0.693
JUL 23 73	8.351	6.232	7.151	5.995	-0.019	0.693
AUG 10 73	7.757	5.309	7.716	7.036	0.140	0.800
AUG 29 73	8.765	6.235	7.711	6.810	0.044	0.738
OCT 4 73	7.187	4.843	6.428	6.095	0.114	0.784
OCT 21 73	9.717	6.359	7.275	6.488	0.010	0.714
OPEN GRASSLAND--DEEP SILT LOAM (HA10 R1 GN)						
SEP 21 72	6.921	4.527	6.698	6.829	0.203	0.838
OCT 26 72	9.799	7.571	7.479	6.349	-0.088	0.642
APR 6 73	9.277	7.758	7.718	6.692	-0.074	0.653
MAY 13 73	8.001	5.755	7.875	7.417	0.126	0.791
MAY 31 73	7.421	5.238	7.955	7.759	0.194	0.833
JUN 17 73	8.552	6.631	8.901	8.300	0.112	0.782
JUL 6 73	7.933	6.059	8.272	7.955	0.135	0.797
JUL 23 73	7.334	6.248	5.893	4.591	-0.153	0.589
AUG 10 73	7.208	4.535	7.907	7.447	0.243	0.862
AUG 29 73	8.329	6.908	7.118	6.195	-0.054	0.668
OCT 4 73	7.030	4.646	6.487	6.326	0.153	0.808
OCT 21 73	9.304	6.840	7.945	7.074	0.017	0.719
OPEN GRASSLAND--DEEP SILT LOAM (HA13 R1 GN)						
SEP 21 72	7.046	4.632	6.930	6.957	0.201	0.837
OCT 26 72	9.537	8.073	8.152	7.127	-0.062	0.662
APR 6 73	9.371	8.349	7.625	6.561	-0.120	0.617
MAY 13 73	8.340	6.292	7.717	7.112	0.061	0.749
MAY 31 73	7.823	5.736	7.770	7.337	0.123	0.789
JUN 17 73	8.307	6.817	8.435	7.623	0.056	0.746
JUL 6 73	8.198	6.405	7.856	7.120	0.053	0.744
JUL 23 73	7.503	5.558	6.315	5.257	-0.028	0.687
AUG 10 73	7.704	5.368	7.628	6.923	0.127	0.792
AUG 29 73	9.679	7.279	8.065	7.140	-0.010	0.700
OCT 4 73	7.072	4.875	6.061	5.637	0.072	0.757
OCT 21 73	10.395	8.035	8.104	7.035	-0.066	0.659

HAYS, KANSAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP SILT LOAM (HA7 R1 GN)						
SEP 21 72	7.378	5.011	6.996	6.955	0.162	0.814
OCT 26 72	9.124	7.262	7.090	6.104	-0.087	0.643
APR 6 73	9.344	8.340	7.693	6.700	-0.109	0.625
MAY 13 73	8.328	6.490	7.463	6.755	0.020	0.721
MAY 31 73	7.276	4.826	7.747	7.527	0.219	0.848
JUN 17 73	8.333	5.905	8.568	7.962	0.148	0.805
JUL 6 73	8.359	6.752	7.894	6.997	0.018	0.720
JUL 23 73	7.435	5.478	6.166	5.160	-0.030	0.686
AUG 10 73	7.271	4.758	7.499	7.036	0.193	0.833
AUG 29 73	8.356	6.915	7.815	6.669	-0.018	0.694
OCT 4 73	6.378	4.582	6.232	5.950	0.130	0.794
OCT 21 73	8.237	5.987	6.451	5.913	-0.006	0.703

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP LOAM (HA2 R1 GN1)						
SEP 21 72	7.753	5.359	8.215	8.330	0.217	0.847
OCT 26 72	10.128	8.575	8.725	7.593	-0.061	0.663
APR 6 73	10.120	8.304	8.208	7.200	-0.071	0.655
MAY 13 73	8.125	5.678	8.448	8.237	0.184	0.827
MAY 31 73	7.036	4.653	7.925	7.956	0.262	0.873
JUN 17 73	8.330	6.153	8.807	8.345	0.151	0.807
JUL 6 73	8.422	6.940	8.217	7.410	0.033	0.730
JUL 23 73	8.778	6.511	8.043	6.939	0.032	0.729
AUG 10 73	7.657	5.070	8.121	7.502	0.193	0.833
AUG 29 73	9.352	7.430	8.274	7.097	-0.023	0.691
OCT 4 73	7.248	4.726	7.185	7.038	0.197	0.835
OCT 21 73	11.100	6.295	7.866	7.127	0.062	0.750

DATE	BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP SILT LOAM (HA9 R1 GN1)						
SEP 21 72	7.736	5.421	7.683	7.560	0.165	0.815
OCT 26 72	10.375	8.767	8.647	7.358	-0.087	0.642
APR 6 73	9.918	8.124	7.790	6.822	-0.087	0.643
MAY 13 73	8.174	5.848	8.084	7.741	0.139	0.800
MAY 31 73	7.109	4.705	7.889	7.790	0.247	0.864
JUN 17 73	8.459	6.337	8.463	7.893	0.109	0.781
JUL 6 73	8.437	7.047	7.904	7.014	-0.002	0.705
JUL 23 73	9.131	6.951	7.931	6.561	-0.021	0.692
AUG 10 73	7.717	5.185	7.716	7.087	0.155	0.809
AUG 29 73	9.213	7.285	7.922	6.775	-0.036	0.681
OCT 4 73	7.327	4.920	6.933	6.764	0.158	0.811
OCT 21 73	11.218	6.221	7.742	7.098	0.066	0.752

SANDHILLS, NEBRASKA

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--SAND DUNES (SH3 R1 GN2)						
AUG 17 72	8.528	6.660	7.861	6.889	0.017	0.719
SEP 4 72	8.508	6.694	7.090	6.934	0.018	0.719
MAY 15 73	10.511	9.184	8.468	7.296	-0.115	0.621
JUN 1 73	10.237	8.580	8.278	7.073	-0.096	0.635
JUL 26 73	8.957	7.191	7.687	6.695	-0.036	0.681
AUG 12 73	8.364	6.861	7.796	6.800	-0.004	0.704
AUG 30 73	9.061	7.160	7.977	6.899	-0.019	0.694
MAY 28 74	9.637	7.875	8.523	7.263	-0.040	0.678
JUN 15 74	8.751	7.133	8.197	7.224	0.006	0.712
JUL 2 74	9.652	8.172	8.729	7.417	-0.048	0.672
*OPEN GRASSLAND--SAND DUNES (SH3 R1 GN1)						
AUG 17 72	8.557	6.860	7.682	6.645	-0.016	0.696
SEP 4 72	8.534	6.853	6.945	6.661	-0.014	0.697
MAY 15 73	10.273	8.947	8.408	7.325	-0.100	0.633
JUN 1 73	10.397	9.488	8.867	7.498	-0.117	0.619
JUL 26 73	9.464	7.800	8.383	7.272	-0.035	0.682
AUG 12 73	10.018	8.450	8.621	7.316	-0.072	0.654
AUG 30 73	9.932	8.383	8.518	7.103	-0.083	0.646
MAY 28 74	10.640	8.908	9.603	8.002	-0.054	0.668
JUN 15 74	9.348	7.830	8.755	7.742	-0.006	0.703
OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH11 R1 GN1)						
AUG 17 72	8.336	6.512	7.253	6.251	-0.020	0.692
SEP 4 72	8.799	6.941	6.081	6.470	-0.035	0.682
MAY 15 73	10.045	8.523	7.969	6.955	-0.101	0.631
JUN 1 73	10.554	8.531	8.033	6.327	-0.111	0.624
JUL 26 73	9.418	8.650	7.713	6.585	-0.136	0.604
AUG 12 73	9.310	7.458	7.735	6.551	-0.065	0.660
AUG 30 73	9.258	7.431	7.677	6.474	-0.069	0.657
MAY 28 74	10.337	8.594	9.046	7.479	-0.069	0.656
JUN 15 74	8.893	7.328	7.988	6.960	-0.026	0.689
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH11 R1 GN2)						
AUG 17 72	9.100	7.400	8.200	7.089	-0.021	0.692
SEP 4 72	9.133	7.437	7.273	7.156	-0.019	0.693
MAY 15 73	10.196	8.746	8.264	7.200	-0.097	0.635
JUN 1 73	10.638	8.882	8.443	7.169	-0.107	0.627
JUL 26 73	9.297	7.519	7.941	6.876	-0.045	0.675
AUG 12 73	9.299	7.406	7.926	6.784	-0.044	0.675
AUG 30 73	9.334	7.507	8.140	6.992	-0.036	0.681
MAY 28 74	9.915	8.193	8.765	7.423	-0.049	0.671
JUN 15 74	9.154	7.586	8.446	7.351	-0.016	0.696
JUL 2 74	9.333	8.321	8.940	7.582	-0.046	0.673

SANDHILLS, NEBRASKA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP WET FINE SANDY LOAM (SH4 R1 GN3)						
AUG 17 72	7.179	5.085	7.257	6.821	0.146	0.804
SEP 4 72	7.275	5.285	5.635	6.887	0.132	0.795
MAY 15 73	9.337	7.705	7.843	6.969	-0.050	0.671
JUN 1 73	7.550	5.342	6.425	5.590	0.023	0.723
JUL 26 73	7.546	5.303	7.191	6.724	0.118	0.786
AUG 12 73	8.141	6.058	7.257	6.411	0.028	0.727
AUG 30 73	8.336	6.253	7.518	6.713	0.035	0.732
MAY 28 74	7.531	5.081	7.450	6.826	0.147	0.804
JUN 15 74	6.454	4.343	7.141	6.805	0.221	0.849
JUL 2 74	8.493	6.403	8.413	7.608	0.086	0.766
OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH11 R1 GN3)						
AUG 17 72	7.445	5.205	7.511	7.050	0.151	0.807
SEP 4 72	7.399	5.464	6.814	6.476	0.085	0.765
MAY 15 73	10.177	9.115	8.283	7.203	-0.117	0.619
JUN 1 73	9.903	8.282	7.921	6.789	-0.099	0.633
JUL 26 73	8.547	6.562	7.286	6.213	-0.027	0.688
AUG 12 73	7.315	5.489	7.151	6.513	0.085	0.765
AUG 30 73	8.070	5.907	7.592	6.986	0.084	0.764
MAY 28 74	9.393	7.800	8.369	7.112	-0.046	0.674
JUN 15 74	7.398	6.155	7.538	7.001	0.064	0.751
JUL 2 74	9.545	8.237	8.818	7.449	-0.050	0.671
OPEN GRASSLAND--SAND DUNES (SH3 R1 GN4)						
AUG 17 72	8.472	6.568	7.574	6.530	-0.003	0.705
SEP 4 72	8.139	6.206	5.783	6.110	-0.008	0.702
MAY 15 73	10.079	8.675	7.799	6.658	-0.132	0.607
JUN 1 73	10.041	8.389	7.730	6.530	-0.125	0.613
JUL 26 73	8.522	6.500	7.073	6.057	-0.035	0.682
AUG 12 73	8.552	6.591	7.115	5.968	-0.050	0.671
AUG 30 73	8.939	6.961	7.669	6.486	-0.035	0.682
MAY 28 74	9.726	7.934	8.416	7.132	-0.053	0.668
JUN 15 74	8.209	6.407	7.500	6.498	0.007	0.712
JUL 2 74	9.535	8.026	8.385	7.047	-0.065	0.660
***OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH2 R1 H4)**						
AUG 17 72	7.124	4.794	7.084	6.504	0.151	0.807
SEP 4 72	7.054	5.111	4.910	5.784	0.062	0.750
MAY 15 73	9.544	8.158	7.604	6.628	-0.104	0.630
JUN 1 73	9.453	7.596	7.481	6.443	-0.082	0.646
JUL 26 73	7.925	5.648	7.025	6.308	0.055	0.745
AUG 12 73	7.340	5.407	6.864	6.067	0.058	0.747
AUG 30 73	8.229	5.910	7.313	6.516	0.049	0.741
MAY 28 74	8.774	6.690	7.877	6.996	0.022	0.723
JUN 15 74	7.244	5.130	7.399	6.768	0.138	0.799
JUL 2 74	8.595	6.819	8.129	7.126	0.022	0.723

SANDHILLS, NEBRASKA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH11 R1 H4)						
AUG 17 72	7.774	5.650	7.074	6.219	0.048	0.740
SEP 4 72	7.427	5.492	5.327	5.901	0.036	0.732
MAY 15 73	9.324	8.444	7.871	6.863	-0.103	0.630
JUN 1 73	9.623	7.912	7.714	6.644	-0.087	0.643
JUL 26 73	8.139	5.997	7.048	6.213	0.018	0.720
AUG 12 73	8.339	6.214	7.004	6.008	-0.017	0.695
AUG 30 73	8.616	6.450	7.493	6.557	0.008	0.713
MAY 28 74	9.018	6.992	8.080	7.037	0.003	0.709
JUN 15 74	7.485	5.460	7.280	6.563	0.092	0.769
JUL 2 74	8.335	7.071	8.114	6.999	-0.005	0.703
OPEN GRASSLAND--SAND DUNES (SH3 R1 GN5)						
AUG 17 72	7.306	5.862	6.976	6.110	0.021	0.722
SEP 4 72	7.709	5.915	5.552	6.107	0.016	0.718
MAY 15 73	9.700	8.292	7.731	6.751	-0.102	0.630
JUN 1 73	9.731	7.993	7.907	6.849	-0.077	0.650
JUL 26 73	8.540	6.592	7.497	6.577	-0.001	0.706
AUG 12 73	8.534	6.516	7.505	6.459	-0.004	0.704
AUG 30 73	8.408	6.244	7.598	6.780	0.041	0.736
MAY 28 74	7.358	5.346	6.314	5.273	-0.007	0.702
JUN 15 74	7.398	5.428	7.218	6.461	0.087	0.766
JUL 2 74	8.500	6.670	7.715	6.528	-0.003	0.705
OPEN GRASSLAND--DEEP WET FINE SANDY LOAM (SH4 R1 GN5)						
AUG 17 72	7.313	5.074	8.029	7.661	0.203	0.839
SEP 4 72	6.399	4.953	5.724	6.601	0.143	0.802
MAY 15 73	8.537	7.105	7.295	6.690	-0.030	0.686
JUN 1 73	8.155	5.990	6.852	5.992	0.000	0.707
JUL 26 73	8.355	6.296	7.021	6.140	-0.013	0.698
AUG 12 73	6.927	4.334	7.784	7.584	0.273	0.879
AUG 30 73	8.275	6.656	7.802	7.337	0.049	0.741
MAY 28 74	6.517	4.480	6.450	5.710	0.121	0.788
JUN 15 74	6.355	4.147	7.104	6.817	0.244	0.862
JUL 2 74	7.030	4.694	7.583	7.141	0.207	0.841
OPEN GRASSLAND--DEEP LOAMY FINE SANDS (SH5 R1 GN5)						
AUG 17 72	6.337	4.641	7.071	6.617	0.176	0.822
SEP 4 72	7.504	5.887	5.869	6.881	0.078	0.760
MAY 15 73	8.270	6.503	7.081	6.443	-0.005	0.704
JUN 1 73	8.131	6.089	7.218	5.537	0.035	0.732
JUL 26 73	8.233	6.314	7.033	6.105	-0.017	0.695
AUG 12 73	7.250	4.878	7.426	6.360	0.169	0.818
AUG 30 73	[illegible]	6.778	7.926	7.079	0.022	0.722
MAY 28 74	[illegible]	4.132	6.679	6.056	0.189	0.830
JUN 15 74	6.233	3.890	7.718	7.592	0.324	0.908
JUL 2 74	7.056	4.585	8.220	7.371	0.264	0.874

SANDHILLS, NEBRASKA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP LOAMY FINE SANDS (SH11 R1 GN5)						
AUG 17 72	7.275	5.053	7.115	6.547	0.129	0.793
SEP 4 72	7.343	5.482	6.205	6.186	0.060	0.749
MAY 15 73	9.173	7.648	7.505	6.669	-0.068	0.657
JUN 1 73	9.035	7.243	7.503	6.594	-0.047	0.673
JUL 26 73	8.202	6.236	7.157	6.324	0.007	0.712
AUG 12 73	7.606	5.381	7.388	6.760	0.114	0.783
AUG 30 73	8.071	6.185	7.659	7.031	0.064	0.751
MAY 28 74	7.092	4.974	6.217	5.233	0.025	0.725
JUN 15 74	6.929	4.829	7.059	6.420	0.141	0.801
JUL 2 74	7.309	5.808	7.551	6.731	0.074	0.757
OPEN GRASSLAND--DEEP LOAMY FINE SANDS (SH2 R1 GN)						
AUG 17 72	7.326	5.128	7.092	6.443	0.114	0.783
SEP 4 72	7.158	4.910	5.627	6.496	0.139	0.799
MAY 15 73	8.182	6.254	6.937	6.304	0.004	0.710
JUN 1 73	8.244	6.025	6.982	6.126	0.008	0.713
JUL 26 73	6.700	4.318	6.623	6.262	0.184	0.827
AUG 12 73	7.919	5.530	6.809	5.934	0.035	0.732
AUG 30 73	8.176	5.971	7.153	6.162	0.016	0.718
MAY 28 74	8.107	5.696	7.908	7.040	0.105	0.778
JUN 15 74	6.443	4.072	7.638	7.367	0.288	0.888
JUL 2 74	8.200	6.110	8.834	8.073	0.138	0.799
OPEN GRASSLAND--SAND DUNES (SH3 R1 GN)						
AUG 17 72	8.315	6.418	7.532	6.599	0.014	0.717
SEP 4 72	8.327	6.515	6.202	6.601	0.007	0.712
MAY 15 73	10.011	8.620	7.991	6.917	-0.110	0.625
JUN 1 73	9.931	8.317	7.997	6.847	-0.097	0.635
JUL 26 73	8.570	6.659	7.548	6.667	0.001	0.708
AUG 12 73	8.757	6.773	7.550	6.489	-0.021	0.692
AUG 30 73	8.915	6.922	7.933	6.915	-0.001	0.707
MAY 28 74	9.008	7.145	7.998	6.785	-0.026	0.689
JUN 15 74	8.205	6.452	7.760	6.914	0.035	0.731
JUL 2 74	9.333	7.733	8.437	7.189	-0.036	0.681
OPEN GRASSLAND--DEEP WET FINE SANDY LOAM (SH4 R1 GN)						
AUG 17 72	7.676	5.605	7.494	6.864	0.101	0.775
SEP 4 72	7.611	5.598	5.918	6.715	0.091	0.769
MAY 15 73	9.311	7.700	7.759	6.915	-0.054	0.668
JUN 1 73	8.112	6.065	6.563	5.608	-0.039	0.679
JUL 26 73	7.333	5.697	7.211	6.561	0.070	0.755
AUG 12 73	8.707	6.701	7.667	6.695	-0.001	0.706
AUG 30 73	8.353	6.856	7.896	6.800	-0.004	0.704
MAY 28 74	7.027	5.717	7.446	6.508	0.065	0.751
JUN 15 74	6.042	4.933	7.056	6.506	0.133	0.795
JUL 2 74	8.326	6.371	8.095	7.304	0.068	0.754

SANDHILLS, NEBRASKA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--MUCK (SH8 R1 GN)						
AUG 17 72	6.905	4.666	7.523	7.273	0.218	0.848
SEP 4 72	6.197	3.927	6.532	7.191	0.294	0.891
MAY 15 73	7.361	5.665	5.917	5.655	-0.001	0.706
JUN 1 73	7.100	4.789	6.919	6.435	0.147	0.804
JUL 26 73	7.770	5.427	7.599	7.031	0.129	0.793
AUG 12 73	6.952	4.251	8.361	8.194	0.317	0.904
AUG 30 73	8.205	5.943	8.775	8.456	0.175	0.821
MAY 28 74	6.652	4.199	6.796	5.970	0.174	0.821
JUN 15 74	5.376	3.231	8.486	8.642	0.456	0.978
JUL 2 74	6.338	4.114	8.955	8.929	0.369	0.932
OPEN GRASSLAND--ROUGH BROKEN LAND (SH9 R1 GN)						
AUG 17 72	7.358	5.769	7.141	6.238	0.039	0.734
SEP 4 72	7.593	5.469	5.241	5.854	0.034	0.731
MAY 15 73	8.263	6.198	6.587	5.744	-0.038	0.680
JUN 1 73	8.964	6.638	7.328	6.245	-0.031	0.685
JUL 26 73	7.640	5.821	6.583	5.767	-0.005	0.704
AUG 12 73	8.006	5.676	6.870	5.955	0.024	0.724
AUG 30 73	8.321	6.201	7.428	6.401	0.016	0.718
MAY 28 74	8.112	5.911	7.487	6.229	0.026	0.725
JUN 15 74	7.328	5.209	7.401	6.723	0.127	0.792
*OPEN GRASSLAND--DEEP LOAMY FINE SAND (SH11 R1 GN)						
AUG 17 72	7.937	5.964	7.258	6.412	0.036	0.732
SEP 4 72	8.024	6.117	6.336	6.605	0.038	0.734
MAY 15 73	9.516	7.995	7.798	6.881	-0.075	0.652
JUN 1 73	9.421	7.582	7.702	6.660	-0.065	0.660
JUL 26 73	8.642	6.593	7.584	6.698	-0.022	0.691
AUG 12 73	8.578	6.497	7.526	6.544	0.004	0.710
AUG 30 73	8.734	6.808	7.756	6.762	-0.003	0.705
MAY 28 74	9.027	6.999	8.295	7.101	0.007	0.712
JUN 15 74	7.955	6.170	7.819	7.088	0.069	0.754
JUL 2 74	8.446	6.493	8.291	7.440	0.068	0.754
OPEN GRASSLAND--DEEP WET FINE SANDY LOAM (SH4 R1 H)						
AUG 17 72	7.568	5.749	7.387	6.735	0.079	0.761
SEP 4 72	6.752	4.389	6.610	8.390	0.313	0.902
MAY 15 73	7.321	5.611	8.632	8.341	0.223	0.851
JUN 1 73	7.630	5.311	8.477	8.256	0.217	0.847
JUL 26 73	8.452	6.381	7.370	6.410	0.002	0.709
AUG 12 73	7.595	5.406	7.661	7.146	0.139	0.799
AUG 30 73	7.360	5.385	8.946	8.924	0.242	0.861
MAY 28 74	6.007	3.283	7.700	7.244	0.376	0.936
JUN 15 74	5.716	3.313	9.392	10.050	0.504	1.002
JUL 2 74	6.731	4.210	9.244	9.608	0.391	0.944

COTTONWOOD, SOUTH DAKOTA

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN1)						
AUG 19 72	7.308	5.169	6.544	5.942	0.070	0.755
SEP 6 72	7.376	6.942	7.035	6.766	-0.013	0.698
SEP 24 72	9.308	7.411	7.723	7.063	-0.024	0.690
OCT 12 72	9.461	7.563	6.789	5.753	-0.136	0.603
MAY 15 73	9.148	7.127	7.966	7.297	0.012	0.715
JUN 21 73	7.633	5.289	7.296	6.699	0.118	0.786
JUL 9 73	8.162	6.481	6.991	6.245	-0.019	0.694
JUL 26 73	8.135	5.954	6.333	5.353	-0.053	0.668
AUG 14 73	8.243	6.298	6.518	5.114	-0.104	0.629
SEP 1 73	8.615	6.667	6.234	5.130	-0.130	0.608
SEP 18 73	7.900	5.931	5.781	5.023	-0.083	0.646
APR 22 74	8.552	6.751	6.871	5.969	-0.061	0.662
JUN 15 74	7.120	4.751	7.026	6.383	0.147	0.804
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN2)						
AUG 19 72	7.305	5.506	6.053	5.323	-0.017	0.695
SEP 6 72	8.619	7.960	6.930	6.889	-0.072	0.654
SEP 24 72	9.792	8.030	7.466	6.864	-0.078	0.649
OCT 12 72	9.404	7.424	6.447	5.331	-0.164	0.580
MAY 15 73	9.241	7.441	7.719	6.957	-0.034	0.683
JUN 21 73	10.759	7.988	8.948	7.798	-0.012	0.699
JUL 9 73	7.927	6.124	6.733	6.017	-0.009	0.701
JUL 26 73	8.316	6.354	6.127	5.087	-0.111	0.624
AUG 14 73	8.307	6.467	6.116	4.873	-0.141	0.600
SEP 1 73	8.345	7.006	6.221	4.989	-0.168	0.576
SEP 18 73	8.072	6.175	5.642	4.740	-0.131	0.607
APR 22 74	8.314	6.872	6.609	5.601	-0.102	0.631
JUN 15 74	7.368	5.139	6.472	5.668	0.049	0.741
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN3)						
AUG 19 72	7.436	5.491	6.261	5.502	0.001	0.708
SEP 6 72	8.753	7.819	7.132	6.771	-0.072	0.654
SEP 24 72	9.738	7.706	7.543	7.179	-0.035	0.682
OCT 12 72	9.414	7.513	6.586	5.513	-0.154	0.589
MAY 15 73	9.249	7.406	7.828	7.089	-0.022	0.691
JUN 21 73	9.401	6.810	8.165	7.203	0.028	0.727
JUL 9 73	8.176	6.291	6.852	6.216	-0.006	0.703
JUL 26 73	8.257	6.144	6.150	5.092	-0.094	0.637
AUG 14 73	8.330	6.544	6.188	4.970	-0.137	0.603
SEP 1 73	8.303	7.062	6.272	5.017	-0.169	0.575
SEP 18 73	8.009	6.118	5.633	4.753	-0.126	0.612
APR 22 74	8.373	6.988	6.685	5.706	-0.101	0.632
JUN 15 74	7.412	5.186	6.645	5.773	0.054	0.744

COTTONWOOD, SOUTH DAKOTA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN4)						
AUG 19 72	7.490	5.489	6.569	5.841	0.031	0.729
SEP 6 72	8.274	7.699	6.678	6.819	-0.061	0.663
SEP 24 72	9.331	7.655	7.718	7.347	-0.021	0.692
OCT 12 72	9.653	7.849	6.950	5.833	-0.147	0.594
MAY 15 73	8.576	6.412	7.986	7.460	0.076	0.759
JUN 21 73	7.371	5.027	7.435	6.909	0.158	0.811
JUL 9 73	8.297	6.383	6.841	6.002	-0.031	0.685
JUL 26 73	8.091	6.066	5.952	4.930	-0.103	0.630
AUG 14 73	8.092	6.297	6.011	4.835	-0.131	0.607
SEP 1 73	8.301	7.046	6.244	5.017	-0.168	0.576
SEP 18 73	7.758	5.918	5.423	4.576	-0.128	0.610
APR 22 74	8.307	6.329	6.706	5.771	-0.046	0.674
JUN 15 74	7.037	4.928	6.407	5.701	0.073	0.757
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN5)						
AUG 19 72	6.657	4.615	6.284	5.864	0.119	0.787
SEP 6 72	7.653	6.682	6.409	6.455	-0.017	0.695
SEP 24 72	9.076	7.003	7.658	7.083	0.006	0.711
OCT 12 72	9.243	7.438	6.777	5.784	-0.125	0.612
MAY 15 73	8.177	5.843	8.339	8.211	0.168	0.818
JUN 21 73	6.737	4.323	7.680	7.567	0.273	0.879
JUL 9 73	8.054	6.194	6.685	6.173	-0.002	0.706
JUL 26 73	7.799	5.640	6.334	5.521	-0.011	0.700
AUG 14 73	7.655	5.747	5.890	5.097	-0.060	0.663
SEP 1 73	8.339	6.476	6.253	5.199	-0.109	0.625
SEP 18 73	7.357	5.423	5.500	4.921	-0.048	0.672
APR 22 74	8.119	6.133	6.718	5.932	-0.017	0.695
JUN 15 74	6.544	4.281	7.132	6.684	0.219	0.848
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN6)						
AUG 19 72	7.904	5.748	6.953	6.151	0.034	0.731
SEP 6 72	8.033	7.456	6.704	6.910	-0.038	0.680
SEP 24 72	10.810	9.452	9.097	8.682	-0.042	0.676
OCT 12 72	10.554	8.952	7.770	6.510	-0.158	0.585
MAY 15 73	9.613	7.693	8.236	7.463	-0.015	0.696
JUN 21 73	8.223	5.839	7.600	6.861	0.081	0.762
JUL 9 73	8.240	6.314	6.695	6.161	-0.012	0.698
JUL 26 73	8.774	6.590	6.882	5.729	-0.070	0.656
AUG 14 73	8.300	6.868	7.483	5.495	-0.112	0.623
SEP 1 73	9.516	7.877	7.016	5.608	-0.168	0.576
SEP 18 73	8.799	6.873	6.466	5.520	-0.109	0.625
APR 22 74	9.106	7.346	7.121	6.041	-0.098	0.634
JUN 15 74	7.313	5.426	7.450	6.668	0.103	0.776

COTTONWOOD, SOUTH DAKOTA (CONTINUED)

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OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN7)						
AUG 19 72	7.591	5.604	6.213	5.465	-0.013	0.698
SEP 6 72	7.752	7.177	6.656	6.310	-0.064	0.660
SEP 24 72	10.217	8.240	7.996	8.227	-0.001	0.707
OCT 12 72	9.334	8.097	7.058	5.781	-0.167	0.577
MAY 15 73	9.271	7.290	7.678	6.945	-0.024	0.690
JUN 21 73	7.328	5.426	7.016	6.316	0.076	0.759
JUL 9 73	7.944	6.127	6.606	6.000	-0.010	0.700
JUL 26 73	8.516	6.323	6.403	5.317	-0.086	0.643
AUG 14 73	8.509	6.627	6.627	4.949	-0.145	0.596
SEP 1 73	9.198	7.320	6.476	5.143	-0.175	0.570
SEP 18 73	8.261	6.303	5.722	4.366	-0.129	0.609
APR 22 74	8.947	6.996	6.747	5.785	-0.095	0.637
JUN 15 74	7.457	5.098	6.829	6.043	0.085	0.765
*OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN8)						
AUG 19 72	7.632	5.702	6.294	5.527	-0.016	0.696
SEP 6 72	7.527	6.827	5.550	5.981	-0.066	0.659
SEP 24 72	10.454	8.543	7.964	7.299	-0.078	0.649
OCT 12 72	9.956	7.998	6.904	5.761	-0.163	0.581
MAY 15 73	9.431	7.558	7.692	6.920	-0.044	0.675
JUN 21 73	7.354	5.606	7.067	6.320	0.060	0.748
JUL 9 73	8.408	6.574	7.073	6.361	-0.017	0.695
JUL 26 73	8.641	6.395	6.492	5.376	-0.087	0.643
AUG 14 73	8.595	6.698	6.373	4.978	-0.147	0.594
SEP 1 73	9.043	7.119	6.394	5.135	-0.162	0.581
SEP 18 73	8.231	6.286	5.848	4.964	-0.118	0.618
APR 22 74	8.779	6.823	6.527	5.577	-0.100	0.632
JUN 15 74	7.337	4.974	6.668	5.382	0.084	0.764
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN9)						
AUG 19 72	7.721	5.786	6.128	5.313	-0.043	0.676
SEP 6 72	7.956	7.285	7.969	6.058	-0.092	0.639
SEP 24 72	9.872	7.776	7.334	6.418	-0.096	0.636
OCT 12 72	9.794	7.853	6.739	5.520	-0.174	0.571
MAY 15 73	9.139	7.245	7.645	6.799	-0.032	0.684
JUN 21 73	8.242	6.070	7.088	6.178	0.009	0.713
JUL 9 73	8.223	6.150	6.897	5.968	-0.015	0.696
JUL 26 73	8.726	7.136	6.459	5.303	-0.147	0.594
AUG 14 73	8.378	7.102	6.441	5.159	-0.158	0.584
SEP 1 73	9.547	7.752	6.737	5.347	-0.184	0.562
SEP 18 73	8.478	6.590	5.831	4.838	-0.147	0.594
APR 22 74	8.317	6.899	6.665	5.621	-0.102	0.631
JUN 15 74	7.459	5.227	6.584	5.753	0.048	0.740

COTTONWOOD, SOUTH DAKOTA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN10)						
AUG 19 72	7.358	5.950	6.442	5.622	-0.028	0.687
SEP 6 72	7.736	7.075	7.389	6.272	-0.060	0.663
SEP 24 72	10.190	8.205	7.911	7.134	-0.070	0.656
OCT 12 72	10.149	8.240	7.199	5.933	-0.163	0.581
MAY 15 73	9.424	7.585	7.813	7.079	-0.034	0.682
JUN 21 73	8.216	5.922	7.320	6.530	0.049	0.741
JUL 9 73	8.238	6.339	6.916	6.007	-0.027	0.688
JUL 26 73	8.633	6.371	6.630	5.585	-0.066	0.659
AUG 14 73	8.320	6.864	7.094	5.337	-0.125	0.612
SEP 1 73	9.231	7.328	6.643	5.375	-0.154	0.588
SEP 18 73	8.556	6.576	6.139	5.261	-0.111	0.624
APR 22 74	8.913	6.988	6.810	5.376	-0.086	0.643
JUN 15 74	7.533	5.295	6.862	6.014	0.064	0.751
***OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN11)**						
AUG 19 72	8.008	6.003	6.663	5.830	-0.015	0.697
SEP 6 72	7.615	7.088	7.201	6.288	-0.060	0.663
SEP 24 72	10.374	8.330	8.045	7.105	-0.079	0.649
OCT 12 72	10.358	8.481	7.265	5.967	-0.174	0.571
MAY 15 73	9.394	7.431	7.715	6.960	-0.033	0.684
JUN 21 73	8.158	5.792	7.220	6.436	0.053	0.743
JUL 9 73	8.352	6.853	7.019	6.089	-0.059	0.664
JUL 26 73	8.631	6.583	6.629	5.561	-0.084	0.645
AUG 14 73	8.934	6.939	6.467	5.189	-0.144	0.596
SEP 1 73	9.363	7.544	6.707	5.411	-0.165	0.579
SEP 18 73	8.764	6.738	6.136	5.196	-0.129	0.609
APR 22 74	9.013	7.033	6.735	5.728	-0.102	0.631
JUN 15 74	7.645	5.304	6.963	6.113	0.071	0.756
***OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN12)**						
AUG 19 72	8.151	6.102	6.819	5.904	-0.016	0.695
SEP 6 72	7.440	7.410	5.810	6.589	-0.059	0.664
SEP 24 72	10.731	9.150	8.897	8.336	-0.047	0.673
OCT 12 72	10.624	8.911	7.656	6.393	-0.165	0.579
MAY 15 73	9.302	7.925	8.051	7.262	-0.044	0.676
JUN 21 73	8.290	5.939	7.494	6.660	0.057	0.747
JUL 9 73	8.333	7.263	7.019	6.117	-0.036	0.644
JUL 26 73	8.300	6.575	6.906	5.708	-0.071	0.655
AUG 14 73	9.014	7.098	7.375	5.355	-0.140	0.600
SEP 1 73	9.546	7.796	6.902	5.505	-0.172	0.573
SEP 18 73	9.074	7.115	6.442	5.598	-0.119	0.617
APR 22 74	9.317	7.438	7.103	6.060	-0.102	0.631
JUN 15 74	7.338	5.523	7.445	6.663	0.094	0.770

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*OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN13)						
AUG 19 72	7.924	5.922	6.248	5.395	-0.047	0.673
SEP 6 72	8.056	7.386	5.741	6.206	-0.087	0.643
SEP 24 72	10.370	8.774	7.969	7.200	-0.099	0.634
OCT 12 72	10.128	8.176	7.019	5.785	-0.171	0.573
MAY 15 73	9.233	7.302	7.629	6.918	-0.027	0.688
JUN 21 73	7.930	5.676	6.947	6.221	0.046	0.739
JUL 9 73	8.301	6.582	7.009	6.007	-0.046	0.674
JUL 26 73	8.602	6.531	6.466	5.398	-0.095	0.636
AUG 14 73	8.547	6.693	6.192	5.024	-0.142	0.598
SEP 1 73	9.150	7.269	6.444	5.185	-0.167	0.577
SEP 18 73	8.499	6.522	5.964	5.012	-0.131	0.608
APR 22 74	8.308	6.842	6.667	5.760	-0.086	0.644
JUN 15 74	7.356	5.084	6.697	5.925	0.076	0.759
OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 GN)						
AUG 19 72	7.725	5.729	6.459	5.684	-0.004	0.704
SEP 6 72	8.742	7.788	7.235	6.804	-0.067	0.658
SEP 24 72	10.156	8.196	7.957	7.300	-0.058	0.665
OCT 12 72	9.920	8.044	7.041	5.388	-0.155	0.588
MAY 15 73	9.443	7.585	7.902	7.126	-0.031	0.685
JUN 21 73	8.925	6.508	7.640	6.710	0.015	0.718
JUL 9 73	8.239	6.430	6.991	6.143	-0.023	0.691
JUL 26 73	8.716	6.570	6.813	5.598	-0.080	0.648
AUG 14 73	8.706	6.843	6.718	5.227	-0.134	0.605
SEP 1 73	9.306	7.480	6.761	5.452	-0.157	0.586
SEP 18 73	8.532	6.615	6.183	5.306	-0.110	0.625
APR 22 74	8.936	7.058	6.934	5.935	-0.086	0.643
JUN 15 74	7.716	5.524	7.123	6.292	0.065	0.752
GRASS-SHRUBLAND--(UNCLASSIFIED) (CW R2 GN)						
AUG 19 72	6.378	4.652	6.819	6.373	0.156	0.810
SEP 6 72	7.241	6.240	6.781	7.340	0.081	0.762
SEP 24 72	8.962	6.562	7.837	7.959	0.096	0.772
OCT 12 72	8.974	7.016	6.498	5.712	-0.102	0.631
MAY 15 73	8.308	6.707	7.853	7.303	0.043	0.737
JUN 21 73	7.191	4.649	7.918	7.657	0.244	0.863
JUL 9 73	8.440	6.911	6.931	6.039	-0.067	0.658
JUL 26 73	7.314	5.294	6.974	6.311	0.088	0.767
AUG 14 73	7.930	5.887	6.255	5.655	-0.020	0.693
SEP 1 73	8.196	6.114	6.381	5.393	-0.063	0.661
SEP 18 73	7.731	5.592	6.247	5.752	0.014	0.717
APR 22 74	8.336	6.388	6.663	5.856	-0.043	0.676
JUN 15 74	6.547	4.158	7.536	7.293	0.274	0.880

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OPEN GRASSLAND--(UNCLASSIFIED) (CW R1 H)						
AUG 19 72	8.448	7.252	6.738	5.536	-0.134	0.605
SEP 6 72	12.772	10.655	6.803	7.934	-0.146	0.595
SEP 24 72	8.340	6.691	6.099	5.227	-0.123	0.614
OCT 12 72	10.111	8.328	7.170	5.822	-0.177	0.568
MAY 15 73	10.728	9.327	8.286	7.109	-0.135	0.604
JUN 21 73	9.390	8.551	7.369	5.936	-0.181	0.565
JUL 9 73	8.147	6.354	7.023	6.150	-0.016	0.696
JUL 26 73	10.045	8.485	7.017	5.427	-0.220	0.529
AUG 14 73	8.004	7.352	6.126	4.777	-0.212	0.536
SEP 1 73	9.734	7.891	6.371	4.697	-0.254	0.496
SEP 18 73	8.345	6.554	5.424	4.435	-0.193	0.554
APR 22 74	8.394	6.147	7.579	7.039	0.068	0.753
JUN 15 74	6.325	3.998	7.607	7.704	0.317	0.904

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DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP SILT LOAM (MA1 R1 GN)						
SEP 24 72	8.522	6.776	7.377	6.385	-0.030	0.686
OCT 12 72	8.405	6.007	6.395	5.808	-0.017	0.695
APR 27 73	9.090	7.127	7.043	6.411	-0.053	0.669
MAY 15 73	8.321	6.400	6.822	6.306	-0.007	0.702
JUN 21 73	7.177	4.987	6.701	6.280	0.115	0.784
JUL 9 73	8.131	6.379	6.717	5.743	-0.052	0.669
MAY 29 74	7.179	4.778	6.499	5.757	0.093	0.770
OPEN GRASSLAND--SHALLOW LOAM (MA2 R1 GN)						
SEP 24 72	8.396	6.561	6.900	6.372	-0.015	0.697
OCT 12 72	8.467	6.025	6.257	5.622	-0.035	0.682
APR 27 73	8.790	6.795	6.601	6.002	-0.062	0.662
MAY 15 73	8.255	6.298	6.806	6.260	-0.003	0.705
JUN 21 73	7.241	4.992	6.694	6.245	0.111	0.782
JUL 9 73	7.931	6.064	6.664	5.755	-0.026	0.688
MAY 29 74	8.378	5.835	7.622	6.759	0.073	0.757
OPEN GRASSLAND--DEEP LOAMY FINE SAND (MA4 R1 GN)						
SEP 24 72	7.756	5.940	5.444	4.880	-0.098	0.634
OCT 12 72	8.552	6.229	6.139	5.711	-0.043	0.676
APR 27 73	8.116	6.155	5.997	5.498	-0.056	0.666
MAY 15 73	7.451	5.579	5.213	4.590	-0.097	0.635
JUN 21 73	6.473	3.783	8.389	8.740	0.396	0.946
JUL 9 73	7.055	5.321	7.253	6.832	0.124	0.790
MAY 29 74	7.201	5.251	5.747	4.955	-0.029	0.686
OPEN GRASSLAND--DEEP SILT LOAM (MA5 R1 GN)						
SEP 24 72	8.342	6.489	6.715	6.391	-0.008	0.702
OCT 12 72	8.159	5.811	6.574	6.097	0.024	0.724
APR 27 73	8.933	6.907	7.130	6.638	-0.020	0.693
MAY 15 73	8.492	6.505	7.196	6.663	0.012	0.716
JUN 21 73	7.450	5.228	6.735	6.183	0.084	0.764
JUL 9 73	8.238	6.498	6.764	5.727	-0.063	0.661
MAY 29 74	7.351	4.892	7.178	6.441	0.137	0.798
OPEN GRASSLAND--DEEP SILT LOAM (MA6 R1 GN)						
SEP 24 72	8.117	6.056	6.632	6.441	0.031	0.729
OCT 12 72	9.679	6.694	5.832	4.401	-0.207	0.542
APR 27 73	8.337	6.274	6.757	6.381	0.008	0.713
MAY 15 73	7.909	5.762	7.116	6.336	0.085	0.765
JUN 21 73	7.050	4.819	6.855	6.427	0.143	0.802
JUL 9 73	7.355	5.838	6.764	5.914	0.006	0.712
MAY 29 74	7.465	4.964	7.558	6.911	0.164	0.815

MANDAN, NORTH DAKOTA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP SILT LOAM (MA9 R1 GN)						
SEP 24 72	8.420	6.573	7.070	6.135	-0.035	0.682
OCT 12 72	8.145	5.763	6.244	5.814	0.004	0.710
APR 27 73	8.630	6.616	6.572	6.056	-0.044	0.675
MAY 15 73	8.153	6.187	6.857	6.371	0.015	0.717
JUN 21 73	7.242	5.058	6.593	6.108	0.094	0.771
JUL 9 73	8.061	6.200	6.724	5.704	-0.042	0.677
MAY 29 74	7.950	5.423	7.169	6.288	0.074	0.758
OPEN GRASSLAND--DEEP SILT LOAM (MA1 R1 H)						
SEP 24 72	7.938	5.864	6.736	6.605	0.059	0.748
OCT 12 72	10.936	7.652	6.017	4.099	-0.302	0.445
APR 27 73	8.230	6.152	7.412	7.156	0.075	0.759
MAY 15 73	8.015	5.957	7.360	7.144	0.091	0.768
JUN 21 73	6.660	4.257	7.111	6.917	0.238	0.859
JUL 9 73	7.499	5.532	7.241	6.705	0.096	0.772
MAY 29 74	6.962	4.478	7.415	6.623	0.193	0.833
OPEN GRASSLAND--SHALLOW LOAM (MA2 R1 H)						
SEP 24 72	8.299	6.410	6.732	6.452	0.003	0.709
OCT 12 72	8.376	5.754	6.333	5.784	0.003	0.709
APR 27 73	8.736	6.785	7.028	6.573	-0.016	0.696
MAY 15 73	8.453	6.513	7.232	6.740	0.017	0.719
JUN 21 73	7.532	5.387	7.076	6.588	0.100	0.775
JUL 9 73	8.501	6.768	7.190	6.152	-0.048	0.673
MAY 29 74	10.562	7.646	9.211	8.143	0.031	0.729

WESLACO, TEXAS

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP FINE SANDY LOAM (WE1 R1 GN1)						
OCT 6 72	8.520	5.686	8.273	7.490	0.137	0.798
MAR 16 73	8.915	6.072	8.942	8.432	0.163	0.814
APR 3 73	8.503	5.709	9.126	8.646	0.205	0.839
JUL 20 73	7.370	5.119	8.093	7.404	0.182	0.826
SEP 12 73	7.309	4.949	7.235	6.477	0.134	0.796
SEP 30 73	7.501	4.317	8.435	7.886	0.292	0.890
OCT 18 73	7.291	4.521	7.173	6.878	0.207	0.841
MAR 29 74	8.204	5.796	7.356	6.672	0.070	0.755
MAY 4 74	8.959	6.146	7.401	6.290	0.012	0.715
OPEN GRASSLAND--DEEP FINE SANDY LOAM (WE3 R1 GN2)						
OCT 6 72	7.443	4.449	7.552	6.840	0.212	0.844
MAR 16 73	8.633	5.835	8.662	8.282	0.173	0.821
APR 3 73	8.490	5.662	9.254	8.936	0.224	0.851
JUL 20 73	7.912	5.204	8.073	7.232	0.163	0.814
SEP 12 73	7.719	4.887	7.443	6.636	0.152	0.807
SEP 30 73	7.995	4.081	7.933	7.306	0.283	0.885
OCT 18 73	7.128	4.123	7.060	6.869	0.250	0.866
MAR 29 74	8.314	5.954	7.554	6.349	0.070	0.755
MAY 4 74	8.948	6.032	7.238	6.270	0.019	0.721
OPEN GRASSLAND--DEEP FINE SANDY LOAM (WE1 R1 GN)						
OCT 6 72	8.054	5.051	7.845	7.041	0.165	0.815
MAR 16 73	9.799	7.106	8.494	7.735	0.042	0.736
APR 3 73	8.339	6.313	8.820	8.298	0.136	0.797
JUL 20 73	8.593	5.939	9.093	8.145	0.157	0.810
SEP 12 73	8.232	5.679	7.495	6.528	0.070	0.755
SEP 30 73	8.338	4.700	8.437	7.748	0.245	0.863
OCT 18 73	7.502	4.503	8.703	8.547	0.310	0.900
MAR 29 74	8.629	6.275	7.809	6.983	0.053	0.744
MAY 4 74	9.351	6.617	7.658	6.535	-0.006	0.703
GRASS-SHRUBLAND--DEEP FINE SANDY LOAM (WE1 R2 GN)						
OCT 6 72	7.033	4.643	8.216	7.442	0.232	0.855
MAR 16 73	14.705	11.145	11.792	10.390	-0.035	0.682
APR 3 73	8.336	5.621	8.667	8.323	0.194	0.833
JUL 20 73	8.200	5.437	8.715	7.838	0.181	0.825
SEP 12 73	7.936	4.975	7.729	6.857	0.159	0.812
SEP 30 73	7.550	4.211	8.437	7.881	0.304	0.896
OCT 18 73	7.314	4.067	8.678	8.676	0.362	0.928
MAR 29 74	8.035	5.409	7.713	7.091	0.135	0.797
MAY 4 74	9.257	6.476	7.578	6.479	0.000	0.707

WESLACO, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*WOODED GRASSLAND--DEEP FINE SANDY LOAM (WE1 R5 GN)						
OCT 6 72	8.245	5.408	7.965	7.128	0.137	0.798
MAR 16 73	9.052	6.326	8.375	7.822	0.106	0.778
APR 3 73	7.979	5.168	8.415	8.199	0.227	0.852
JUL 20 73	7.721	5.129	7.914	7.232	0.170	0.819
SEP 12 73	7.731	5.121	6.839	6.015	0.080	0.762
SEP 30 73	7.615	4.337	7.724	7.120	0.243	0.862
OCT 18 73	6.996	3.846	7.608	7.533	0.324	0.908
MAR 29 74	7.925	5.326	7.277	6.619	0.108	0.780
MAY 4 74	8.374	5.955	7.305	6.278	0.026	0.726
OPEN GRASSLAND--MODERATELY DEEP FINE SANDY LOAM (WE2 R1 GN)						
OCT 6 72	8.212	5.093	7.894	7.055	0.162	0.813
MAR 16 73	10.736	8.514	9.218	8.336	-0.011	0.700
APR 3 73	9.114	7.295	7.914	7.122	-0.012	0.699
JUL 20 73	8.452	6.081	7.854	7.017	0.071	0.756
SEP 12 73	8.513	6.826	7.069	6.007	-0.064	0.660
SEP 30 73	8.750	6.642	8.620	7.651	0.071	0.755
OCT 18 73	7.351	4.883	8.669	8.489	0.270	0.877
MAR 29 74	10.397	8.705	9.046	7.833	-0.053	0.669
MAY 4 74	8.730	5.819	7.906	6.965	0.090	0.768
GRASS-SHRUBLAND--MODERATELY DEEP FINE SANDY LOAM (WE2 R2 GN)						
OCT 6 72	7.956	4.820	7.772	6.963	0.182	0.826
MAR 16 73	11.439	8.437	9.433	8.375	-0.004	0.705
APR 3 73	8.525	5.955	8.580	8.155	0.156	0.810
JUL 20 73	8.205	5.755	8.616	7.705	0.145	0.803
SEP 12 73	8.107	5.273	7.910	6.984	0.140	0.800
SEP 30 73	7.555	4.369	8.528	7.854	0.285	0.886
OCT 18 73	7.542	4.356	8.472	8.312	0.312	0.901
MAR 29 74	8.442	5.974	7.583	6.789	0.064	0.751
MAY 4 74	9.132	6.560	7.441	6.350	-0.016	0.696
WOODED GRASSLAND--MODERATELY DEEP FINE SANDY LOAM (WE2 R5 GN)						
OCT 6 72	7.799	4.873	7.139	6.309	0.128	0.793
MAR 16 73	8.734	5.942	7.730	7.139	0.092	0.769
APR 3 73	8.246	5.734	8.383	8.017	0.166	0.816
JUL 20 73	8.053	5.701	8.256	7.435	0.132	0.795
SEP 12 73	7.939	5.486	7.232	6.389	0.076	0.759
SEP 30 73	7.657	4.413	8.003	7.304	0.247	0.864
OCT 18 73	7.138	4.161	7.742	7.571	0.291	0.889
MAR 29 74	7.932	5.438	7.593	6.958	0.123	0.789
MAY 4 74	8.933	6.033	7.663	6.657	0.049	0.741

WESLACO, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--DEEP FINE SANDY LOAM (WE3 R1 GN)						
OCT 6 72	8.025	4.886	7.984	7.238	0.194	0.833
MAR 16 73	9.700	6.983	8.732	8.065	0.072	0.756
APR 3 73	8.761	6.197	8.791	8.314	0.146	0.804
JUL 20 73	8.653	5.848	9.469	8.539	0.187	0.829
SEP 12 73	8.329	5.940	7.375	6.352	0.033	0.730
SEP 30 73	8.342	4.902	8.837	8.082	0.245	0.863
OCT 18 73	7.710	4.517	8.940	8.760	0.320	0.905
MAR 29 74	8.363	6.609	7.781	6.863	0.019	0.720
MAY 4 74	9.223	6.513	7.771	6.690	0.013	0.716
GRASS-SHRUBLAND--DEEP FINE SANDY LOAM (WE3 R2 GN)						
OCT 6 72	8.138	5.072	8.108	7.356	0.184	0.827
MAR 16 73	11.097	7.952	8.824	7.884	-0.004	0.704
APR 3 73	8.752	6.034	8.651	8.194	0.152	0.807
JUL 20 73	8.740	5.814	9.391	8.399	0.182	0.826
SEP 12 73	8.497	5.968	7.547	6.478	0.041	0.736
SEP 30 73	7.907	4.490	8.827	8.106	0.287	0.887
OCT 18 73	7.354	4.556	8.900	8.616	0.308	0.899
MAR 29 74	8.504	6.217	7.296	6.463	0.019	0.721
MAY 4 74	9.391	6.840	7.496	6.340	-0.038	0.680
*WOODED GRASSLAND--DEEP FINE SANDY LOAM (WE3 R5 GN)						
OCT 6 72	7.913	4.997	7.667	6.923	0.162	0.813
MAR 16 73	8.598	5.787	7.771	7.275	0.114	0.784
APR 3 73	7.946	5.184	8.233	7.982	0.213	0.844
JUL 20 73	7.327	5.176	8.027	7.346	0.173	0.821
SEP 12 73	7.702	5.172	6.572	5.758	0.054	0.744
SEP 30 73	8.119	4.157	7.797	7.217	0.269	0.877
OCT 18 73	7.094	3.939	7.736	7.607	0.318	0.904
MAR 29 74	8.013	5.501	6.983	6.295	0.067	0.753
MAY 4 74	8.733	6.025	7.025	5.996	-0.002	0.705
OPEN GRASSLAND--DEEP LOAM (WE4 R1 GN)						
OCT 6 72	8.705	6.007	8.539	7.700	0.124	0.790
MAR 16 73	9.423	6.857	8.698	8.124	0.085	0.765
APR 3 73	8.535	6.075	8.125	7.305	0.128	0.792
JUL 20 73	9.035	5.430	9.241	7.372	0.152	0.807
SEP 12 73	8.323	5.937	7.535	6.562	0.050	0.742
SEP 30 73	9.048	5.360	7.624	7.201	0.147	0.804
OCT 18 73	7.405	4.375	7.560	7.287	0.250	0.866
MAR 29 74	8.331	6.210	9.280	7.701	0.107	0.779
MAY 4 74	9.341	6.746	7.345	6.112	-0.049	0.671

WESLACO, TEXAS (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
WOODED GRASSLAND--DEEP LOAM (WE4 R5 GN)						
OCT 6 72	7.933	4.658	8.582	7.922	0.259	0.871
MAR 16 73	9.352	7.654	8.809	8.055	0.026	0.725
APR 3 73	8.575	5.914	8.696	8.256	0.165	0.816
JUL 20 73	8.153	5.477	9.411	7.671	0.167	0.817
SEP 12 73	8.214	5.588	7.255	6.322	0.062	0.749
SEP 30 73	8.159	4.529	8.769	7.273	0.233	0.856
OCT 18 73	7.026	3.950	7.903	7.809	0.328	0.910
MAR 29 74	8.448	5.930	7.826	7.142	0.093	0.770
MAY 4 74	9.130	6.355	7.490	6.367	0.001	0.708
OPEN GRASSLAND--VERY SHALLOW GRAVELLY LOAM (WE6 R1 GN)						
OCT 6 72	7.942	4.798	7.977	7.280	0.206	0.840
MAR 16 73	9.613	7.703	8.543	7.844	0.009	0.713
APR 3 73	8.915	7.009	8.316	7.616	0.041	0.736
JUL 20 73	8.454	6.342	8.634	7.824	0.105	0.778
SEP 12 73	8.508	6.731	7.136	6.029	-0.055	0.667
SEP 30 73	8.539	5.967	8.433	7.514	0.115	0.784
OCT 18 73	7.630	4.804	8.220	7.895	0.243	0.862
MAR 29 74	9.247	7.278	8.088	7.101	-0.012	0.698
MAY 4 74	8.906	6.460	7.579	6.532	0.006	0.711
WOODED GRASSLAND--VERY SHALLOW GRAVELLY LOAM (WE6 R5 GN)						
OCT 6 72	8.275	5.192	7.804	7.073	0.153	0.808
MAR 16 73	8.294	5.853	7.209	6.780	0.073	0.757
APR 3 73	7.922	5.344	8.134	7.303	0.187	0.829
JUL 20 73	7.560	4.911	8.229	7.697	0.221	0.849
SEP 12 73	7.731	5.478	6.345	5.513	0.003	0.709
SEP 30 73	7.593	4.517	7.981	7.403	0.242	0.861
OCT 18 73	7.207	3.999	8.255	8.030	0.335	0.914
MAR 29 74	7.948	5.756	6.521	5.331	0.006	0.712
MAY 4 74	8.777	6.284	6.987	5.923	-0.030	0.686
PASTURELAND--DEEP FINE SANDY LOAM (WE3 P1 GT)						
OCT 6 72	7.904	4.991	7.595	6.831	0.156	0.810
MAR 16 73	8.909	6.511	7.777	7.137	0.046	0.739
APR 3 73	8.310	6.471	7.934	7.271	0.058	0.747
JUL 20 73	8.778	6.178	8.982	7.914	0.123	0.789
SEP 12 73	8.470	5.856	7.855	6.670	0.065	0.752
SEP 30 73	9.275	4.911	8.986	8.081	0.244	0.863
OCT 18 73	7.926	4.643	9.365	9.059	0.322	0.907
MAR 29 74	10.019	8.075	8.441	7.218	-0.056	0.666
MAY 4 74	9.254	6.505	7.954	6.918	0.031	0.729

WESLACO, TEXAS (CONTINUED)

PASTURELAND--VERY SHALLOW GRAVELLY L]AM (WE6 P1 GT)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OCT 6 72	8.046	4.998	7.957	7.026	0.169	0.818
MAR 16 73	9.056	6.681	8.188	7.602	0.065	0.751
APR 3 73	8.972	6.957	8.015	7.348	0.027	0.726
JUL 20 73	8.438	5.914	9.331	8.086	0.155	0.809
SEP 12 73	8.155	5.937	7.060	5.918	-0.002	0.706
SEP 30 73	10.179	4.846	8.184	7.337	0.204	0.839
OCT 18 73	7.911	4.815	8.517	8.121	0.256	0.869
MAR 29 74	8.835	7.754	7.528	6.310	-0.103	0.630
MAY 4 74	8.967	6.234	7.364	6.200	-0.003	0.705

PASTURELAND--DEEP FINE SANDY LOAM (WE3 P1 H)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OCT 6 72	7.536	4.480	7.383	6.681	0.197	0.835
MAR 16 73	10.311	8.083	8.961	8.165	0.005	0.711
APR 3 73	9.170	6.955	9.117	8.557	0.103	0.777
JUL 20 73	8.530	5.472	10.700	9.957	0.291	0.889
SEP 12 73	8.421	6.093	7.714	6.739	0.050	0.742
SEP 30 73	8.500	5.024	9.681	8.955	0.281	0.884
OCT 18 73	7.758	4.573	9.302	9.286	0.340	0.917
MAR 29 74	9.623	7.563	8.941	7.881	0.021	0.722
MAY 4 74	9.404	6.910	8.515	7.400	0.034	0.731

CHICKASHA, OKLAHOMA

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP LOAMY AND CLAYEY (CH1 R1 GN1)						
SEP 19 72	8.238	7.566	7.143	6.013	-0.114	0.621
OCT 25 72	8.056	7.445	6.690	5.710	-0.132	0.607
FEB 10 73	7.610	6.345	5.832	5.362	-0.084	0.645
APR 5 73	7.727	6.981	6.513	5.860	-0.087	0.642
APR 23 73	7.361	6.668	6.929	6.079	-0.046	0.674
MAY 11 73	8.636	6.374	8.265	7.333	0.070	0.755
MAY 29 73	8.040	8.044	9.080	8.087	0.003	0.709
AUG 27 73	9.342	7.641	8.617	7.295	-0.023	0.691
OCT 2 73	7.520	6.643	7.521	6.608	-0.003	0.705
OCT 20 73	7.537	6.582	7.917	7.101	0.038	0.733
DEC 13 73	9.066	8.137	8.188	7.424	-0.046	0.674
MAY 6 74	7.630	7.168	8.424	7.346	0.012	0.716
JUN 29 74	8.338	7.920	8.490	7.137	-0.052	0.669
*OPEN GRASSLAND--DEEP FINE SANDY LOAM AND SILT LOAM (CH5 R1 GN2)						
SEP 19 72	8.212	7.121	7.040	6.030	-0.083	0.646
OCT 25 72	9.118	7.223	6.621	5.791	-0.110	0.625
FEB 10 73	8.310	6.657	6.643	6.325	-0.026	0.689
APR 5 73	7.677	6.161	7.098	6.907	0.057	0.746
APR 23 73	7.336	5.746	6.829	6.240	0.041	0.736
MAY 11 73	9.302	7.483	9.522	8.441	0.060	0.748
MAY 29 73	7.442	6.038	7.864	7.372	0.099	0.774
AUG 27 73	8.957	6.113	8.069	7.310	0.089	0.768
OCT 2 73	7.366	5.498	7.232	6.521	0.085	0.765
OCT 20 73	6.734	5.193	6.276	5.943	0.067	0.753
DEC 13 73	8.130	6.718	6.481	5.762	-0.077	0.651
MAY 6 74	7.116	5.181	7.812	7.303	0.170	0.819
JUN 29 74	8.276	6.747	7.841	6.787	0.003	0.709
*OPEN GRASSLAND--DEEP FINE SANDY LOAM AND SILT LOAM (CH5 R1 GN34)						
SEP 19 72	8.002	6.760	7.021	5.964	-0.063	0.661
OCT 25 72	9.475	7.354	6.828	5.973	-0.104	0.630
FEB 10 73	8.310	6.627	6.146	5.706	-0.075	0.652
APR 5 73	7.702	6.029	7.160	6.953	0.071	0.756
APR 23 73	7.314	5.756	6.770	6.093	0.028	0.727
MAY 11 73	9.039	7.256	9.098	8.091	0.054	0.745
MAY 29 73	7.177	5.681	7.966	7.482	0.137	0.798
AUG 27 73	9.064	6.113	7.931	7.250	0.085	0.765
OCT 2 73	7.253	5.305	6.943	6.416	0.095	0.771
OCT 20 73	6.373	5.193	6.397	5.905	0.064	0.751
DEC 13 73	8.130	6.844	6.766	5.873	-0.076	0.651
MAY 6 74	7.000	5.125	7.803	7.217	0.169	0.818
JUN 29 74	8.174	6.674	7.969	7.081	0.030	0.728

CHICKASHA, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
*OPEN GRASSLAND--DEEP LOAMY AND CLAYEY (CH1 R1 GN5)						
SEP 19 72	7.647	6.506	6.378	5.474	-0.086	0.643
OCT 25 72	8.518	6.699	6.310	5.347	-0.112	0.623
FEB 10 73	7.721	6.553	5.898	5.546	-0.083	0.646
APR 5 73	7.777	6.657	7.240	6.344	0.014	0.717
APR 23 73	7.208	5.699	6.210	5.508	-0.017	0.695
MAY 11 73	8.952	6.701	8.417	7.432	0.052	0.743
MAY 29 73	7.122	5.708	7.613	7.028	0.104	0.777
AUG 27 73	8.930	6.531	8.146	7.100	0.042	0.736
OCT 2 73	6.739	5.226	6.235	5.681	0.042	0.736
OCT 20 73	6.525	5.330	5.957	5.442	0.010	0.714
DEC 13 73	7.751	6.341	6.007	5.319	-0.098	0.642
MAY 6 74	7.238	6.035	7.722	6.759	0.057	0.746
JUN 29 74	8.298	7.420	7.921	6.815	-0.042	0.676
OPEN GRASSLAND--DEEP LOAMY AND CLAYEY (CH1 R1 GN)						
SEP 19 72	8.129	7.359	7.153	5.978	-0.104	0.630
OCT 25 72	8.950	7.268	6.652	5.611	-0.129	0.609
FEB 10 73	7.703	6.524	5.842	5.559	-0.080	0.648
APR 5 73	7.968	7.420	7.352	6.754	-0.047	0.673
APR 23 73	7.390	6.217	7.140	6.360	0.011	0.715
MAY 11 73	8.305	6.778	8.365	7.323	0.039	0.734
MAY 29 73	7.548	6.723	8.494	7.862	0.078	0.760
AUG 27 73	9.033	6.851	8.176	7.055	0.015	0.717
OCT 2 73	7.309	5.938	7.237	6.485	0.044	0.738
OCT 20 73	7.052	5.687	7.029	6.374	0.057	0.746
DEC 13 73	8.457	7.272	7.297	6.291	-0.072	0.654
MAY 6 74	7.332	6.338	8.039	7.150	0.060	0.748
JUN 29 74	8.543	7.960	8.414	7.124	-0.055	0.667
OPEN GRASSLAND--DEEP FINE SANDY LOAM (CH2 R1 GN)						
SEP 19 72	7.801	6.790	6.706	5.672	-0.090	0.640
OCT 25 72	8.603	6.662	6.146	5.234	-0.120	0.616
FEB 10 73	7.670	6.393	5.904	5.466	-0.078	0.650
APR 5 73	7.528	6.552	6.944	6.377	-0.014	0.697
APR 23 73	7.177	5.851	6.587	5.810	-0.004	0.705
MAY 11 73	8.330	7.162	8.643	7.654	0.033	0.730
MAY 29 73	7.303	6.304	8.059	7.367	0.078	0.760
AUG 27 73	8.954	6.493	7.773	6.711	0.016	0.719
OCT 2 73	6.323	5.092	5.343	5.692	0.056	0.745
OCT 20 73	6.755	5.328	6.269	5.737	0.037	0.733
DEC 13 73	8.003	6.691	6.524	5.852	-0.067	0.658
MAY 6 74	7.110	5.873	7.339	6.554	0.055	0.745
JUN 29 74	7.955	6.717	7.606	6.549	-0.013	0.698

CHICKASHA, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--SHALLOW FINE SANDY LOAM (CH3 R1 GN)						
SEP 19 72	7.873	6.821	6.678	5.680	-0.091	0.639
OCT 25 72	8.699	6.778	6.305	5.353	-0.117	0.619
FEB 10 73	7.932	6.318	6.215	5.850	-0.038	0.679
APR 5 73	7.357	5.938	7.303	6.983	0.081	0.762
APR 23 73	7.210	5.380	6.964	6.355	0.083	0.764
MAY 11 73	8.737	6.191	8.325	7.402	0.089	0.768
MAY 29 73	7.029	5.400	7.983	7.522	0.164	0.815
AUG 27 73	8.338	6.212	7.659	6.638	0.033	0.730
OCT 2 73	6.921	4.974	6.646	6.022	0.095	0.772
OCT 20 73	6.556	4.745	6.078	5.473	0.071	0.756
DEC 13 73	7.731	5.916	5.822	5.135	-0.071	0.655
MAY 6 74	6.775	4.924	7.507	6.896	0.167	0.817
JUN 29 74	7.955	6.076	7.612	6.683	0.048	0.740
OPEN GRASSLAND--SHALLOW AND MODERATELY DEEP LOAMY (CH4 R1 GN)						
SEP 19 72	7.304	6.565	6.646	5.717	-0.069	0.656
OCT 25 72	8.701	6.675	6.294	5.402	-0.105	0.628
FEB 10 73	8.062	6.544	6.080	5.679	-0.071	0.655
APR 5 73	7.607	6.315	6.758	6.291	-0.002	0.706
APR 23 73	7.254	5.501	6.626	5.970	0.041	0.735
MAY 11 73	8.654	6.301	8.066	7.139	0.062	0.750
MAY 29 73	7.092	5.413	7.723	7.232	0.144	0.802
AUG 27 73	8.932	6.357	7.735	6.796	0.033	0.730
OCT 2 73	6.330	4.928	6.497	5.930	0.092	0.770
OCT 20 73	6.618	4.838	6.199	5.710	0.083	0.763
DEC 13 73	7.390	6.197	6.098	5.455	-0.064	0.661
MAY 6 74	6.924	5.191	7.395	6.743	0.130	0.794
JUN 29 74	7.350	6.165	7.615	6.651	0.038	0.733
OPEN GRASSLAND--DEEP FINE SANDY LOAM AND SILT LOAM (CH5 R1 GN)						
SEP 19 72	7.632	6.060	6.526	5.724	-0.029	0.687
OCT 25 72	8.305	6.642	6.414	5.564	-0.088	0.642
FEB 10 73	8.304	6.764	6.266	5.887	-0.069	0.656
APR 5 73	7.652	6.243	6.620	6.177	-0.005	0.703
APR 23 73	7.330	5.385	6.697	6.102	0.062	0.750
MAY 11 73	8.631	6.196	8.039	7.199	0.075	0.758
MAY 29 73	6.950	4.878	7.648	7.315	0.200	0.837
AUG 27 73	8.934	6.112	7.801	6.398	0.060	0.749
OCT 2 73	6.737	4.667	6.568	6.118	0.135	0.797
OCT 20 73	6.521	4.696	6.303	5.906	0.114	0.784
DEC 13 73	7.006	6.342	6.388	5.799	-0.045	0.675
MAY 6 74	6.972	5.025	7.498	6.941	0.160	0.812
JUN 29 74	7.363	5.968	7.732	6.338	0.068	0.754

CHICKASHA, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
OPEN GRASSLAND--MODERATELY DEEP TO VERY SHALLOW LOAMY TO CLAYEY (CH6 R1 GN)						
SEP 19 72	7.628	6.205	6.389	5.454	-0.064	0.660
OCT 25 72	8.643	6.517	6.140	5.173	-0.115	0.620
FEB 10 73	8.200	6.582	5.954	5.524	-0.087	0.642
APR 5 73	7.731	6.328	6.448	6.003	-0.026	0.688
APR 23 73	7.302	5.757	6.274	5.556	-0.018	0.694
MAY 11 73	8.306	6.385	8.359	7.382	0.072	0.757
MAY 29 73	7.129	5.360	7.480	6.932	0.128	0.792
AUG 27 73	8.944	6.319	7.666	6.701	0.029	0.728
OCT 2 73	6.508	4.769	6.221	5.640	0.084	0.764
OCT 20 73	6.433	4.681	5.730	5.343	0.066	0.752
DEC 13 73	7.586	5.904	5.628	5.078	-0.075	0.652
MAY 6 74	6.990	5.184	7.196	6.472	0.111	0.781
JUN 29 74	7.318	6.200	7.592	6.596	0.031	0.729
OPEN GRASSLAND--DEEP LOAMY (CH7 R1 GN)						
SEP 19 72	7.943	6.556	6.478	5.559	-0.082	0.646
OCT 25 72	8.358	6.786	6.268	5.360	-0.117	0.619
FEB 10 73	8.321	6.687	6.103	5.669	-0.082	0.646
APR 5 73	7.661	6.208	6.563	6.112	-0.008	0.702
APR 23 73	7.301	5.462	6.434	5.790	0.029	0.727
MAY 11 73	8.596	6.289	7.865	6.872	0.044	0.738
MAY 29 73	7.045	5.135	7.420	6.930	0.149	0.805
AUG 27 73	8.939	6.236	7.702	6.690	0.035	0.731
OCT 2 73	6.917	4.888	6.545	6.012	0.103	0.777
OCT 20 73	6.533	4.798	5.958	5.464	0.065	0.752
DEC 13 73	7.365	6.184	5.978	5.383	-0.069	0.656
MAY 6 74	7.039	5.194	7.395	6.749	0.130	0.794
JUN 29 74	7.913	6.105	7.696	6.789	0.053	0.744
OPEN GRASSLAND--DEEP FINE SANDY LOAM BOTTOMLANDS (CH8 R1 GN)						
SEP 19 72	7.200	5.437	5.957	5.220	-0.020	0.693
OCT 25 72	8.205	5.884	5.737	5.039	-0.077	0.650
FEB 10 73	8.244	6.547	5.761	5.238	-0.111	0.624
APR 5 73	7.503	6.114	5.824	5.357	-0.066	0.659
APR 23 73	7.437	5.677	6.066	5.399	-0.025	0.689
MAY 11 73	8.543	5.970	7.594	6.771	0.063	0.750
MAY 29 73	7.002	5.254	7.391	6.939	0.138	0.799
AUG 27 73	9.049	6.969	7.905	6.750	-0.016	0.696
OCT 2 73	6.358	5.655	6.076	5.324	-0.030	0.685
OCT 20 73	6.916	6.028	6.380	5.579	-0.039	0.679
DEC 13 73	8.273	7.134	6.558	5.683	-0.113	0.622
MAY 6 74	7.036	5.969	6.308	5.261	-0.063	0.661
JUN 29 74	7.554	5.892	6.570	5.521	-0.033	0.684

CHICKASHA, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
WOODLAND--DEEP FINE SANDY LOAM AND SILT LOAM (CH5 R6 GN)						
SEP 19 72	7.095	5.157	6.102	5.520	0.034	0.731
OCT 25 72	8.275	5.772	5.872	5.089	-0.063	0.661
FEB 10 73	8.292	6.852	6.190	5.356	-0.078	0.649
APR 5 73	7.622	6.136	6.608	6.354	0.018	0.719
APR 23 73	7.263	5.446	6.306	5.615	0.015	0.718
MAY 11 73	8.744	5.951	8.117	7.323	0.103	0.777
MAY 29 73	6.746	4.528	7.604	7.350	0.238	0.859
AUG 27 73	8.945	6.024	7.671	6.671	0.051	0.742
OCT 2 73	6.278	4.232	5.930	5.477	0.128	0.793
OCT 20 73	6.413	4.671	5.983	5.639	0.094	0.771
DEC 13 73	7.846	5.908	6.077	5.540	-0.032	0.684
MAY 6 74	6.755	4.797	7.154	6.587	0.157	0.811
JUN 29 74	7.579	5.476	7.450	6.559	0.090	0.768
WOODLAND--DEEP FINE SANDY LOAM BOTTOMLANDS (CH8 R6 GN)						
SEP 19 72	7.018	5.603	6.758	6.131	0.045	0.738
OCT 25 72	8.047	5.773	6.335	5.766	-0.001	0.707
FEB 10 73	7.530	6.094	6.384	6.174	0.007	0.712
APR 5 73	7.247	5.754	7.158	6.957	0.095	0.771
APR 23 73	6.332	4.732	6.991	6.562	0.162	0.814
MAY 11 73	8.760	6.429	8.607	7.773	0.095	0.771
MAY 29 73	6.720	4.894	8.264	8.258	0.256	0.869
AUG 27 73	8.399	6.432	7.797	6.848	0.031	0.729
OCT 2 73	6.463	4.528	6.424	5.983	0.138	0.799
OCT 20 73	6.621	4.583	7.002	6.676	0.186	0.828
DEC 13 73	7.862	5.947	6.694	6.143	0.016	0.718
MAY 6 74	6.615	4.693	8.191	7.791	0.248	0.865
JUN 29 74	7.477	5.754	7.779	7.100	0.105	0.778
PASTURELAND--SHALLOW AND MODERATELY DEEP LOAMY (CH4 P1 GT)						
SEP 19 72	8.336	7.436	7.171	6.037	-0.104	0.629
OCT 25 72	9.320	7.609	6.985	5.910	-0.126	0.612
FEB 10 73	8.052	6.775	6.581	6.229	-0.042	0.677
APR 5 73	7.601	6.598	7.315	6.788	0.014	0.717
APR 23 73	7.302	5.676	7.623	6.936	0.100	0.775
MAY 11 73	8.333	6.316	8.155	7.126	0.060	0.748
MAY 29 73	7.058	5.334	8.265	7.918	0.195	0.834
AUG 27 73	8.758	6.062	7.311	6.136	0.006	0.711
OCT 2 73	6.950	5.027	6.543	5.793	0.071	0.756
OCT 20 73	6.547	4.850	6.064	5.598	0.071	0.755
DEC 13 73	7.956	6.359	6.116	5.481	-0.074	0.653
MAY 6 74	6.937	5.381	7.646	6.923	0.125	0.791
JUN 29 74	8.130	6.633	7.929	6.845	0.016	0.718

CHICKASHA, OKLAHOMA (CONTINUED)

DATE	RADIANCE (MWATTS/SQCM-STR-MICROMETER) BAND 4	BAND 5	BAND 6	BAND 7	BAND RATIO PARAMETER	TRANSFORMED VEGETATION INDEX
PASTURELAND--DEEP FINE SANDY LOAM AND SILT LOAM (CH5 P1 GT)						
SEP 19 72	8.496	7.539	6.966	5.859	-0.125	0.612
OCT 25 72	9.260	7.471	6.735	5.739	-0.131	0.607
FEB 10 73	8.108	6.546	6.274	6.003	-0.043	0.676
APR 5 73	8.001	7.113	7.851	7.413	0.021	0.722
APR 23 73	7.296	5.528	6.766	6.173	0.055	0.745
MAY 11 73	8.535	6.662	7.834	6.789	0.009	0.714
MAY 29 73	7.177	5.529	7.848	7.427	0.146	0.804
AUG 27 73	9.037	6.661	8.104	7.029	0.027	0.726
OCT 2 73	7.124	5.137	6.927	6.344	0.105	0.778
OCT 20 73	6.541	4.764	6.440	5.949	0.111	0.781
DEC 13 73	8.165	6.817	6.608	5.953	-0.068	0.657
MAY 6 74	7.122	5.639	7.721	6.950	0.104	0.777
JUN 29 74	8.220	6.575	7.763	6.789	0.016	0.718
PASTURELAND--DEEP FINE SANDY LOAM BOTTOMLAND (CH8 P1 GT)						
SEP 19 72	6.539	5.260	5.340	4.724	-0.054	0.668
OCT 25 72	7.935	5.400	5.108	4.513	-0.090	0.641
FEB 10 73	7.773	6.349	6.824	6.708	0.027	0.726
APR 5 73	7.594	6.301	7.166	6.819	0.039	0.734
APR 23 73	6.350	4.110	7.158	7.004	0.260	0.872
MAY 11 73	8.733	5.935	8.423	7.699	0.129	0.793
MAY 29 73	6.977	5.124	8.105	7.927	0.215	0.845
AUG 27 73	8.300	5.999	7.491	6.468	0.038	0.733
OCT 2 73	7.105	5.730	6.366	5.785	0.005	0.710
OCT 20 73	6.658	4.391	7.628	7.683	0.273	0.879
DEC 13 73	7.978	6.042	6.812	6.397	0.028	0.727
MAY 6 74	6.950	5.436	7.696	7.186	0.139	0.799
JUN 29 74	7.505	6.018	6.939	6.068	0.004	0.710

RESOURCE-LAND USE AND DATE LEGEND

COLLEGE STATION (NORTH), TEXAS

RESOURCE-LAND USE CODE	MASK SYMBOL
CS3 R1 GN N1	1
CS3 R1 GN N2	2
CS3 R1 GN N3	3
CS3 R4 GN	F
CS3 R5 GN	G
CS3 R6 GN	H
CS4 R1 GN	N
CS5 R6 GN	O
CS3 P1 GT	J

CALENDAR DATE	OBSERVATION-ID DATE
AUG 30 72	1038-16303
OCT 23 72	1092-16305
NOV 28 72	1128-16311
DEC 16 72	1146-16311
MAR 16 73	1236-16314
MAY 9 73	1290-16312
MAY 27 73	1308-16311
JUL 20 73	1362-16304
OCT 18 73	1452-16284
MAR 29 74	1614-16254
JUN 27 74	1704-16231

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

COLLEGE STATION (SOUTH), TEXAS

RESOURCE-LAND USE CODE	MASK SYMBOL
CS1 R2 GN	A
CS1 R5 GN	B
CS2 R6 GN	C
CS3 R1 GN	D
CS3 R2 GN	E
CS3 R4 GN	F
CS3 R5 GN	G
CS3 R6 GN	H
CS2 P1 GT	I
CS3 P1 GT	J

CALENDAR DATE	OBSERVATION-ID DATE
OCT 23 72	1092-16305
NOV 28 72	1128-16311
DEC 16 72	1146-16311
MAR 16 73	1236-16314
MAY 9 73	1290-16312
MAY 27 73	1308-16311
JUL 20 73	1362-16304
OCT 18 73	1452-16284
MAR 29 74	1614-16254
JUN 27 74	1704-16231

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

SONORA, TEXAS

RESOURCE-LAND USE CODE	MASK SYMBOL
SO4 R2 GN1	1
SO4 R2 GN2	2
SO4 R2 GN3	3
SO4 R2 GN4	4
SO4 R2 GN5	5
SO4 R2 GN6	6
SO4 R2 GN7	7
SO4 R2 GN8	8
SO4 R2 GN9	9
SO4 R2 GN10	0
SO4 R2 GN11	A
SO4 R2 GN12	B
SO4 R2 GN13	C
SO4 R2 GN15	D
SO4 R2 GN17	E
SO4 R2 GN19	F
SO4 R2 GN22	G
SO4 R2 GN23	H
SO4 R2 GN24	I
SO4 R1 GN25	J
SO4 R2 GN26	K
SO4 R1 GN27	L
SO4 R2 GNB	M
SO4 R2 GNC	N
SO4 R1 GND	P
SO4 R2 GNG	Q
SO4 R2 GNH	R
SO4 R2 GNK	S
SO1 R2 GNK	T
SO5 R2 GNK	U
SO1 R2 GNN	V
SO4 R2 GNN	W
SO4 R2 GN	Z
SO5 R2 GN	Y

CALENDAR DATE	OBSERVATION-ID DATE
SEP 20 72	1059-16474
NOV 13 72	1113-16482
DEC 1 72	1131-16483
MAR 1 73	1221-16484
MAR 18 73	1238-16430
APR 5 73	1256-16430
APR 24 73	1275-16484
MAY 29 73	1310-16424
JUL 4 73	1346-16422
JUL 23 73	1365-16475
SEP 14 73	1418-16411
JAN 19 74	1545-16442
MAR 31 74	1616-16371
APR 19 74	1635-16422

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

THROCKMORTON, TEXAS

RESOURCE-LAND USE CODE	MASK SYMBOL
TH1 R1 GN	G
TH1 R2 GN	H
TH2 R1 GN	I
TH2 R2 GN	J
TH3 R1 GN	K
TH4 R1 GN	L
TH4 R2 GN	M
TH R1 GN	N
TH R2 GN	O
TH R3 GN	P

CALENDAR DATE	OBSERVATION-ID DATE
SEP 19 72	1058-16410
OCT 8 72	1077-16470
NOV 13 72	1113-16473
DEC 19 72	1149-16473
FEB 10 73	1202-16420
MAR 18 73	1238-16421
APR 5 73	1256-16421
MAY 11 73	1292-16420
MAY 29 73	1310-16415
JUL 4 73	1346-16413
OCT 2 73	1436-16395
OCT 20 73	1454-16392
DEC 13 73	1508-16385
FEB 24 74	1581-16424
MAR 31 74	1616-16362
MAY 24 74	1670-16345
JUN 11 74	1688-16342
JUN 29 74	1706-16334

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

WOODWARD, OKLAHOMA

RESOURCE-LAND USE CODE	MASK SYMBOL
WO6 R1 GN1	1
WO11 R1 GN2	6
WO6 R1 GN2	2
WO11 R1 GN3	3
WO6 R1 GN4	4
WO6 R1 GN5	5
WO6 R1 GNR	A
WO7 R1 GNR	B
WO11 R1 GNR	C
WO2 R1 GN	E
WO3 R1 GN	F
WO4 R1 GN	G
WO6 R1 GN	I
WO8 R1 GN	J
WO11 R1 GN	K
WO3 R1 GNB	L

CALENDAR DATE	OBSERVATION-ID DATE
DEC 1 72	1131-16465
APR 6 73	1257-16471
JUN 17 73	1329-16463
JUL 5 73	1347-16462
AUG 10 73	1383-16455
AUG 28 73	1401-16453
OCT 21 73	1455-16441

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

HAYS, KANSAS

RESOURCE-LAND USE CODE	MASK SYMBOL
HA2 R1 GN	A
HA3 R1 GN	B
HA6 R1 GN	C
HA9 R1 GN	D
HA10 R1 GN	E
HA13 R1 GN	F
HA7 R1 GN	G
HA2 R1 GN1	H
HA9 R1 GN1	J

CALENDAR DATE	OBSERVATION-ID DATE
SEP 21 72	1060-16505
OCT 26 72	1095-16454
APR 6 73	1257-16462
MAY 13 73	1294-16515
MAY 31 73	1312-16514
JUN 17 73	1329-16454
JUL 6 73	1348-16511
JUL 23 73	1365-16452
AUG 10 73	1383-16450
AUG 29 73	1402-16503
OCT 4 73	1438-16494
OCT 21 73	1455-16432

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

SANDHILLS, NEBRASKA

RESOURCE-LAND USE CODE	MASK SYMBOL
SH3 R1 GN2	C
SH3 R1 GN1	A
SH11 R1 GN1	B
SH11 R1 GN2	D
SH4 R1 GN3	E
SH11 R1 GN3	F
SH3 R1 GN4	G
SH2 R1 H4	V
SH11 R1 H4	H
SH3 R1 GN5	I
SH4 R1 GN5	J
SH5 R1 GN5	K
SH11 R1 GN5	L
SH2 R1 GN	M
SH3 R1 GN	N
SH4 R1 GN	O
SH8 R1 GN	P
SH9 R1 GN	Q
SH11 R1 GN	R
SH4 R1 H	S

CALENDAR DATE	OBSERVATION-ID DATE
AUG 17 72	1025-16553
SEP 4 72	1043-16552
MAY 15 73	1296-17020
JUN 1 73	1313-16561
JUL 26 73	1368-17011
AUG 12 73	1385-16551
AUG 30 73	1403-16545
MAY 28 74	1674-16545
JUN 15 74	1692-16541
JUL 2 74	1709-16482

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

COTTONWOOD, SOUTH DAKOTA

RESOURCE-LAND USE CODE	MASK SYMBOL
CW R1 GN1	1
CW R1 GN2	2
CW R1 GN3	3
CW R1 GN4	4
CW R1 GN5	5
CW R1 GN6	6
CW R1 GN7	7
CW R1 GN8	8
CW R1 GN9	9
CW R1 GN10	0
CW R1 GN11	A
CW R1 GN12	B
CW R1 GN13	C
CW R1 GN	D
CW R2 GN	E
CW R1 H	F

CALENDAR DATE	OBSERVATION-ID DATE
AUG 19 72	1027-17063
SEP 6 72	1045-17063
SEP 24 72	1063-17062
OCT 12 72	1081-17064
MAY 15 73	1296-17020
JUN 21 73	1333-17070
JUL 9 73	1351-17064
JUL 26 73	1368-17011
AUG 14 73	1387-17061
SEP 1 73	1405-17060
SEP 18 73	1422-17001
APR 22 74	1638-16555
JUN 15 74	1692-16541

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

MANDAN, NORTH DAKOTA

RESOURCE-LAND USE CODE	MASK SYMBOL
MA1 R1 GN	L
MA2 R1 GN	M
MA4 R1 GN	N
MA5 R1 GN	O
MA6 R1 GN	P
MA9 R1 GN	Q
MA1 R1 H	R
MA2 R1 H	S

CALENDAR DATE	OBSERVATION-ID DATE
SEP 24 72	1063-17053
OCT 12 72	1081-17055
APR 27 73	1278-17012
MAY 15 73	1296-17011
JUN 21 73	1333-17061
JUL 9 73	1351-17055
MAY 29 74	1675-16592

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

WESLACO, TEXAS

RESOURCE-LAND USE CODE	MASK SYMBOL
WE1 R1 GN1	1
WE3 R1 GN2	2
WE1 R1 GN	3
WE1 R2 GN	4
WE1 R5 GN	5
WE2 R1 GN	6
WE2 R2 GN	7
WE2 R5 GN	8
WE3 R1 GN	9
WE3 R2 GN	0
WE3 R5 GN	Z
WE4 R1 GN	Y
WE4 R5 GN	X
WE6 R1 GN	W
WE6 R5 GN	V
WE3 P1 GT	U
WE6 P1 GT	T
WE3 P1 H	S

CALENDAR DATE	OBSERVATION-ID DATE
OCT 6 72	1075-16373
MAR 16 73	1236-16325
APR 3 73	1254-16325
JUL 20 73	1362-16315
SEP 12 73	1416-16310
SEP 30 73	1434-16303
OCT 18 73	1452-16300
MAR 29 74	1614-16270
MAY 4 74	1650-16260

RESOURCE-LAND USE AND DATE LEGEND (CONTINUED)

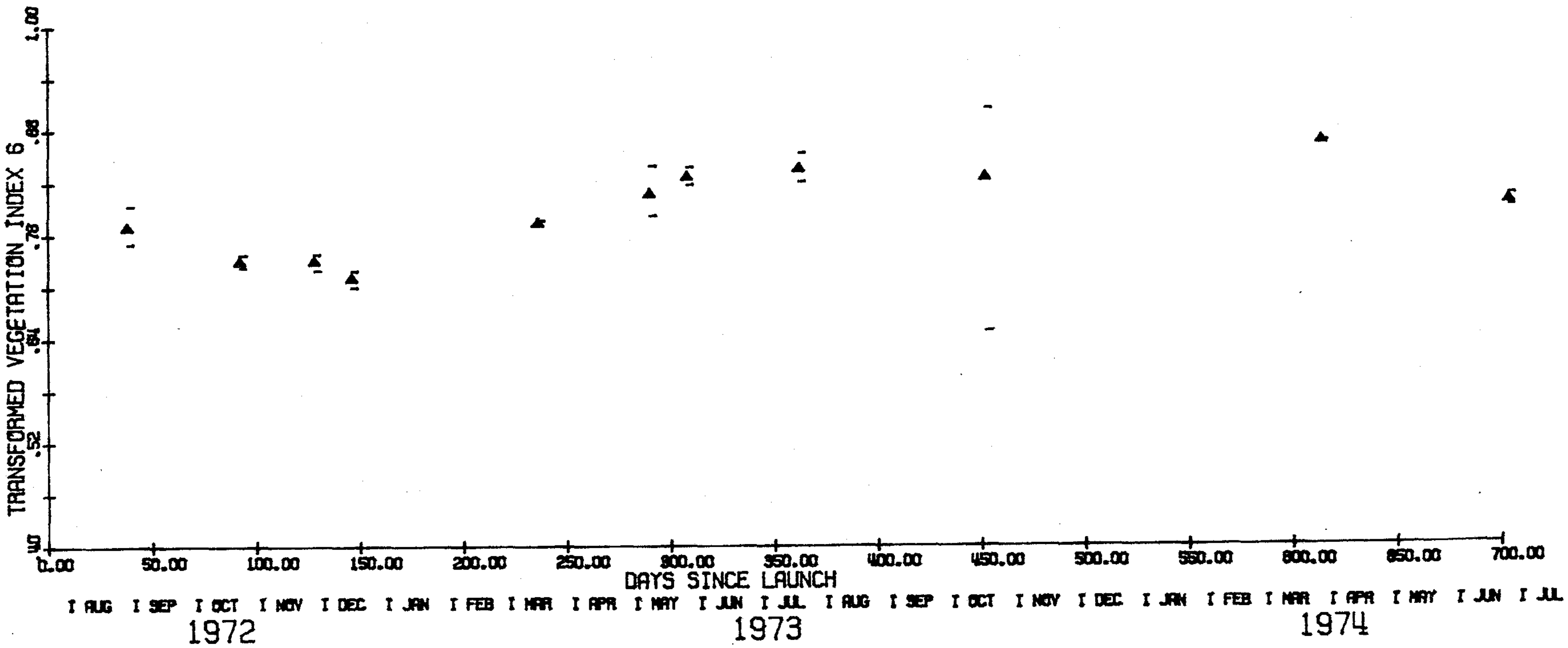
CHICKASHA, OKLAHOMA

RESOURCE-LAND USE CODE	MASK SYMBOL
CH1 R1 GN1	1
CH5 R1 GN2	2
CH5 R1 GN34	3
CH1 R1 GN5	5
CH1 R1 GN	A
CH2 R1 GN	B
CH3 R1 GN	C
CH4 R1 GN	D
CH5 R1 GN	E
CH6 R1 GN	F
CH7 R1 GN	G
CH8 R1 GN	H
CH5 R6 GN	I
CH8 R6 GN	J
CH4 P1 GT	K
CH5 P1 GT	L
CH8 P1 GT	P

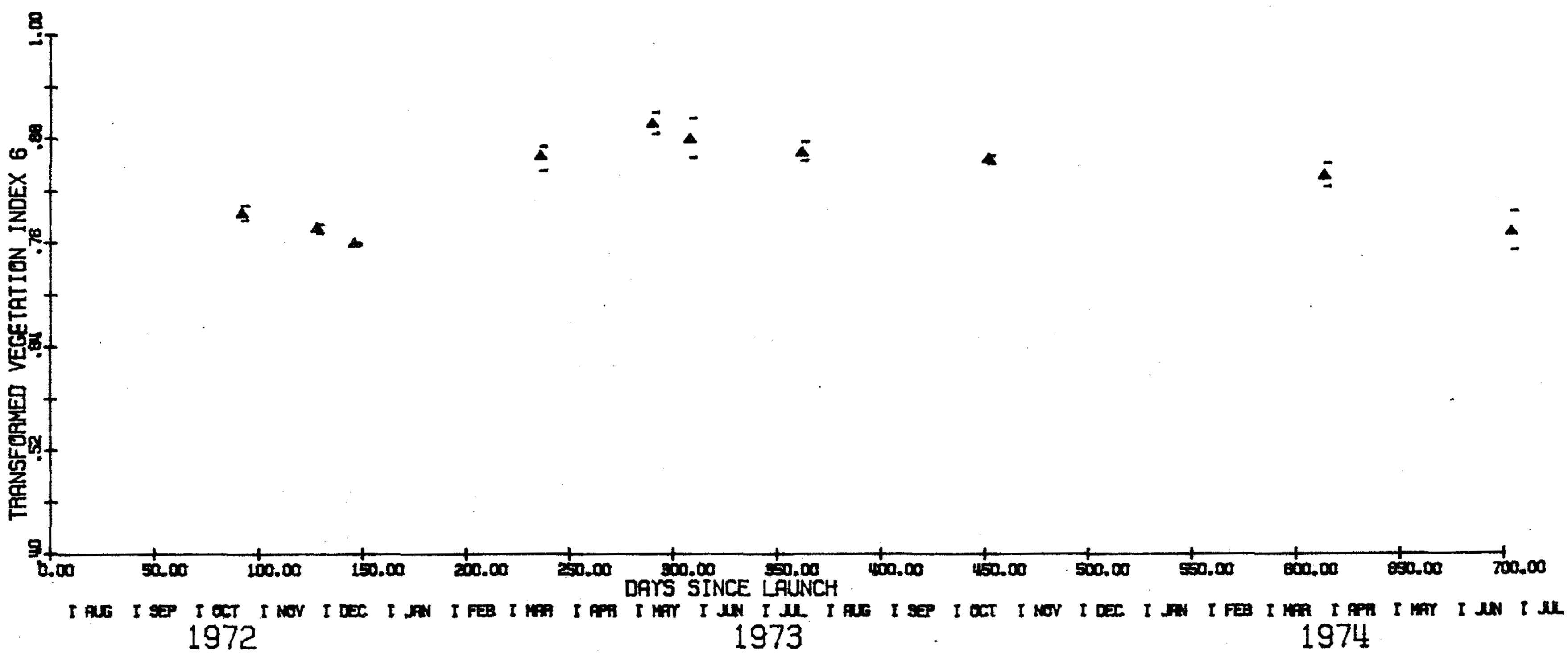
CALENDAR DATE	OBSERVATION-ID DATE
SEP 19 72	1058-16404
OCT 25 72	1094-16411
FEB 10 73	1202-16413
APR 5 73	1256-16415
APR 23 73	1274-16414
MAY 11 73	1292-16414
MAY 29 73	1310-16413
AUG 27 73	1400-16402
OCT 2 73	1436-16393
OCT 20 73	1454-16385
DEC 13 73	1508-16383
MAY 6 74	1652-16350
JUN 29 74	1706-16332

APPENDIX G

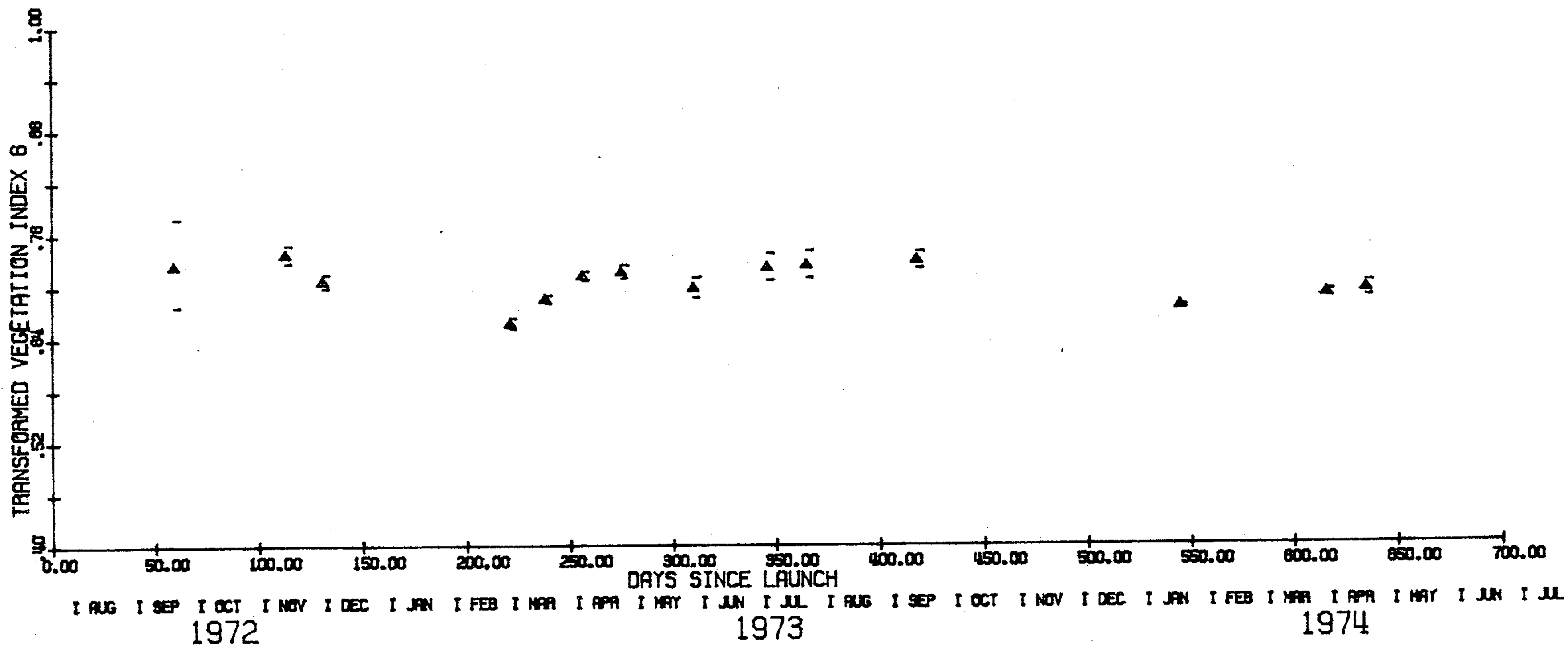
ERTS1
TRANSFORMED VEGETATION INDEX 6
NORTH COLLEGE STATION, TEXAS
SUBSITE AREAS - 1,2,3 (AVE)



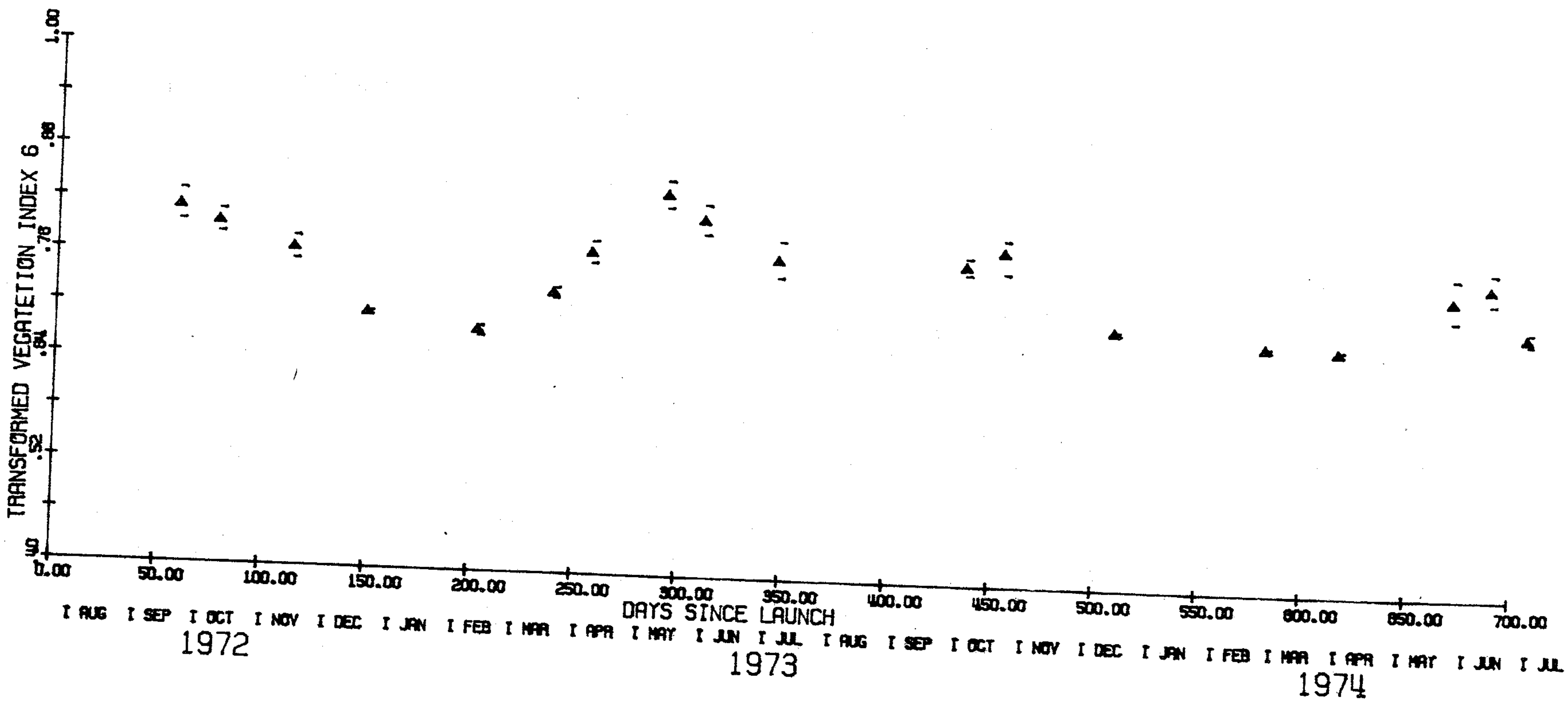
ERTS1
TRANSFORMED VEGETATION INDEX 6
SOUTH COLLEGE STATION, TEXAS
SUBSITE AREAS - D,J (AVE)



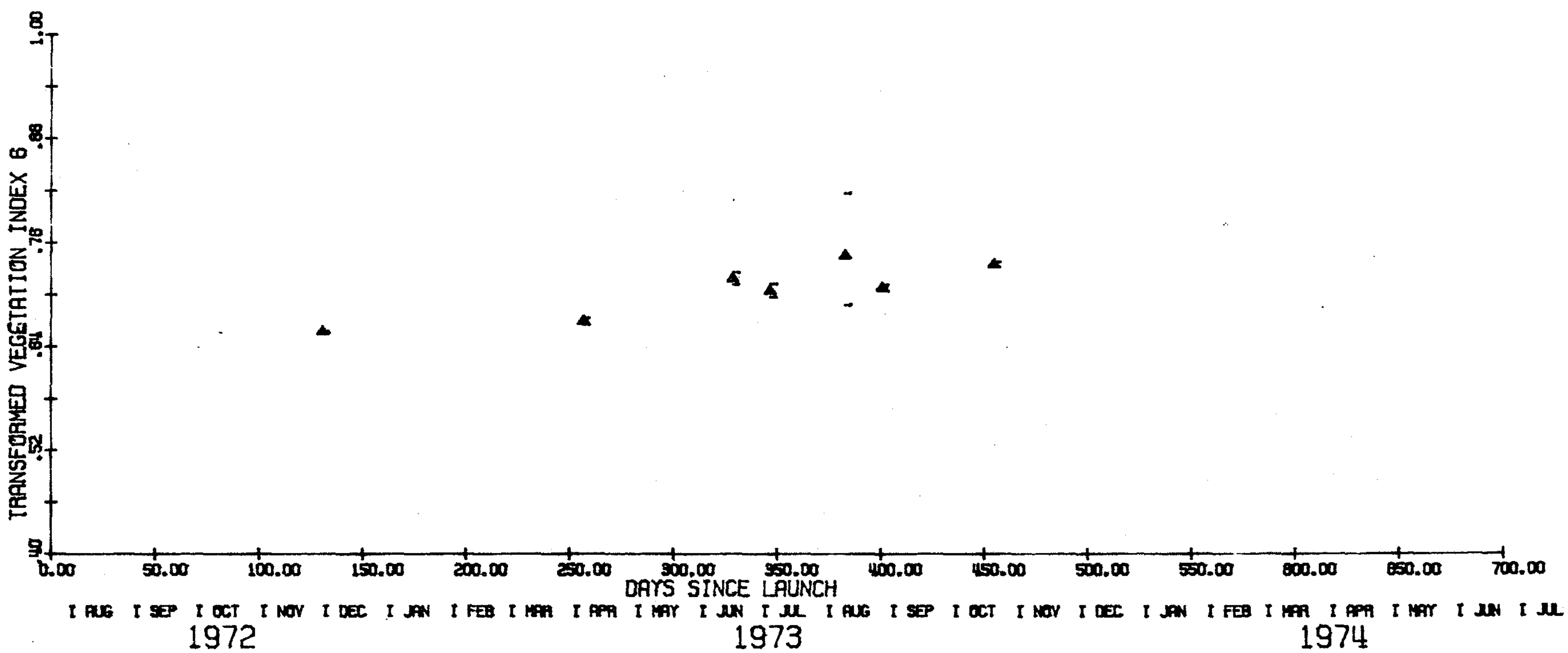
ERTS1
TRANSFORMED VEGETATION INDEX 6
SONORA, TEXAS
SUBSITE AREAS - 8,9,E,F,J (AVE)



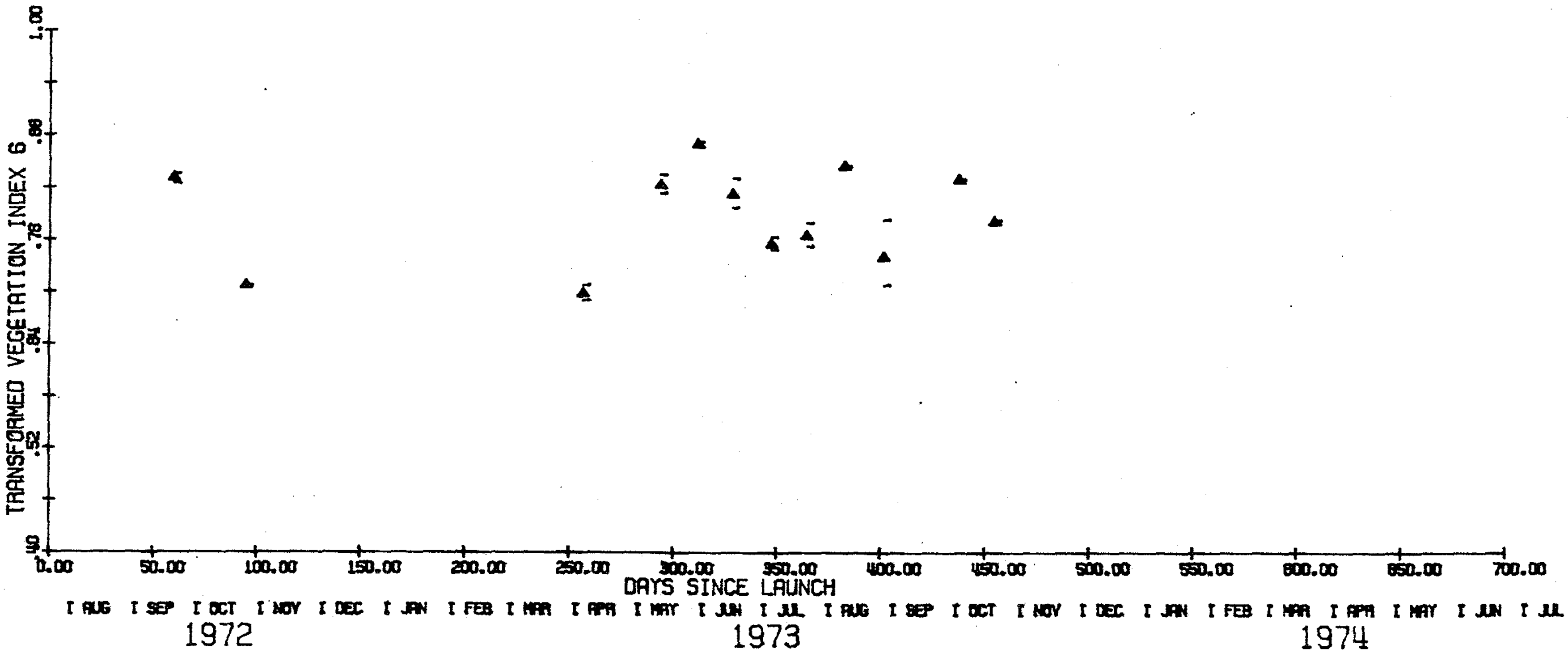
ERTS1
TRANSFORMED VEGETATION INDEX 6
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



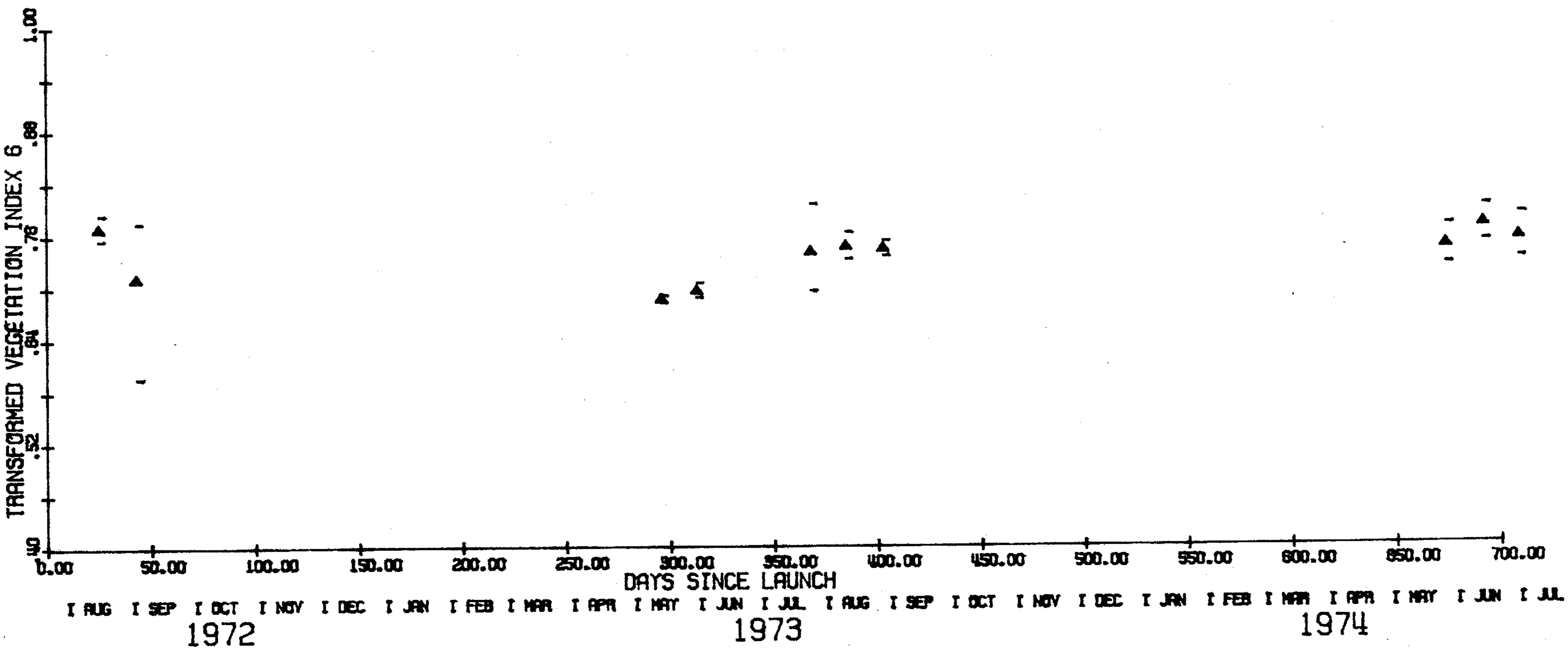
ERTS1
TRANSFORMED VEGETATION INDEX 6
WOODWARD, OKLAHOMA
SUBSITE AREAS - 1,2,3,4,5 (AVE)



ERTS1
TRANSFORMED VEGETATION INDEX 6
HAYS, KANSAS
SUBSITE AREAS - H,J (AVE)



ERTS1
TRANSFORMED VEGETATION INDEX 6
SANDHILLS, NEBRASKA
SUBSITE AREAS - A,C,D,R,V (AVE)

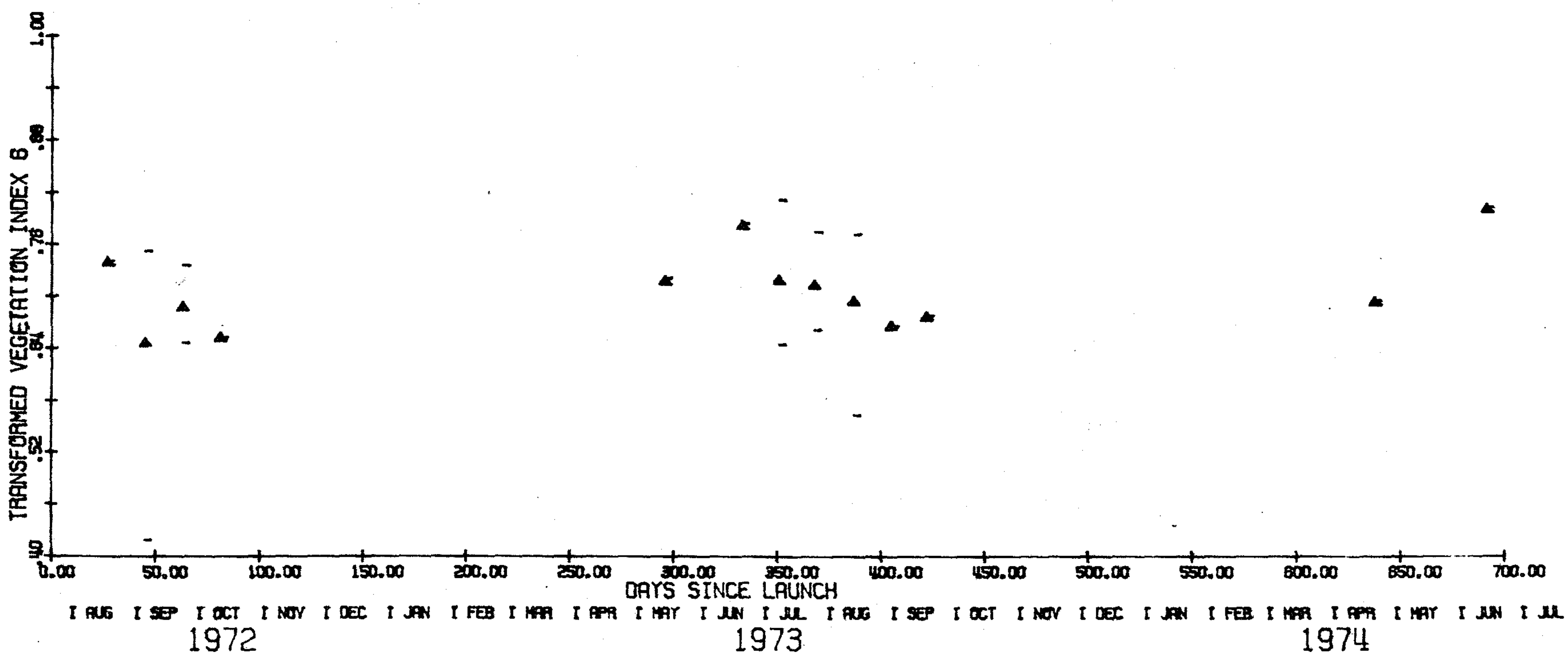


ERTS1

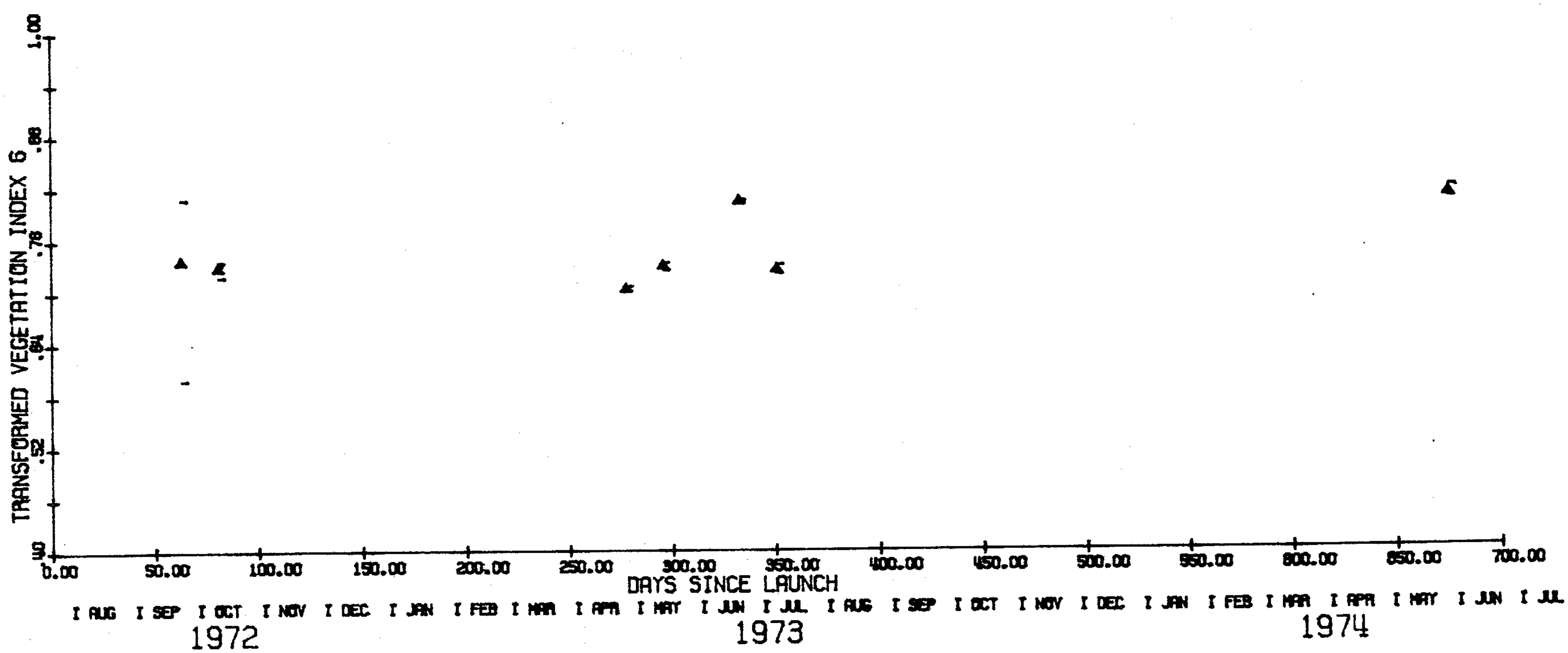
TRANSFORMED VEGETATION INDEX 6

COTTONWOOD, SOUTH DAKOTA

SUBSITE AREAS - 8,A,B,C (AVE)



ERTS1
TRANSFORMED VEGETATION INDEX 6
MANDAN, NORTH DAKOTA
SUBSITE AREA - L

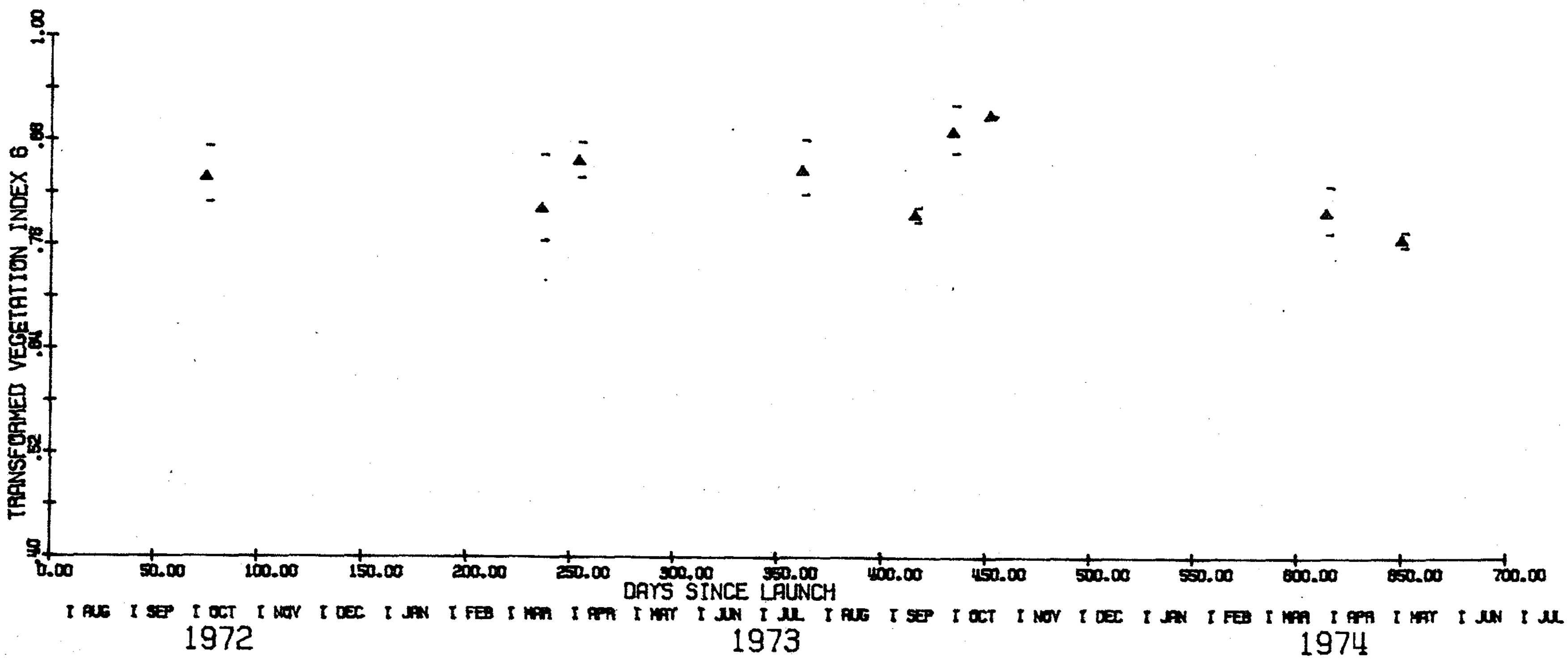


ERTS1

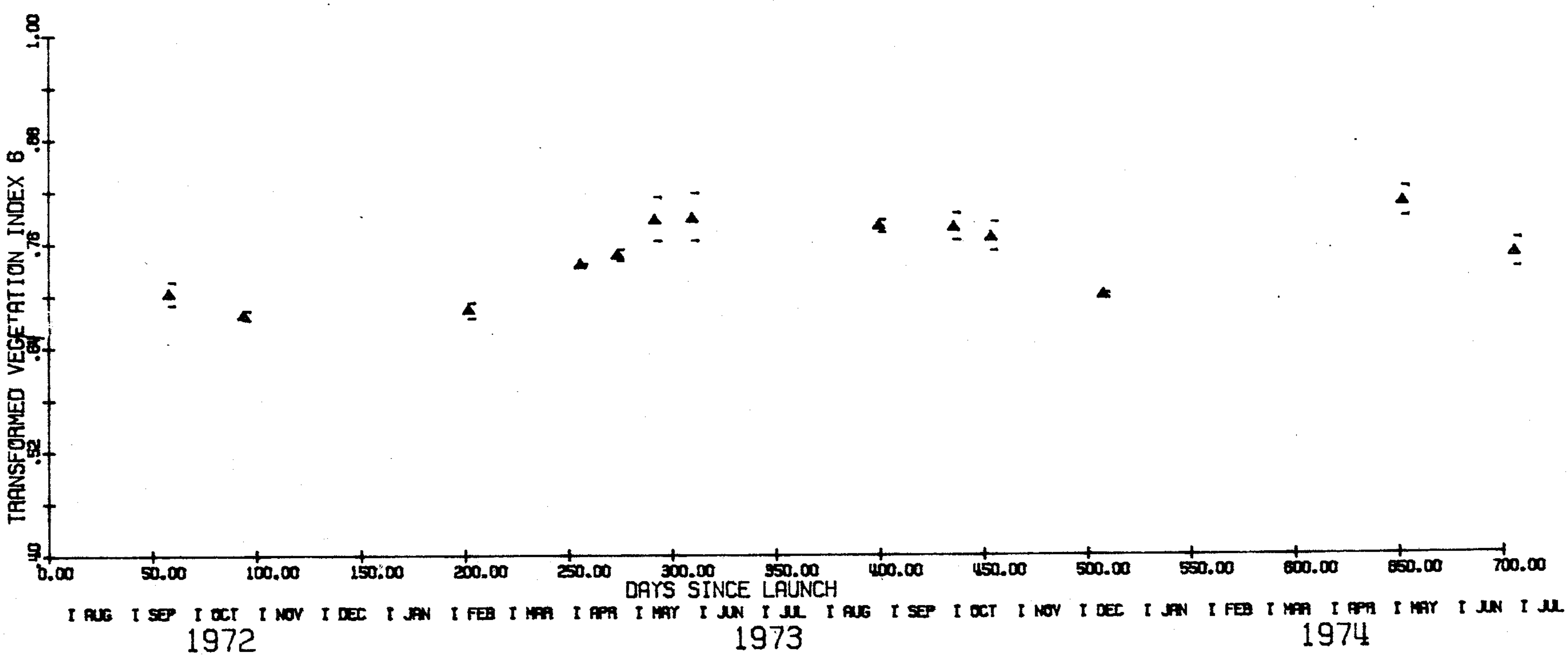
TRANSFORMED VEGETATION INDEX 6

WESLACO, TEXAS

SUBSITE AREAS - 5,Z (AVE)

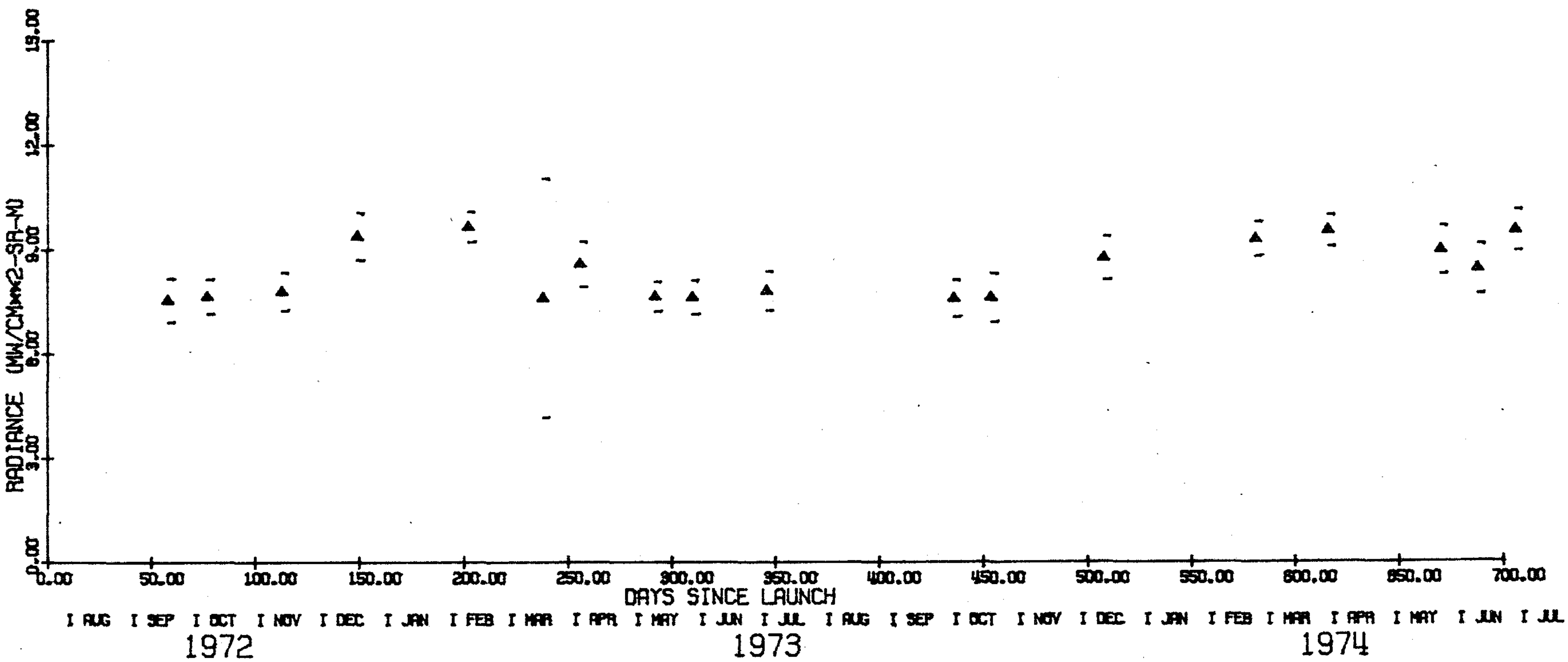


ERTS1
TRANSFORMED VEGETATION INDEX 6
CHICKASHA, OKLAHOMA
SUBSITE AREAS - 1,2,3,5 (AVE)

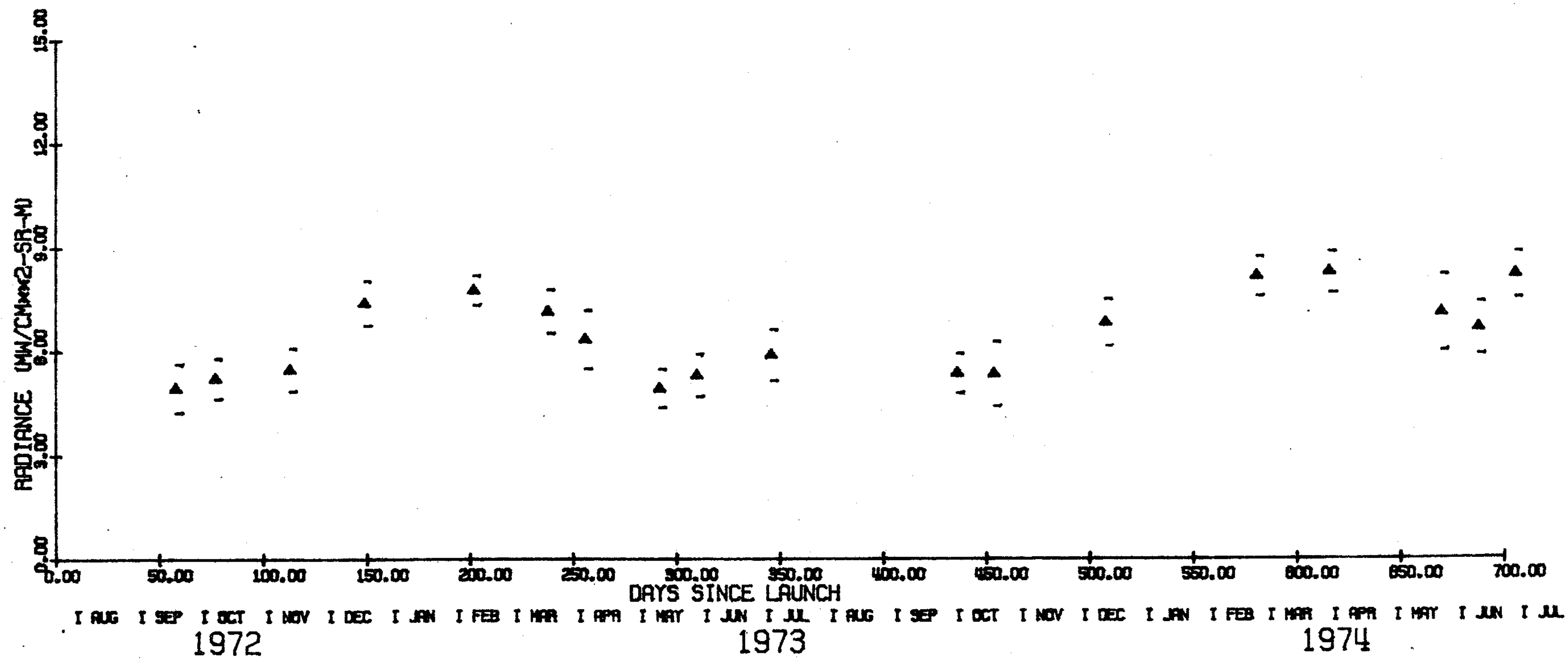


APPENDIX H

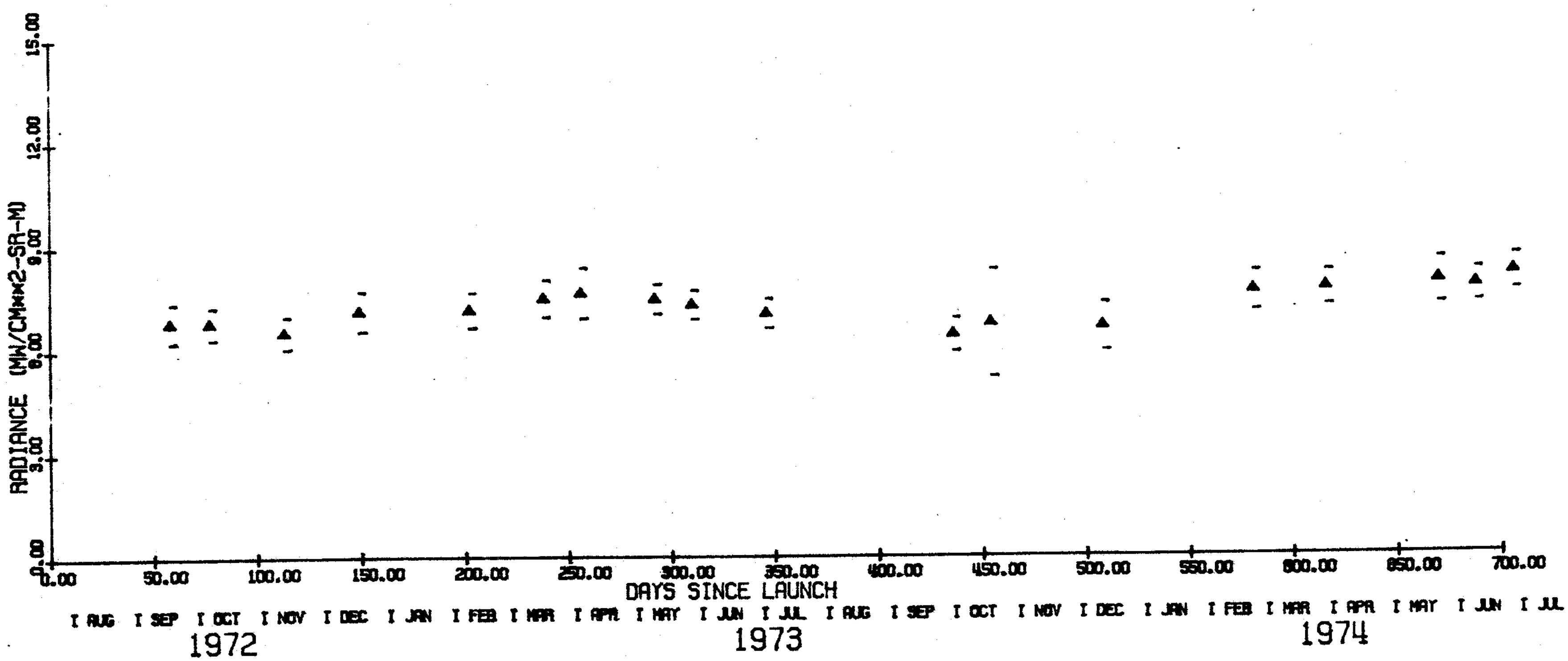
ERTS1 RADIANCE AND
RELATIVE SPECTRAL RESPONSE
BAND 4 0.5-0.6 MICROMETERS
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



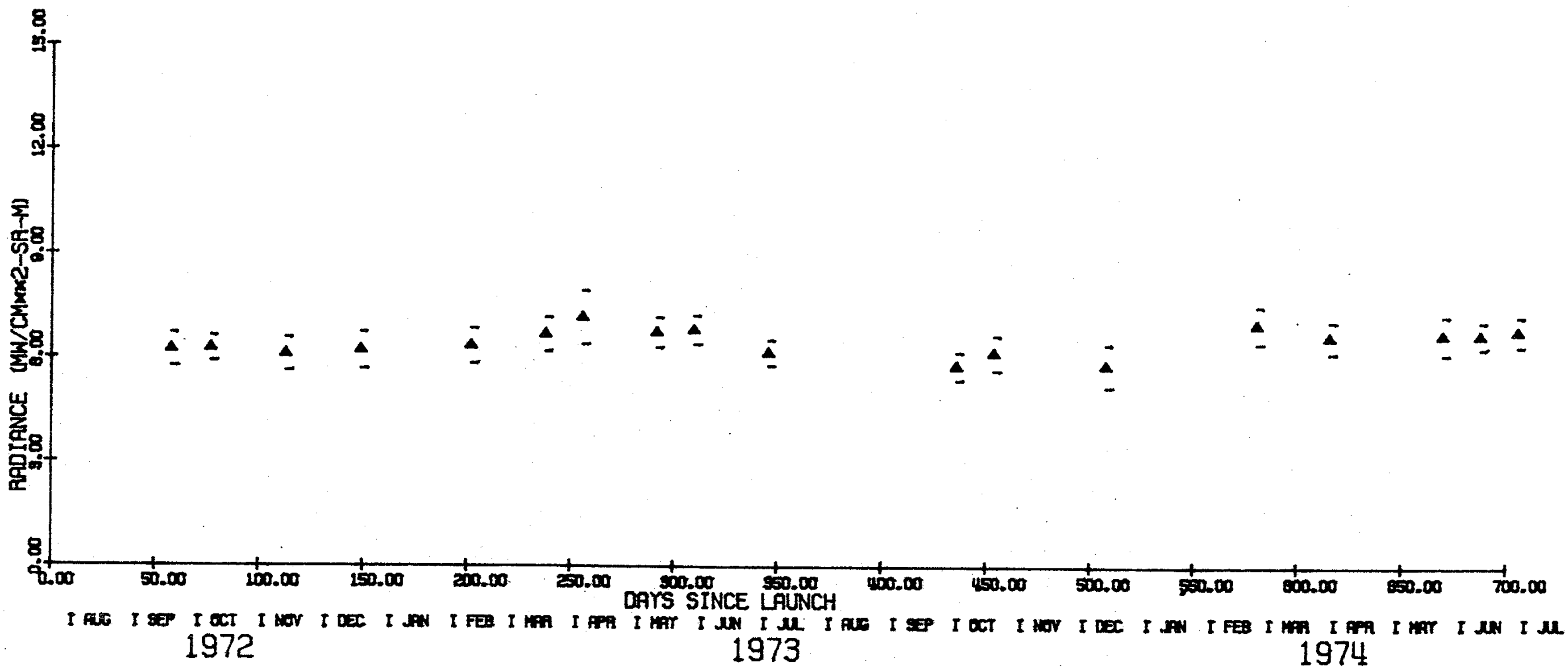
ERTS1 RADIANCE AND
RELATIVE SPECTRAL RESPONSE
BAND 5 0.6-0.7 MICROMETERS
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



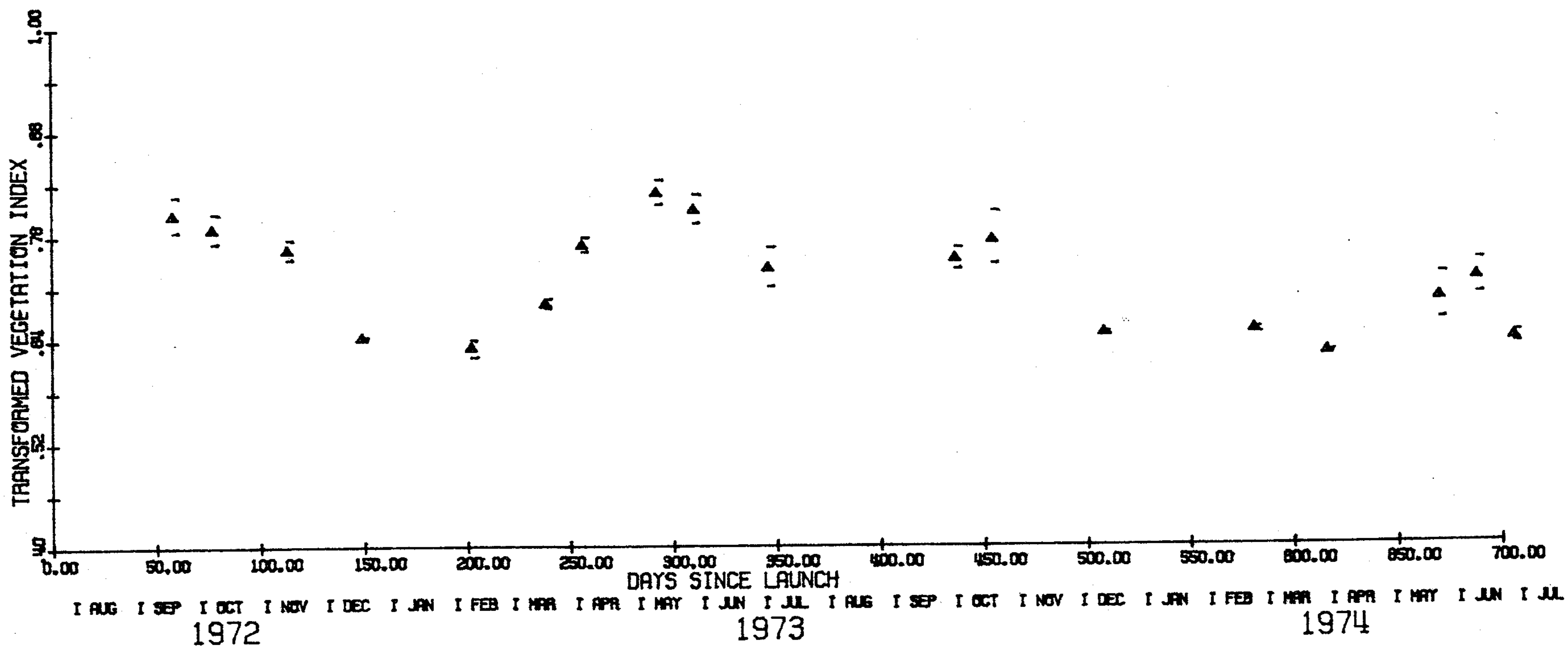
ERTS1 RADIANCE AND
RELATIVE SPECTRAL RESPONSE
BAND 6 0.7-0.8 MICROMETERS
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



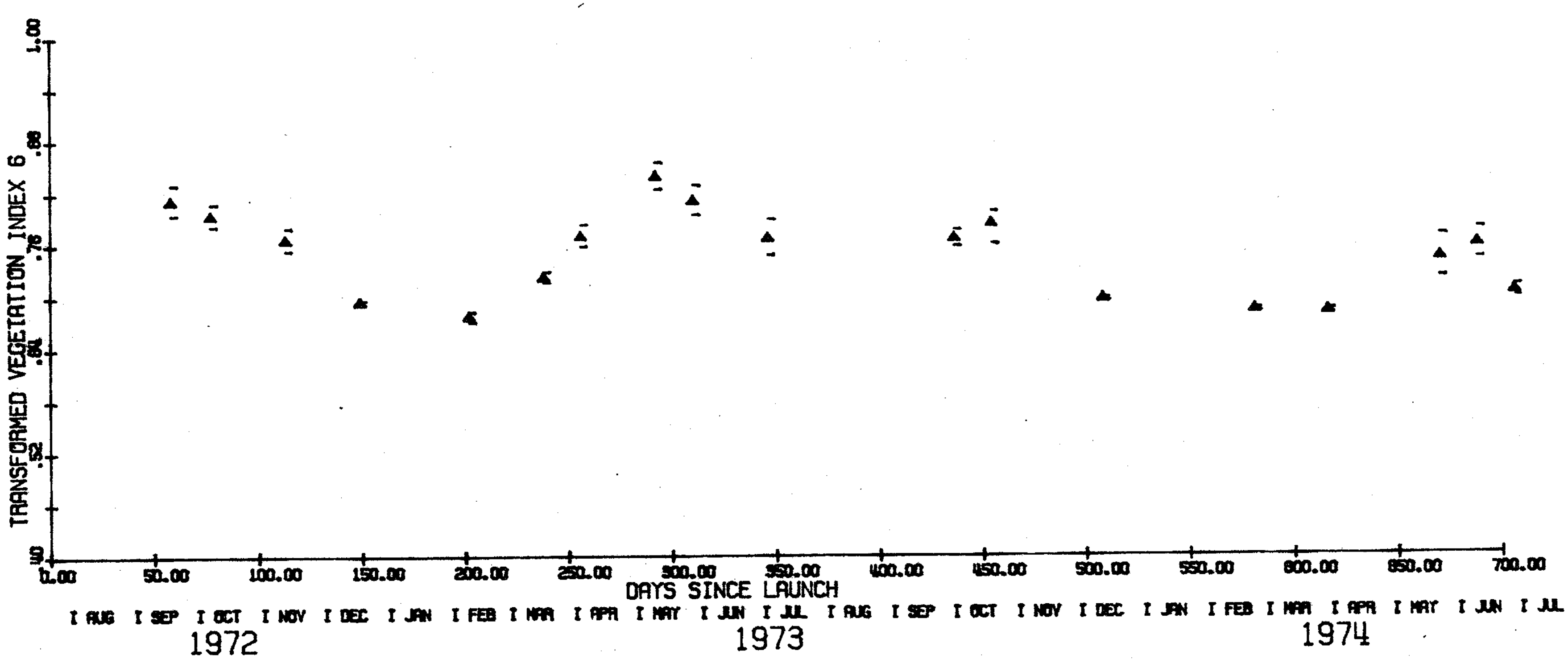
ERTS1 RADIANCE AND
RELATIVE SPECTRAL RESPONSE
BAND 7 0.8-1.1 MICROMETERS
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



ERTS1
TRANSFORMED VEGETATION INDEX
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



ERTS1
TRANSFORMED VEGETATION INDEX 6
THROCKMORTON, TEXAS
SUBSITE AREAS - G,H,L,M (AVE)



The REMOTE SENSING CENTER was established by authority of the Board of Directors of the Texas A&M University System on February 27, 1968. The CENTER is a consortium of four colleges of the University; Agriculture, Engineering, Geosciences, and Science. This unique organization concentrates on the development and utilization of remote sensing techniques and technology for a broad range of applications to the betterment of mankind.