https://ntrs.nasa.gov/search.jsp?R=19740022614 2020-05-19T04:13:30+00:00Z

Paper A 20

MONITORING VEGETATION SYSTEMS IN THE GREAT PLAINS WITH ERTS

J. W. Rouse, Jr., R. H. Haas, J. A. Schell and D. W. Deering, *Remote Sensing Center, Texas A&M University, College Station, Texas*

ABSTRACT

The Great Plains Corridor rangeland project being conducted at Texas A&M University utilizes natural vegetation systems as phenological indicators of seasonal development and climatic effects upon regional growth conditions. A method has been developed for quantitative measurement of vegetation conditions over broad regions using ERTS-1 MSS data. Radiance values recorded in ERTS-1 spectral bands 5 and 7, corrected for sun angle, are used to compute a band ratio parameter which is shown to be correlated with aboveground green biomass on rangelands.

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 this region is a $23 billion operation, which is extremely vulnerable to adverse seasonal or climatic conditions. The stability of the beef and agricultural products industry in the Great Plains is contingent upon decisions made by the 400,000 farm and ranch owners 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 paper reports on an ERTS-1 study of rangelands in the Great Plains that has established the potential for using ERTS-type data to provide quantitative regional vegetative condition information required in support of these agricultural operations.

The Great Plains Corridor rangeland project utilizes natural vegetation systems as phenological indicators of seasonal development and climatic effects upon regional growth conditions. The basic task is that of monitoring the vernal advancement and retrogradation of vegetation (green wave effect) throughout the uniform Mixed Prairie Grassland Association extending from south Texas into Canada. The objective of the work is to determine the feasibility of using ERTS-type data to map regional vegetation conditions throughout the growing season for the Great Plains.

N74 30727

The study employs a network of ten test sites in six states extending from south Texas into North Dakota. Ground observations recorded every eighteen days at each site include green biomass, moisture content of vegetation, weather information, etc. ERTS-1 MSS data have been acquired for all sites for four full seasons.

The ERTS-1 MSS data were computer processed for selected areas of each site. Spectral reflectance data were analyzed for each available date for each site. 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 compute a Band Ratio Parameter which is shown to be correlated with aboveground green biomass and vegetation moisture content.

This research has established a method for obtaining a quantitative measurement of vegetation conditions over broad regions using ERTS-1 MSS data. It is anticipated that this capability will be further developed to provide regional rangeland vegetation condition and growing condition information needed in rangeland management and agri-business activities in the Great Plains.

OBJECTIVES

The objectives of the Great Plains Corridor Project were established to examine three basic hypotheses:

Hypothesis 1: *The vernal advancement and retrogradation of vegetation (green wave effect) can be discriminated on a regional basis using repetitive multispectral data.*

Hypothesis 2: *Natural vegetation parameters provide a new information source for regional agri-business use.*

Hypothesis 3: *Temporal effects are important in discriminating broad landforms, soil associations, vegetation types, and other natural resource features.*

The specific objectives are:

1. Establish a test site network for collection of ERTS-1 correlated ground data in the Great Plains Corridor.

2. Use ERTS-1 data for charting the "Green Wave Effect" in the Great Plains Corridor.

3. Correlate changes in reflectance characteristics of vegetation measured by ERTS-1 with environmental and growth conditions.

4. Evaluate the use of ERTS-1 data for measuring the kind, amount, and condition of rangeland vegetation.

5. Evaluate the feasibility of an operational satellite system for monitoring the status of natural vegetation in the Great Plains Corridor.

GREAT PLAINS CORRIDOR

An effective rangeland test site network was established within the Great Plains Corridor region during the initial phases of the ERTS-1 investigation. This test site network consists of ten study sites (Fig. 1), nine of which 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.

With the exception of the College Station and Weslaco study sites, which are at elevations of 314 and 225 ft., respectively, the Great Plains Corridor test site elevations span only 1800 ft., from Texas through North Dakota. Their elevations range between 1100 and 2900 ft.

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 clayey soils.

Important community dominants within the Corridor include warm-season grasses (bluegrams, buffalograss, sideoats grams, 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 and of the included study sites, in terms of climate and soils as evidenced through vegetation expression, is demonstrated in Figure 2.

Each of the ten sites is an established research area of a state agricultural experiment station or the USDA. All sites are monitored by the experienced personnel normally associated with the several stations. The ground observations recorded coincident with the ERTS-1 passes include green biomass, standing biomass, moisture content of vegetation, and phenology of dominant species. Ground photography and grass clippings are obtained during each sampling. Weather information is also recorded for all sites.

DATA PROCESSING

The objectives of this study require the acquisition of ERTS-1 measurements showing temporal changes at each of ten locations throughout the Great Plains Corridor. The problem of obtaining radiance data from identical locations are multiple orbits has been handled in two stages. In the first stage, a 7km x 7km area centered on the test site is located, using a computer greymap, and the integrated radiance is computed for each of the MSS bands. The data presented in this paper were obtained from this type processing. The second stage involves "masking" the 7km x 7km sections to remove non-grassland areas. For many sites, this procedure removes only a small percentage of the scene, e.g. Throckmorton.

The radiance measured in each MSS band is computed from the ERTS CCT counts and corrected for seasonal sun angle differences by dividing the CCT value by the sine of the inclination angle of the sun. The correction procedure has been tested using measurements of temporally independent targets.

The data processing procedure has been formalized and implemented on a digital computer to generate the Site Processing Report shown in Figure 3 for each frame of usable data.

SPECTRAL ANALYSIS

The processing of ERTS MSS data provides four parameters which can be analyzed relative to the ground observations. However, previous studies have shown that combinations of these four parameters can provide more useful parameters for specific comparisons. For the purposes of this project, the parameter obtained by taking the difference between the radiance values in bands 5 and 7 has been found to be of particular significances. Although other combinations have been found which correlate with vegetation condition, this project has established that bands 5 and 7 do provide a single quantity indicative of the aboveground green biomass, and consequently the present analysis activity has been restricted to this parameter.

The specific parameter employed is the Band Ratio Parameter (BRP) defined as the difference in the ERTS radiance value measured in bands 5 and 7, divided by their sum. The normalization procedure is used to eliminate seasonal sun angle differences and to minimize the effect of atmospheric attenuation. To avoid working with negative BRP values and the possibility that the variance of the ratio would be proportional to the mean values, a square-root transformation is also computed. This parameter, termed the

Transformed Vegetation Index (TVI), is equal to the square-root of the BRP plus an arbitrary constant. The constant selected was 0.5.

A step-down regression analysis of twenty-nine data sets from the five southern test sites indicated that dry biomass, percent green estimate, moisture content, and their interactions accounted for 60% of the variation in TVI values computed from the heterogeneous 7km x 7km areas. However, data from the uniform grassland site near Throckmorton, Texas show that TVI is highly correlated to vegetation condition. At Throckmorton, the vegetation moisture content and percent green estimate, along with their interaction, accounts for 99% of the variation of TVI for eight sampling dates. The green biomass parameter alone accounts for 89% of the variation in TVI. Addition of the vegetation moisture content and green biomass interaction to the regression of green biomass with TVI increases the accountable variation to 93%. Figure 4 shows the relationship of TVI and green biomass measured for eight dates at the Throckmorton test site.

Analysis of these data suggest that a threshold exists such that the TVI is insensitive to biomass and/or vegetation moisture content below the threshold values. The implication is that sparsely vegetated areas are not amenable to TVI characterization. However, further analysis is necessary to confirm this preliminary indication.

The TVI parameters appear to be most adequate for monitoring the vernal progression and retrogradation of vegetation within the Great Plains Corridor and has good potential for measuring green biomass in increments to useful for regional agricultural applications.

CONCLUSION

This paper provides a brief summary of selected aspects of the Great Plains Corridor Project being conducted at Texas A&M University. The emphasis here is on the quantification of ERTS-1 MSS data to provide measurements of vegetation conditions on a regional basis. The project includes other analysis activities using ERTS-1 data, including image analysis, using color composites and black and white images, and interactive computer analysis. The net result of these activities is confirmation that the basic hypotheses of the study are true.

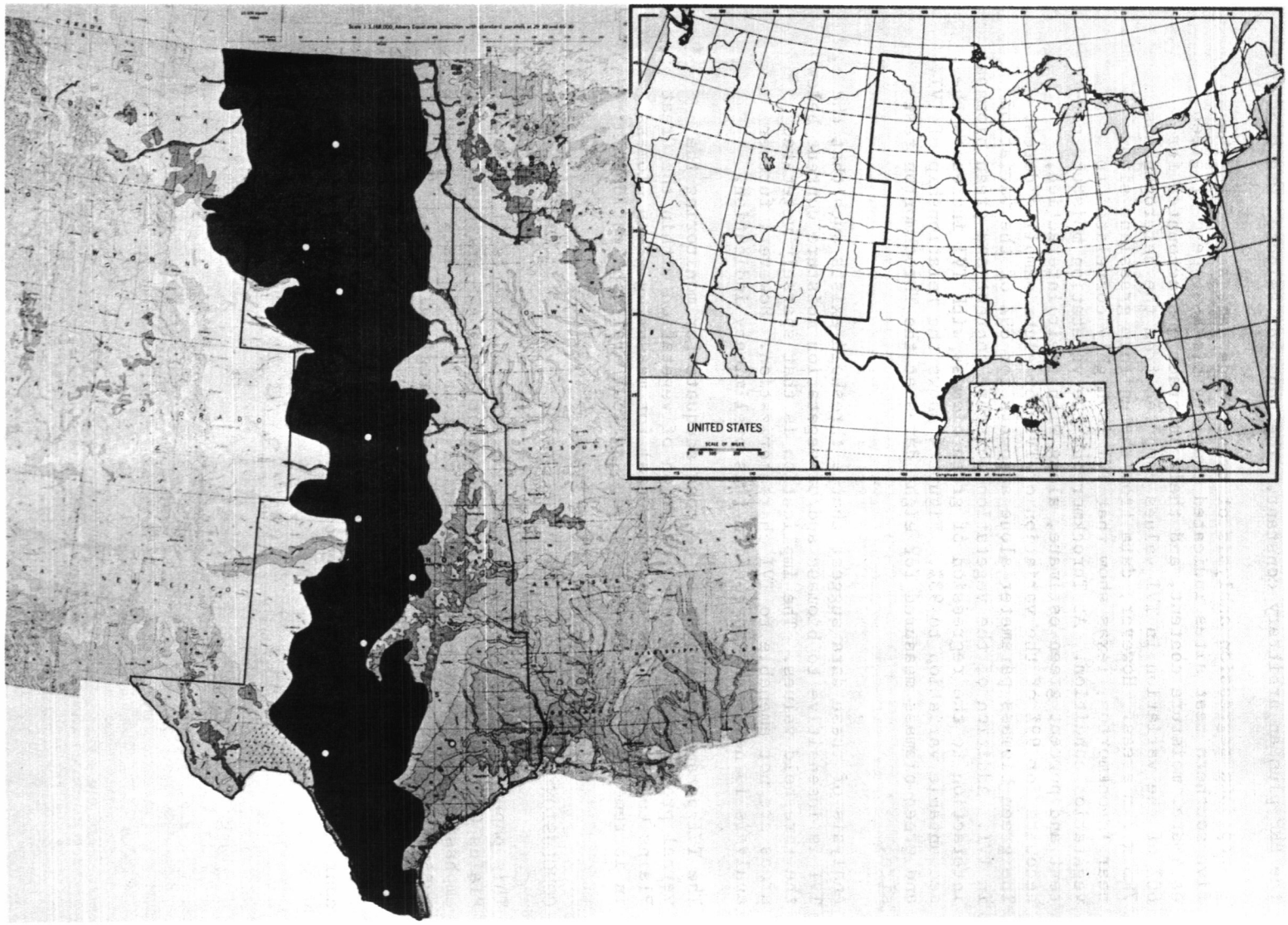

Figure 1. Great Plains Corridor and test site network.

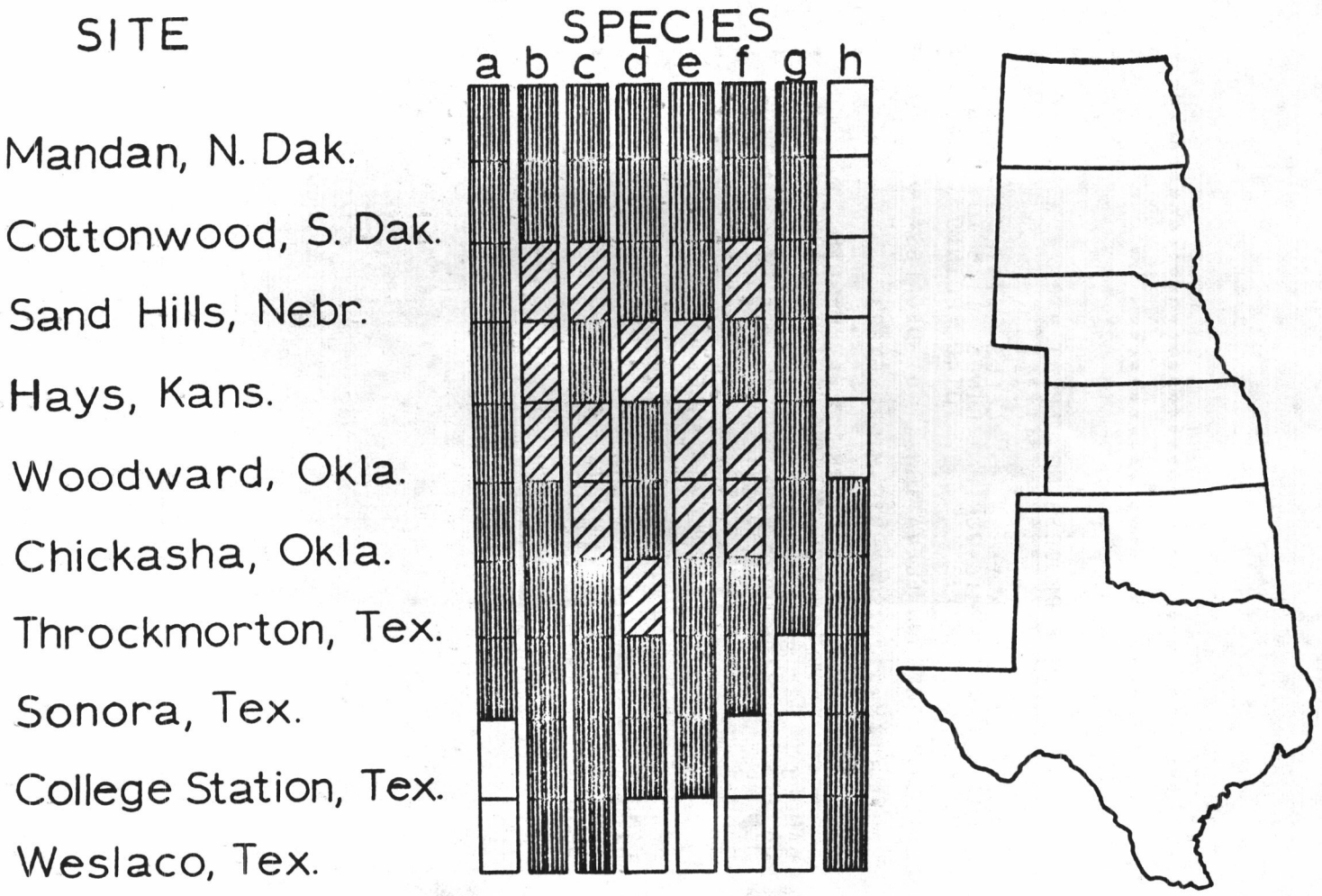

Figure 2. Occurrence of eight dominant grasses on the Great Plains Corridor test sites (vertical stripes), or within the region indicated (diagonal stripes). Dominant grasses are: a)blue grama, b)sideoats grama, c)buffalograss, d)little bluestem, e)big bluestem, f)western wheatgrass, g)needle-and-thread, h)Texas wintergrass.

```
*****************************************************************
*                                                               *
*                  ************************                     *
*                  *                      *                     *
*                  *        ERTS-1        *                     *
*                  *                      *                     *
*                  * SITE PROCESSING REPORT *                   *
*                  ************************                     *
*                                                               *
*  SITE DESIGNATOR:   GP 3* 1          CELLS  1147 TO  1266     *
*  IMAGE IDENTIFIER:  1292-16420       LINES  1115 TO  1196     *
*  DATE ACQUIRED:     11MAY73          TOTAL  POINTS   9840     *
*                                                               *
*    ***CORRECTED FOR SUN ELEVATION    61 DEGREES***            *
*                                                               *
*        RADIANCE(MWATTS/SQCM-STR-MICROMETER)                   *
*                                                               *
*                     MEAN     STANDARD    WAVELENGTH           *
*                              DEVIATION   (MICROMETERS)        *
*        BAND 4       8.01       1.59      .5 - .6              *
*        BAND 5       5.22       0.80      .6 - .7              *
*        BAND 6       7.56       0.57      .7 - .8              *
*        BAND 7       6.76       0.58      .8 -1.1              *
*                                                               *
*                   NORMALIZED COVARIANCES                      *
*                                                               *
*                   BAND 4     BAND 5     BAND 6     BAND 7     *
*        BAND 4      1.000      0.301      0.084     -0.025     *
*        BAND 5      0.301      1.000      0.278     -0.059     *
*        BAND 6      0.084      0.278      1.000      0.803     *
*        BAND 7     -0.025     -0.059      0.803      1.000     *
*                                                               *
*              BAND RATIO PARAMETER  0.128                      *
*              TRANSFORMED PARAMETER 0.793                      *
*                                                               *
* 16.0  +                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*  8.0  +     *                    *                            *
*       :        -                -           -          *      *
*       :           -     -                                     *
*       :              *                                        *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*       :                                                       *
*  0.0  +---------+---------+---------+---------+---------+     *
*      0.5       0.6       0.7       0.8       0.9       1.0    *
*              RADIANCE VS WAVELENGTH                           *
*                                                               *
*  PREPARED BY:TEXAS A&M UNIVERSITY, REMOTE SENSING CENTER      *
*              DATA ANALYSIS LABORATORY  11SEP73                *
*                                                               *
*****************************************************************
```

Figure 3. Site Processing Report.

GREAT PLAINS CORRIDOR PROJECT

THROCKMORTON TEST SITE
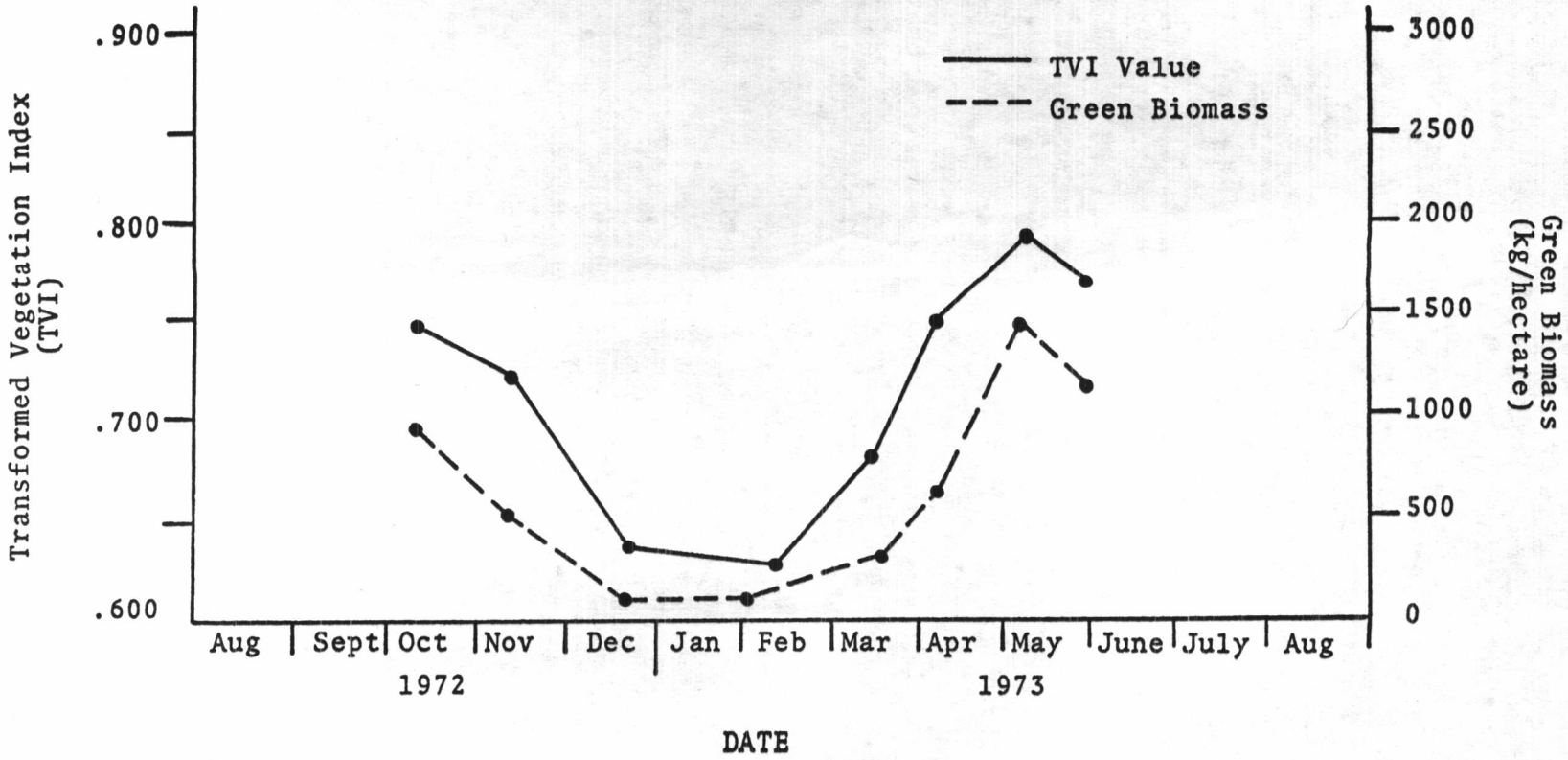
Figure 4. ERTS-1 Transformed Vegetation Index Values Vs. Green Biomass Data