https://ntrs.nasa.gov/search.jsp?R=19800004273 2020-03-21T20:42:56+00:00Z

N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE

06 20540

Final Report RSC 3018-7

III SQT

APPLIED REGIONAL MONITORING OF THE VERNAL ADVANCEMENT AND RETROGRADATION (GREEN WAVE EFFECT) OF NATURAL VEGETATION IN THE GREAT PLAINS CORRIDOR

"Made available under NASA sponsorship in the interest of early and wide dissemination of Earth Resources Survey Program information and without liability for any use made thereof."

E8-10008
CR-162385

Prepared by

J. C. Harlan and D. W. Deering
Remote Sensing Center
College Station, Texas 77843

RECEIVED
OCT 29 1979
SIS/902.6

September 1979
Type III Final Report

In cooperation with the
Texas Agricultural Experiment Station
Texas A&M University
College Station, Texas 77843

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 29771

Contract No. NAS5-20796

(E80-10008) APPLIED REGIONAL MONITORING OF THE VERNAL ADVANCEMENT AND RETROGRADATION (GREEN WAVE EFFECT) OF NATURAL VEGETATION IN THE GREAT PLAINS CORRIDOR Final Report (Texas A&M Univ.) 30 p HC A03/MF A01 G3/43 N80-12524 Unclas 00008

TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

Progress Report 3018-7

APPLIED REGIONAL MONITORING OF THE VERNAL ADVANCEMENT AND RETROGRADATION (GREEN WAVE EFFECT) OF NATURAL VEGETATION IN THE GREAT PLAINS CORRIDOR

By

J.C. Harlan and D.W. Deering

Remote Sensing Center
Texas A&M University
College Station, Texas 77843

September 1979
Final Report

Original photography may be purchased from:
EROS Data Center

Sioux Falls, SD 57198

Prepared for

Goddard Space Flight Center
Greenbelt, Maryland 20771

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 OBJECTIVES AND APPROACH

This document describes the work conducted as a modification (No. 9) of the Landsat-2 investigation entitled "Applied Regional Monitoring of the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation in the Great Plains Corridor" (Contract NAS5-20796). The contract modification was proposed to add a sixth objective to the investigation, whereby rangelands in southwest Texas would be used to establish threshold values and limitations on measuring herbaceous biomass under typical arid and semi-arid range conditions. The overall objective of this follow-on study was to determine the effectiveness of Landsat data in measuring and monitoring the arid and semi-arid rangeland vegetation biomass and growth conditions which are of direct concern to rangeland managers in these regions.

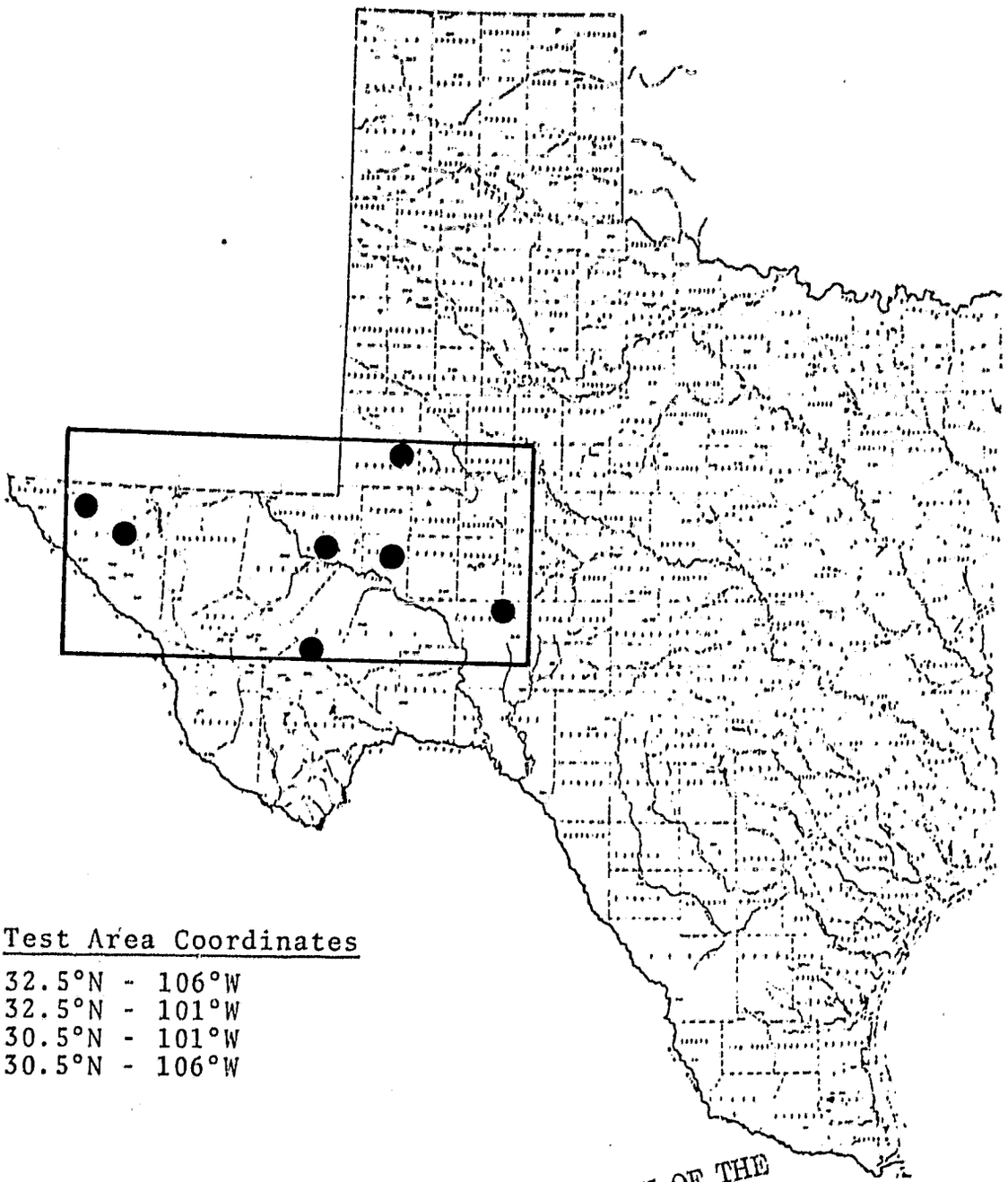
A twelve-month extension to the Landsat-2 follow-on study was incorporated as Modification Number 9 of the original contract. The original Landsat-2 study evaluated the capability for regional vegetation condition monitoring through quantitative assessment of Landsat MSS data. The semi-arid to sub-humid rangelands of the Mixed Prairie region in the central United States served as the study area. The results of this aspect of the study was reported in RSC Final Report 3018-6 (January 1977). The modification of the Landsat-2 follow-on study extended the project to rangelands in west Texas.

Test sites were established within the Trans-Pecos Mountains and Basins, Edwards Plateau and southern High Plains vegetational areas of Texas. Seven locations were pre-selected as possible test sites

(Figure 1.1; note test area corner location coordinates). The final five test sites were selected following on-site visits. The sites were selected to represent a range of herbaceous biomass and ground cover for vegetation cover types typical of arid and semi-arid rangelands.

Ground measurements and multistage sampling techniques were used to determine the amounts of green and brown herbaceous biomass, bare ground and woody plant cover. Other test site data included the dominant herbaceous and woody plant species, soil type, apparent grazing influence and other relevant site-specific information and available weather data. Ground data were collected coincident with two Landsat overpasses during the 1977 growing season.

Landsat MSS radiance measurements (from CCT data) for the test sites were related to the ground measurement parameters, particularly herbaceous green biomass, for developing quantitative estimation models. The ND6 parameter developed and tested during the Texas A&M University Remote Sensing Center Landsat-1 and Follow-on Great Plains Corridor projects for measurement of green biomass in mixed prairie grasslands of sub-humid to semi-arid areas was tested in the more arid areas.



Test Area Coordinates

32.5°N - 106°W
32.5°N - 101°W
30.5°N - 101°W
30.5°N - 106°W

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

Figure 1.1 Test area and potential (see text) test sites from which several sampling sites were established and ground data collected coincident with Landsat overpass.

2.0 DATA ACQUISITION AND PROCESSING

2.1 The Study Area

Five test sites in west Texas were chosen after on-site visits. In Figure 1.1 the southern-most and next to western-most sites are the two which were deleted. The five test sites chosen are illustrated through a series of Landsat images (Figure 2.1, 2.2 and 2.3) progressing from east to west across the study area.

In order to determine the influence of brush cover on the ability to use Landsat for herbaceous biomass estimates, sample sites with a wide range of brush canopy covers were selected. Figures 2.4, 2.5 and 2.6 portray typical sites as shown in the large scale photography (originals are at 1:4000 scale). Besides the three sites shown in the figures, 21 others were chosen and were sampled. The distribution of sample areas among the five test sites was as follows: Andrews - 4 sample areas; Big Lake - 5; Crane - 4; Hudspeth - 5; and Pyote - 6.

2.2 Sampling Procedure and Summary of Data

A combination of vegetation clipping, dimension measuring and visual estimates of parameters comprised the ground sampling procedures. At approximately 30 locations (each one a 1/4 m^2 area) in each of the 24 sample areas visual estimates were made of the percent of ground cover in four categories: green canopy cover; forb canopy cover; brown canopy cover; and bare ground. Additional visual estimates were made to characterize the vegetation that was there: the percent of the total herbaceous biomass which was green; and the percent of the total

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

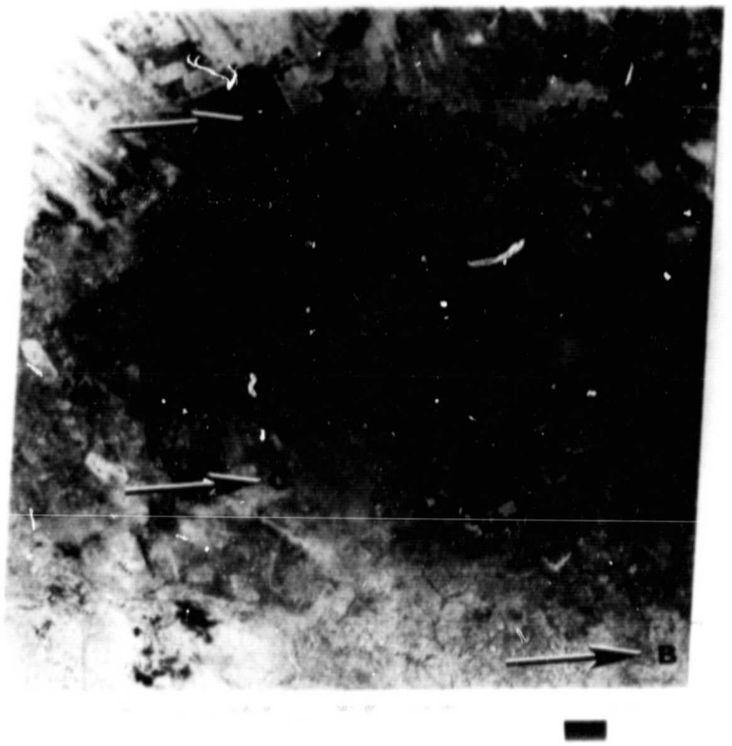


Figure 2.1. The Andrews (A), Crane (C), and Part of the Big Lake (B) sites are included in this 22 September 1977 Landsat image (Path 32, Row 38).

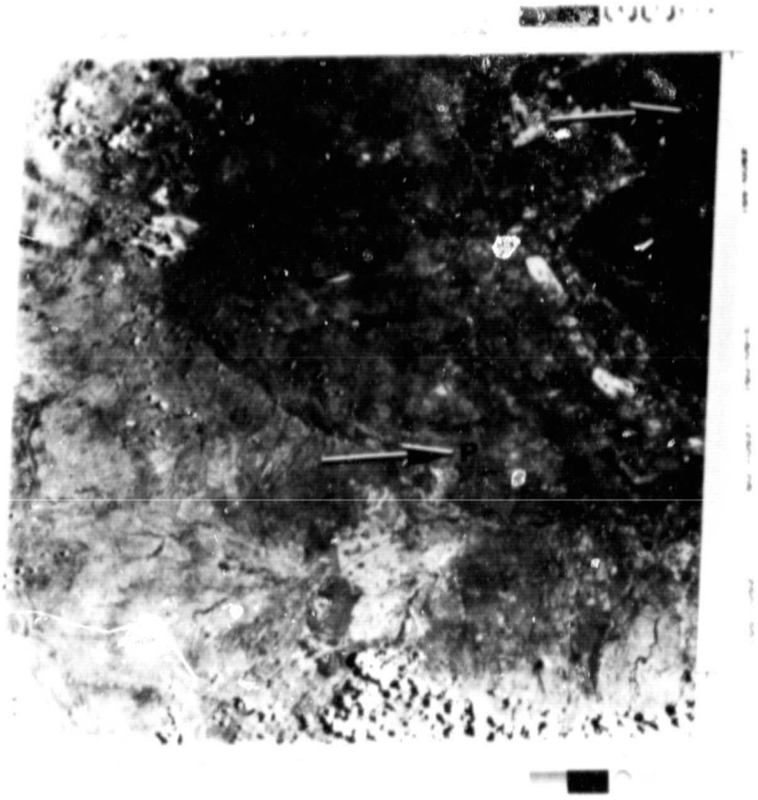


Figure 2.2. The Pyote site (P) and part of the Andrews site (A) are included in this Landsat image acquired 07 June 1977 (Path 33, Row 38).

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

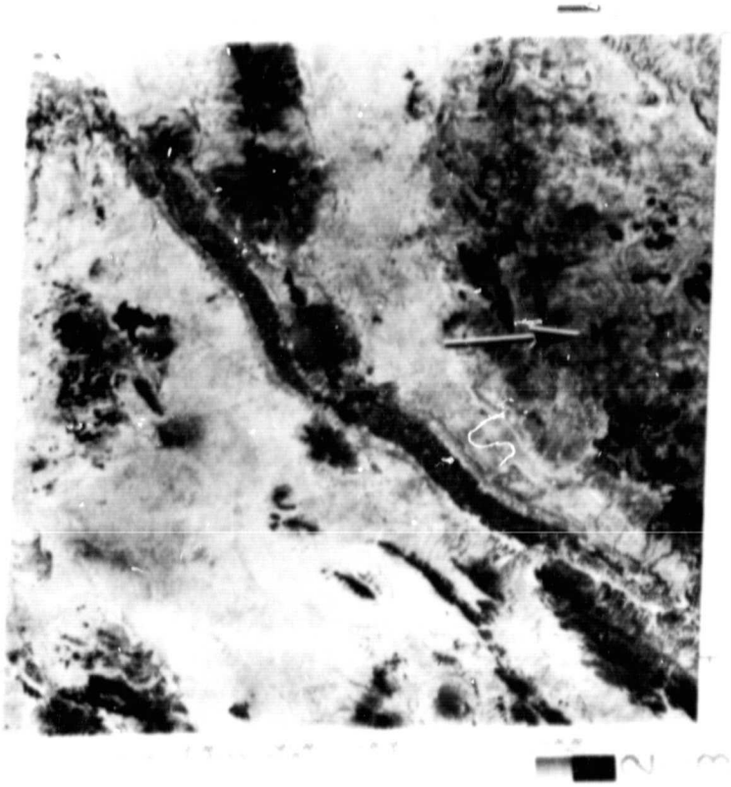


Figure 2.3. The Hudspeth site (H) is shown on this 25 September 1977 Landsat image (Path 35, Row 38).

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

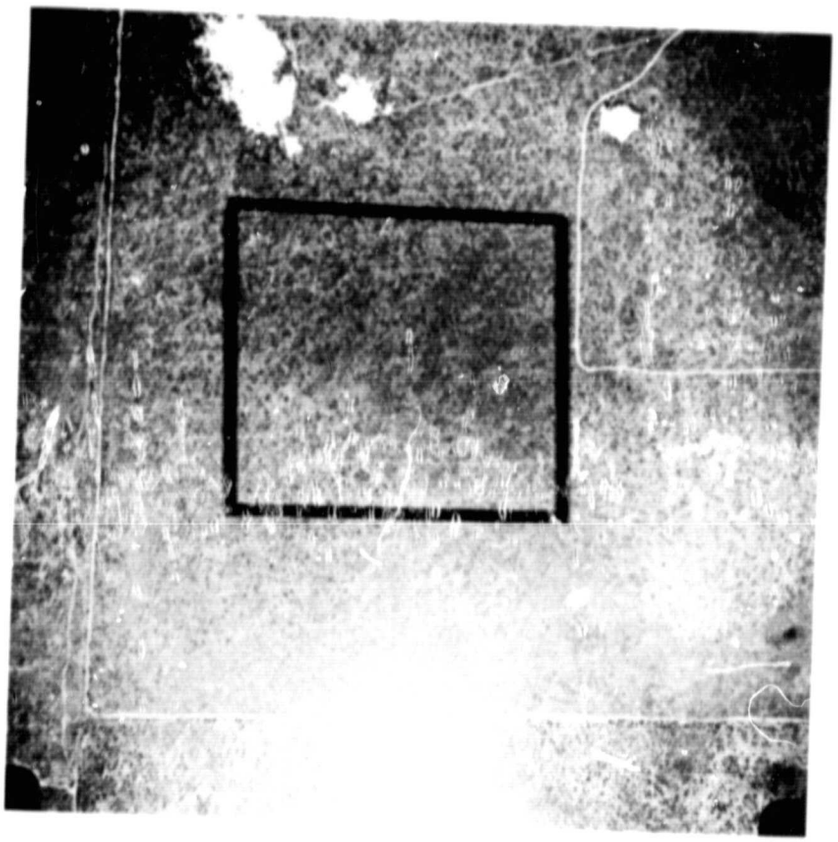


Figure 2.4. Big Lake site B typifies low brush cover sites with the best herbaceous ground cover.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

Figure 2.5. Crane site D typifies medium brush cover sites with the best herbaceous ground cover.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

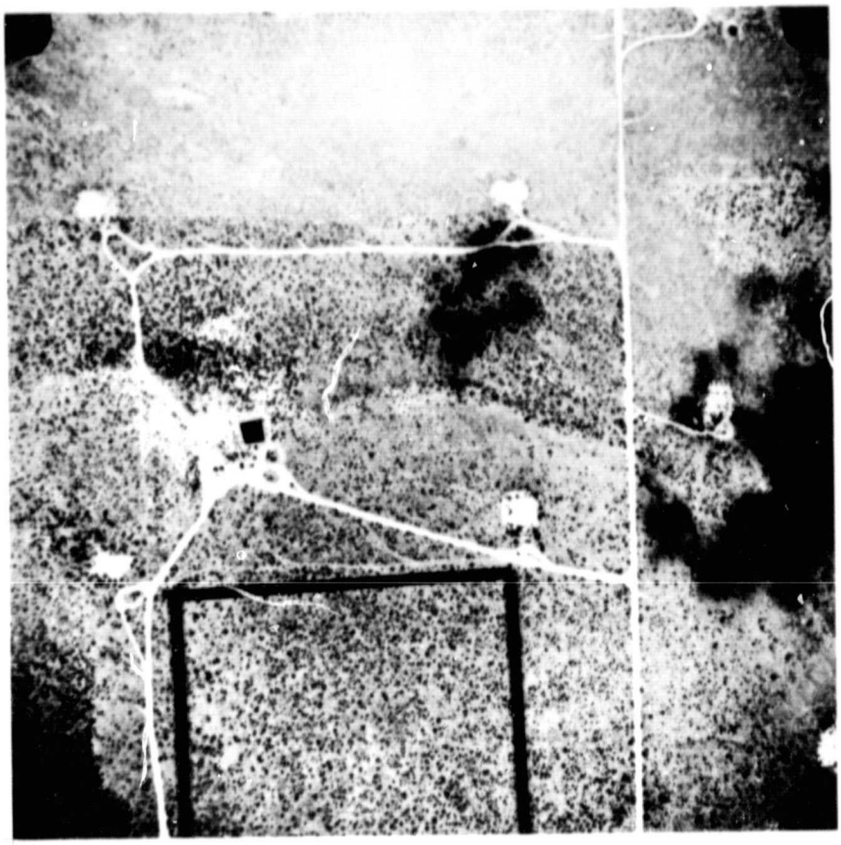


Figure 2.6. Big Lake site C typifies heavy brush cover sites with the best herbaceous ground cover.

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

which was forbs. Measurements were made of the average height of the herbaceous vegetation at each location. After the visual estimates and height measurements had been completed the vegetation within the 1/4 m^2 frame was clipped off at ground level and a fresh weight measured for it. The vegetation was oven-dried and a dry weight recorded. These data comprise the ground observations used in the analysis described in later sections of this report.

Table 2.1 lists the dates of ground and Landsat observations for each site as used in the analysis.

Table 2.1 Ground and Landsat Data Acquisition Schedule

Spring Sample	Ground Data Acquisition Site	Ground Data Acquisition Date	Landsat Data Acquisition Site	Landsat Data Acquisition Date
	AA	5/19/77	AA	6/6/77
	AB	6/9/77	AB	6/7/77
	AD	6/9/77	AD	6/7/77
	BB	6/13/77	BB	6/6/77
	BC	6/13/77	BC	6/6/77
	BD	6/7/77	BD	6/6/77
	BE	6/12/77	BE	6/6/77
	BG	6/12/77	BG	6/6/77
	CA	5/18/77	CA	6/6/77
	CB	5/18/77	CB	6/6/77
	CC	6/8/77	CC	6/6/77
	CD	6/8/77	CD	6/6/77
	HA	5/23/77	HA	5/22/77
	HB	5/23/77	HB	5/22/77
	HC	5/23/77	HC	5/22/77
	HD	5/23/77	HD	5/22/77
	HE	5/22/77	HE	5/22/77
	PA	6/11/77	PA	6/7/77
	PB	6/11/77	PB	6/7/77
	PC	6/10/77	PC	6/7/77
	PD	6/10/77	PD	6/7/77
	PE	6/10/77	PE	6/7/77
	PF	6/11/77	PF	6/7/77

Table 2.1 Continued

Summer Sample	Ground Data Acquisition		Landsat Data Acquisition	
	Site	Date	Site	Date
	AA	9/29/77	AA	9/22/77
	AB	9/28/77	AB	9/22/77
	AC	9/28/77	AC	9/22/77
	AD	9/28/77	AD	9/22/77
	CA	9/20/77	CA	9/22/77
	CB	9/20/77	CB	9/22/77
	CC	9/29/77	CC	9/22/77
	CD	9/29/77	CD	9/22/77
	HA	9/24/77	HA	9/25/77
	HB	9/25/77	HB	9/25/77
	HC	9/25/77	HC	9/25/77
	HD	9/25/77	HD	9/25/77
	HE	9/25/77	HE	9/25/77
	PA	9/23/77	PA	9/22/77
	PB	9/23/77	PB	9/22/77
	PC	9/27/77	PC	9/22/77
	PD	9/27/77	PD	9/22/77
	PE	9/27/77	PE	9/22/77
	PF	9/23/77	PF	9/22/77

3.0 DATA ANALYSIS AND RESULTS

3.1 Ground Observations

As stated in Section 1.0 ground observations, coincident with two Landsat overpasses, were made of green and brown herbaceous biomass, bare ground and woody plant cover. Information was also obtained on dominant herbaceous and woody plant species, soil type, apparent grazing influence and other relevant site-specific information and available weather data.

The most important of the ground observations, from the standpoint of the analysis described below, are given in Figures 3.1 and 3.2. Both figures show the data values acquired on each of the two sampling dates as a function of site and brush canopy characteristics. Figure 3.1 portrays the percent of herbaceous ground cover, while Figure 3.2 shows the values of oven-dried green biomass. In both figures the sites are ordered from left to right starting with the largest value on the first date and continuing in descending order. A comparison of the ordering of the sites between the two figures shows that, as should be suspected, there is not a one-to-one correspondence between ground cover and green biomass. When examining the Brush Site portion of each figure it is also seen that there is no direct correspondence between brush canopy cover and either ground cover or green biomass.

3.2 Landsat Observations

In Table 2.1 the sites are listed for which successful Landsat acquisition occurred. Sites not acquired because of cloud cover were left off the list. Overall (i.e. across the two dates) 18 data points

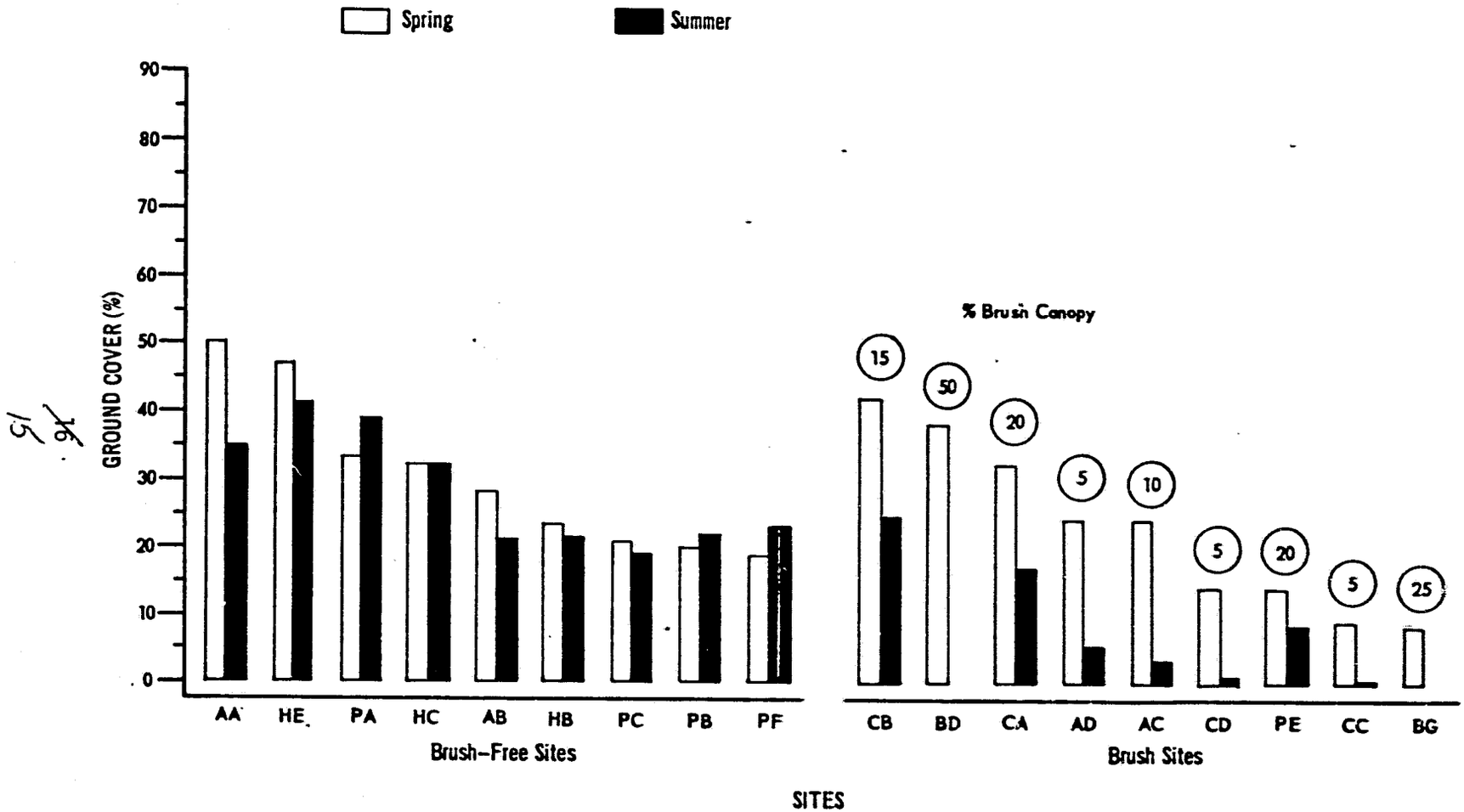


Figure 3.1 Ground Observations of Percent Herbaceous Ground Cover

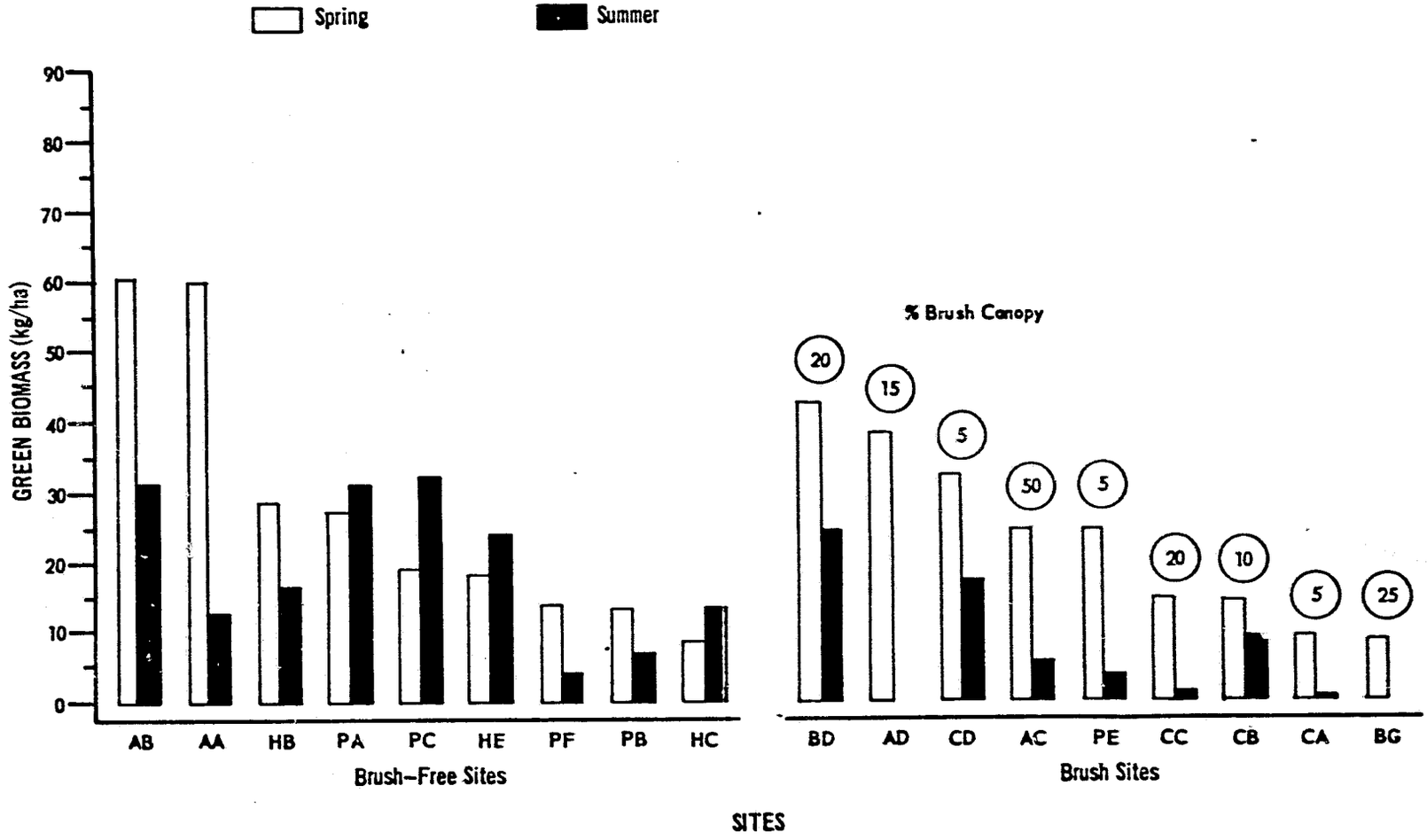


Figure 3.2 Ground Observations of Green Biomass

were obtained for the brushless sites with both ground and Landsat values. For the sites with five or more percent brush canopy cover 17 data points were obtained. Six other data points were acquired, but were left out of the analysis because they were creosote bush sites, whereas the other brush sites were predominantly mesquite.

The Landsat data for each site was handled in the following way to produce one Normalized Difference parameter value per site. A graymap was produced of the localized region in which the site could be found. The site was identified and the pixels representing the site were noted. For each site a Site Processing Report was produced from manipulations of the pixel by pixel data, including: mean and standard deviation of the sun angle corrected radiance values for each band; the normalized covariance matrix; a radiance vs. spectral bandpass curve; and the Normalized Difference value. The Normalized Difference parameter using MSS band 6 is defined as

$$ND6 = \frac{\text{MSS band 6 - MSS band 5}}{\text{MSS band 6 + MSS band 5}}$$

where the values are the mean band radiance for a site.

3.3 ND6 vs. Ground Measurements

The ND6 and Green Biomass data set is portrayed in Figures 3.3 and 3.4 where the first figure represents the values for the brushless sites ($\leq$ 3 percent brush cover) and the second is for the brush covered sites (5 to 50 percent brush cover). In both figures the regression line (Pawnee Regression Line) shown was derived for an extensive set of data

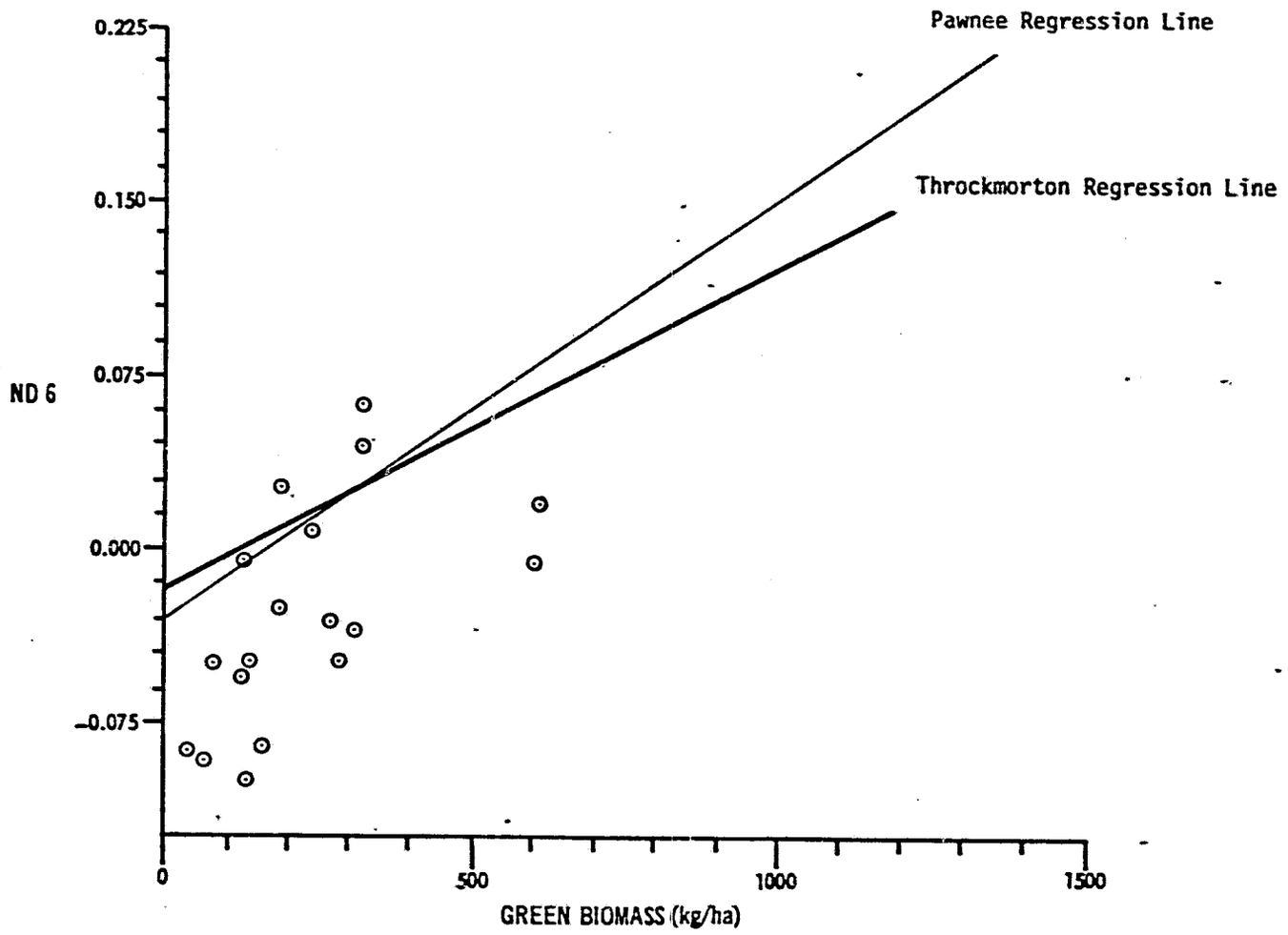


Figure 3.3 Green Biomass for the Brush-Free Sites

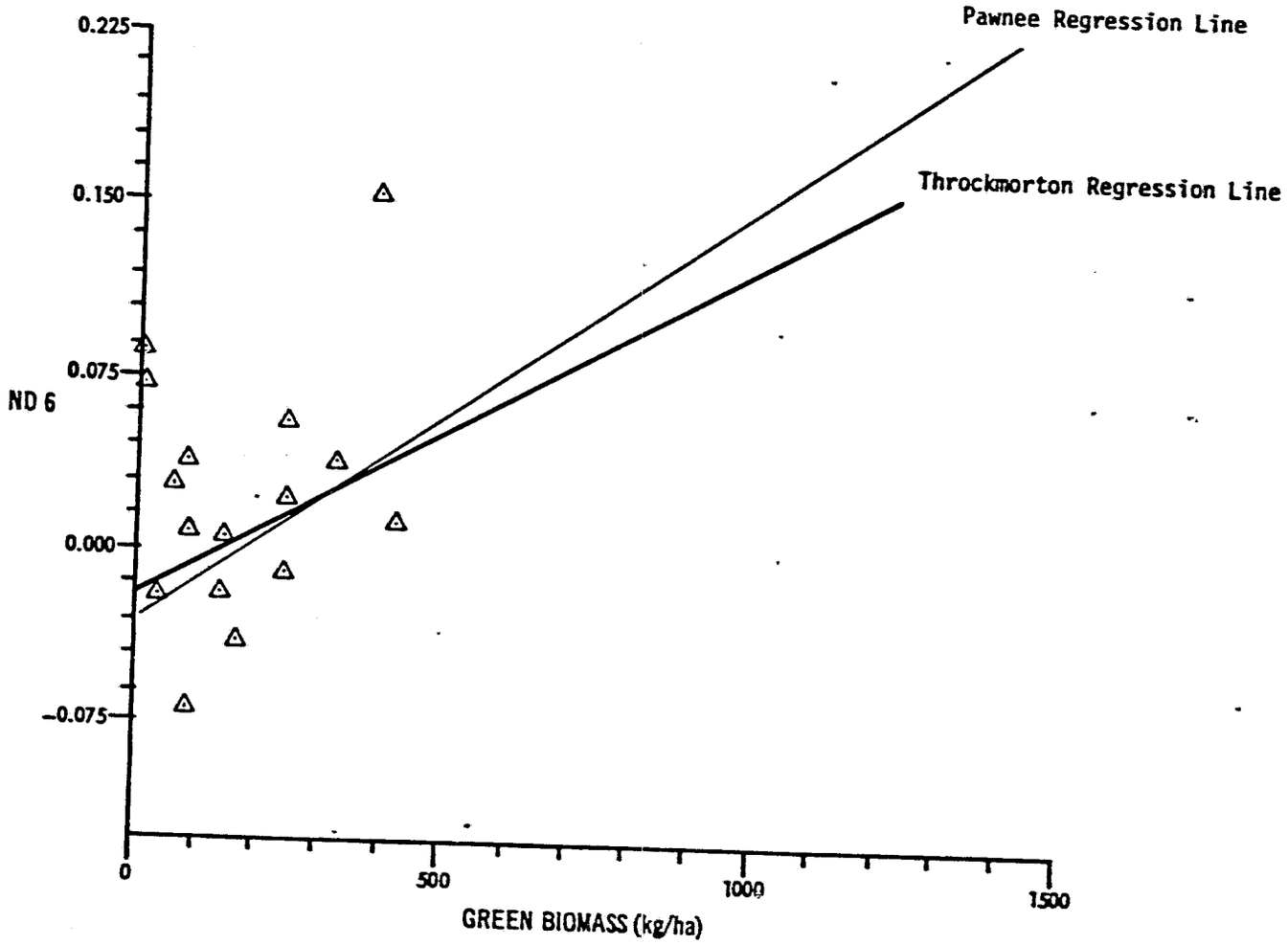


Figure 3.4 Green Biomass for the Brush Sites

from a similar ecosystem (Harlan et al, 1979). The Pawnee regression line fits the Throckmorton, Texas data acquired under this contract from 1972 to 1975, as well. It is included in these graphs, then, as a reference line representing other studies: one in the same type ecosystem (short grass prairie); and the other in a different ecosystem, the mixed prairie grasslands association.

In Figure 3.3 it is seen that most of the points fall below the Pawnee line. A fairly strong relationship between ND6 and biomass exists, but it is apparent that a best fit line for the data points shown would have a steeper slope than the Pawnee relationship. If the Pawnee line were used to estimate biomass for the brush-free site ND6 values acquired in this study, consistent underestimation would occur.

For the brush sites, Figure 3.4 shows that the majority of data points fall above the Pawnee line. In this case overestimation of herbaceous biomass would occur if the Pawnee line were used with the ND6 values acquired. Examination of the actual data points, however, shows that no consistent pattern occurred, and that the brush canopy has adversely affected the ND6 relationship with herbaceous biomass. This is not a new result, as it was first established in the first contract period of this study (Rouse et al, 1974), but it is verified here.

The results of regression analyses accomplished with the ND6 vs. ground observations of this study are given in Table 3.1. Comparing results for brush-free sites to those for brush covered sites shows quantitatively the detrimental effect the brush canopy has; a consistent lowering of the regression coefficient.

TABLE 3.1 WEST TEXAS REGRESSION RESULTS

CORRELATIONS BETWEEN ND6 AND TOTAL DRY WEIGHT (R^2)

DATE	BRUSHLESS SITES	BRUSH SITES
EARLY JUNE	0.757	0.485
LATE SEPTEMBER	0.375	0.044
COMBINED DATES	0.607	0.323

CORRELATIONS BETWEEN ND6 AND GREEN BIOMASS (R^2)

DATE	BRUSHLESS SITES	BRUSH SITES
EARLY JUNE	0.698	0.630
LATE SEPTEMBER	0.636	0.313
COMBINED DATES	0.029*	0.025

CORRELATIONS BETWEEN ND6 AND PERCENT GROUND COVER (R^2)

DATE	BRUSHLESS SITES	BRUSH SITES
EARLY JUNE	0.930	0.650
LATE SEPTEMBER	0.385	0.204
COMBINED DATES	0.767	0.559

*EACH DATE ACTED AS A SEPARATE POPULATION.

4.0 SUMMARY AND CONCLUSIONS

Comparison of Landsat and ground observations data collected for this project against those acquired previously show the following results. Previous regression relationships established between ND6 and green biomass for two different ecosystems were similar as shown in Figure 3.3 (slightly different slopes with the regression lines close enough that they intersected). The West Texas data set for brush-free sites was too small to be statistically conclusive. It appears that a line with a third (and steeper) slope would be best for the West Texas data, and that line would intersect the other two. The overall conclusion reached upon comparing results of the three studies is that similar relationships exist between ND6 and green biomass under low brush canopy cover conditions, but local variations require a calibration to determine the best fit for an ecosystem.

As a second result it was verified that brush canopy cover has a detrimental effect on the ND6 vs. herbaceous green biomass relationship. Previous studies had pointed to ten to fifteen percent brush canopy cover as a threshold above which on ND6 vs. biomass relationship became inaccurate. In this study too few data points were acquired to define that threshold any more closely.

In view of the effect of brush canopy cover on the herbaceous biomass estimation capability from Landsat it is recommended that research be conducted to account for the brush. A recommended approach would consist of two parts: developing a technique to quantitatively map brush density levels; and determining the relationship between brush canopy cover and the amount of herbaceous biomass below it. Mapping the brush density will

allow partitioning of Landsat image data into parts where biomass estimation will be accurate and parts where it will not. In the latter, an estimate of biomass can be obtained by applying a relationship for herbaceous biomass under brush canopy; a relationship which may require calibration for each local area.

5.0 NEW TECHNOLOGY STATEMENT

In accordance with the New Technology Clause of Contract NAS 5-20796, it is noted that no developments during the period of this report are considered applicable to the reporting requirements.

References

Deering, D. W., R. H. Haas, R. I. Welch, J. C. Harlan, and P. R. Whitney. 1977. Applied Regional Monitoring of the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation in the Great Plains Corridor. Final Report RSC 3018-6, Remote Sensing Center, Texas A&M University.

Harlan, J. C., W. E. Boyd, C. Clark, S. Clarke and O. C. Jenkins. 1979. Rangeland Resource Evaluation from Landsat. Final Report RSC 3715-2, Remote Sensing Center, Texas A&M University.

Rouse, J. W., Jr., R. H. Haas, J. A. Schell, D. W. Deering, and J. C. Harlan. 1974. Monitoring the Vernal Advancement and Retrogradation (Green Wave Effect) of Natural Vegetation. Final Report RSC 1978-4, Remote Sensing Center, Texas A&M University.

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.