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Identification of Rangeland Sites on Small Scale (1:120,000) Color-Infrared Aerial Photos

Microdensitometer readings made with either white or blue light were better for distinguishing higher order classification of the three range types (brushland, grassland, and barren land), but readings made with red light distinguished more of the ten range sites.

Abstract: *Microdensitometry was tested on small-scale (1:120,000), color-infrared (CIR) aerial photos to distinguish among ten rangeland sites (two Brushland, six grassland, two barren land) in southern Texas. Aerial photos were taken in May 1981 when the vegetation was in its peak foliage development. Optical density readings were made on CIR film with white, red, green, and blue light. Optical density readings made with either white or blue light were better for distinguishing higher order classification of three range types (brushland, grassland, and barren land), but readings made with red light distinguished more of the ten range sites. Discriminant analysis using all four optical density light readings differentiated among the ten sites with 100 percent classification accuracy. By these results, we showed that automated photointerpretation could be used to identify a variety of rangeland sites on small-scale CIR photos.*

Introduction

For decades, wildland ecologists, range scientists, and others have obtained information about plant communities and other landscape features primarily by ground research and inference. Their goals have been to identify plants and soils, characterize, classify, and map plant communities and their components, and, over time, monitor changing environmental and ecological conditions. These efforts have partially failed because wildland areas are often too large and inaccessible to determine their characteristics and extent by ground surveys (Driscoll, 1974). Remote sensing techniques offer a potentially timely, cost-effective means of obtaining reliable data for these areas (Tueller, 1979).

Aerial photography has considerable potential to identify vegetation, monitor changing conditions, and interpret data of rangeland resource surveys (Johnson, 1969; Polton, 1970; Driscoll and Coleman, 1974; Tueller, 1977). Microdensitometry is a useful tool to obtain quantitative measurements of range sites, plant communities, and individual plant species on both very small- and large-scale aerial photos (Driscoll *et al.*, 1974; Francis and Driscoll, 1976; Everitt *et al.*, 1977; Gausman *et al.*, 1977; Everitt *et al.*, 1980). Everitt *et al.* (1980) used microdensitometry on color-infrared (CIR) aerial photos (scales 1:19,000 and 1:42,000) taken on different dates during the year to distinguish among a variety of range sites in southern Texas. They concluded that the best separations among the different sites were obtained in summer when vegetation was in its peak foliage development following heavy rainfall. Our objective was to test the feasibility of using microdensitometry on very small-scale (1:120,000) CIR aerial photos of this same rangeland area (Everitt *et al.*, 1980) in spring when the vegetation was again at its peak foliage development.

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Materials and Methods

The present study was conducted on the H. and Frank Yturria Ranches in Kenedy and Willacy Counties of southern Texas. This area is in a transition zone between the Texas Coastal Prairies and the South Texas Plains vegetational regions (Gould, 1975). The Gulf of Mexico borders the area on the east. The topography, climate, and vegetation of the area were described by Everitt *et al.* (1980). They described eleven different rangeland sites in that study, but because of land-use changes, only ten of these sites were available for our study; there was no coastal sand (burned) site in the present study.

Three areas of each of the ten rangeland sites were used for study. The selected areas were sufficiently large that they were discernible on aerial photos and, therefore, microdensitometer measurements could be made. Thus, 30 different areas were used. However, ground measurements were not made on all 30 areas because we wanted to complete measurements within a few days of the photography date to avoid drastic changes in the phenology and condition of the vegetation. Herbaceous biomass production and cover were measured on a single location for eight of the ten rangeland types within a week of the aerial photography, taken on 26 May 1981. Ground measurements were not taken on the dune land (essentially bare soil) and laguna sites (wetlands). However, the lagunas do produce considerable herbaceous vegetation and are, therefore, classified as grassland sites. Biomass production was measured by clipping all vegetation at ground level in 20 quadrats, each 50 cm by 50 cm in area (Stewart and Hutchins, 1936). The line transect method was used to measure herbaceous cover (Canfield, 1941). Ten 30.5-m long transects were run on each site. Ground measurements for both biomass and cover were randomly made throughout each site. Thus, data collected from these eight sample sites were used as a general index of ground conditions for the various rangeland types.

Photographic equipment used included (1) a Zeiss wide-angle survey camera 4 (RMK-A 15/23, 180-mm lens, 22.9 by 22.9 cm format); (2) a filter packet of Zeiss KLF 36 and Wratten 12 (yellow) filters; and (3) Eastman Kodak Aerochrome color infrared (CIR) type SO-193 film. The camera setting was *f*/4 at 1/300 sec. Photos (scale 1:120,000) were taken at an altitude of 18,290 m on 26 May 1981, between 1000 and 1100 hours under clear sunny conditions.

Film density readings were made on CIR film with a Joyce, Loebl and Company (England) microdensitometer*, equipped with an automatic scanning attachment made by Tech/Ops (Burlington, Massachusetts). Density readings were made with four different light sources: white (no filter), red (Wratten 92 filter), green (Wratten 93 filter), and blue (Wratten 94 filter). The microdensitometer output was described by Everitt *et al.* (1980). One scan line was run on each of the three replications used for the ten different range sites. There were 40 to 50 readings (data bits) for each scan line on the film. Density readings were made in the central 110- by 175-mm area of the transparencies in order to avoid the effects of lens fall-off (Roberts and Dana, 1981). Lens fall-off could possibly cause artificially high density readings because the edges of the frame are under exposed. The area of a data bit on film was about 0.01 mm^2 and represented about 144 m^2 on the ground.

Analysis of variance was used to determine statistically significant differences for each color light density on the CIR film. The three different areas used for each of the ten different rangeland sites were considered to be replications. Duncan's multiple range test, $P = 0.05$, was used to test the significance statistically of mean differences among the rangeland sites (Steel and Torrie, 1960). Linear correlation and regression analysis was calculated between herbaceous biomass measurements and mean optical counts and between herbaceous cover and mean optical counts.

Discriminant analysis, using all four color light densities on the CIR film, was used to test the classification accuracy among the ten range sites (Lachenbruch, 1975). A 1964 BMD discriminant analysis computer program was used for the analysis (Dixon, 1964). This program computes a generalized Mahalanobis *D*-squared. It does not compute a Mahalanobis distance to measure separability between each group mean. The probability associated with the largest discriminant function for each observation is also computed. A scatter diagram of the best pair-wise light densities was developed to graphically show the spectral distinction among the ten sites.

* Trade names are included for the benefit of the reader and do not imply an endorsement of or a preference for the product listed by the U.S. Department of Agriculture.

Results and Discussion

Ground Truth Data

During the winter and spring seasons of 1981, the study area received above normal precipitation. The long-term average precipitation for this area from January through May is 22.8 cm, with highest rainfall (9.5 cm) occurring in May (NOAA, 1982). In 1981, however, the study area received 40.3 cm of rain during this period, with much higher rainfall in March and April. The area's average precipitation for March and April is 2.2 and 3.9 cm, respectively, but in 1981 this area received 7.2 and 11.1 cm of rain in March and April, respectively. The higher rainfall associated with the area's mild temperatures caused earlier green-up of the vegetation with flush foliage development occurring by late May when ground measurements and aerial photos were taken. Herbaceous biomass and cover data are given in Table 1. Both biomass and cover measurements were much lower on the brushland and barren land sites than on the grassland sites. Among the grassland sites, the tight sandy loam (improved) and Alicia grass sites had the highest biomass. Herbaceous cover did not always correlate with biomass because of differences in growth forms of the various plant species and the distribution of cover on the sites. These data are similar to those reported for these sites in August 1976, when the vegetation was in its peak foliage development (Everitt *et al.*, 1980).

FILM DENSITY RESULTS

Numerous separations on CIR film were obtained with all four colored lights, but the most meaningful separations were made with either white or blue light (Table 1). With white light, seven separations were made by the microdensitometer among the ten sites: brushland, grassland, and barren land sites were distinguishable from each other. The two brushland sites could be distinguished from each other and the two barren land sites could be differentiated. The microdensitometer, however, could not distinguish among several of the grassland sites. The site separations obtained using blue light were essentially the same as those for white light, but separations among the grassland sites were not as distinct.

Although complete separations were obtained among density readings for nine sites using red light and six sites using green light, the microdensitometer was not able to differentiate completely among all three rangeland types with either light source. Using red light, the two brushland sites were separated from both grassland and barren land sites, as well as from each other. The two barren land sites were differentiated from each other, but the salt flat barren land site could not be separated from the tight sandy loam grassland site. With green light, the two barren land sites could be distinguished from each other and from the brushland and grassland sites. The two brushland sites could also be separated from each other, but the tight sandy loam brushland site could not be differentiated from the Alicia grass grassland site. These misclassified sites could be visually distinguished from each other on the film, but apparently the red and green bandpass filters altered their spectra.

The scatter diagram in Figure 1 indicates that all ten rangeland sites can be separated using the red and white light combinations that yielded the best pair-wise separations. A discriminant analysis of these data using all four lights yielded 100 percent classification accuracy among all ten sites. The generalized Mahalanobis *D*-Square of 4,817 was signif-

TABLE 1. MICRODENSITOMETER READINGS WITH WHITE, RED, GREEN, AND BLUE LIGHT ON AERIAL COLOR-INFRARED FILM (SCALE 1:120,000) EXPOSED ON A ZEISS WIDE-ANGLE SURVEY CAMERA FOR TEN RANGE SITES IN KENEDY AND WILLACY COUNTIES, TEXAS ON 26 MAY 1981

Range Site	Herbaceous		EK-2443 Color IR Film (0.5- to 0.9-μm)			
	Biomass (kg/ha)	Cover (%)	White* light	Red light	Green light	Blue light
Brushland sites						
Tight sandy loam (+80% brush cover)	466	21	120b	107b	103b	119b
Sandy Mound (+50% brush cover)	620	30	134a	119a	116a	129a
Grassland sites						
Deep sand (native)	1428	51	71d	72f	73c	77de
Laguna	—	—	68d	49h	73c	74de
Coastal sand	2746	78	55e	85d	57d	58f
Tight sandy loam (improved)	4585	72	69d	58g	74c	72e
Deep sand (improved)	2150	56	72d	79e	73c	79d
Alicia grass	3890	87	105c	101c	101b	110c
Barren land sites						
Salt flat	468	14	36f	62g	35e	36g
Dune land	—	—	18g	20i	20f	24h

* Means followed by a common letter are not significantly different at the 5 percent probability level, according to Duncan's multiple range test.

icant at the 0.01 probability level [Degrees Freedom = Number Variables (Number Groups −1) = 36]. The probability associated with the largest discriminant function was very close to 1.0 for 28 out of the 30 observations. The probability of the other two observations was over 0.78. These high probabilities appear to be in agreement with the group separation observed from Figure 1. A more thorough analysis probably should be done of CIR film density and rangeland sites employing stepwise analysis for color band selection and a specific unbiased test of error rates using a BMD program P7M (Dixon and Brown, 1979).

Coefficients calculated for linear correlation and regression analysis between herbaceous biomass or cover measurements with film optical counts were not significant ($P = 0.10$).

Conclusions

In this study we showed that photointerpretation by microdensitometry could be used to identify a variety of South Texas rangeland sites quantitatively on CIR (0.50- to 0.90-μm) aerial film (scale 1:120,000) exposed in spring (May), when the vegetation was in its flush foliage development. Microdensitometer readings made with either white or blue light were better for distinguishing higher order classification of the three range types (brushland, grassland, and barren land), but readings made with red light distinguished more of the ten range sites. Discriminant analysis using all four microdensitometer light readings yielded 100 percent classification accuracy among all ten sites. These results agreed closely with those of Everitt *et al.* (1980), who reported that the best separations among these sites were obtained on CIR film (scales 1:19,000 and 1:42,000) exposed in summer (August) when the vegetation was in its flush growth. Our present study indicated that these sites also can be identified earlier in the growing season on much smaller-scale CIR photos when the vegetation is in its flush growing conditions.

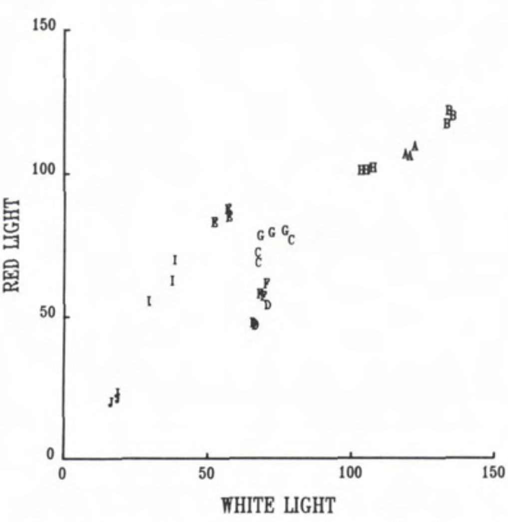

Fig. 1. Scatter diagram of ten rangeland sites in southern Texas using color-infrared film optical density readings for red and white light. Rangeland sites are identified as tight sandy loam—native (A), sandy mound (B), deep sand-native (C), laguna (D), coastal sand (E), tight sandy loam-improved (F), deep sand-improved (G), Alicia grass (H), salt flat (I), and dune land (J).

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Remote Sensing in Colombia, Selected Papers from the First Colombian Symposium on Remote Sensing, July 27-31, 1981. R. D. Mower, M. Ardela, and W. A. Dando (Eds.). University of North Dakota Institute for Remote Sensing, Grand Forks, ND 58202. Paperback, 21.5 × 27.5 cm, 174 + ix pages. 1983.

This volume of selected papers from the Symposium held in Bogota, Colombia, all in English (except for a 12-page recapitulation in Spanish at the end), contains 22 papers divided into four parts: (1) Opportunities for Remote Sensing in Colombia; (2) Applications to Colombia and to Colombian Needs; (3) Image Inhancement, Analysis, and Statistical Techniques; and (4) Regional Integration, Technology Transfer, and Further Promise. Nine authors were from Colombia, eight from the United States, two from Costa Rica, and two from The Netherlands. The book is well put together with quality figures, including eight pages of glossy colored illustrations from NASA. Copies may be ordered from the above address.