

Videography and Color Photography in Resource Assessment

Proceedings of the
16th Biennial Workshop on
Videography and Color Photography
in Resource Assessment

Weslaco, Texas
April 29-May 1, 1997

Sponsors:

American Society for Photogrammetry
and Remote Sensing

USDA Subtropical Agricultural Research Laboratory

LIGHT REFLECTANCE CHARACTERISTICS AND VIDEO REMOTE SENSING OF TWO RANGE SITES ON THE JORNADA EXPERIMENTAL RANGE

J. H. Everitt, M. A. Alaniz, M. R. Davis, and D. E. Escobar
USDA-ARS, Remote Sensing Research
2413 E. Highway 83, Weslaco, TX 78596
Telephone No.: (210) 969-4824
FAX No.: (210) 969-4893
Email: j-everitt@tamu.edu
WWW:<http://rsru2.tamu.edu>

K. M. Havstad
USDA-ARS, Jornada Experimental Range,
Las Cruces, NM 88003

J. C. Ritchie
USDA-ARS, Hydrology Laboratory
Beltsville, MD 20705

ABSTRACT

The Jornada Experimental Range in southern New Mexico is the site of a long-term ecological research program to investigate the processes leading to desertification. This paper describes the light reflectance characteristics of dominant plant species and soil on two study sites (desert grassland and mesquite dune sites) on the Jornada and evaluates airborne color-infrared video imagery for distinguishing among vegetation types and soil of the two sites. Ground reflectance measurements showed significant differences among major plant species and soil at both sites. At the desert grassland site, black grama [*Bouteloua eripoda* (Torr.) Torr.] had lower near-infrared reflectance than the other plant species and soil. Honey mesquite [*Prosopis glandulosa* L. var. *torreyana* (L. Benson) M. C. Johnston] had lower reflectance than the other plant species and soil at the mesquite dune site. Qualitative analyses of the video imagery showed that black grama and two additional species could be distinguished on the desert grassland site. Honey mesquite and broom snakeweed [*Gutierrezia sarothrae* (Pursh.) Britt. and Rusby] could be distinguished on the mesquite dune site. These results showed that remote sensing techniques can be useful to distinguish desert vegetation and soil.

INTRODUCTION

The Jornada Experimental Range in southern New Mexico is the largest

USDA Agricultural Research Service (ARS) field station (783 km²). Located in the northern Chihuahuan Desert, the Jornada presents a unique opportunity to study the ecology of the region. The Jornada is a National Science Foundation (NSF) Long-Term Ecological Reserve (LTER) and a United Nations (UN) Man and the Biosphere (MAB) site, and has been the site of numerous long-term ecological research programs to investigate the processes related to desertification.

A research experiment known as JORNEX (the JORNada EXperiment) was initiated in 1995 on the Jornada Experimental Range to collect remotely sensed data from ground, airborne, and satellite platforms to provide spatial and temporal data on the physical and biological state of the rangeland (Ritchie et al., 1996). Two of the many objectives of this study were to establish the light reflectance characteristics of the vegetation and soil on two rangeland sites on the Jornada Experimental Range and to evaluate airborne multispectral videography for distinguishing among vegetation cover types.

STUDY AREA AND METHODS

The Jornada Experimental Range is located approximately 37 km north of Las Cruces, New Mexico (32° 37' N, 106° 40' W). Most of the Experimental Range lies on undulating plains of the Jornada basin near an elevation of 1260 m. It lies between the Rio Grande Valley on the west and the San Andres Mountains on the east (Gibbens and Beck, 1987). Average annual precipitation on the plains is 247 mm, with 52% occurring in July, August, and September. The frost-free period averages 200 days, but the effective growing season, when soil water and temperatures are favorable, is often less than 90 days. Mean monthly maximum temperatures are highest in June (36°C) and lowest in January (13°C).

Two study sites were selected for this experiment: (1) desert grassland site and (2) mesquite dune site. The two sites are located in close proximity to each other on the western portion of the Jornada. The sites are located on Typic Haplargid and Paleargid soils that have developed from alluvium in level basins below the piedmonts. The soils are loamy sands and fine sandy loams typical of the Onite, Pajarito, Pintura and Wink series. Black grama [*Bouteloua eriopoda* (Torr.) Torr.] dominates the grassland site and is within a long term study area where grazing has been excluded. The site is relatively level. Honey mesquite [*Prosopis glandulosa* L. var. *torreyana* (L. Benson) M. C. Johnston] on coppice dunes dominates the mesquite dune site. The dunes vary in height from 1 to 5 m with a honey mesquite on each. Predominantly bare soil areas occur between dunes.

Ground reflectance measurements, aerial video imagery, Landsat Thematic Mapper (TM) satellite data, and ground observations were conducted for this study. Reflectance measurements and ground truth observations were made to aid in interpreting and verifying the imagery.

Radiometric plant canopy and soil reflectance measurements were made at each study site on September 24, 1995 and September 10, 1996. Reflectance measurements were made on honey mesquite, soaptree yucca (*Yucca elata* Engelm.), broom snakeweed [*Gutierrezia sarothrae* (Pursh.) Britt. & Rusby], black grama, and bare soil at the desert grassland site. For the mesquite dune site, measurements were made on honey mesquite, broom snakeweed, four-wing saltbush [*Atriplex canescens* (Pursh.) Nutt.], and bare soil. These plants are the dominant species on each study site. Reflectance measurements were made of 10 randomly selected plant canopies (each species) and soil surfaces with a Barnes* modular multispectral radiometer (Anonymous, 1980). Measurements were made in the visible green (0.52 - 0.60 μm), visible red (0.63 - 0.69 μm), and NIR (0.76 - 0.90 μm) spectral bands with a sensor that had a 15-degree field-of-view placed 1 to 1.5 m above each canopy/soil surface. Reflectance measurements were made between 1130 and 1400 hours under sunny conditions. Radiometric measurements were corrected to reflectance at a common solar irradiance reference condition (Richardson, 1981).

Video imagery was obtained with a three-camera multispectral digital video imaging system (Everitt et al., 1995). The system is comprised of three charge-coupled device (CCD) analog video cameras, a computer equipped with an image digitizing board, a color encoder, and super (S)-VHS portable recorder. The cameras are visible/near-infrared (NIR) (0.4 - 1.1 μm) light sensitive. Two of the cameras are equipped with visible yellow-green (YG, 0.555 - 0.565 μm) and red (R, 0.623 - 0.635 μm) filters, respectively, while the third camera has a NIR (0.845 - 0.857 μm) filter. The computer is a 486-DX50 system that has an RGB image grabbing board (640 x 480 pixel resolution). The NIR, R, and YG image signals from the cameras are subjected to RGB inputs of the computer digitizing board, thus giving a color-infrared (CIR) composite digital image similar in color rendition to that of CIR film. The hard disk can store 1000 CIR composite images. In addition, the cameras' signals are also subjected to a color encoder that provides an analog CIR composite which is stored on the S-VHS recorder. The analog CIR imagery recording serves as a back-up in the event the computer malfunctions.

A GPS (Trimble* Transpack II) is integrated with this system. The navigation system constantly receives data from GPS satellites and readily calculates and displays continuously the flight direction (bearing), altitude, time, ground speed, and latitude/longitude coordinates. An interphaser (Compix model LP-701) transfers the continuous GPS information on the last two lines of the R-filtered camera, which in turn is also superimposed on the

* 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.

composite image. The latitude/longitude coordinates correspond to the approximate center of each image and have an accuracy of ± 100 m.

Video imagery was obtained of the two study sites on September 24-26, 1995. The video system was mounted in the floor (port) of a fixed-wing Aerocommander aircraft. Imagery was acquired at altitudes of 300, 750, and 1500 m between 1000 and 1530 hours under sunny conditions.

Satellite imagery of the study area was obtained on September 25, 1995 from the LANDSAT-5 TM satellite. The resolution of the TM imagery was 30 m. Only the green (0.52 - 0.60 μm), red (0.63 - 0.69 μm), and NIR (0.76 - 0.90 μm) TM bands were used in this study. These bands correspond to the same spectral bands used on the radiometer and encompass the narrower bandwidth filters used on the video system.

Ground truth surveys were made at both study sites where imagery was obtained. Observational data recorded were plant species, density, cover, and soil type. Ground level photographs were taken to help interpret the video and satellite imagery. Overhead photographs were taken of plant canopies and soil surfaces measured with the radiometer to help interpret reflectance data.

A video mosaic scene was made from the CIR video imagery acquired of the desert grassland site to demonstrate the usefulness of video in the interpretation of the Landsat TM imagery of the area. Four recorded video scenes were digitized with a 486 IBM compatible computer having a Matrox Magic color image board. Adobe Photoshop software was used to create the mosaic of the area. The Adobe marque move/drop function, plus image size, color levels, and free rotation command functions were used to merge the scenes and produce the mosaic.

Yellow-green, red, and NIR reflectance data were analyzed using analysis of variance techniques. Duncan's multiple range test was used to test statistical significance at the 0.05 probability level among means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Reflectance values of four plant species and soil at three wavelengths for two sampling dates on the desert grassland site are given in Table 1. In September 1995, bare soil had significantly higher ($P=0.05$) reflectance than the four plant species at both the green and red visible wavelengths. Broom snakeweed had higher reflectance than black grama, honey mesquite, and soaptree yucca at both the green and red wavelengths. The green and red reflectance values of black grama, honey mesquite, and soaptree yucca were similar. The high visible reflectance of the soil was attributed to its light reddish-brown color (Bower and Hanks, 1965; Gerbermann et al., 1987). The light green flower buds and yellow flowers of broom snakeweed caused it to absorb less green and red light than the various green (honey mesquite and soaptree yucca) and gray-green (black grama) foliage colors of the other plant

species, thus giving it higher visible reflectance (Gausman, 1985; Everitt et al., 1992).

Table 1
Light reflectance measurements of four plant species and soil for the desert grassland site on the Jornada Experimental Range on two dates at green, red, and near-infrared wavelengths.

Date	Plant Species and Soil	Reflectance (%) values for three wavelengths		
		Green	Red	Near-infrared
September 24, 1995	Broom snakeweed (early flowering)	9.4b ¹	7.8b	20.7d
	Black grama	5.5c	5.0c	10.9e
	Honey mesquite	5.6c	3.9d	22.8c
	Soaptree yucca	6.0c	4.5cd	28.1a
	Bare soil/ sparsely vegetated	13.7a	15.1a	24.7b
September 10, 1996	Broom snakeweed (flower buds)	6.8b	5.1b	22.3c
	Black grama	5.6c	5.1b	12.0d
	Honey mesquite	5.6c	3.9c	22.1c
	Soaptree yucca	5.7c	4.3bc	29.5a
	Bare soil/ sparsely vegetated	13.0a	15.3a	26.2b

¹ Means within a column at each sampling date followed by the same letter do not differ significantly at the 5% probability level, according to Duncan's multiple range test.

The NIR reflectance among the four plant species and soil differed significantly ($P = 0.05$) in September 1995 (Table 1). Soaptree yucca had the highest NIR reflectance while black grama had the lowest. Near-infrared reflectance in vegetation is highly correlated with plant density (Tucker, 1979; Everitt et al., 1986). An overhead view of the plant species showed that soaptree yucca had greater leaf density and less gaps than the other plant species. Honey mesquite had gaps in its canopy exposing dark in-canopy shadowing which caused its NIR reflectance to be lower than that of soaptree yucca. The lower NIR reflectance of black grama was attributed to its canopy having a mixture of green and brown plant material and dark in-canopy shadowing (Richardson et al., 1975). The high NIR reflectance of the soil agrees with the findings of other researchers (Bowers and Hanks 1965; Everitt

et al. 1992).

Reflectance data for the four plant species and soil on the desert grassland site in September 1996 followed a similar pattern to that shown in September 1995 (Table 1). Bare soil had higher visible reflectance than the plant species, while black grama had lower NIR reflectance than associated plant species and soil.

Mean reflectance values of three plant species and soil on the mesquite dune site in September 1995 are given in Table 2. Bare soil had higher visible reflectance than the plant species at both the green and red wavelengths. Conversely, honey mesquite had lower reflectance at both visible wavelengths than soil, broom snakeweed, and four-wing saltbush. The green and red reflectance values of broom snakeweed and four-wing saltbush did not differ. At the NIR reflectance wavelength, soil had higher reflectance than the three associated plant species; the plant species had similar NIR

Table 2
Light reflectance measurements of three plant species and soil for the shrub site on the Jornada Experimental Range on two dates at green, red, and near-infrared wavelengths.

Date	Plant Species and Soil	Reflectance (%) values for three wavelengths		
		Green	Red	Near-infrared
September 24, 1995	Broom snakeweed (early flowering)	10.2b ¹	8.6b	23.3b
	Four-wing saltbush	9.6b	7.0b	25.6b
	Honey mesquite	5.8c	4.0c	22.3b
	Bare soil/ sparsely vegetated	17.5a	20.5a	33.0a
September 10, 1996	Broom snakeweed (flower buds)	7.5b	6.9b	19.6c
	Four-wing saltbush	8.4b	7.3b	25.1b
	Honey mesquite	5.5c	4.5c	20.9c
	Bare soil/ sparsely vegetated	15.5a	19.6a	30.2a

¹ Means within a column at each sampling date followed by the same letter do not differ significantly at the 5% probability level, according to Duncan's multiple range test.

reflectance values. The light brown color of the soil contributed greatly to its

high visible reflectance (Gerbermann et al., 1987). The darker green foliage color of honey mesquite caused it to absorb more visible light than the other plant species and soil (Richardson et al., 1975; Gausman, 1985). The similar visible reflectance values of broom snakeweed and four-wing saltbush were attributed to the lighter foliage color of both species. The mixture of light green flower buds and yellow flowers within the canopy of broom snakeweed apparently gave it similar green and red reflectance to that of four-wing saltbush which had a gray-green foliage color.

Visible and NIR reflectance values of the three plant species and soil on the mesquite dune site in September 1996 followed a similar trend to that shown in September 1995 (Table 2). Soil had higher visible (green and red wavelengths) and NIR reflectance than the three plant species, whereas honey mesquite had lower visible reflectance than broom snakeweed, four-wing saltbush, and soil.

Figure 1 (upper) shows a CIR video image of a portion of the desert grassland site. The GPS information is recorded on the bottom of the print. The image was obtained at an altitude above ground level of approximately 1000 m on September 24, 1995. The gray to dark gray background image response throughout the scene is black grama. Soap tree yucca is characterized by a bright red image, while honey mesquite has a darker red response integrated with black. Sparsely vegetated and bare soil areas have a light gray to whitish tone. Broom snakeweed plants cannot be detected because of their small stature and the dark background image of black grama. The dark image response of black grama was primarily due to its low NIR reflectance and in-canopy shadowing (Table 1). The distinct image of soap tree yucca was attributed to both its generally low visible red and high NIR reflectance. The darker image response of honey mesquite was attributed to its low visible red reflectance and in-canopy shadowing. The high visible reflectance of bare soil contributed significantly to its light image response.

The CIR video image of the mesquite dune site is shown in Figure 1 (lower). The image was obtained at an altitude above ground level of about 700 m on September 24, 1995. Individual honey mesquite plants on the coppice dunes have a dark red to nearly black image caused by its low visible reflectance and in-canopy shadowing. The small black rounded images in the background are broom snakeweed plants. Four-wing saltbush plants are located on the coppice dunes with honey mesquite, but can not be distinguished in the image. The large amount of exposed bare soil has a bright whitish response due to its high reflectivity (Table 2).

Figure 2 (upper) shows a CIR video mosaic image made up of four video scenes of an area dominated by the desert grassland site. The video imagery was obtained at an altitude of 1800 m above ground level on September 24, 1995. The dark image response over much of the scene is black grama. The light image tones in the approximate center of the print and on the right side are desert grassland-mesquite dune transition areas. The lower portion of Figure 2 is an enlargement of a portion of a TM satellite scene of the same

area obtained on September 25, 1995. The area shown in the video mosaic is outlined in white on the satellite image. The video mosaic clearly delineates much more detail about the desert landscape than can be distinguished in the TM scene. Thus, videography can be a useful tool to interpret lower resolution satellite imagery.

CONCLUSIONS

Ground reflectance measurements showed significant differences among major plant species and soil at both the desert grassland and mesquite dune sites. Black grama had lower NIR reflectance than the other plant species and soil at the desert grassland site. Honey mesquite had lower visible green and red reflectance than the other plant species and soil at the mesquite dune site.

Results showed that CIR video imagery can be a useful tool for characterizing dominant vegetation cover types on the two study sites. The electronic signal of video makes it highly amenable to computer image processing capabilities; thus, useful products such as video mosaics of several scenes can be obtained and used for interpreting coarser resolution satellite imagery. The capability to differentiate among dominant desert rangeland species with airborne video will be useful to natural resource and range managers.

ACKNOWLEDGEMENTS

The authors thank Buck Cavazos for his expertise in image processing and Joe Gallardo for his assistance in preparing illustrations. Thanks is also extended to Angie Cardoza for word processing.

LITERATURE CITED

- Anonymous. 1980. Modular-multiband radiometer model 12-1000. Barnes Engineering Co., Stamford, CT. Bull. 12-1000A. 7 pp.
- Bowers, S. A. and R. J. Hanks. 1965. Reflection of radiant energy from soils. *Soil Sci.* 100:130-138.
- Everitt, J. H., M. A. Alaniz, D. E. Escobar, and M. R. Davis. 1992. Using remote sensing to distinguish common (*Isocoma coronopifolia*) and Drummond goldenweed (*Isocoma drummondii*). *Weed Sci.* 40:621-628.
- Everitt, J. H., D. E. Escobar, I. Cavazos, J. R. Noriega, and M. R. Davis. 1995. A three-camera multispectral digital video imaging system. *Remote Sens. Environ.* 54:333-337.
- Everitt, J. H., A. J. Richardson, and P. R. Nixon. 1986. Canopy reflectance characteristics of succulent and nonsucculent rangeland plant species. *Photogramm. Eng. and Remote Sens.* 52:1891-1897.
- Gausman, H. W. 1985. Plant leaf optical parameters in visible and near-infrared light. Graduate Studies Texas Tech University, No. 29. Texas Tech Press. Lubbock, TX. 78 pp.
- Gerbermann, A. H., C. L. Wiegand, A. J. Richardson, and R. R. Rodriguez. 1987. Diurnal soil reflectance in the 450- to 2450-nm interval as related to photographic and video sensing. Proc. 11th Biennial Workshop Color Aerial Photography and Videography in the Plant Sciences. Amer. Soc. Photogramm. and Remote Sens., Falls Church, VA. pp. 184-195.
- Gibbens, R. P. and R. F. Beck. 1987. Increase in number of dominant plants and dominance classes on a grassland in the Northern Chihuahuan desert. *J. Range Manage.* 40:136-139.
- Richardson, A. J. 1981. Measurement of reflectance factors under daily and intermittent irradiance variations. *Appl. Opt.* 20:1336-1340.
- Richardson, A. J., C. L. Wiegand, H. W. Gausman, J. A. Cuellar, and A. H. Gerbermann. 1975. Plant, soil, and shadow reflectance components of row crops. *Photogramm. Eng. and Remote Sens.* 41:1401-1407.
- Ritchie, J. C., A. Rango, W. P. Kustas, T. J. Schmugge, K. Brubaker, K. M. Havstad, B. Nolan, J. H. Prueger, J. H. Everitt, M. R. Davis, F. R. Schiebe, J. D. Ross, K. S. Humes, L. E. Hipps, M. Menenti, W. G. M. Bastiaansen, and H. Pelgrum. 1996. JORNEX: An airborne campaign to quantify rangeland and vegetation change and plant community-atmospheric interactions. Proc. 2nd Int. Airborne Remote Sensing Conference. pp. 54-66.
- Steel, R. G. D. and J. H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill Book Co., New York, NY. 481 pp.
- Tucker, C. J. 1979. Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sens. Environ.* 8:127-150.

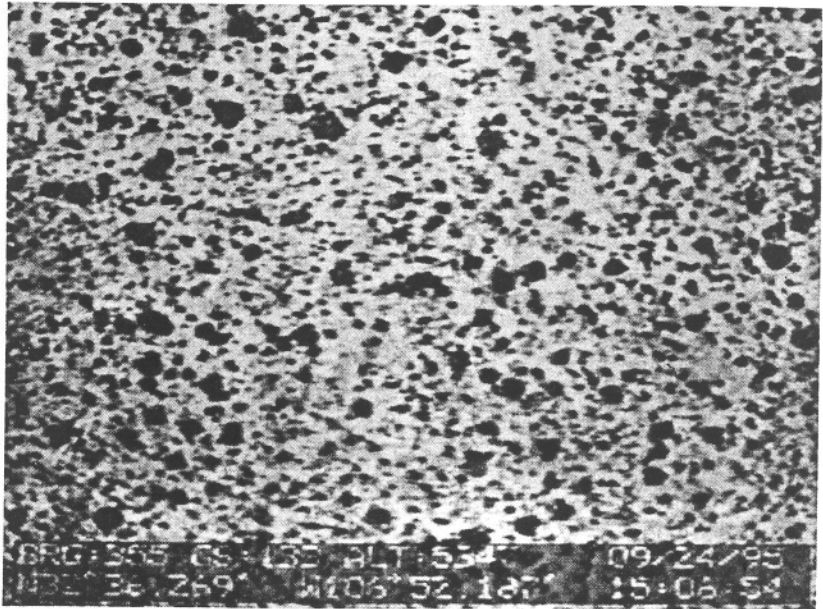
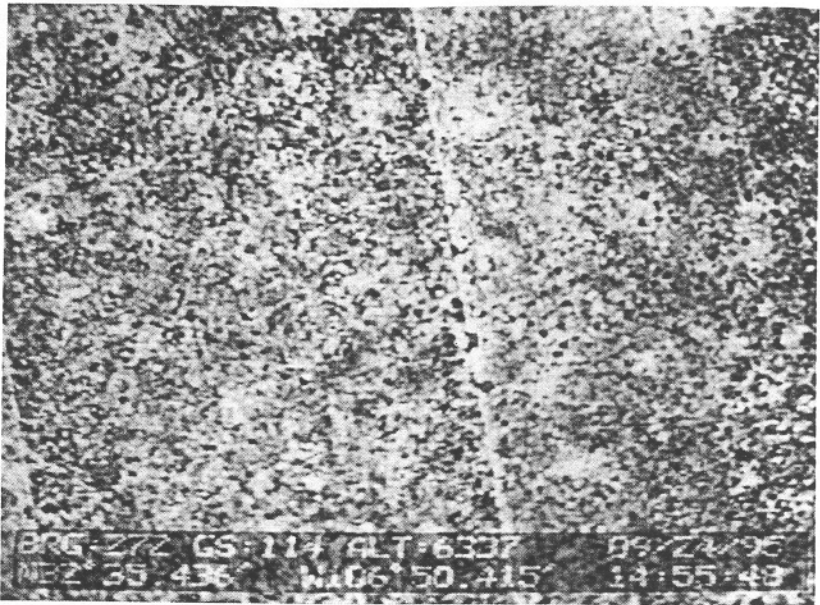


Figure 1. Color-infrared video images of portions of the desert grassland (upper) and mesquite dune (lower) sites on the Jornada Experimental Range. The global positioning system data appears on the bottom of the images.

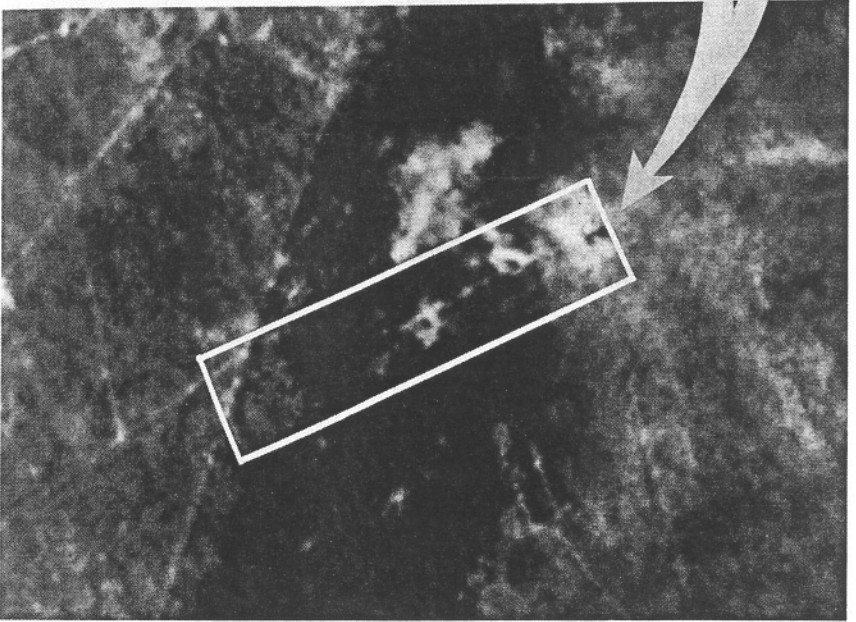
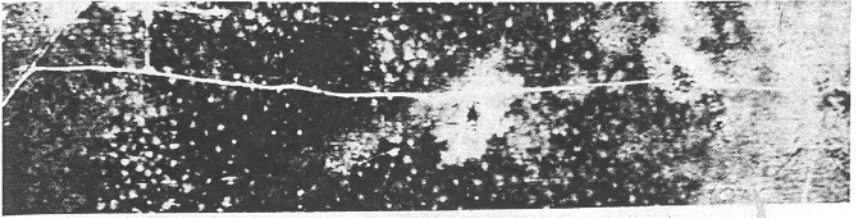


Figure 2. Color-infrared video mosaic image (upper) of an area dominated by the desert grassland site on the Jornada Experimental Range. The lower image shows an enlargement of a portion of the Thematic Mapper Satellite scene of the same area. The area shown in the video mosaic is outlined in white on the satellite image.