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False Color Video Imagery: A Potential Remote Sensing Tool for Range Management

The color responses of video composite images to various rangeland species were similar to those of color-infrared photographic imagery.

Abstract: False color video imagery was evaluated as a potential remote sensing tool to assist in assessing rangeland resources. Aerial video and CIR photographic imagery were obtained simultaneously of three different rangeland areas in south Texas: (1) a range infested with huisache and mesquite trees, (2) a fertilized bermudagrass range, and (3) a native range comprised of mesquite and live oak trees. Video imagery was obtained with three black-and-white video cameras—two of them visible and one visible/near-infrared sensitive—each equipped with narrowband filters. The narrowband video images of each scene were combined on an image processor to produce false color video composite images. The color responses of the video composite images to the rangeland species were similar to those of the CIR photographic imagery. These results showed that a false color video camera would have considerable potential as a tool to assist in rangeland evaluation and other applications that necessitate "real time" analysis.

Introduction

Color-infrared (CIR) aerial photography has long been a useful tool for the assessment of rangeland resources (Johnson, 1969; Tueller, 1982). Numerous workers have shown that CIR aerial photography has considerable potential to map plant communities, distinguish plant species, monitor changing conditions, and detect a variety of other rangeland ecological ground conditions (Carneggie, 1970; Tueller and Swanson, 1973; Driscoll, 1974; Driscoll and Coleman, 1974; Poulton, 1975; Young *et al.*, 1976; Gausman *et al.*, 1977a, 1977b; Everitt *et al.*, 1984). However, CIR film requires a minimum of 1 or 2 days for processing and development. Occasionally, rangeland managers need information sooner about catastrophic events such as rangeland fires and flooding in order to make proper management decisions.

Recently, video recording systems have been used as remote sensing tools, primarily because they provide immediately useful imagery. For example, Edwards (1982) and Escobar *et al.* (1983) used a black-and-white near-infrared video recording system to detect freeze-damaged citrus trees and leaves. With this technique, the time to assess freeze-damaged citrus was decreased from about one day for conventional photography to one hour for video systems. A similar system was also used to detect early and late blight of potato plants (Manzer and Cooper, 1982).

Nixon *et al.* (1984) evaluated CIR photos and color-infrared video composite images prepared by an image processing system from three spectrally-filtered black-and-white video images of various agricultural crops and reported on the potential of the development of a color-infrared video camera system. The false color video composite images showed very similar color image characteristics to those of the CIR photos. Meisner and Lindstrom (1984) recently reported on the development of a CIR aerial video camera that has the same color scheme as CIR film. The system acquires CIR images on standard video cassettes, and the imagery is sim-

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ilar to CIR film. Our objective was to evaluate false color video composites of various rangeland scenes with respect to CIR aerial photos of these same scenes, and ascertain whether a false color video system might be a useful and versatile tool to assist in rangeland evaluation.

Materials and Methods

Simultaneous imagery of rangeland areas was taken with three black-and-white (Sony* AVC-3450) video cameras with 50-mm lenses, each with a (Sony SLO-340) cassette recorder, and a Hasselblad 70-mm camera with a 150-mm lens. One of the three video cameras was modified with a camera tube to give a sensitivity to reflect light energy from the 0.30- to 1.10-μm waveband (WB). The other two video cameras had a sensitivity from the 0.40- to 0.70-μm WB. Visible and near-infrared narrowband filters were used with the cameras, thus allowing the video cameras to record any selected light segment within the visible (0.40- to 0.75-μm WB) or near-infrared (0.75- to 1.10-μm WB) region of the electromagnetic spectrum. The Hasselblad camera contained Kodak Aerochrome CIR (0.50- to 0.90-um WB) type 2443 film and employed a Hasselblad No. 12 orange filter.

Imagery was taken between 1200 and 1450 hours under clear, sunny conditions at three different rangeland areas in southern Texas: (1) a rangeland site infested with honey mesquite (*Prosopis glandulosa*) and huisache (*Acacia smallii*) trees near Mercedes, Texas, on 11 October 1983; (2) a recently fertilized (168 kg N/ha) improved range seeded to bermudagrass (*Cynodon dactylon*) near Weslaco, Texas, on 24 October 1983; and (3) a native rangeland site with a dense stand of live oak (*Quercus virginiana*) and honey mesquite trees near Encino, Texas, on 2 September 1983. All imagery was taken at an altitude of 1500 m above the ground. Imagery of the woody plant species was taken during September and October because their phenological stages during this period contribute to differences in their spectral response (Gausman *et al.*, 1977a).

Ground truth was collected at each study site at the time imagery was obtained. Plant canopy reflectance measurements were made at the honey mesquite-huisache site using a spectroradiometer (Exotech Model 20) (Leamer *et al.*, 1973). Canopy light reflectance measurements were made on ten plant canopies of both species. Reflected radiation was measured over the 0.45- to 0.90-μm WB with a sensor that had a 15-degree field-of-view (0.5 m^2). Reflectance measurements were made at 3.0 m above each plant canopy under clear and sunny conditions between 1100 and 1450 hours.

* 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.

Table 1. Narrowband Filters Used on Video Cameras

Filter	Sensitive Waveband (μm)
Blue	0.42–0.45
Yellow green-yellow-orange	0.54–0.62
Red	0.64–0.67
Infrared	0.85–0.88

Video imagery of the rangeland site infested with honey mesquite and huisache was taken using blue, red, and infrared (IR) narrowband filters. Imagery of both the fertilized and live oak-honey mesquite range was taken using yellow green-yellow-orange, red, and IR narrowband filters. Table 1 shows the sensitive wavebands of the narrowband filters used on the video cameras. Various narrowband filters can be used on the video cameras (Nixon *et al.*, 1985). Consequently, the same filters were not used on all missions.

After the video recordings were obtained, color composites were made from the three narrowband images of the same scene using an image processing system. The video tapes were played back with a video cassette player (Betamax Model SLO-383) that was connected to an image processor (I^2S Model 70-F) using an Edutron time base corrector (Model CCD2H-3). The video scene for each narrowband filter image was digitized by the image processor and stored on a disk, and also on magnetic tapes, in order to avoid loss of data. The image processor was used to register three digitized black-and-white narrowband images of the same scene. False color video composites were prepared using the red, green, and blue color channels of the image processor with three superimposed images. Video images presented here were photographed from the color monitor. Efforts were made to scale the video images to the CIR photographs, but differences in focal length, lens optics, and format made this difficult. Thus, video images appear distorted when compared to CIR photographs.

The t-test was used to test mean differences statistically between canopy reflectances (Steel and Torrie, 1960).

Results and Discussion

Plate 1 shows comparisons of CIR photographs and false color video composite images of three different rangeland areas. The honey mesquite and huisache trees had similar brown and magenta color characteristics, respectively, in the false color video composite (Plate 1A) and in the CIR photograph (Plate 1B). The two species were as readily separated in the video composite as in the CIR photographic image. The arrow on the video composite points to a stand of huisache trees. Other ground features such as the stand of mixed herbaceous vegetation

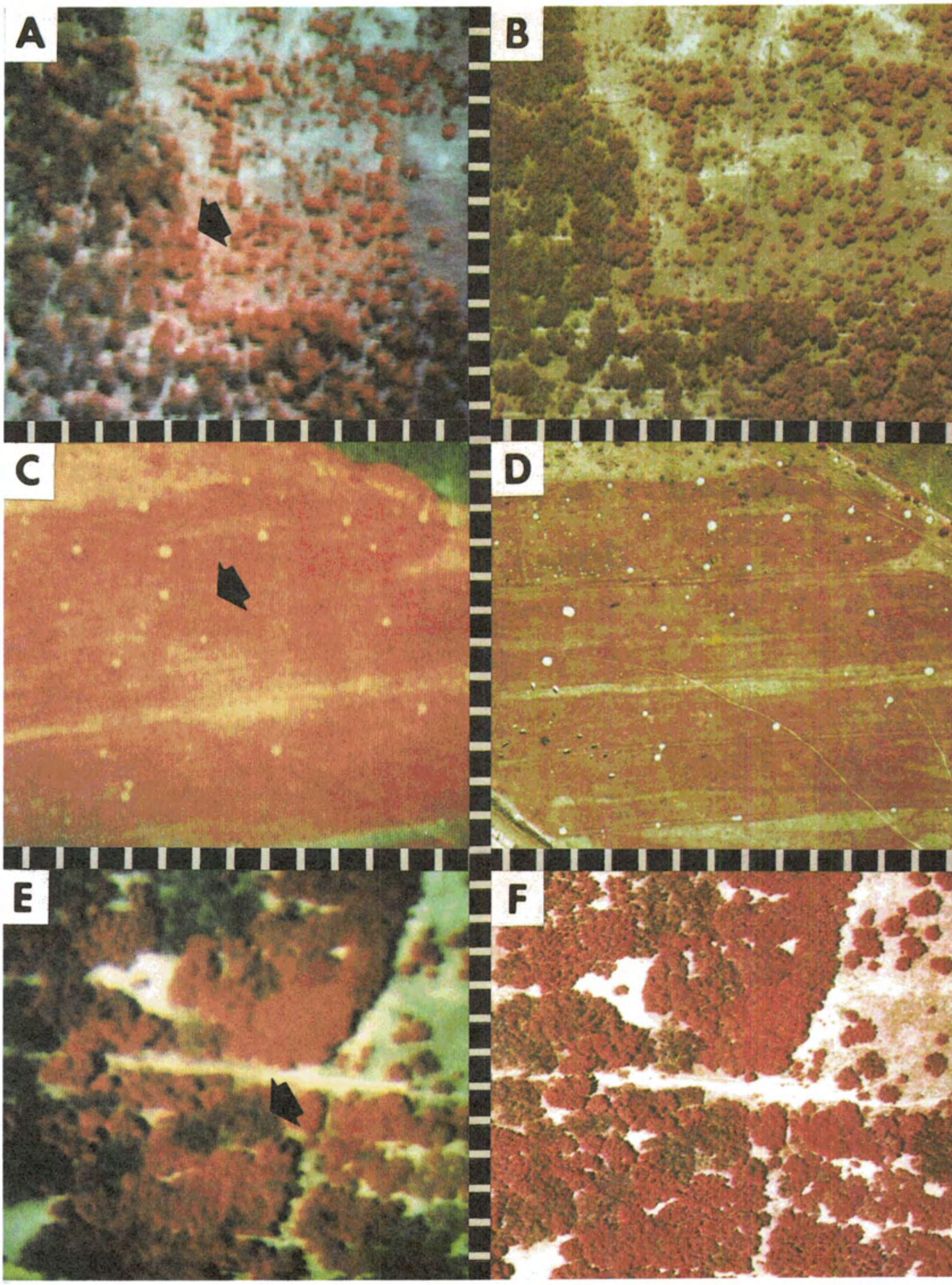

Plate 1. Color photographs of false color video composite images (A, C, and E) and color-infrared photographic images (B, D, and F) of a honey mesquite and huisache infested range, fertilized range, and native range comprised of live oak and honey mesquite, respectively. Imagery was obtained at an altitude of 1500 metres.

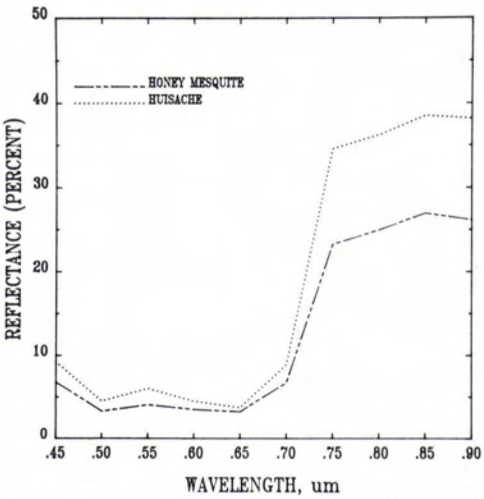

FIG. 1. Field spectroradiometric measured canopy light reflectance over the 0.45- to 0.90-μm waveband for huisache and honey mesquite.

(light magenta color), which is in the center of the images, and sparsely vegetated areas (whitish color), which are scattered throughout, were also distinguishable on the video composite. The herbaceous vegetation was more pronounced on the video composite than on the CIR photograph. This may be attributed to the blue narrowband filter used to obtain the video imagery. In CIR photography, the orange filter absorbs the blue light. The contrasting image color characteristics between huisache and honey mesquite were attributed to differences in their canopy light reflectance. Huisache had significantly higher ($p = 0.05$) spectroradiometric canopy light reflectance than did honey mesquite over the 0.45- to 0.90-μm WB (Figure 1).

The false color video and CIR photographic images of the fertilized bermudagrass range are shown in Plates 1C and 1D, respectively. The arrow on the video composite points to the characteristic red color of the fertilized grass. The fertilized grass was as pronounced in the video composite as in the CIR photograph. The light streaks, where the fertilizer was unevenly applied, and most of the harvester ant (*Pogonomyrex barbatus*) mounds (white spots) were also as distinct in the video image as in the CIR photographic image. The image color of the fertilized grass can be attributed to its higher chlorophyll content and greater above ground phytomass than that of the nonfertilized grass (Thomas and Oerther, 1972; Wiegand *et al.*, 1974; Gausman *et al.*, 1975). The fertilized grass was taller, had greater leaf density, and was much darker green than the nonfertilized grass.

Plates 1E and 1F show the false color video composite and CIR photographs, respectively, of the rangeland areas comprised of live oak and honey mesquite trees. The color characteristics in the false color video image were similar to those of the CIR photographic image. Live oak trees were characterized by a dark red color in both images, while honey mesquite had a brownish image color (see arrow on video image). A photo interpretation test showed that the live oak and honey mesquite trees were more easily separated on the monitor screen than in the photographic reproduction (Plate 1E). The photographic reproduction is darker and has a more "fuzzy" appearance than the original monitor image. Differences in color image characteristics between live oak and honey mesquite were related to differences in their canopy light reflectance; live oak has higher near-infrared (0.75- to 0.90-μm WB) canopy light reflectance than honey mesquite (Gausman *et al.*, 1977a).

The video images in Plate 1 show a vignetting effect because the camera optics were not designed for the near-IR WB. Use of an anti-vignetting filter on the IR video camera may have resulted in more uniform densities across the images.

Summary and Conclusions

These comparisons between false color video composite and CIR photographic images of various rangeland scenes demonstrate that a false color video system has considerable potential as a remote sensing tool to assist in evaluation of some rangeland resources. Although the false color video composites were prepared using narrowband spectral filters, their color image characteristics were comparable to those of CIR photographic images.

The "fuzzy" appearance of the video images was primarily caused by the poorer resolution of the video imagery as compared to that of photographic film. However, part of the "fuzzy" appearance can be attributed to the hard copy photographic reproduction process from the color monitor, because the original digital images were sharper than the photographic copies. In addition, the three video images may not have been perfectly registered in the image processor, contributing further to the "fuzzy" appearance.

The initial cost of a CIR video system (approximately \$10,000 to \$12,000) will be considerably higher than that of a small format photographic system (Meisner and Lindstrom, 1984). But, considering the lower cost of video tapes versus film, the overall cost of the video system could offer significant savings. Standard video tapes cost less than \$10.00, which is less than the processing for a 36-exposure roll of 35-mm film. The tape would cover two hours of imagery versus one or two minutes for the film.

Based on the initial evaluation of computer generated false color video composite images of agricultural crops by Nixon *et al.* (1983) and our illustrated false color video composite examples presented in this paper to assist in assessing some rangeland situations, a CIR video camera should be a useful tool for remote sensing of rangeland resources. It should be useful in applications requiring rapid turnaround time such as assessing rangeland burns and flooding. Moreover, because many rangeland areas are often remote, the ability to view video imagery immediately can be very cost saving. The recorded imagery can be monitored in the aircraft; therefore, if problems are found (e.g., poor focus, inadequate light, insufficient field of view), additional imagery can be taken without repeating travel to the area. Also, the ability to view imagery immediately can enable ground truth to be collected in near "real time," which can be useful when studying highly changeable resources such as crops where harvesting may take place the same day imagery is obtained. Video imagery could be an asset in areas where processing of CIR film may not be immediately available. In some countries, film must be sent to other countries for processing, thus greatly increasing the delay in viewing the imagery (Meisner and Lindstrom, 1984).

Acknowledgments

The authors thank R. L. Bowen and D. E. Escobar for their help in obtaining the imagery and producing the illustrations, and for their encouragement during this study. Thanks are also extended to M. A. Alaniz for his assistance in the field and laboratory.

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(Received 23 June 1984; revised and accepted 18 February 1985)