Video Imagery: A New Remote Sensing Tool for Range Management

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Abstract

A multi-video system that provides immediately useful narrowband black-and-white imagery within the visible to near-infrared light (0.40- to 1.10-μm waveband) region of the electromagnetic spectrum was evaluated as a remote sensing tool to assess several ecological rangeland ground conditions in southern Texas. The system provided imagery to detect many variables including: the presence of weeds, heavy grazing, fertilized grassland, burned areas, and gopher and ant mounds. Certain narrowband filters provided better discrimination among vegetation than others. For example, a red narrowband filter provided the best imagery to distinguish between fertilized and nonfertilized bermudagrass [*Cynodon dactylon* (L.) Pers.]. These results demonstrated that narrowband multi-video imagery could assist in assessing some ecological ground conditions of rangelands.

Rangelands are often so large and inaccessible that photography or other imagery is necessary to determine their characteristics and extent. The value of remote sensing for rangeland assessment has been well established. Several investigators have shown that rangelands can be classified, mapped, and monitored with both aerial photography (Johnson 1969, Poulton 1970, Driscoll and Coleman 1974, Gausman et al. 1977-a, Everitt et al. 1980, Tueller 1982) and satellite imagery (Seevers et al. 1973, Everitt et al. 1979, McGraw and Tueller 1983).

Recently, video recording systems have been used as remote sensing tools because they provide immediately useful imagery. Several investigators have demonstrated the use of video imagery for agricultural assessment (Edwards 1982, Manzer and Cooper 1982, Escobar et al. 1983, Nixon et al. 1984).

Nixon et al. (1985) recently reported the use of a multi-video system that provided narrowband imagery at selected wavelengths within the visible to near-infrared [0.40- to 1.10-μm waveband (WB)] energy region. This system provided acceptable imagery showing that certain wavebands were more effective in discerning vegetative stresses or crop species differences than other wavebands. Our objective was to show that this video system may be a useful remote sensing tool to assess selected rangeland resource characteristics.

Materials and Methods

The video system consisted of 4 black-and white Sony[1] AVC-3450 video cameras, each with a Sony SL0-340 cassette recorder. One of the 4 video cameras was modified with an RCA Ultricon (TM) 4875/U camera tube to give a sensitivity to light from the 0.30-to 1.10-μm WB. The other cameras were sensitive to light that ranged from the 0.40- to 0.70-μm WB. Visible and near-infrared narrowband filters were used on the camera lens, thus giving the video camera system the capability to record selected segments within the visible (0.40- to 0.75-μm WB) to near-infrared (0.75- to 1.10-μm WB) light region. The camera lens focal length was 50 mm. Imagery was taken between 1200 and 1400 hr under sunny conditions.

Video recordings were obtained from 4 different rangeland areas in southern Texas: (1) a native rangeland site infested with the weedy species woolly stemodia [*Stemodia tomentosa* (Mill.) Greenm. and Thomps.[2]] near Encino, Texas; (2) a heavily grazed

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[1]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.
[2]Plant names are according to Correll and Johnston (1970).

native rangeland site near Raymondville, Texas; (3) a fertilized (168 kg N/ha) improved range seeded to bermudagrass [*Cynodon dactylon* (L.) Pers.] near Weslaco, Texas; and (4) a burned native rangeland near Armstrong, Texas. The bermudagrass was fertilized 3 weeks before the imagery was obtained. Imagery of the rangeland near Encino was taken at an altitude of 1,050 m using blue (0.42- to 0.45-μm WB), green (0.50- to 0.53-μm WB), red (0.64- to 0.67-μm WB), and infrared (IR) (0.85- to 0.89-μm WB) narrowband filters. Video imagery obtained near Raymondville and Weslaco was taken at an altitude of 1,500 m. The imagery obtained near Raymondville was taken with blue, yellow green-yellow-orange (0.54- to 0.62-μm WB), red, and IR narrowband filters, whereas imagery obtained near Weslaco was taken with yellow (0.56- to 0.59-μm WB), yellow green-yellow-orange, red, and IR narrowband filters. Video imagery obtained near Armstrong was taken at an altitude of 3,000 m using green, yellow green (0.53- to 0.56-μm WB), yellow, and IR narrowband filters. Various narrowband filters were used to acquire the video imagery to assess their influence on images of selected scenes. Images shown here were photographed from the TV screens.

Ground data were taken at each study site at the time imagery was obtained. Plant canopy light reflectance measurements were made at the Encino, Weslaco, and Armstrong sites using an Exotech Model 20 spectroradiometer (Leamer et al. 1973). Canopy light measurements were taken on 5 plant canopies for each of 4 species or mixtures of species at the Encino site: woolly stemodia, honey mesquite (*Prosopis glandulosa* Torr.), live oak (*Quercus virginiana* Mill.), and mixed herbaceous vegetation. Canopy light measurements were also made on 5 plant canopies for each of 3 categories of herbaceous vegetation at the Armstrong site: burned, dormant, and green herbaceous vegetation. Ten canopy measurements were made randomly for both fertilized and nonfertilized bermudagrass at the Weslaco site. 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 conditions between 1100 and 1430 hr. Total chlorophyll concentration was determined on both fertilized and nonfertilized bermudagrass. Leaf sample composites were randomly collected from each of 10 fertilized and 10 unfertilized bermudagrass plants. Total chlorophyll was determined according to Horwitz (1965). Herbaceous biomass was measured for both heavily and lightly grazed areas at the Raymondville site. Biomass was measured by clipping all vegetation at ground level within 10 randomly selected 50- by 50-cm quadrats on each area.

Student's *t*-test was used to test differences between canopy reflectances and between leaf chlorophyll concentrations for fertilized and nonfertilized bermudagrass, and to evaluate biomass production differences between heavily and lightly grazed areas. Canopy reflectance data for the 4 species or mixtures of species at the Encino site, and the 3 types of herbaceous vegetation at the Armstrong site were subjected to the analysis of variance, and Duncan's multiple range test was used to evaluate differences among means for each site (Steel and Torrie 1960).

Results and Discussion

The blue narrowband video image of the rangeland with woolly stemodia illustrates the characteristic whitish-gray image of woolly stemodia in contrast to the darker gray tone of other herbaceous vegetation and the almost black tone of live oak trees (Fig. 1). The small white spots were pocket gopher (*Geomys personatus* True) mounds. The leaves and stems of woolly stemodia were covered with a dense white pubescence (hairs) which gave it a conspicuous whitish-gray appearance on the image. Plant canopy light reflectance measurements made over the 0.45- to 0.90-μm WB showed that woolly stemodia had significantly higher ($p = 0.01$) reflectance in the visible WB (0.45- to 0.75-μm WB) than the other associated species or mixtures of species, but its near-IR (0.75- to 0.90-μm WB) reflectance did not differ from that of honey mesquite and mixed herbaceous species. The high visible light reflectance of woolly stemodia was attributed to its dense white hairs (Gausman et al. 1977-b). The blue narrowband filter resulted in the most distinct image for discriminating woolly stemodia from other vegetation.

Fig. 1. *Black-and-white video image of the rangeland with woolly stemodia near Encino, Texas, obtained with the blue narrowband filter. The arrow points to the characteristic whitish-gray image of woolly stemodia.*

The image of the heavily grazed native rangeland that was acquired using a yellow green-yellow-orange narrowband filter shows the characteristic light gray of heavily grazed vegetation (Fig. 2). The dark gray in the upper right part and at the bottom of the image were lightly grazed areas. The black area adjacent to the

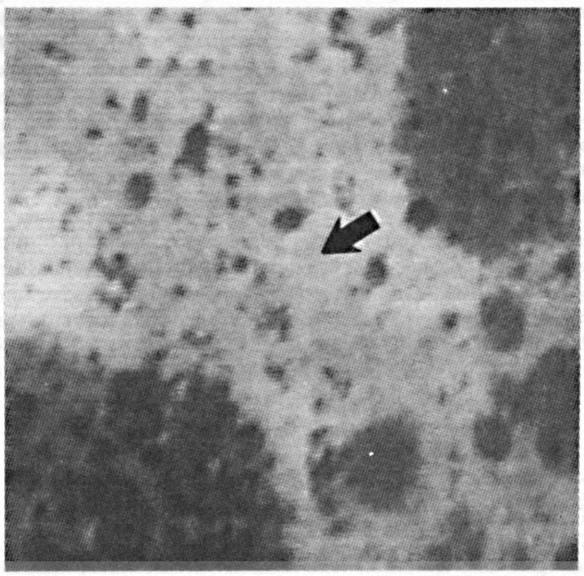

Fig. 2. *Black-and-white video image of the heavily grazed rangeland area near Raymondville, Texas, obtained with the yellow green-yellow-orange narrowband filter. The arrow points to the characteristic light gray image of the heavily grazed vegetation.*

lightly grazed area in the lower left part of the image and scattered throughout the area was huisache [*Acacia farnesiana* (L.) Willd.]. The biomass on the lightly grazed areas (3,460 kg/ha) was significantly higher (p=0.01) than that on the heavily grazed areas (620 kg/ha). The heavily grazed areas were dominated by longtom (*Paspalum lividum* Trin.), a highly palatable grass. The lightly grazed areas were dominated by less palatable species. The yellow green-yellow-orange narrowband filter gave the most distinct image of this site, but the image obtained using the red filter was also good.

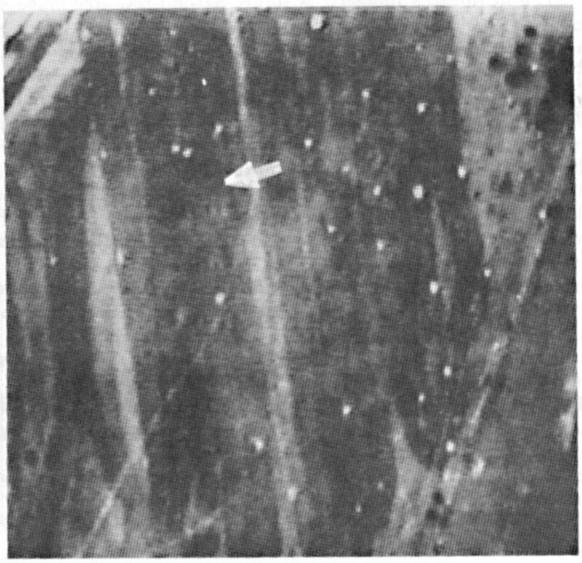

Fig. 3. *Black-and-white video image of recently fertilized bermudagrass range near Weslaco, Texas, obtained with the red narrowband filter. The arrow points to the dark gray image of the fertilized grass.*

Figure 3 shows the red narrowband video image of the fertilized bermudagrass range. The light streaks were areas where the fertilizer was unevenly applied. The white spots were caused by harvester ant (*Pogonomyrmex barbatus* F. Smith) mounds and the dark area in the upper right corner is a stand of mixed brush. Two days after fertilization, the area received 4 cm of rain which apparently activated the fertilizer and subsequent plant growth. The chlorophyll concentration of the fertilized grass (4.9 mg/g) was significantly higher (p=0.01) than that of the unfertilized grass (2.0 mg/g). The red narrowband filter used to obtain this image corresponds approximately to the chlorophyll absorption peak of plant leaves (Gausman 1983). Consequently, the dark gray image of the fertilized grass (highest chlorophyll concentration) indicated that more red light was absorbed, or less was reflected. Conversely, the lighter gray image of the nonfertilized grass (lower chlorophyll concentration) indicated that less red light was absorbed, or more was reflected.

The darker green fertilized grass had significantly lower (p=0.01) visible reflectance (0.45- to 0.75-μm WB) than did the lighter green nonfertilized grass (Fig. 4). However, the fertilized grass had significantly higher (p=0.01) near-IR (0.75- to 0.90-μm WB) reflectance than did the nonfertilized grass. The higher near-IR reflectance of the fertilized grass was probably caused by its greater biomass, since vegetation biomass and near IR-reflectance are positively linearly correlated until a stable reflectance is reached (Myers and Allen 1968, Wiegand et al. 1974). Although biomass measurements were not taken, the fertilized grass was taller and had greater leaf cover than did the nonfertilized grass.

The red narrowband filter gave the best overall image of the fertilized area. This is substantiated in Figure 4 where the greatest difference in visible reflectance between the fertilized and nonfertilized grass occurred at the 0.65-μm wavelength.

The IR video image of the burned rangeland clearly illustrates

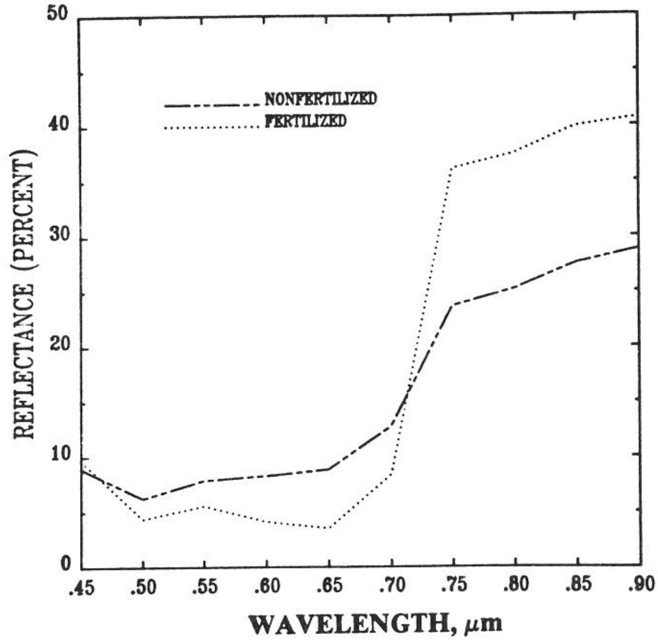

Fig. 4. *Field spectroradiometric measured canopy light reflectance over the 0.45- to 0.90-μm waveband for fertilized and nonfertilized bermudagrass.*

the extent of the burn (Fig. 5). Green herbaceous vegetation has a whitish image, whereas areas dominated by dormant herbaceous vegetation have a gray tone. Plant canopy light reflectance measurements showed that the burned vegetation had lower reflectance than the dormant and green vegetation over the entire 0.45-to

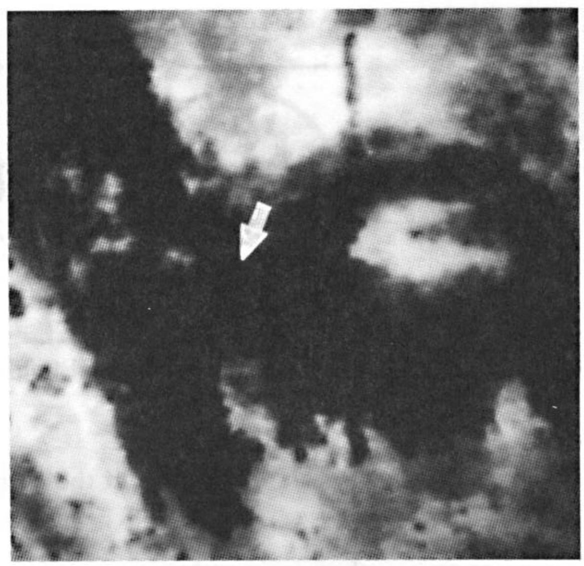

Fig. 5. *Black-and-white video image of a recently burned rangeland area near Armstrong, Texas, obtained with the IR narrowband filter. The arrow points to the characteristic black image of the burned herbaceous vegetation.*

0.90 μm WB, but the greatest difference occurred in the near-IR (0.75- to 0.90-μm WB) region. The black ash from the burned vegetation apparently absorbed a high percentage of the incident light, resulting in extremely low near-IR reflectance.

Conclusions

Data presented in this study showed that the multi-video system could be used to detect a variety of selected ecological ground conditions on south Texas rangelands. Although video imagery does not have as sharp a resolution as photographic film, it can provide users with immediately useful information. Airborne video imagery should be particularly useful in applications requiring rapid turnaround time such as assessing rangeland burns and flooding.

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