

Canopy Reflectance and Film Image Relations among Three South Texas Rangeland Plants

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Highlight: Field spectroradiometric measurements for canopy reflectances of three dominant south Texas woody plants (cenizo, honey mesquite, live oak) were used successfully to predict their color infrared film images and distinguishability: cenizo, whitish; honey mesquite, relatively light magenta; and live oak, darker magenta.

Three plant communities are prominent in south Texas (Kuchler 1964; Davis and Spicer 1965): (i) live oak (*Quercus virginiana* Mill.) on deep sands that grows in formations ranging from dense, uniform stands to frequent thickets or motts in underbrush; (ii) honey mesquite (*Prosopis glandulosa* Torr.) that grows as motts or dense stands on a variety of soil types (deep sands, sandy loams, clay loams, heavy clays); and (iii) cenizo [*Leucophyllum frutescens* Berl.] I. M. Johnst.] that grows as either dense or sparse stands among a wide variety of woody shrubs on shallow soils. The distribution and condition of these plant communities should be inventoried regularly to provide optimum livestock and wildlife management on south Texas rangelands.

The visible (0.40 to 0.74 μm) and near-infrared (0.75 to 1.35 μm) laboratory measured leaf reflectance was much greater for cenizo than for honey mesquite (Gausman et al. 1976). We speculated that this difference could be used to distinguish remotely between cenizo and honey mesquite plants on rangelands. Unfortunately, we did not determine the reflectance of live oak leaves in the laboratory.

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This study was supported in part by the National Aeronautics and Space Administration under Contract No. S-53876-AG. The authors thank J. Noriega and R. R. Rodriguez for assisting with spectroradiometric measurements and J. A. Cuellar for obtaining microdensitometric readings.

Manuscript received March 14, 1977.

Field spectroradiometric measurements have been used to determine canopy reflectance differences between stressed and nonstressed crop plants (Gausman et al. 1974, 1975). Unlike laboratory measurements, field measurements take into account plant, soil, and shadow reflectance (Richardson et al. 1975). However, there is a paucity of canopy reflectance data for rangeland plants.

Our objective was to measure the canopy reflectances of cenizo, live oak, and honey mesquite plants in the field and to relate these data to the plants' images on Eastman Kodak Aerochrome¹ infrared color film.

Materials and Methods

Canopy reflectances over the 0.5- to 2.5- μm waveband of cenizo, honey mesquite, and live oak plants were field measured in June 1976 with an Exotech Model 20 spectroradiometer (Leamer et al. 1973). The sensor had a 15-degree field-of-view (0.5 m²) and was placed 3 to 3.4 m above each of five randomly selected canopies for each plant species.

Reflectance data at selected wavelengths were analyzed using analysis of variance techniques, and Duncan's multiple range test was used to test the statistical significance among species' means (Steel and Torrie 1960). Wavelengths selected were 0.55, 0.65, 0.85, 1.65, and 2.2 μm , representing, respectively, the green reflectance peak, chlorophyll absorption band, a wavelength on the near-infrared plateau, the 1.65- μm peak following the 1.45- μm water-absorption band, and the 2.2- μm peak following the 1.95 μm water-absorption band. Field measurements were made on clear sunny days in June 1976 at three different locations in south Texas. Measurements of cenizo were made on a shallow ridge range site in Jim Wells County, 15 miles north of Alice; honey mesquite measurements were made on a red sandy loam range site in Hidalgo County, 20 miles north of Edinburg; and live oak measurements were made on a sandy mound range site in Kenedy County, 15 miles south of Sarita.

¹ Mention of company name or trademark is for the readers' benefit and does not constitute endorsement of a particular product by the U.S. Dep. Agr., over others that may be commercially available.

Photographic equipment used included: (i) Hasselblad camera (80 mm lens, 5.7 × 5.7 cm format); (ii) filter packet of Hasselblad 4 × 0.2 (orange) and 3.5 × CB12-1.5 (blue filters; and (iii) Eastman Kodak Aerochrome color infrared (CIR) type-2443 film. The camera exposure used was f8 at 1/250 sec. Aerial photographs were taken between 1250 and 1530 hours under clear sunny conditions on September 23, 1976, at 3,050 m altitude above the ground. Photographs were taken about 3 months later than the field reflectance measurements because of inclement weather and cloudy conditions. Shortly after field measurements were made, inclement weather and cloudy conditions set in and postponed the aerial photography for 3 months. Due to the subtropical climate in south Texas, these woody plant species initiate annual growth in March and attain relative stable growth conditions by mid-June. Therefore, phenological changes among these species from June through September were probably minimal.

Optical count readings were made on CIR film with a Joyce, Loebel automatic recording microdensitometer using a red (Wratten 92; 0.615 to 0.700 μm) bandpass filter in the light beam. Red-filtered light is more responsive to CIR's red color tones than green- and blue-filtered light (Gausman et al. 1977). The microdensitometer output is an optical count (reciprocal of transmission) that is related to optical density (O. D.) by the relation:

$$\text{O. D.} = [(\text{optical count} - \text{base reading}) (\text{wedge factor})] + (\text{step wedge density}).$$

One scan line was run for each of three plant canopies of each species. There were 65 readings (data bits) for each scan line on the film. The area of a data bit was about 1.0 mm² and represented 14.5 m² of ground.

Results and Discussion

A knowledge of vegetation geometry is needed to understand canopy reflectance differences among plants. Overhead views of the three species showed that their leaf densities within the canopies were: live oak > cenizo > honey mesquite. Live oak had a planophile (horizontal-leaf) canopy with a regular leaf distribution with minimized gaps (Allen et al. 1975); cenizo's canopy was shaped irregularly with drooped branches and clumped leaves with a few gaps; and honey mesquite's canopy had many crooked and drooped branches with small leaflets with many gaps.

Reflectances of the three species are shown in Figure 1. Whitish cenizo plants had significantly greater ($p=0.01$) visible (0.45 to 0.70 μm) reflectance than did the greener live oak and honey mesquite plants. Near-infrared (0.75 to 1.30 μm) reflectance was significantly greater for the dense live oak canopy than for the less dense cenizo and honey mesquite canopies as vegetation density and near-infrared reflectance are positively correlated until a stable reflectance is reached (Wiegand et al. 1974). The leaves of live oak canopies had a high water content (74.4%) that caused significantly lower ($p=0.01$) 1.65- and 2.2 μm wavelength reflectances than did leaves of lower water content for cenizo (72.8%) and honey mesquite (55.7%) canopies with their lower water content. However, honey mesquite canopies had lower reflectance and lower leaf-water content than did cenizo. Apparently, undetermined soil background reflectance and plant shadow effects interacted with cenizo's and honey mesquite's vegetation reflectance (Richardson et al. 1975).

The aerial CIR film images were predicted for the three species from the reflectance data within the 0.45- to 0.90- μm waveband (Fig. 1): (i) cenizo's very high visible light reflectance gave a whitish image, (ii) honey mesquite's low visible and intermediate near-infrared reflectance gave a relatively light magenta image, and (iii) live oak's very high near-infrared light reflectance gave a darker magenta image. These results were

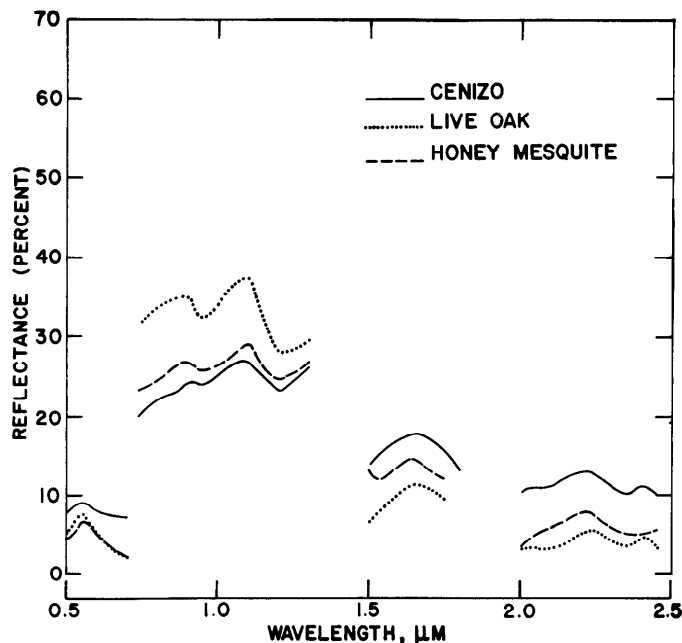


Fig. 1. Field spectroradiometric measurements over the 0.5- to 2.5- μm waveband for canopy reflectances of three important woody plant species on south Texas rangelands.

substantiated by microdensitometric measurements made with red-filtered light. Optical counts were significantly lower ($p=0.01$) for live oak (32) than for cenizo (57) and honey mesquite (74); honey mesquite's optical counts, in turn, were significantly higher than cenizo's.

In conclusion, field spectroradiometric measurements of canopy reflectances for three important south Texas plants (cenizo, honey mesquite, live oak) were used successfully to predict their CIR film images and distinguishability. The ability to remotely distinguish among these three plants should enhance future rangeland inventories in south Texas.

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