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Monitoring physical and biological properties at the Sevilleta LTER using remote sensing

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Abstract In 1997 the USDA Agriculture Research Service (ARS), Hydrology Laboratory began collecting remotely sensed ground, aircraft, and satellite data on the physical and biological states of two semiarid ecosystems (grass and shrub) typical of the Sevilleta Long-Term Ecological Research (LTER) site (New Mexico, USA). Remote sensing measurements were made at Sevilleta in May/June and September/October of 1997, 1998, and 1999. Radiance measured at ground and aircraft platforms was 12 to 40% higher for a 30 × 30 m area at the shrub site when compared with the grass site. Landscape surface temperatures that were similar in the morning were 3 to 5°C higher under the shrub when compared with the grass site by 1300 h local time. The shrub site had a lower LAI indicating less surface cover and giving a greater soil contribution to the total radiance measured. These differences could have significant effects on the energy and water balances of the Sevilleta if shrubs continue to expand at the expense of the grassland.
Key words arid land; Chihuahuan Desert; desert grassland; grass; Landsat; leaf area index; radiance; shrubs; surface temperature

INTRODUCTION

In 1997, the USDA Agriculture Research Service (ARS) Hydrology Laboratory began collecting remotely sensed data from ground, airborne, and satellite platforms at the Sevilleta Long-Term Ecological Research (LTER) site as an extension of JORNEX (Ritchie *et al.*, 1998), a companion project in the Chihuahuan Desert biome on the Jornada Experimental Range in southern New Mexico, USA (32°30′N, 106°48′W, elevation ~1300 m, 783 km^2). The Sevilleta LTER is located on the Sevilleta National Wildlife Refuge (NWR) in central New Mexico, USA (34°21′N, 106°41′W, elevation ~1600 m, 3600 km^2). The Sevilleta NWR straddles the Rio Grande River riparian corridor at the northern edge of the Chihuahuan Desert biome, the western edge of the Great Plains Shortgrass Prairie biome, and the southeastern edge of the Colorado Plateau Shrub-Steppe biome. The objectives of this study were to use remote sensing platforms (ground, aircraft, and satellite) to provide spatial and temporal data on the physical and biological states of the different biomes, to quantify plant responses to changes in components in the water and energy balance, and to evaluate techniques for scaling remote sensing data.

METHODS

Study sites typical of the grass and shrub communities of the Sevilleta were chosen for intensive study. The grass site (Great Plains Grassland Biome) was predominantly black grama (*B. eriopoda)*, blue grama (*B. gracilis*), other grasses and forbs. The shrub site (Chihuahuan Desert Biome) is thought to have been a grassland in the recent past, but now is dominated by creosote bush (*L. tridentate).* Vegetation monitoring at the Sevilleta LTER since 1988 indicates that creosote bush is slowly encroaching into the grass area. The two sites are approximately 5 km apart.

Ground and aircraft measurement campaigns at the two sites have been made in May/June and September/October of 1997, 1998, and 1999 centred on the date of an overpass of Landsat-5 or Landsat-7. Ground measurements included landscape surface temperature measured with an Everest thermal infrared radiometer (IRT), radiance of plant canopy and soil measured using an Analytical Spectral Devices (ASD) full range (0.35–2.5 μm) spectroradiometer. Leaf area index (LAI) was measured with a LICOR LAI-2000 instrument. Vegetation transects (400 m) have been routinely measured twice a year since 1988 at the two sites as part of the LTER research programme.

An ARS aircraft stationed at Weslaco, Texas was used to collect thermal (IRT), 4-band spectral radiance (Exotech), 3-band multispectral digital video, and Global Positioning System (GPS) data at 100 and 300 m above ground level along flight lines crossing the grass and shrub sites. An aircraft under contract to NASA and DOE flew the same flight lines in June and September 1997 with the Thermal Infrared Multispectral Scanner (TIMS) and a 12-channel Daedelus multispectral scanner (TMS-Thematic Mapper Simulator). Flights of the MASTER (MODIS/ASTER Airborne Simulator) instrument were made in September 1998, June 1999 and September 1999. More details on methods and instrumentation are discussed in Ritchie *et al.* (1998).

RESULTS

Spatially averaged LAI was lower at the shrub site than at the grass site (Table 1) reflecting differences in plant canopy cover at the sites. The LAI is an average of measurements at the same location made at 5 m intervals along a 400 m transect at the grass site and at 5 m intervals for a 30 × 30 m grid at the shrub site. The shrub site has individual creosote bushes, some ground cover, and bare soil between bushes while the grass site had a more uniform cover over the area. Differences between years reflect differences in patterns of precipitation between 1997 and 1998 with 1998 being wetter than 1997.

Radiance data measured at 1 m above the landscape surface with the ASD Full Range Spectroradiometer and averaged for 49 measurements made at 5 m intervals on a 30 × 30m grid showed total radiance (0.35–2.5 μm) to be 12 to 40% higher at the

Table 1 Leaf-area index (LAI) measured with a LICOR LAI-2000. Measurements were made at 5 m intervals on a 30 × 30m grid (shrub site) and 400 m transect (grass site).

Site	June 1997	October 1997	May 1998	September 1998
Grass	0.82	0.97	0.96	1.52
Shrub	0.52	0.74	0.30	0.80

shrub site than the grass site (Fig. 1). Differences between year, season, and vegetation were found with the shrub site always having higher radiance values. Radiance measured from the aircraft at 100 and 300 m above ground level, with an Exotech 4-band radiometer with filters for the first 4-bands of the Landsat TM, showed greater variability and higher radiance at the shrub site than at the grass site. The higher variability over the shrub site would be due to the patchy nature of the shrubs. The higher radiance measurements both from the ground and aircraft were probably due to the lower surface cover at the shrub site giving a higher soil contribution to the total radiance measured. Data from the digital video, TMS, and MASTERS instruments also measured higher radiance over the shrub site when compared to the grass site.

Landscape surface temperatures measured from aircraft and on the ground with IRTs were 3–5°C higher at the shrub site than grass site on clear days at 1300 h local time following the radiance patterns. TIMS measured temperatures were also 2–4°C higher at the shrub site.

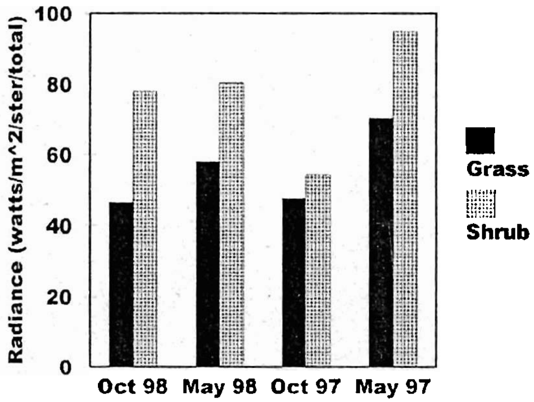

Fig. 1 Total radiance based on the average radiance from 49 measurements made at 5 m intervals on a 30 × 30 m grid at the grass and shrub sites.

CONCLUSIONS

A unique remote sensing dataset to measure change in semiarid grasslands and shrublands is being collected at the Sevilleta LTER. Radiance measured at ground and aircraft platforms was 12 to 40% higher for a 30 × 30 m area at the shrub site than at the grass site. Landscape surface temperatures were 3 to 5°C higher temperatures for a 30 × 30 m area at the shrub site than the grass site by 1300 h local time. These differences in surface radiance and temperature between the shrub and grass sites could have significant effects on the energy and water balances of the Sevilleta LTER if shrubs continue to expand at the expense of the grassland.

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