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**MEASURING DRY PLANT RESIDUES IN GRASSLANDS:
A CASE STUDY USING AVIRIS**

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INTRODUCTION

Grasslands, savannah, and hardwood rangelands are critical ecosystems and sensitive to disturbance. Approximately 20% of the Earth's surface are grasslands and represent 3 million ha. in California alone. Developing a methodology for estimating disturbance and the effects of cumulative impacts on grasslands and rangelands is needed to effectively monitor these ecosystems. Estimating the dry biomass residue remaining on rangelands at the end of the growing season provides a basis for evaluating the effectiveness of land management practices. The residual biomass is indicative of the grazing pressure and provides a measure of the system capacity for nutrient cycling since it represents the maximum organic matter available for decomposition, and finally, provides a measure of the erosion potential for the ecosystem.

Remote sensing presents a possible method for measuring dry residue. However, current satellites have had limited application due to the coarse spatial scales (relative to the patch dynamics) and insensitivity of the spectral coverage to resolve dry plant material. Several hypotheses for measuring the biochemical constituents of dry plant material, particularly cellulose and lignin, using high spectral resolution sensors have been proposed. We have investigated the use of AVIRIS to measure dry plant residues over an oak savannah on the eastern slopes of the Coast Range in central California and have asked what spatial and spectral resolutions are needed to quantitatively measure dry plant biomass in this ecosystem.

MEASUREMENTS

The study site is located west of Winters, CA (38°30'N lat, 122°00'W long.) near Lake Berryessa on 260ha. private land that is part of an undeveloped block that includes the University of California Stebbins Preserve and the Quail Ridge Nature Conservancy. Although historically grazed, these lands are currently managed to promote native perennial grasslands. Other private lands within the scene are currently grazed. The study area was stratified by aspect (principally NE and SE facing slopes), soil type (three soil units identified on 1:24,000 maps), and position (lower, mid, and upper elevation) on the hillside and 45 sites were chosen for sampling. Aboveground biomass (fresh and dry weights) on 3m x 3m plots were harvested in spring (at peak growth) and in late summer, 1991. Spring biomass ranged between 27 and

7757 g. on the plots, late summer residue from 13 to 2457 g.. Spring biomass was a poor predictor of late summer residue ($r^2=0.12$). Locations of plots were recorded using a Trimble Navigation Pathfinder Basic and Pathfinder Professional base station. Nominal slope and aspect were recorded with field measurements, correlated with a DEM created by scanning contours, then used to correct the data. Mean (n=20) field spectra (450-850nm) of about 1.5 m resolution were obtained adjacent to each plot using an Analytical Spectral Devices Perspec II in fall of 1991. Additional spectra of soils, dry plant litter, and green foliage were measured to obtain library endmember spectra. In addition, soil (n= 20) and litter (n=8) samples were analyzed in the lab (400-2500nm) using a Perkin-Elmer Model 330 spectrophotometer with 1nm wavelength resolution.

Two nonradiometrically and nongeometrically corrected AVIRIS scenes of the area were acquired on August 20, 1992 (910820, run 5 scenes 1,2) with a nominal pixel resolution of 20m. The fourth (D) spectrometer was not functioning at the time of acquisition. Images were nominally radiometrically calibrated using Modtran and spectral mixture analysis. Additional AVIRIS images were available from 23 March 1990, 31 July 1990 and used for comparisons. For all AVIRIS scenes, coincident high spatial resolution CIR photos using the RC-10 camera were obtained. Additionally, low altitude aerial CIR photography was obtained at 3665m elevation from NASA C-130 aircraft with a Zeiss camera concurrent with a NS001 (TMS) on 31 May 1991. All aerial photographs were digitized using the Eikonix model EC 78-99 scanner creating a 4096 x 4096 RGB image.

COMPARISONS

AVIRIS images were analyzed using GenIsis and IDIMS software for pixel extractions and exploratory comparisons. Spectral mixture analysis software was provided by J. Adams and M. Smith of the University of Washington.

Spatial patterns

Field plots were identified in the low altitude scanned photos and corresponding AVIRIS pixels were selected for analysis by manual interpretation without resampling. Numerous distinct ground targets made it possible to visually locate points without coregistration. The analysis was repeated after registering the AVIRIS image to a map base, integrating the GPS coordinates, and then examining the effects of resampling. This low altitude scanned photo was later degraded to 10 and 20 m pixels to permit comparisons between spatial resolutions of the other sensors. Scanned CIR photos at 10m resolution closely approximated the NS001 band 4 and at 20 m resolution a synthetic AVIRIS NIR band. The topographically determined major features related to larger scale patterns are maintained throughout the spatial degradation from 1 to 20m although the fine-scale variance related to tree shape and bare patches was lost.

In late summer, annual grasslands in the area are completely dormant and NDVI values are low and indistinguishable from patches of bare soil. Albedo variation was due principally to topography. Irradiance was adjusted for local slope and aspect using a cosine correction and regressed against biomass during late summer.

Spectral patterns

AVIRIS spectral signatures from each of the sample sites were analyzed using GenIsis software. Similarity indexes were generated from these signatures and the spectral homogeneity of the study area was mapped and compared to field measures.

Several SWIR wavelengths have been shown in previous studies to be useful for identifying cellulose. We have begun to investigate the use of wavebands in the third (C) spectrometer as predictors of dry plant biomass through regressions against field measurements. These results will be contrasted with those derived from mixture modeling. We have used spectral mixture analysis to identify the dominant scene components as an alternative method for identifying and quantifying dry plant material in the AVIRIS images. We examined the AVIRIS images under two mixture models; a three member model of soil, green vegetation and shade and examined high residuals at wavelengths indicating presence of dry plant material (e.g., lignin and cellulose features) and a four endmember mixture model that included dry vegetation. Preliminary analysis indicates that we are able to derive a better relationship using spectral mixture analysis although many uncertainties remain. We contrast the results of this study with those of Jasper Ridge, CA presented by Roberts et al., Gamon et al. and Ustin et al., in this workshop, to evaluate the consistency of green and dry biomass predictions using images acquired in different seasons over savannah landscapes composed of similar ecosystems.