USING AVIRIS IMAGES TO MEASURE TEMPORAL TRENDS IN ABUNDANCE OF PHOTOSYNTHETIC AND NONPHOTOSYNTHETIC CANOPY COMPONENTS

SUSAN L. USTIN, DEPARTMENT OF LAND, AIR, AND WATER RESOURCES,
UNIVERSITY OF CALIFORNIA, DAVIS, CALIFORNIA 95616

MILTON O. SMITH, DAR ROBERTS, DEPARTMENT OF GEOLOGICAL SCIENCES, UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON 98519

JOHN A. GAMON, DEPARTMENT OF BIOLOGY,
CALIFORNIA STATE UNIVERSITY, LOS ANGELES, CALIFORNIA 90032
AND
CHRISTOPHER B. FIELD, DEPARTMENT OF PLANT BIOLOGY,
CARNEGIE INSTITUTION OF WASHINGTON, STANFORD, CALIFORNIA 94035

INTRODUCTION

The Jasper Ridge Biological Preserve, Stanford, California is a good example of hardwood rangeland ecosystems in California. Structurally, it is composed of a mosaic of serpentine grasslands, oak savannah, coastal chaparral, and mixed evergreen woodland, representing a broad cross-section of physiognomic classes. The Mediterranean climate produces an extended seasonal drought lasting throughout most of the growing season and has significant impact on the expression of divergent phenological patterns related to contrasting ecological strategies of these taxa. The region is well understood biologically due to the rich history of ecological research at the site. Thus, community characteristics, physiological characteristics, phenology, and temporal dynamics are reasonably well understood for many of the dominant species. Because of its proximity to NASA Ames Research Center, it has been subject to a large number of aircraft data acquisitions over many years. A more complete examination of this database would provide an opportunity to test current remote sensing hypotheses for measurement and detection of ecological attributes, particularly those involving canopy chemistry and physiology. Better definition of ecological rules might permit development of remotely sensed surrogate variables for biological properties that cannot be directly measured or measured with sufficient accuracy.

RESEARCH

An AVIRIS image of Jasper Ridge was acquired May 15, 1991 (910515B, run 10, segment 2) under clear sky conditions. Linear and non-linear spectral mixture analysis was performed and four spectral endmembers were identified. These endmembers corresponded with those reported for Jasper Ridge in 1989 and 1990 and included a green photosynthetic canopy component, a non-photosynthetic canopy component, greenstone soil, and shade. This cross-calibration among multidate AVIRIS scenes implies that analyses can be examined for temporal trends (changes in endmember proportions and residuals) using a consistent reference base. In 1991, plant characteristics and surface reflectance measurements were made at 20m intersections over a 6 ha. permanently staked grid referenced to known coordinates. Additional points were located using Trimble Navigation Pathfinder Basic and Professional GPS. We examined spatial patterns for the photosynthetic and nonphotosynthetic canopy fractions in the grasslands in relation to field data and from aerial photography and their temporal trends.

RESULTS

Our field studies show that when a high fraction of the canopy is nonphotosynthetic, NDVI from field data underestimates the abundance of the photosynthetic fraction. Interactions among the photosynthetic and nonphotosynthetic vegetation fractions , subpixel shade, and residuals, derived in mixture analysis provide a basis for further evaluation. Foliar chlorophyll and nitrogen concentrations in the grasslands varied within limited ranges and were proportional to the foliar biomass per unit surface area (Gamon et al., this proceeding). Preliminary results indicate that the abundance of the photosynthetic endmember fraction in the grasslands approximates spatial abundance patterns in the green foliar biomass (and other correlated measures, gLAI, chlorophyll, and nitrogen). This relationship results because the enzyme for carbon fixation, RUBP carboxylase, is the largest foliar pool of soluble nitrogen. The summation of photosynthetic and nonphotosynthetic fractions provides a basis for estimating total canopy biomass, which for grasslands represents a measure of the net primary productivity, and over time, the magnitude of change in carbon storage. The ratio of photosynthetic fraction : total canopy fraction provides a basis to measure canopy N:C ratios.

We examined the patterns of endmember abundances and residuals for temporal trends related to site conditions (Fig. 1). One example of the temporal and spatial patterns we observed is shown for the three endmember models for July and October 1989. This figure shows endmember abundances from 10 sites including grasslands, chaparral, oaks, forest and a golf course. During this period photosynthetic endmember abundances did not indicate appreciable changes except in the evergreen oak and forested areas (sites 7,8) where photosynthetic fraction decreased. Grasslands and chaparral had lowest photosynthetic fractions, forest and the golf course had the highest. These results demonstrate that for a given region, the same endmembers can model images from different seasons and produce consistent fractional conditions that follow expected ecological trends. We believe that this approach has promise for providing an internally consistent basis for interpreting environmental gradients and temporal changes.

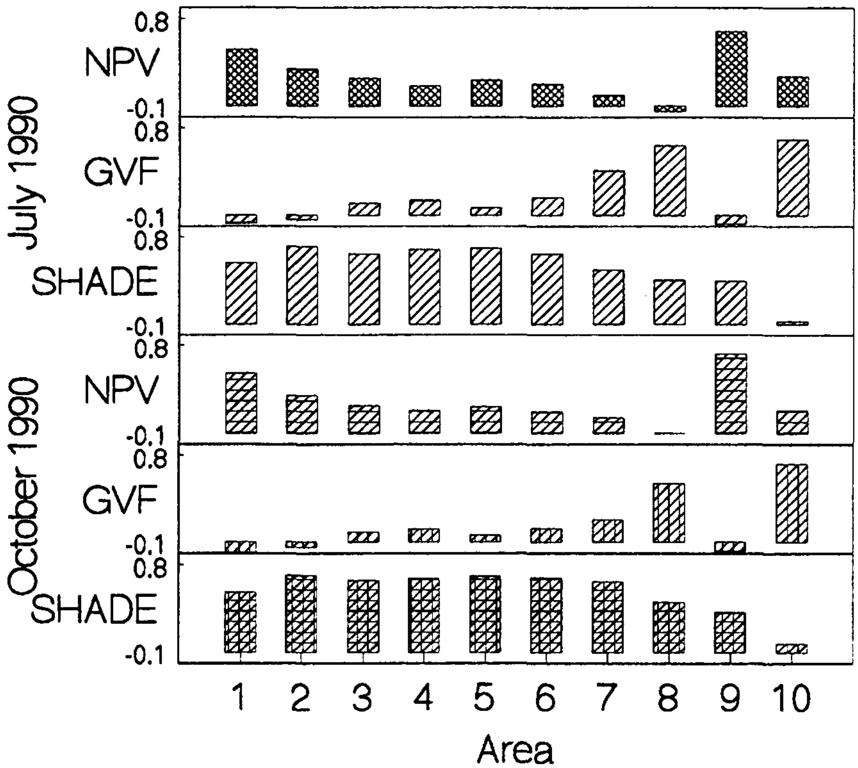

Figure 1. Endmember abundances for two AVIRIS images of Jasper Ridge, California. The endmembers are labeled npv (non-photosynthetic vegetation), GVF (green vegetation fraction), and shade. The 10 sites correspond to 1) non-serpentine grassland, 2) serpentine grassland, 3) serpentine chaparral, 4) non-serpentine chaparral, 5) non-serpentine chaparral of lowest cover, 6) blue oak, 7) evergreen oak, 8) forest wetland, 9) Webb Ranch grassland, and 10) golf course. The endmembers from the two different times indicate similar endmember fractions. The greatest changes are in the evergreen oak and the forest wetland.