A GROUND TRUTHING METHOD FOR AVIRIS OVERFLIGHTS USING CANOPY ABSORPTION SPECTRA

John A. Gamon[1], Lydia Serrano[1], Dar A. Roberts[2], and Susan L. Ustin[3]

[1]Department of Biology & Microbiology
California State University, Los Angeles
5151 State University Drive
Los Angeles, CA 90032

[2]Department of Geography
University of California
Santa Barbara, CA 93106

[3]Department of Land, Air and Water Resources
University of California
Davis, CA 95616

1. INTRODUCTION

Remote sensing for ecological field studies requires ground truthing for accurate interpretation of remote imagery. However, traditional vegetation sampling methods are time consuming and hard to relate to the scale of an AVIRIS scene. The large errors associated with manual field sampling, the contrasting formats of remote and ground data, and problems with coregistration of field sites with AVIRIS pixels can lead to difficulties in interpreting AVIRIS data. As part of a larger study of fire risk in the Santa Monica Mountains of southern California (see Roberts et al. and Ustin et al., this volume), we explored ground-based optical method of sampling vegetation using spectrometers mounted both above and below vegetation canopies. The goal was to use optical methods to provide a rapid, consistent, and objective means of "ground truthing" that could be related both to AVIRIS imagery and to conventional ground sampling (e.g., plot harvests and pigment assays).

2. METHODS

Ground measurements were conducted at several sites in the Santa Monica Mountains of southern California in June and October, 1995 (coincident with AVIRIS overflights of this region). Vegetation was characteristic of either chaparral or coastal sage scrub (Munz and Keck, 1959), representing various stages of post-fire succession. The June sampling occurred at the end of a season of particularly heavy rain (an "el Niño" year), and the October sampling occurred at the end of a summer dry period characteristic of this region's Mediterranean climate. At each site, above and below-canopy measurements were made with a narrow-band spectrometer (model SE590, Spectron Engineering, Denver CO, USA) outfitted with hemispherical, cosine corrected fore-optics. In some cases (e.g., during below-canopy measurements), a fiber-optic extension was used between the spectrometer and the cosine head to minimize contamination by radiation scattered by the user's clothing or body. In tall canopies, above-canopy measurements were made using either a tall tripod or a bucket truck. Canopy absorption was calculated several ways, and expressed here as "spectral absorbance," estimated as follows:

$$\text{absorbance} = \log (I_o/I) \qquad (1)$$

where I_o is the above-canopy spectral irradiance, and I is the below-canopy spectral irradiance.

3. RESULTS

Canopy absorbance spectra showed striking differences between sites and dates. For example, large differences were noted between stands of different species composition and time since last fire (Figure 1). In this between-site comparison, absorbance, particularly visible absorbance (400-700 nm) was much greater in the taller and older stands that had greater biomass.

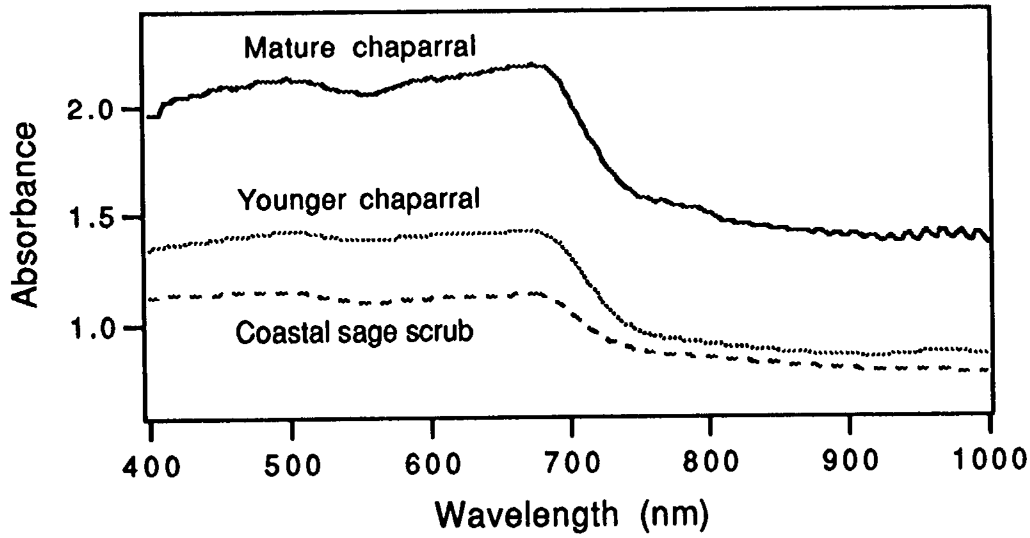

Figure 1. Canopy absorbance spectra measured in June, 1995, for three sites composed of mature chaparral (tall vegetation, at least 50 years since fire), younger chaparral (medium stature, burned 17 years ago) and coastal sage scrub (short stature, burned 17 years ago).

There were also striking seasonal differences in absorbance spectra, both for coastal sage scrub (which included both evergreen and partially drought-deciduous, perennial species) and for mature chaparral (composed primarily of "evergreen" species) (Figure 2). The seasonal decline in absorption in the blue and red spectral regions in both vegetation types is consistent with a loss of chlorophyll pigments associated with the progression of the summer drought. The decline in absorbance in the near-infrared region (e.g., above 700 nm in the mature chaparral spectra) is consistent with either seasonal foliage loss or leaf reorientation. This particular stand was largely composed of *Ceanothus* sp., a common chaparral genus known to adopt a more vertical leaf orientation with the onset of summer drought (Comstock and Mahall 1985).

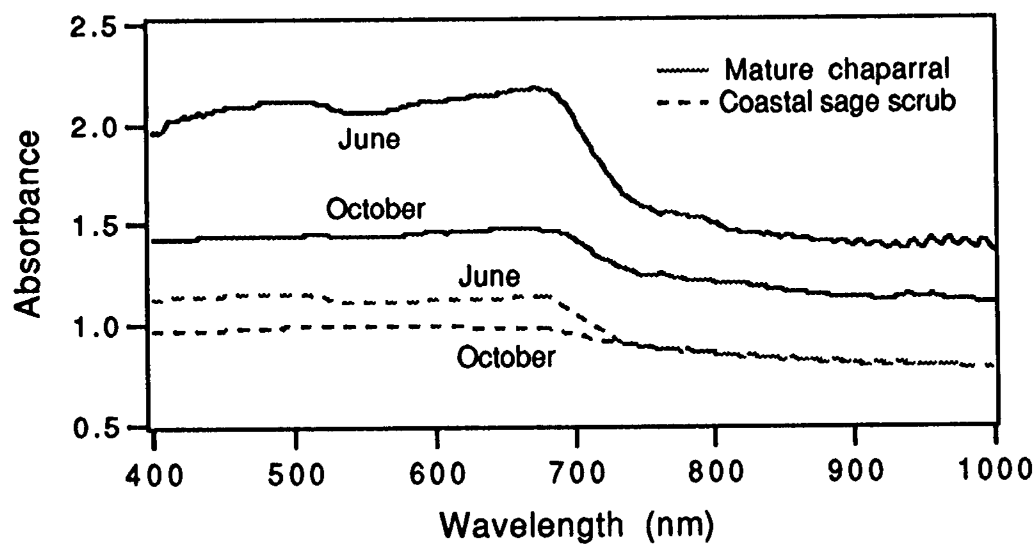

Figure 2. Seasonal change in canopy absorbance spectra for two vegetation types (mature chaparral and coastal sage scrub). The loss of blue and red absorption features between June and October suggests a loss of chlorophyll pigments in these canopies. The large decline in canopy absorbance in the mature chaparral (composed largely of *Ceanothus* sp.) can partly be explained by seasonal leaf reorientation in this evergreen canopy.

4. DISCUSSION

Patterns in whole canopy absorption spectra clearly varied with changes in stand structure and composition associated with different vegetation types, seasonal state, and stand age. Because these factors reflect fire history and are often good correlates with fire hazard, canopy absorption spectra may be useful in assessing fire risk in the Mediterranean climate vegetation characteristic of the Santa Monica Mountains.

In a medium that obeys Beer's law, and at low (≤ 1) absorbance values, absorbance is directly related to the concentration of absorbing compounds (Hipkins and Baker, 1986). Clearly both conditions were violated in this case. However, the clearly discernible patterns in these canopy absorbance spectra suggest that spectral absorbance (or some similar expression of radiation absorption) might provide a useful measure of canopy structure, and function. Furthermore, because radiation absorption influences both canopy energy balance and photosynthetic fluxes, measurements of canopy spectral absorption might provide a more direct way to link remotely sensed spectra to stand-level processes than is possible with traditional field methods (e.g., plot harvests). Unlike destructive field sampling, this optical method is non-destructive and relatively rapid. If spectra obtained with this optical sampling technique can be reliably linked to features present in AVIRIS spectra, then this method might be a useful ground-truthing tool for AVIRIS overflights. Further goals are to relate these spectra to canopy pigment content, harvest data, and AVIRIS imagery as it becomes available.

5. ACKNOWLEDGEMENTS

Project equipment was funded by grants from NASA and NSF, and student assistance supported by a grant from the US EPA. Thanks to several Cal State LA Students, including Vache Marcarian, John Scott Surfus, and Kokeb Tefera, for their enthusiastic technical support.

6. REFERENCES

Comstock J.P. and B.E. Mahall (1985) Drought and changes in leaf orientation for two California chaparral shrubs: *Ceanothus megacarpus* and *Ceanothus crassifolius*. *Oecologia* (Berlin) vol. 65, pp. 531-535.

Hipkins M.F. and N.R. Baker (1986) *Photosynthesis Energy Transduction: A Practical Approach.* IRL Press Limited, Oxford, pp. 58-59.

Munz, P.A.and D.D. Keck (1959) *A California Flora.* University of California Press, Berkeley, CA, pp. 11-18.