Mapping the Spectral Variability in Photosynthetic and Non-photosynthetic Vegetation, Soils and Shade using AVIRIS

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The primary objective of this research was to map as many spectrally distinct types of green vegetation (GV), non-photosynthetic vegetation (NPV), shade and soil (endmembers) in an AVIRIS scene as is warranted by the spectral variability of the data. Once determined, a secondary objective was to interpret these endmembers and their abundances spatially and spectrally in an ecological context.

Primarily, imaging spectrometer data has been viewed as a means for making direct measurements of canopy chemistry, such as protein, lignin and nitrogen (e.g. Wessman et al., 1988). The data also have potential for direct measurements of vegetation liquid water thickness and atmospheric water vapor (Gao and Goetz, 1990; Green et al. 1991).These approaches focus on the presence of subtle absorption features, some of which, in the context of a spectral mixture and canopy complexity, may not be readily detectable in imaging spectrometry data. Furthermore, they neglect much of the information inherent in spectral continua (Gillespie et al., 1990).

In previous papers (Roberts et al. (1990, 1991, 1992)), it was found that most (over 97%) of the spectral variability in an AVIRIS scene collected over Jasper Ridge could be described by 3 or 4 endmembers, GV, soil and shade (with a 4th endmember consisting of NPV). In a three-endmember model, NPV was distinguished from soil based on wavelength-specific residuals attributed to lignin and cellulose. Different types of GV were distinguished on the bases of different degrees of non-linearity, changes in the spectral quality of shade (canopy shade) and changes in the GV fraction when the analysis was applied separately to visible, near-infrared and short-wave-infrared subsets of the total spectrum.

In this paper we report upon a new approach to the problem of interpreting imaging spectrometry data. This is accomplished by extending the spectral mixture concept to allow the endmembers, as well as their abundances, to vary on a pixel-to-pixel basis. This approach has the potential of providing a large suite of ecologically significant variables, including reflectance spectra of multiple types of vegetation (GV and NPV), soil and shade (canopy and photometric) and maps showing the spatial distribution of each endmember type as well as the endmember abundances. It has further advantages over the approach of applying a single suite of endmembers to an entire image in that it provides a greater number of endmembers and optimizes endmember detectability (Sabol et al., 1991,1992).

The new approach was tested on two AVIRIS scenes collected in the vicinity of the Jasper Ridge Biological Preserve on July 27, 1990 and October 3, 1990. The results for the October scene are presented in this paper. A comparison between the July and October data is presented in a companion paper (see Sabol et al., this issue). The AVIRIS data were calibrated to reflectance using an empirical line calibration and three non-photosynthetic targets to avoid non-linear effects (Roberts et al., 1991). Sets of two and three image endmembers were selected automatically from the scene. Based on two criteria, a RMS threshold of 8 DN and required endmember fractions between 0 and 1, over 92% of the scene was modeled by 12 endmember pairs. The endmember pairs consisted primarily of mixtures of shade and either GV or NPV. The total number of endmember pairs included several shades, GVs, NPVs and soils. Representative GV and NPV spectra are shown in Figures 1A and 1B. The three endmember case provided little additional information above the two endmember case. For most pixels two endmembers were adequate. This result is not surprising considering the analysis was restricted to image endmembers, which themselves can be complex mixtures. The next step is to interpret these image-endmembers in terms of laboratory reference endmembers (see Gillispie et al., 1990 for a description of this procedure).

Spatially, the endmember pairs corresponded to the dominant cover types in the region. As an example, the most abundant pair, which was categorized as a shade-GV mixture, corresponded to Forested Wetland, Evergreen Broadleaf Forest, Conifer Forests and water. In this instance water was a spectral analog of photometric shade. The second most abundant pair, which was categorized as a shade-NPV/GV mixture, corresponded to chaparral and forested/urban areas. In this case the NPV/GV image endmember is most likely a mixture of several photosynthetic and non-photosynthetic materials.

Conclusions

A new spectral mixture approach, in which the endmembers vary from pixel to pixel across an AVIRIS image was tested using data collected over the Jasper Ridge Biological Preserve on October 3, 1990. A preliminary analysis of the image endmembers determined that most of the scene could be described as mixtures of two endmembers, primarily shade and either GV or NPV.The endmember pairs were spatially coherent, varying broadly with community types. Near-term objectives include extending the analysis to reference endmembers and new criteria for selecting endmembers, including the use of wavelength specific-residuals in addition to an RMS error.

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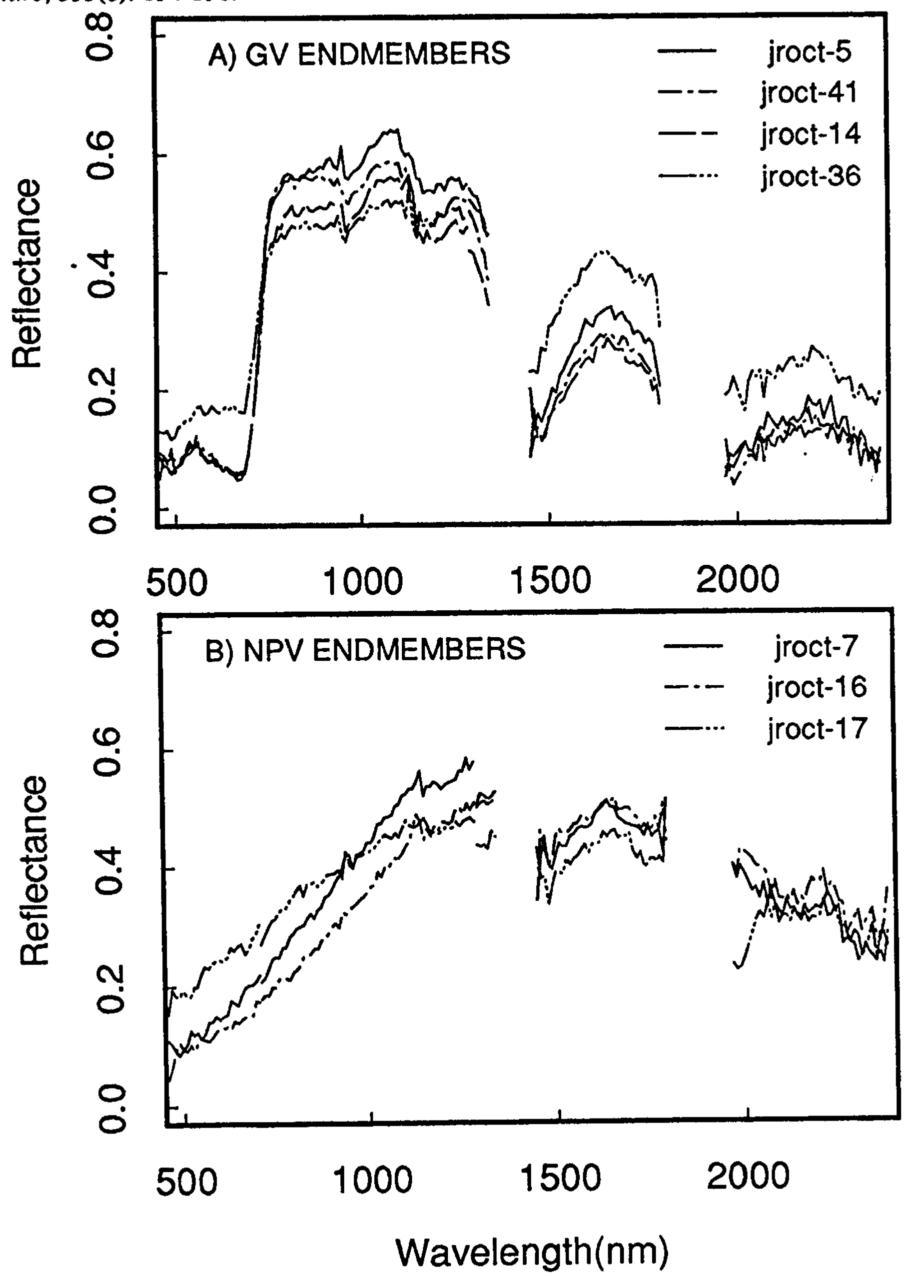

Figure 1 A) Representative GV endmembers automatically selected from the AVIRIS data as part of an endmember pair. B) NPV endmembers selected from the image.