Ecological Applications of Imaging Spectrometry: Examples from Fire danger, Plant Functional Types and Disturbance

Roberts, D.A.[*,1], Asner, G.P.[2], Dennison, P.E.[3], Halligan, K.E.[1], and Ustin, S.L.[4]
[1] Department of Geography, University of California, Santa Barbara, California 93106, 805-893-2276, dar@geog.ucsb.edu
2 Department of Global Ecology, Carnegie Institution, Stanford, California 94305
[3]Department of Geography, University of Utah, Salt Lake City, Utah, 84112
4 Department of Land, Air and Water Resources, University of California, Davis, California, 95616
[*] Corresponding author

Imaging spectrometry has considerable potential for improving our ability to identify plant functional types (PFTs), quantify plant biophysical properties and monitor vegetation changes in response to disturbance. Susceptibility to disturbance and response following disturbance are highly dependent upon PFT and associated biophysical properties. We address disturbance in the form of wild fire and invasive species. Fire danger represents one example, in which certain PFTs are adapted to fire and may even promote fire, such as schlerophyllous vegetation in California shrublands. In these communities, fire adaptations include highly flammable chemicals in foliage, flammable barks and fire cued regrowth, either from fire resistant burls or seeds that require high temperatures or smoke to germinate. Extreme fire events occur when low moisture in foliage and a build up of non-leaf materials combine with low relative humidities, high temperatures and high winds to promote rapidly moving, high temperature fires. Post-fire recovery is also dependent upon PFT, in which facultative seeders such as chamise are favored over obligate seeders, such as big pod Ceanothus when fire frequencies are high. Another example is provided by the Hawaiian islands, in which major vegetation changes are occurring in response to invasive plant species that promote fire and thus increase the frequency and severity of these disturbance events, ultimately leading to a loss of native, non-fire resistant forests.

In this talk, we present examples from imaging spectrometry that focus on the theme of PFTs and disturbance with an emphasis on fire and invasive species as disturbance mechanisms. In our first example, we draw upon extensive research using the Airborne Visible Infrared Imaging Spectrometer (AVIRIS) to map several fire adapted shrub types in Southern California. We expand the analysis to include estimates of live fuel moisture and fuel condition, two canopy properties that vary seasonally and are used to quantify fire danger. To map PFTs and estimate fractional we use an approach called Multiple Endmember Spectral Mixture Analysis (MESMA), in which the number and type of endmembers are allowed to vary on a per pixel basis. Map accuracy is assessed using field polygons mapped in the field.

A second example is provided by research in the Hawaiian islands, in which radiative transfer models are used to estimate pigment, nitrogen and water for native and introduced PFTs from high resolution AVIRIS data acquired over several islands. Hawaiian research is extended to include analysis of grass cover, fuel moisture content and fractional cover as indicators of fire danger in Hawaiian woodlands and the detection of understory invasives in Hawaiian forests using canopy water metrics. As a final example, AVIRIS is used to map invasive species in coastal central California. In this example a maximum likelihood classifier is applied to Minimum Noise Fraction (MNF) bands from AVIRIS to map two important invasive species at Vandenberg Airforce Base, ice plant and jubata grass.

As we progress through the 21st century, we are increasingly faced with the need to map, monitor and quantify changes in our physical environment. Imaging spectrometry, through its ability to discriminate PFTs and improved abilities to quantify vegetation biophysical properties, represents an increasingly important tool for environmental monitoring.