Post-fire characterization of the land surface and vegetation using imaging spectroscopy data for Cerro Grande NM and Left Hand Creek WY

Raymond Kokaly, Barnaby Rockwell, Laurie Morath, Ralph Root, Susan Goodman

Introduction

Historically, fire has been among the dominant disturbances in the rocky mountain region of the U.S. Recent occurrences of large wildfires, necessitate that resource managers acquire post-fire information on the state of the land surface to plan erosion mitigation strategies and to guide re-vegetation efforts. This paper reports on the analysis of spectroscopic remote sensing data collected following wildland fire.

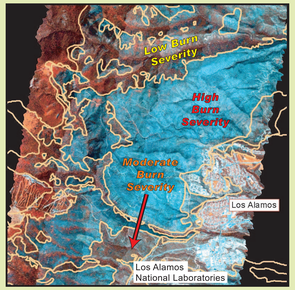
Two areas are being studied:

1) the May 2000 Cerro Grande fire in Los Alamos NM
2) the Left Hand Creek BLM area in Central Wyoming, which has been subject to wildland fires in 2000 and 2001.

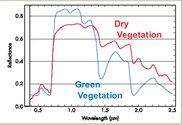
Cerro Grande Fire, Los Alamos NM

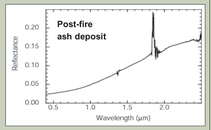
The Cerro Grande fire burned over 42,000 acres, from May to June 2000, destroying homes in Los Alamos NM. The fire was initiated as a prescribed fire in nearby Bandelier National Park. As part of a multi-disciplinary effort funded by the U.S. Geological Survey's Venture Capital Fund, we are using Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data to characterize the landscape following the fire.

High spatial resolution (~3.5 meter pixel size) AVIRIS data were collected in September 2000. After converting the data from radiance to reflectance, we used the USGS Tetracorder processing system (Clark et al., 2002) to create maps of materials on the land surface including, ash deposits, minerals in exposed soils and rocks, green vegetation, and dry vegetation.



Color-infrared composite derived from three of the 224 channels of the AVIRIS imaging spectrometer AVIRIS data were collected on September 3-5, 2000, in 20 lines over the Cerro Grande fire, Bandelier National Park, Los Alamos National Laboratories and the town of Los Alamos. Shown here is a subset of the data covering the high burn severity area of the Cerro Grande fire, west of Los Alamos NM. The polygons overlaying the image are burn severity classes developed by the US Forest Service Burned Area Emergency Rehabilitation (BAER) team.



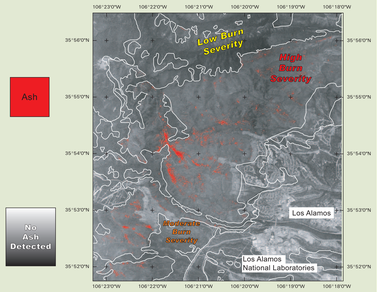


Materials have characteristic spectral reflectance curves that arise from their chemical makeup (see the examples above). The spectral features in each pixel of remotely-sensed imaging spectrometer data can be compared to laboratory and field measurements of known materials to generate maps of where these materials are distributed in the images.

Results: Post-Fire Characterization at Cerro Grande NM

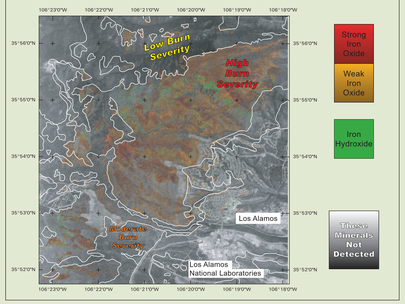
Residual Deposits of Ash

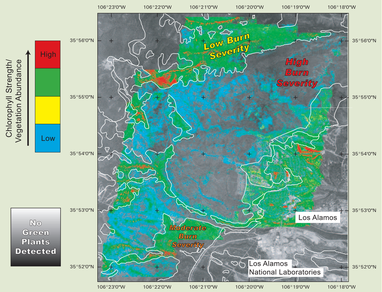
Residual deposits of ash were detected primarily in the high burn severity areas of the Cerro Grande fire. The detection of ash deposits on the surface implies that erosional forces have not removed material and that vegetation has not regrown. The continued presence of ash deposits were confirmed by field survey in August 002.



Minerals in Exposed Soils/Rocks

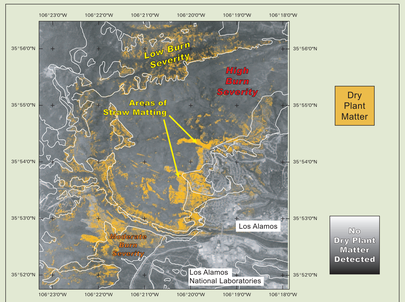
Iron-bearing minerals were detected in areas of exposed soil/rock (see image below). These minerals were found to be distributed mainly in the high burn severity areas. Variations in iron composition may be related to changes caused by the heat of the fire. Other minerals, such as kaolinite and montmorillonite clays, and carbonates, were detected in very distinct patterns within the high burn severity areas, but are not pictured here.





Differences in the strength of the chlorophyll absorption by green plants were detected between burn severity categories. These differences relate to variations in the amount of vegetation present, with more vegetation in the moderate and low burn severity areas. In the high burn severity areas, vegetation cover is low or in many areas not present (indicated by the gray scale pixels).

Vegetation Cover - Green Plants



The spectral signature of dry vegetation was detected in defined patterns within the high burn severity areas. Such occurrences were found to be straw matting distributed on the surface to mitigate erosion. Dry vegetation was also detected in areas of low and moderate burn severity, identifying dry, brown needles on conifers that were killed by the heat of the fire, but not consumed by the flames.

Vegetation Cover - Dry Plant Matter

Contacts

Raymond F. Kokaly
Denver Spectroscopy Lab - GD
U.S. Geological Survey
MS 973, Box 25046
Denver Federal Center
Denver, CO 80225
raymond@usgs.gov

Barnaby Rockwell
Denver Spectroscopy Lab - GD
U.S. Geological Survey
MS 973, Box 25046
Denver Federal Center
Denver, CO 80225
barnaby@usgs.gov

Laurie Morath
Denver Spectroscopy Lab - GD
U.S. Geological Survey
MS 973, Box 25046
Denver Federal Center
Denver, CO 80225
lmorath@usgs.gov

Ralph R. Root
Rocky Mtn Mapping Ctr- NMD
U.S. Geological Survey
MS 516, Box 25046
Denver Federal Center
Denver, CO 80225
ralph_root@usgs.gov

Susan Goodman
National Science and Technology Center
Bureau of Land Management
Box 25047
Denver Federal Center
Denver, CO 80225
susan_goodman@blm.gov

Fire on the range: Left Hand Creek WY

This research, funded by the Joint Fire Science Program, seeks to assess the impact of wildland and prescribed fire on a sagebrush dominated ecosystem. The study area is Left Hand Creek, part of a Bureau of Land Management (BLM) unit in central WY, near the town of Thermopolis.

Hymap imaging spectrometer data over the site were collected on July 2, 2002. Field measurements of vegetation reflectance and surveys of plant species composition were made for 33 sites with different fire histories. Vegetation cover and species composition were documented in order to assess the effect of fire on vegetation regeneration in this sagebrush ecosystem. These assessments will be extended to a regional level using the Hymap data.

Left Hand Creek, Wyoming, is covered by a mosaic of sagebrush, grasslands, and conifer forests that have been subject to prescribed and wildland fires. As a result of fire, sagebrush cover has been reduced (see above photo). Imaging spectroscopy data (see below image) from the Hymap sensor is being analyzed to characterize the density of sagebrush in relation to fire

Making field reflectance measurements of burned and unburned areas at Left Hand Creek, WY.

Conclusions

Following wildland fire, imaging spectroscopy can be used to:

- map residual deposits of ash
- detect and characterize the mineral content of exposed soil/bedrock surfaces
- detect unburned, live green vegetation
- measure the intensity of vegetation regrowth
- identify conifers that were killed but not consumed by the fire
- delineate areas where erosion treatment remains in place

Within each burn severity category, variations in cover by ash deposits, exposed soil/rock, and vegetation cover can be characterized.

Future Directions

For the Cerro Grande fire, additional work remains to link the vegetation and soil properties, detected by imaging spectroscopy, to erosion potential and vegetation regeneration using field measurements made by collaborators.

For the study of Left Hand Creek, after converting the Hymap data to reflectance, field measurements will be compared to the remote sensing data for areas of varying sagebrush density.

Ongoing efforts in both study areas include the development of predictive models of landscape response to wildland and prescribed fires.

References

Clark, R. N., Swayze, G. A., Livo, K. E., Kokaly, R. F., Sutley, S. J., Dalton, J. B., McDougal, R. P., & Gent, C. A. (2002). Imaging spectroscopy: earth and planetary remote sensing with the USGS Tetracorder and expert system. In press, Journal of Geophysical Research.

Presented at the 3rd USGS Fire Science Workshop, November 12-15, 2002, Denver, Colorado, USA.