Land Cover Conversion and Degradation Analyses Through Coupled Soil-Plant Biophysical Parameters Derived From Hyperspectral EO-1 Hyperion

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Land degradation is a major environmental concern in many parts of the world. It can affect issues such as the availability of food, the quality and quantity of fresh water, the preservation of natural resources, biodiversity, and climate change. It is responsible for soil erosion and can lead to desertification, a major socio-ecological problem worldwide.

A number of indicators and signals that lend themselves to monitoring by remote-sensing satellites provide a warning of land degradation. These include loss of vegetative cover, wind and water erosion, soil salinization, deterioration of the soil structure, drier soil, increased reflectance, higher land surface temperatures, and changes in land cover type. But because soil and vegetation changes often occur in several areas simultaneously, it can be difficult to develop adequate remote-sensing measures of land degradation. The development of hyperspectral remote sensing has improved the likelihood of unambiguously identifying numerous soil and plant absorption features.

This investigation examined images acquired from the EO-1 Hyperion hyperspectral sensor and from low-altitude Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) flights.

The area studied was in restored and degraded parts surrounding the Ñacuñán Reserve in the Mendoza region of Argentina. This is a warm semi-desert region characterized by a variety of vegetation and some areas of sand dunes and playas, which are easily seen in an IKONOS image acquired in June 2001 (Figure 1). The Hyperion images were acquired on January 24, 2001, and the low-altitude AVIRIS images were acquired on February 15, 2001. The hyperspectral imagery was corrected and converted to surface reflectance using the ATREM atmosphere correction program and calibration ground control points.

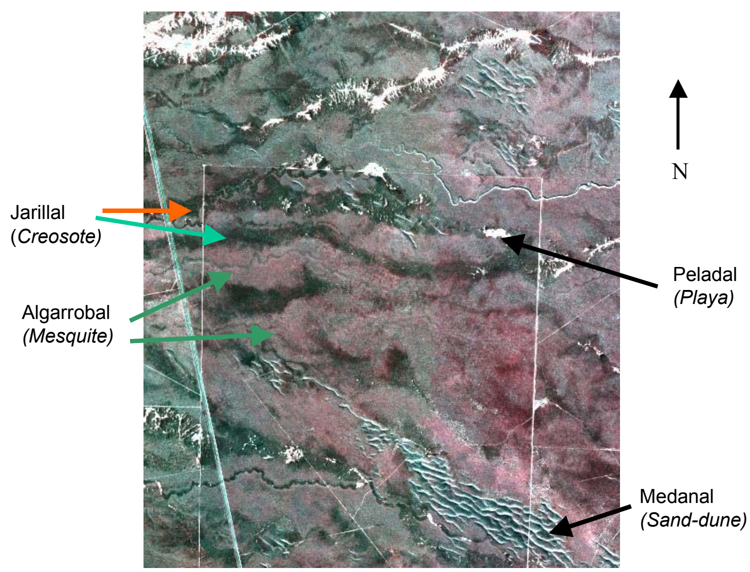

Figure 1. IKONOS image of Ñacuñán Reserve.

The investigators subjected the AVIRIS and Hyperion images to a Principal Components Analysis (PCA) to understand the spectral content of the imagery and to assess the dimensionality of the datasets. A linear spectral mixture analysis (SMA) then was used to assess the capability of the two hyperspectral datasets to discriminate and allow separation of green vegetation, non-photosynthetic (NPV) or dry vegetation, and soil landscape features to evaluate how best to detect and monitor land degradation using this technique. It was determined that use of spectral signatures representing soil, vegetation, NPV, and shade was necessary to allow an analysis of the degree and stage of degradation.

With both image datasets, PCA revealed sufficient spectral detail in the shortwave infrared (SWIR) region to allow SMA to extract an NPV image. This result was crucial to the study goals of detecting various land degradation classes. A comparison has not yet been made of the AVIRIS and Hyperion images because they only slightly overlap in spatial extent, even though they are both looking at the same general area. The issue of the 4-m pixel size of AVIRIS vs. the 30-m pixel size from Hyperion must also be considered for a careful comparison, although the Hyperion pixel was coarser and hence could still see the lignin features for NPV extraction.

Conclusion

The introduction of hyperspectral sensors has improved the ability of remote sensing satellites to play a role in the management of soil resources and monitoring of land degradation processes. These sensors, with more than 200 bands, have great promise for extracting and characterizing soil and vegetation components. This study was able to identify soil properties, NPV properties, and green vegetation amounts and types. It was found that the best indication of land degradation was obtained by combining soil, NPV, and green vegetation imagery data. When combined with other types of models, the investigator can assess the processes that contribute to desertification.