MEASUREMENTS OF CANOPY CHEMISTRY WITH 1992 AVIRIS DATA AT BLACKHAWK ISLAND AND HARVARD FOREST

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1 Introduction

The research described in this paper was designed to determine if high spectral resolution imaging spectrometer data can be used to measure the chemical composition of forest foliage, specifically nitrogen and lignin concentration. Information about the chemical composition of forest canopies can be used to determine nutrient cycling rates and carbon balances in forest ecosystems (Melillo et al. 1982, Aber et al. 1992). This paper will describe the results relating data from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) to field measured canopy chemistry at Blackhawk Island, WI and Harvard Forest, MA.

2 Methods

A total of forty plots were sampled at Harvard Forest, Petersham, MA and Blackhawk Island, Wisconsin Dells, WI. Plots were characterized by the collection of green leaf samples at the time of the AVIRIS overflight and by litterfall collections to determine the species compostion of the canopy. Fresh leaf samples collected within 10 days of the overflight were used to determine the concentrations of nitrogen, lignin, cellulose, and water for each species. Water content was determined by measuring fresh and oven dry sample weights. Lignin and cellulose concentrations were determined by sulfuric acid digestion, and CHN combustion method determined carbon, hydrogen and nitrogen concentrations.

Atmospheric corrections of the AVIRIS data were done by the ATREM program(Gao et al. 1992). Following the ATREM correction, a secondary correction was made based on field spectra measured at Blackhawk Island. The first derivative of the mean of four spectra for each plot was used in the analysis. Two to three wavelengths were chosen in a multiple linear regression of reflectance data vs field measured chemistry. Specific wavelengths were chosen due to their statistical fit to the data and their relationship to known absorption features of molecular bonds present in the samples.

3 Results

AVIRIS reflectance data at .946 and 2.29nm were used to predict nitrogen concentration at Blackhawk Island, corresponding to absorption features in C-H and N-H bonds, respectively. All references to molecular bond absorption features are from Osborne et al. 1986. Reflectance data at .79 and 1.7nm were used to predict lignin concentrations, corresponding to absorption by aromatic molecular structures. The relationships between measured and predicted nitrogen and lignin concentrations are shown in Figure 1. This relationship, based on field sampling at Blackhawk Island, was then applied to the entire image, yielding chemical concentration estimates for the entire island (Figure 2).

In the analysis of Harvard Forest data, the equations developed at Blackhawk Island were applied to the AVIRIS data. This resulted in an overestimation of both nitrogen and lignin concentration. However, when the same wavelengths were used in a regression equation relating reflectance data to *Harvard Forest* field data, a much better prediction was obtained. The equations which best predicted nitrogen and lignin at Harvard Forest used different wavelengths than the Blackhawk Island equations (Figure 3). Differences in atmospheric corrections between the two scenes, i.e. both scenes were normalized to Blackhawk Island field spectra, may explain the selection of different wavelengths for the best predictive equation. Nitrogen was best predicted with .773 and 2.15nm, corresponding to N-H and NH2 bonds, respectively. Lignin was predicted best with 1.54, 2.11nm. An estimation of foliar nitrogen and lignin concentration is shown if Figure 4.

Predictions from AVIRIS data at Harvard Forest are currently being used to drive an ecosystem model predicting ecosystem carbon balance. A critical input parameter in this model is foliar nitrogen concentration which is used to determine the maximum rate of photosynthesis (Aber et al 1992).

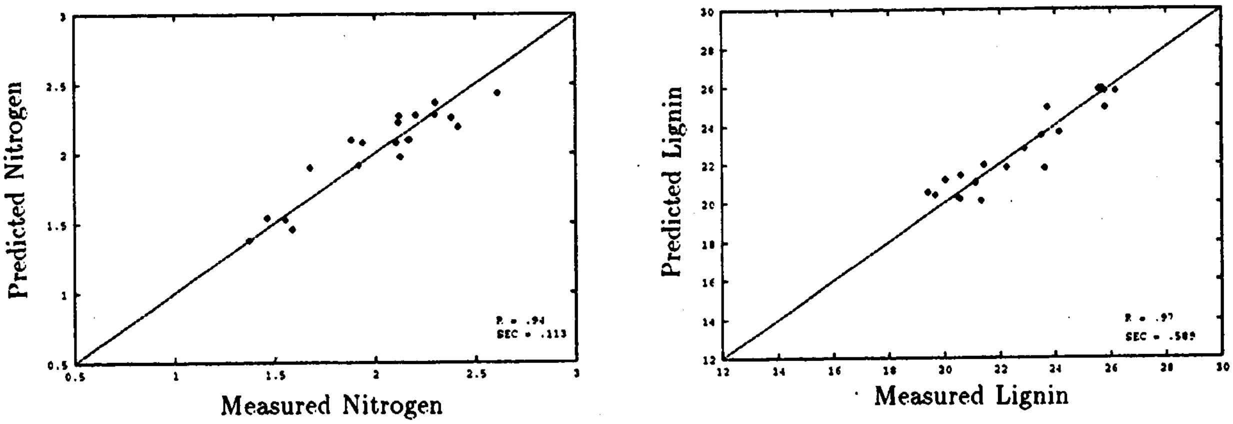
4 References

Aber, J.D. and C.A. Federer, 1992, "A generalized, lumped-parameter model of photosynthesis, evapotranspiration and net primary production in temperate and boreal forest ecosystems," *Oecologia*, vol. 92, pp463-474.

Gao, B.-C, H.B. Heidebrecht, and A.F.H. Goetz, 1992, *Atmospheric Removal Program (ATREM) User's Guide*, Center for the Study of Earth from Space/CIRES, University of Colorado, Boulder, CO.

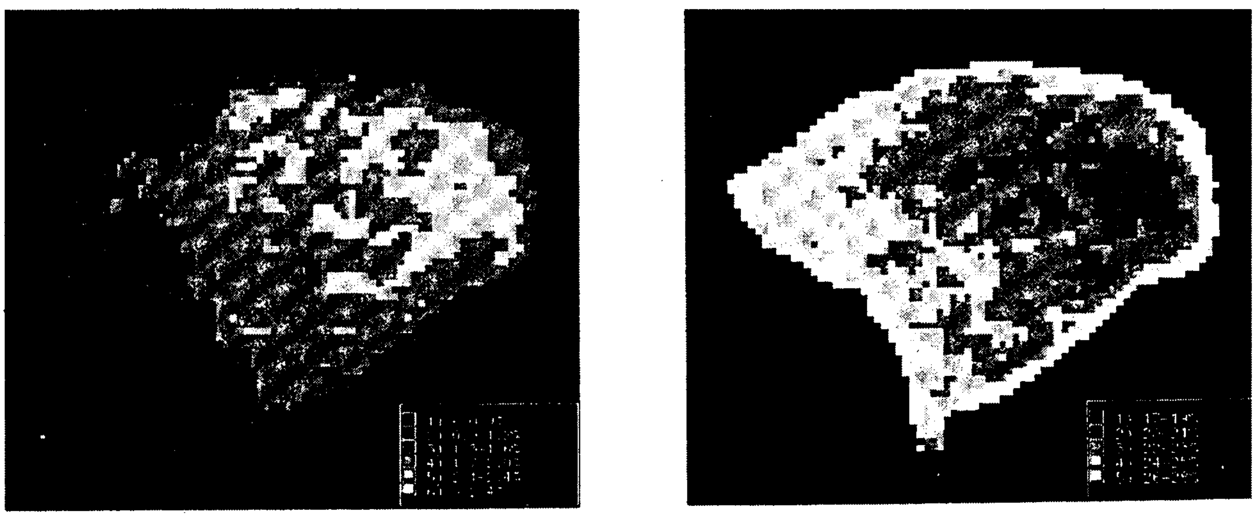
Melillo, J.M., J.D. Aber, and J.F. Muratore, 1982, Nitrogen and lignin control of hardwood leaf litter decomposition in relation to soil nitrogen dynamics and litter quality, *Ecology*, vol. 66, pp266-275.

Osborne, B.G. and T.Fearn, 1986, *Near Infrared Spectroscopy in Food Analysis*, Longman Scientific and Technical Publishing Co.



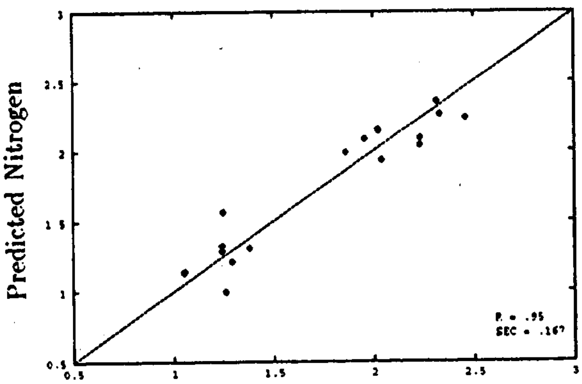
a.   b.

Figure 1. Blackhawk Island canopy nitrogen(a) and lignin(b) concentrations predicted from 1992 AVIRIS data vs field measured nitrogen and lignin. R = correlation coefficient, SEC = standard error of calibration.

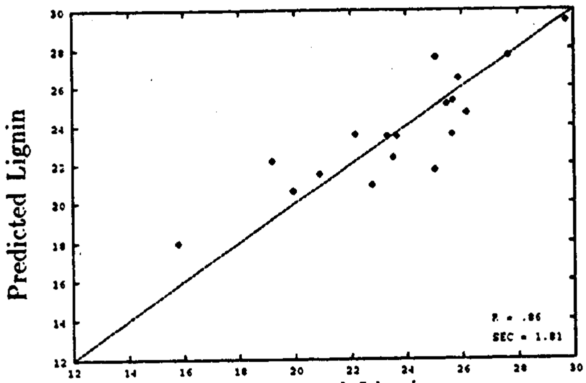


a.   b.

Figure 2. Blackhawk Island canopy nitrogen(a) and lignin(b) concentrations predicted from 1992 AVIRIS data.

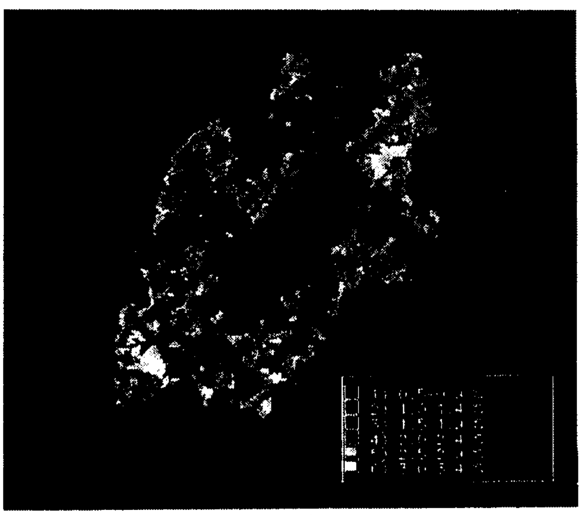


a.

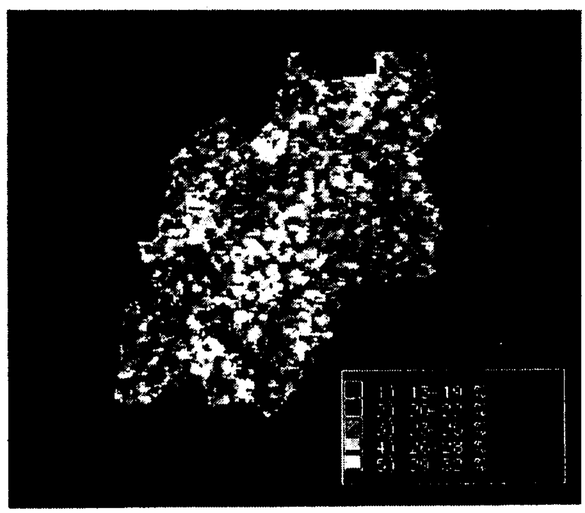


b.

Figure 3. Harvard Forest canopy nitrogen(a) and lignin(b) concentrations predicted from 1992 AVIRIS data vs field measured nitrogen and lignin.



a.



b.

Figure 4. Harvard Forest canopy nitrogen(a) and lignin(b) concentrations predicted from 1992 AVIRIS data.