

# Regional Forest Health and Stream and Soil Chemistry Using a Multi-Scale Approach and New Methods of Remote Sensing Interpretation, Catskill Mountains, NY



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**Introduction**  
 The New York-New England region is the most densely forested region in the U.S. It is also one of the most densely populated, and experiences air pollution levels among the highest in the country. Over 30 million people in the region seek potable water, forest products, recreation and aesthetic renewal from a complex patchwork of forested lands with a rich and diverse history of human use and current ownership. The health of these forest lands and the waterways they feed are a critical component of the economic well-being and quality of life in the region.

Forest health and stream water quality both depend on the integrity of biogeochemical cycles within forest ecosystems. It has been clearly established that both atmospheric deposition and forest management can alter the biogeochemistry of forest ecosystems, inducing significant changes in forest production, species composition and stream water quality. Nutrient-cation imbalances have been associated with soil and stream acidification, nutrient imbalances in forest vegetation, and in some cases with decreased forest production.

Monitoring the biogeochemical status of forest and stream ecosystems is a key component of assessing environmental quality in the northeastern U.S. Any monitoring system requiring spatially-continuous capabilities will need to utilize some form of remote sensing technology. Forest canopies are the only portion of the system accessible to optical remote sensing instruments and so offer the most likely target surface for monitoring forest health in this spatial mode. The usefulness of remote sensing of canopy chemistry depends on tight relationships between canopy chemistry and the critical processes of forest production and element losses in drainage water.

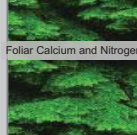
## Satellite Imagery



## Forest Health



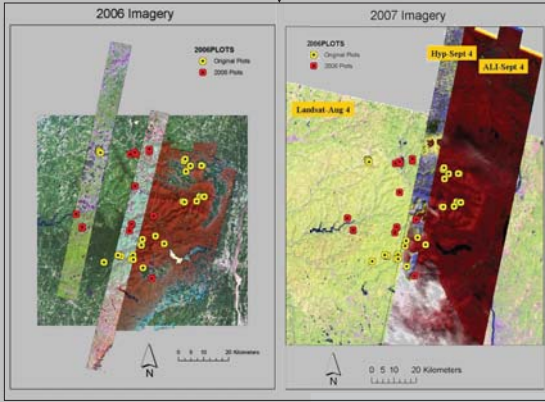
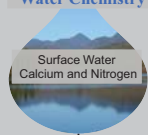
## Foliar Chemistry



## Soil Chemistry



## Water Chemistry



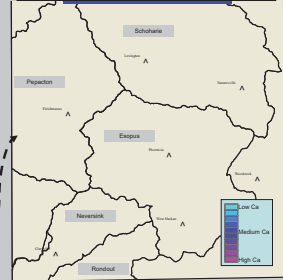
Health Plots

Soil Pits

Stream Samples

## Interpolated Stream and Soil Chemistry Maps

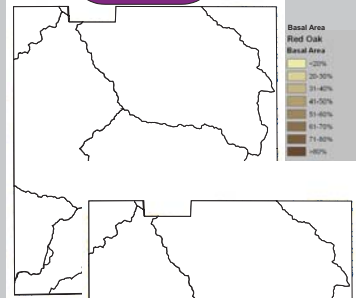
Regional stream and soil sampling efforts conducted by the USGS and USFS - FIA program have resulted in the ability to create interpolated maps for a wide range of soil and stream water chemical characteristics. These data layers will be used in conjunction with the remote sensing data layers to create an integrated spatially explicit model that utilizes a wide variety of ecologically sensitive indicators to create maps of areas that are sensitive to acid deposition.



Non-forest Mask  
 Image Registration  
 Atmospheric Correction  
 View Angle Correction  
 Topographic Correction

Final Processed Image Reflectance  
 Minimum Noise Transform  
 Pixel Purity Index  
 Mixture Tuned Match Filtering

## Species Mapping



Red oak, sugar maple, and hemlock maps above represent preliminary results of spectral mixture analysis of the hyperspectral data sets—a somewhat novel approach to species mapping. Rather than detecting discrete classes spectral mixture analysis allows for detection of sub-pixel species composition. These products will be augmented with FIA plot data to improve fractional species composition maps for the Catskills region.

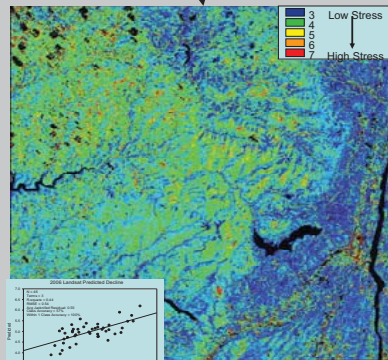
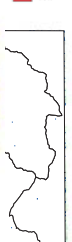
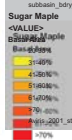
Signature Analysis  
 MPLS Full Spectrum Regression  
 Simple Linear Regression

Calibration

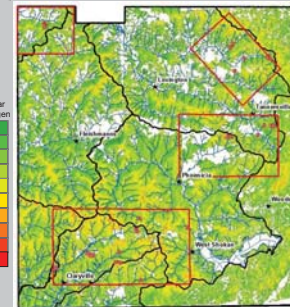
Validation

Forest Health Predictive Equation

Foliar Chemistry Predictive Equation



A three term linear regression using a unique combination of Landsat TM bands was able to predict a 10 class decline rating with 57% accuracy and to within 1 class with 98% accuracy. The resulting coverage of forest health was limited to the range in plot level health observations. While this coverage is not stress specific, it is likely that these upper elevational "hot spots" coincide with areas of extreme forest tent caterpillar defoliation in 2006.



Foliar nitrogen maps are under development from a number of data sources. In 2001, the entire region was imaged by NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS); nitrogen image to the left). In 2006-7, data were acquired from Hyperion (hyperspectral), the Advanced Land Imager (ALI; broadband) and Landsat 2006-7 field data is being used with these recent data to update estimates of foliar nitrogen for selected areas.

## Data Synthesis

Landscape-scale coverages shown in this poster are currently being incorporated into a spatially-explicit index of forest sensitivity to biotic and abiotic disturbance.

These data products will have immediate utility for developing forest harvest strategies in the watersheds feeding the NYC water supply.