**Towards Methodologies for Global Monitoring of Forest Cover Characteristics with Coarse Resolution Data**

Progress Report

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Background

This project addresses the need to develop prototype methodologies for global monitoring of forest cover with coarse resolution data in the context of the Global Observations of Forest Cover activities. The project builds on previous research to improve methodologies for characterizing forest cover and changes in forest cover independent of the often varying thresholds of canopy cover considered to be "forest." By developing a training and validation data set based on in situ measurements as well as high resolution Landsat data, we are developing a prototype product for the conterminous United States using 250m and 500m MODIS data. The methodology for combining in situ, high resolution, and coarse resolution data serves as a prototype that can be extended to other parts of the world. We are also examining the ability of the methodology to identify changes in forest cover by applying it to individual years and assessing the extent to which differences represent actual change. This aspect of the project necessarily relies on AVHRR data as a time series of MODIS data has not yet been acquired. We are also addressing the need within GOFC for methodologies that are automated and repeatable. A number of techniques such as automated noise reduction for training data, feature selection, and enhancements to decision tree classifiers are being assessed for their potential to automate the procedures.

Key words:
Research fields: Deforestation, Forest conversion, Land cover classification
Geographic area/biome: Global
Remote sensing: AVHRR, Landsat, MODIS
Methods/scales: Global scale, mixture modeling

Themes and Questions Addressed in this Project

This project addresses the LCLUC long-term goal of reliable, verifiable and repeated global monitoring of land-cover and land-use processes from space and addresses the question "what are the changes in land cover and/or land use?"

The project does not address the human dimensions directly, though monitoring of anthropogenic land cover change is crucial to understanding the causes of the change.

The theme addressed in the project is GOFC (100%).

Objectives and Timeline for the Project

The objectives of the project are to:

- Establish a prototype methodology for characterizing global tree cover as proportional coverage with coarse resolution (250m - 100m) data based on in situ measurements

- Develop and test automated procedures for mapping tree cover at repeated intervals from coarse resolution data

- Develop and test the prototype methodology for a number of years to assess the capability for identifying locations undergoing rapid changes in forest cover

- Provide the prototype data sets and descriptions of the methodologies to the GOFC community through the Global Land Cover Facility at the University of Maryland.

To begin to meet these objectives in the first year of the project, we had proposed to do the following:

1) Identify sites for field work and assemble high resolution data
2) Conduct field work on approximately 6 sites during the growing season
3) test and assess techniques for noise reduction, feature selection, and decision tree enhancements regarding prospects for automation
4) Apply existing training data and procedure individually to 2 year of AVHRR 1km data

Progress during this Reporting Period

Progress has been made in a number of areas during the first year. First, several summertime acquisitions of 250m MODIS data were obtained and a preliminary product of percent tree cover was derived for the eastern United States. This effort involved reinterpretation of the training data derived from Landsat data as continuous fields rather than land cover type. We also tested and successfully applied a regression tree to derive estimates of tree cover, an improvement on the previous linear mixture model method. Figure 1 shows the result and a comparison between the MODIS and AVHRR-derived products. The data has been made available through the Global Land Cover Facility (http//glcf.umiacs.umd.edu).

Second, we developed protocols for field measurements and procedures for using these data to calibrate and validate high resolution and MODIS data to derive the percent forest cover estimates. Because field measurements were obtained from western Zambia in association with the SAFARI 2000 activity (not funded by this project), we used these field measurements to develop the procedure. We also conducted field measurements locally to identify the proper instrumentation and protocols.

Third, we have identified a number of sites where we will conduct field work during the summer of 2001. The sites were selected based on availability of cloud-free Landsat data and locations that transcend a gradient of ecosystems types. Sites have been selected in the upper Midwest, eastern US, Pacific northwest, southern California, and Arizona. Preparation is currently underway for the summer field work.

Fourth, a number of techniques for improving automation of the methodology have been tested. These include application of a regression tree to estimate percent tree cover, automated feature selection to identify the metrics that best discriminate tree cover and identification of outliers in the training data.

Finally, in relation to the objective of using a time series of AVHRR data to estimate changes in tree cover over time, we applied the methodology to two years of 1km AVHRR data. However, the noise in the data makes it difficult to identify real differences. Instead, we applied the methodology to the 8km AVHRR time series (1982-2000). In spite of the reduced spatial resolution, the longer time series makes this a more suitable test. Analysis of the results are underway and suggest that trends can be identified.

Plans for Coming Year

The second year of the project will focus on several activities:

1) Field measurements and analysis of results - A major activity in the coming year will be the summertime field measurements and analysis of results for calibrating and validating percent tree cover estimates.

2) Analysis of a full year of MODIS data - As a full year of MODIS data becomes available, we will derive multitemporal metrics for the conterminous US. These metrics will be used in conjunction with the improved training data to derive a preliminary product of percent tree cover for the entire conterminous US. Several technical issues

will need to be addressed, in particular the compositing procedure. Products will be distributed through the Global Land Cover Facility if appropriate.

3) Analysis of percent tree cover estimates over the time series - The percent tree cover estimates derived for each year in the AVHRR time series will be analyzed and compared with high resolution data and derived products to identify whether actual changes in percent tree cover are detectable.

4) Techniques for automation - Machine learning techniques, such as bagging and boosting, will be applied. Tests will be carried out to assess the increased accuracy obtained by using these techniques in relation to the increased computation requirement.

Results in First Year

Figure 1 shows a preliminary product of percent tree cover for the eastern US. The estimates were obtained using the regression tree methodology developed in the first year and the improved training data set.

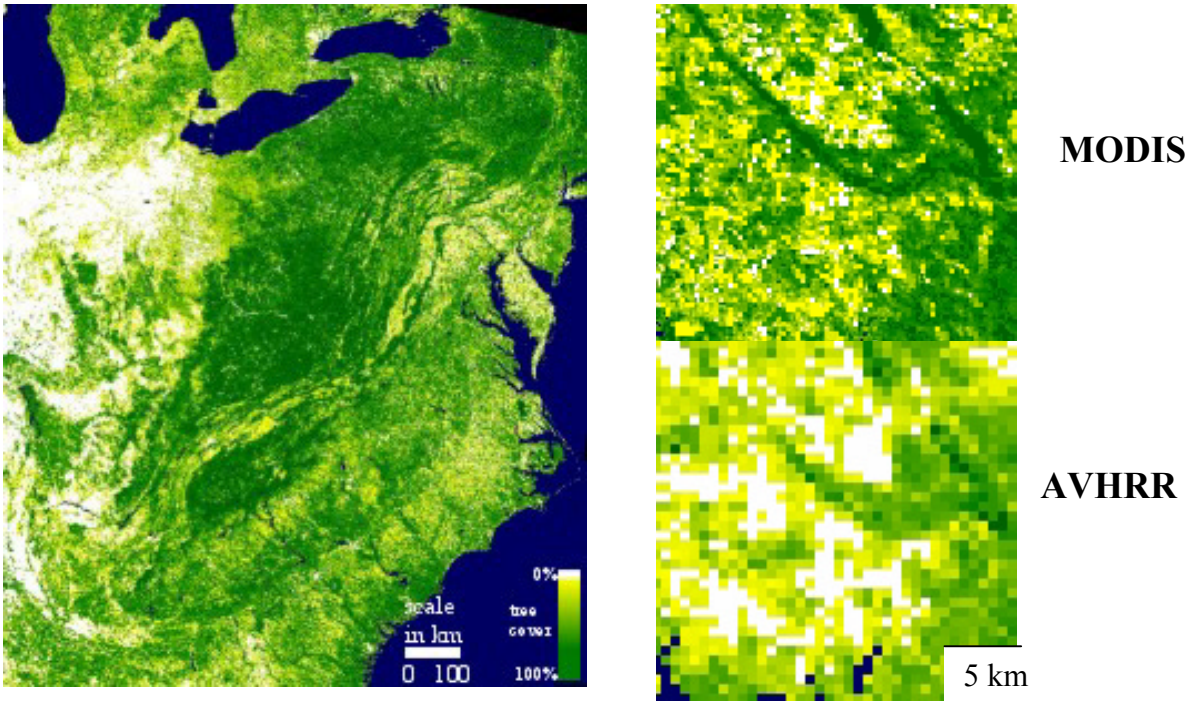


Figure 1. Preliminary result using two acquisitions of MODIS data to estimate percent tree cover. The figures on the right illustrate the improved spatial detail obtained from MODIS data compared with AVHRR.

## Conclusions

Global monitoring of forest cover is a key goal for the Global Observations of Forest Cover. Results from the first year of the project indicate that MODIS data will provide greatly improved abilities to characterize forest cover. The methodology developed in previous projects and improved in this project will provide a largely-automated approach for monitoring forest cover through time. Field measurements to be carried out in summer, 2001 will be a major effort in the second year of the project to develop data for calibrating and validating the methodology.

## Publications and Presentations

Peer-review journals:
Hansen, M., DeFries, R., et al. Estimating Percent Tree Cover in Western Zambia with MODIS data: calibration and validation using high resolution satellite data and ground measurements. To be submitted to special issue of Remote Sensing of the Environment.

Hansen, M., DeFries, R., Townshend, J., and Sohlberg, R. Continuous field of tree cover product: the MODIS algorithm. To be submitted to special issue of Remote Sensing of theEnvironment.

Conference abstracts and presentations:
Hansen, M., DeFries, R. et al. *Using Continuous Fields of Tree Cover Maps from Satellite Data to Assess Degradation within Ecoregions, an Example from South America*. To be presented American Geophysical Union spring meeting 2001.

Hansen, M., DeFries, R. et al. *Development of a MODIS Validation Tree Cover Data Set for Western Zambia and its Use in Testing MODIS Data*. To be presented American Geophysical Union spring meeting 2001.

DeFries, R. and Hansen, M. 2001. *Using MODIS Data to Assess Regional Forest Degradation from Human Activity*. to be presented at 2001 Ecological Society of America meeting, Madison, Wisconsin, August 2001.

DeFries, R. and Hansen, M. *Continuous Fields of Vegetation Properties Derived from Remotely Sensed Data*, Invited presentation to Association of American Geographers, April 2000.