CANOPY REFLECTANCE MODELING IN A TROPICAL WOODED GRASSLAND

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Semi-annual Report

NASA Award NAGW-788
January 31, 1986

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Introduction

The following brief report summarizes the research accomplished on NASA Grant NAGW-788 during the period 7/1/85 to 1/31/86. The topics to be addressed are; 1) field data collection, 2) image and collateral data acquisition, 3) model development and 4) data analysis and processing. Based on progress in this period, we have formulated appropriate goals for the second half of the year (2/1/86 through 7/31/86), and for the second year of the grant (8/1/86 through 7/31/87). A complete description of this research can be found in our original proposal.

Field Reconnaissance and Data Collection

A study area was selected in the Gourma region of Mali, West Africa. A study is already being conducted there by the Centre International pour l'Elevage en Afrique (CIPEA), Pierre Hiernaux, Principal Investigator, in collaboration with the GIMMS (Global Inventory, Monitoring and Modeling) Project at NASA/Goddard Space Flight Center (Chris Justice, Brent Holben and Jim Tucker, Investigators). This area has been monitored for two years in order to establish a relationship between rainfall and grassland productivity, and also to provide ground measurements and support for the GIMMS investigation of the use of AVHRR vegetation index data for monitoring grassland biomass and productivity.

Janet Franklin (UCSB Graduate Student and research assistant on this grant) visitied Mali from 10/17/85 to 11/24/85. This visit was deemed necessary in order to establish a working relationship with our colleagues there, locate suitable test sites, collect some preliminary field data and acquire collateral data that is difficult to get outside of Mali (aerial photographs, maps, and so forth).

Ms. Franklin was able to visit the Gourma field sites with Mr. Hiernaux and other CIPEA personnel, and observe their data collection procedures. In the Gourma study, thirty one-kilometer line transects have been located along a north-south trans-Sahelian climatic gradient from near Douna in the south (14° 40' N, 1° 35' W, average annual rainfall approximately 500 mm), to Gourma-Rharous in the north (17° 45' N, 1° 50' W average annual rainfall approximately 250 mm). These transects are being monitored for aboveground biomass through the growing season, a census is being taken of the seed bank, and spectral reflectance measurements are being taken from a hand-held radiometer. The CIPEA team has also estimated woody cover by the line intercept method, and sampled tree height, circumference, and crown diameter for certain dominant species within the sites. These measurements can be used in part for parameterizing our canopy model, although more field measurements will be required.

We have requested the tree cover and dimensional data from CIPEA so that a relationship can be established between tree height, circumference and crown diameter, for calibrating the canopy reflectance model. Additional calibration data will be required, and will be collected in the next field season.

An additional field area was visited in Mali. It is located in the Ségou region of the Sudanian bioclimatic zone. The area between Tamani and Konodimini (6° 50' W and 6° 20' W) and the Niger River and Nango (13° 25' N and 13° 10' N) is being used by Mr. Roy Cole, a graduate student in the Department of Geography, Michigan State University, in his study of the changes in land use practices in response to the drought since the early 1970's. This area lies within an extensive bioclimatic region where rainfed

naturally occurring trees which are preserved because of their economic and agricultural value. This long history of land use results in a partly artificial vegetation structure, consisting of sparse tree cover with an understory of crops. The structure and extent of this vegetation type make it suitable for testing the canopy model.

Ms. Franklin visited this area with Mr. Cole during her stay in Mali, and collected some preliminary tree structural measurements, as none were available for this area. In sixteen 50 m radius plots (eight in each on two canopy types) the diameter at breast height (dbh) of each tree was recorded, and height, and shape parameters were measured for a subsample of the trees. A total of 482 trees were measured.

Image and Collateral Data

Thematic Mapper data for the study areas have been ordered and recently received. The satellite imagery was not ordered until Ms. Franklin returned from the field, which delayed the progress of research somewhat, but was a necessary and prudent precaution, so that appropriate dates and subscenes could be ordered, based on first-hand knowledge of the areas.

In addition, invaluable aerial photography and maps were acquired by Ms. Franklin in Mali. Topographic maps at several scales (1:200,000 and 1:1,000,000) were acquired for both the Gourma and Ségou sites. Black and white aerial photographs are available for the whole country at a scale of 1:60 000, but they date from 1956. These are the only small-scale photographs available in the Gourma region, and will be required for image registration, location of study sites, strata labeling, and so forth. Therefore, partial coverage for the Gourma region has been ordered. In the Ségou region, 1:50,000 black and white panchromatic photos from 1974 are available for part of the region due to the presence of "Projet Riz" (an extensive irrigation project for rice growing) in this area. These photos have been purchased. Current (1985-1986) low-level color air photos for some of the study sites in both regions were made available to us by CIPEA. All of these maps and photo data sources will be used for model parameterization (calculating tree spatial pattern, measuring actual density and cover for sample stands to be used in accuracy assessment, etc.), image registration (to help interpret from satellite imagery to topographic maps) and strata labeling during the image stratification step.

Model Development

Li and Strahler at Hunter College have continued to refine their family of canopy models, and have modified the simple variance-dependent model to run for tree shapes appropriate to these study sites (hemiellipsoid and inverted cone). Sensitivity analysis of the model with modified geometric parameters shows that the model is less sensitive to changes in tree shape than it is to changes in other parameters, such as background signature, for an area with small trees and sparse cover.

The next step (see below) is to run the model with its modified tree shape parameter using field data collected this year, and produce a preliminary evaluation of the model for a few sample stands. Other modifications underway by Li and Strahler, also of relevance to our work, is incorporation of canopy transmissivities, rather than total reflectance. The sparse canopies of many semi-arid tree species, and different species-specific phenological patterns (dry season vs. wet-season deciduous) also need to taken into consideration when applying the model.

Data Analysis and Processing

Analysis of the Ségou field data has been initiated. The objective is to come up with reasonable shape parameters for the woodland types sampled, and product population statistics for these trees that can be used in the canopy model (e.g., allometric relationships among tree dimensional measurements, tree size distribution and spatial pattern). Preliminary results are encouraging. In the crop/woodland vegetation of the Ségou region, the trees have a very predictable shape (because they are pruned for fodder), and a Gaussian size class distribution (which would be unusual for a natural population, but for these preserved trees with very little natural regeneration, is not too surprising). Unfortunately, due to the pruning practices, the correlation between tree height and diameter is not good, which will make fieldwork more difficult. Diameter cannot be measured to predict height, but rather height will have to be measured directly. However, it was observed that these stands have low spatial variability, so perhaps a smaller subsample of trees can be chosen for field measurement.

Because of our deliberate delay in ordering image data, image processing has only proceeded as far as a cursory examination the data for quality. We expect to progress rapidly with image pre-processing and stratification in the second half of this year (see below).

Goals for Second Half of First Year

In the second half of the first year, the period from 2/1/86 through 7/31/86, the following tasks will be accomplished:

(1) **Data Analysis and Processing:** The analyses of tree population statistics and spatial point pattern that have been initiated for the Ségou sites will be completed. When the raw field data is received from CIPEA, a similar analysis will be performed for the Gourma test sites.

The Thematic Mapper data for the test sites will be registered to a map base, corrected and enhanced in other ways if necessary. One exploratory task will be to perform image spatial analysis by looking at image variograms for different vegetation types in the study region. The image will then be stratified according to the procedures specified in our original proposal. An appropriate sampling scheme will be worked out for assessing the accuracy of the image stratification and inventory during the next field sampling period.

The temporal pattern of the vegetation index from AVHRR data for the study sites will also be analyzed in conjunction with the GIMMS study in this area. This is to examine the possibility of using AVHRR data to identify areas of woody cover based on phenological patterns. This analysis has been carried out by Hiernaux and Justice for 1984, which was a very bad rain year. The analysis will be repeated with the AVHRR vegetation index data for 1986.

(2) **Model Development:** Once the above processing tasks are completed, spectral data for sample stands can be extracted from the images, and the canopy model can be tested for some sample stands of varying densities.

Goals for the Second Year

Our goals for the second year are essentially those outlined in our original proposal, but will be refined and elaborated on in the renewal proposal we will be sending within the month.

Publications

No publications have been produced as yet in conjunction with this project, but we anticipate presenting a paper on the initial testing of the canopy model at the International Symposium of Remote Sensing of Environment, in Nairobi, Kenya, December 1986. This paper will become the first is a series of manuscripts that will be produced based on this work.