Time-Series Land Cover/Land Use Change and Socio-Economic Driving Forces in the Northern Peten Region, Guatemala

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Steven A. Sader - Principal Investigator
Department of Forest Management
University of Maine
Orono, Maine

Thomas Sever - Co-Investigator
NASA - Marshall Space Flight Center
Huntsville, Alabama

Carlos Soza - Co-Investigator
ProPeten Program - Conservation International
Flores, Guatemala

Norman Schwartz - Consultant
Department of Anthropology
University of Delaware
Newark, Delaware

Introduction

The Maya Biosphere Reserve (MBR) in Northern Guatemala represents the largest contiguous tract of protected tropical forest remaining in Central America. Recently, the MBR has become more accessible as new roads have been constructed by petroleum companies and logging interests. Peasant farmers have followed the roads to establish maize-based agricultural plots. New settlements have become established in the buffer zone attracting more landless farmers to the area.

This report documents the activities of the Maya Biosphere Reserve, Guatemala project approximately one-half way through the first funding period. The objective of the first 18 months is to develop a time series land cover/land use change (LCLUC) data base, and initiate socio-cultural household and vegetation surveys to understand trends in LCLU conversion related to human driving forces in the region.

Data Acquisition and Preprocessing

Landsat-MSS data of 1974 and 1979 were acquired for the majority of the study area, however MSS imagery with acceptably low cloud cover was not available for the northeast border region with Belize. 1997 Landsat-TM imagery was acquired for all three scene locations. These acquisitions expand the existing TM data base (1986, 90, 93, 95) backward and forward in time to cover a 23 year time-series.

Other remotely sensed data collected over portions of the study area include October 1994, SIR-C synthetic aperture radar and aerial videography flight lines flown in July 1997. The video data linked to GPS on the aircraft will complement the time-series analysis and second-growth forest studies using Landsat and radar imagery. Video interpretation will support training set development and accuracy assessment especially in areas not easily accessible by road or river.

All Landsat imagery were co-registered to the NAD27 West Central America datum with a 30m UTM projection. Well-distributed control points were selected and a first or second-order transform applied with nearest neighbor resampling. Residual mean square errors were less than one pixel for all dates registered to the 1995 base image. Cloud and water masks were prepared for each scene/date.

Forest Change Detection: Updated Estimates for 1995-97

Analysis of the recent forest change (updated to 1997) was prioritized in the early stage of the project at the request of our co-investigator team at ProPeten and U.S. Agency for International Development - Guatemala. A complete manuscript on this aspect of the research is now under internal review (Sader et al., 1998).

The normalized difference vegetation index (following atmospheric corrections) was computed for each Landsat-TM date (1986-90-93-95-97). Unsupervised classification of 3-date sequences (1986-90-93 and 1993-95-97) were performed and interpreted using a procedure described as ARGB-NDVI classification≅ (Sader et al. 1998). The procedure combines machine classification with visual interpretation of single and multi-date color composites. Cluster classes were grouped into change/no change time-series categories. Land cover stratification using 1995 TM classified data and geographic information system (GIS) editing techniques were applied to resolve some confusion between forest change events and spectral change associated with non-forest types.

Results indicated that primary forest clearing rates in the MBR were less than 0.4 percent per year in the 1990's, but the forest in the buffer zone continued to be cleared at high rates, approximately 3.3% per year during the 1995-97 time period. The 1995 to 1997 clearing rates for the MBR and buffer zone together were nearly equal to the previous time period (1993-95), however, the foci of some areas of forest clearing shifted to new locations in the Reserve. The updated forest change detection map appears on the Maine Image Analysis Laboratory web site (http://www.ume.maine.edu/~MIAL).

Socio-Cultural Surveys

Four communities in the MBR and buffer zone were selected to conduct household surveys. The survey instrument was designed by Dr. Norman Schwartz (U. Of Delaware) and Amilcar Corzo of ProPeten. A team of field extensionists lead by Mr. Corzo interviewed men and women separately in each community. These four communities have different demographic and ethnographic backgrounds. Two communities (El Cruce dos Aguadas and Centro Campesino) are located in the MBR buffer zone. Buen Sarmaritano is a recent community established in Laguna del Tigre National Park. Carmelita is a long established community in the multiple use zone near the center of MBR. Approximately 180 men and 100 women were interviewed. The results are being analyzed.

Vegetation Surveys

Approximately 40, second-growth forest age class patches are being sampled. Plot size varies by age class with young age classes (<5 years) composed of 2m diameter circular plots and older age classes (5-30 years) with 20 x 50m plots. Species and number of stems by height class are recorded in all stands. Diameters and total height are measured for all trees greater than 5cm diameter breast height. Soil texture, degree of rockiness, slope gradient and related site information (GPS reading and ground photos) are collected at each location.

Activities Planned for Next Phase of Investigation

Land cover type will be classified at each time period. Pathways and time sequences of forest conversion will be determined and coded. Land cover/land use classification of the 1997

TM data (merged with the time-series data) will be performed. Accuracy assessments of the land cover maps will be evaluated using aerial videography interpretation, aerial photography (limited availability) and ground truth.

SIR-C imagery will be preprocessed at Marshall S.F.C. JERS-1 (L-band) SAR will be acquired from the Jet Propulsion Laboratory and Radarsat (C-band) SAR will be searched and acquired for second-growth study sites. Fifteen to 20 more vegetation sample plots will be measured to expand the second-growth age class database. Training and test areas will be selected from the second-growth data set to analyze relationships between SAR backscatter and vegetation canopy structure and above ground biomass. Biomass equations will be developed from local and regional data in the second funding period.

Socio-cultural data collected in the four communities will be analyzed. A sub-sample of households in each community will be selected for follow-up interviews. Time series LCLUC and socio-cultural data will be compared among the four communities to examine trends and patterns of LCLUC related to demographic and ethnographic profiles. Socio-economic data collected through other programs (CARE, USAID) in the MBR and buffer zone will be compiled and analyzed to expand our observations about human driving forces related to LCLUC patterns.

Other Activities Related to the Project

A new web site (http://www.ume.maine.edu/~MIAL) was established in April, 1998. Information about the project including this project report will be posted on the web site.

S. Sader attended the first two LCLUC science team meetings in Airlie, VA (April 1997 and 1998).

Related Publications

Sader, S.A., C. Reining, T. Sever and C. Soza. 1997. Human migration and agricultural expansion: a threat to the Maya Tropical Forests. Journal of Forestry 95(12):27-30.

Sader, S.A. 1997. Changing ecosystems: human patterns on the landscape from time-series satellite monitoring. Supplement to Bulletin of the Ecological Society of America, Washington, D.C. 78(4):175 (Abstract).

Sader, S.A., M. Coan and D. Hayes. 1998. Time series tropical forest change detection for the Maya Biosphere Reserve: updated estimates for 1995 to 1997. (Manuscript in internal review.)