Pattern to Process: Research and Applications for Understanding Multiple Interactions and Feedbacks on Land Cover Change (NAG 5 – 9232)

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ABSTRACT

This project implements a conceptual framework based on landscape ecology that will enable statistical work on both the drivers of land use and land cover change, and the impacts on ecosystem structure and function that follow as a consequence. To this end, the project is developing a suite of remotes sensing products that will be used in the Brazilian Amazon and Costa Rica. Keywords for the project are as follows:

KEYWORDS

Research Fields
Biodiversity, Deforestation, Habitat Fragmentation, Land Use Modeling
Selective logging

Geographic Area/Biome
Amazonia, Central America

Remote Sensing
Landsat, IKONOS, Atmospheric Corrections

Methods/Scales
Regional Scale, Stochastic Processes, GIS
Mixture Modeling

Scientific Questions posed by Study:

The present project is attempting to answer the questions:

1) what are the causes of land cover and land use change?
2) what are the consequences of land cover and land use change?
3) what are the actual changes occurring in land cover in certain parts of the world?

Project resources and activities are broken down as follows:

33 1/3 %: Human Dimensions
33 1/3 %: GOFC (mapping/monitoring of forest cover and change detection)
33 1/3 %: Biodiversity

GOALS for year 1 of Project:

Remote Sensing Activities, Year 1 TASK:
Algorithm Development

Human Drivers Model, Year 1 TASK:
Mathematical Model Development

Biodiversity Activities, Year 1 TASK:
Biodiversity Model and Field Work in Coast Rica

Narrative Statement of Progress of Study The **Remote Sensing Activities** for year one focused on (1) the development and assessment of new algorithms, and (2) the identification of existing algorithms for the various remote sensing products indicated in the proposal text. We made significant progress on an algorithm for calculating Fractional Cover (linear mixture modeling – LMM) and evaluated the product at several locations. Moreover, we have in our possession algorithms for forest fragmentation (Parcel Size, Parameter L (total length of fragmented area), and Connectivity C), for selective logging, for fire scars, for Leaf Area Index, and for fPAR. Note that the VCL sensor is presently cancelled, which compromises our ability to prosecute biomass estimation using VCL-dependent data. ***Our priority now is to develop new empirical approaches in this regard. We also need to undertake field validations for the Fractional Cover measures***.

The advances of the project in terms of **Mathematical Model Development** (for the human drivers) during the first year of activities relate to specifications of an optimization problem for both shifting cultivators and colonist farmers, taking into account the constraints of household structure and resource base. Solutions were obtained using constrained, non-linear optimization techniques, a so-called, variable metric approach (Powell 1978; SAS 1995; Miller 2000), to demonstrate key aspects of the land cover change process, namely the number of times a family clears land (or the number of deforestation *events*) and the amount of land cleared each time (the *deforestation event magnitudes*). Using field-based data, the number of events predicted, namely 3 or 4 depending on the farming system involved, are in close agreement with actual field observation (Homma et al 1993). The size of clearings is also quite close (Dale et al. 1994; Walker et al. 1997). The theoretical model was used to provide a conceptual foundation for a spatial simulation that predicts the pattern of landscape change in the Brazilian Amazon. ***The next steps will involve adding a road construction component to the model.***

In the **Biodiversity Activities** we focused on developing sampling routes in Costa Rica, classification of land-cover types, assessment of fragmentation measures to be used in modeling, and determination of appropriate techniques for the statistical analysis of the biodiversity model. *Due to a death in the family of one of our field assistants, sampling on certain routes (7 in the north) could not be completed, and will be deferred until November of 2001.* We collected diversity data on locations along the majority of our sampling routes (34), and then overlaid the positions on a Landsat 7 ETM+ image (February 14, 2000), for which we developed a land-cover classification scheme (forest, disturbed forest, regenerating forest, coffee plantations, pasture, sparse cover, water, and clouds). We conducted a literature review on the relationship between forest fragmentation and species diversity (e.g., Boulinier et al. 1998; Nichols et al. 1998), and assessed various techniques for statistical analysis of the data, which may be affected by spatial autocorrelation. We ensured that the proper computer software is available for dealing with this problem (Anselin 1988). ***Our next steps will be to finish with the diversity sampling, and implement an initial biodiversity statistical model.***

►***New Product:*** Fractional Cover Algorithm
►***New Model:*** Behavioral Model of Colonist Agriculture
►***New Model:*** Stochastic Simulation of Spatial Deforestation Patterns

Conclusions

In sum, our project accomplished its main objectives for the first year. We developed and tested a fractional cover algorithm, and assessed availability of other algorithms for project products. We developed a theoretical model for land use and land cover change at the agent level, and transformed it into a spatial simulation for areas of settlement in the Amazon. We established our Costa Rican field sites, commenced with sampling, and made progress on developing data to be used in the statistical model linking biodiversity to habitat fragmentation. We submitted one article for possible publication, and organized a special session at National Meetings of the Association of American Geographers to introduce the discipline to our project. The paper title and session titles are listed below.

Paper:

Mapping Process to Pattern in the Landscape Change of Forest Frontiers
Submitted to the *Annals of the Association of American Geographers* (submitted)

Special Session of the meetings of the National Association of American Geographers, New York City, February 28, 2001:

Land Use and Land Cover Change: Remote Sensing and GIS Applications (Sponsored by Basic Science and Remote Sensing Initiative)

Organizers: Jiaguo Qi, Michigan State University, Robert Walker, Michigan State University

Chair: Jiaguo Qi, Michigan State University

Robert Walker, Michigan State University, Land Use and Land Cover Change: A Forest Dynamics Model for Low Intensity Agriculture and Forest Fragmentation

Jiaguo Qi, Michigan State University, Biophysical Attributes of Tropical Forests From Remotely Sensed Imagery

Marcellus Caldas, Michigan State University, Spatial Evolution of Farm Properties: A Histogram Analysis

Catherine Lindell, Michigan State University, Landscape Characteristics as Predictors of Avian Biodiversity at Mid-Elevation Sites in Costa Rica

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