Hierarchical Investigation of Socioeconomic Drivers of Decadal Scale Land-Cover Changes in the Upper Midwest

Phase I Performance Report

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Introduction

This report describes progress in Phase I of this NASA Land Cover Land Use Change (LCLUC) project. Progress is reported in three general areas: Data Collection and Pilot Testing, Model Development and Programming, and Educational Impact. So far, the project has progressed as anticipated. All equipment, provided by matching funds, has been purchased. Where slight modifications in the plan of action have been made, they are described below.

Data Collection and Pilot Studies

Data collection efforts focus on 136 sample sites (each about 2500 ha is size), for which we had previously digitized three-date parcel maps, located throughout the Upper Midwest. To collect three-date (1972, 1983, and 1991) aerial photography for each of the 136 sites, we have visited the air photo archives at Michigan State University, the University of Wisconsin, and the University of Minnesota. To date we have obtained a total of 1104 photographs, ranging in scale from 1:15,000 to 1:78,000 and including black and white, color, color infrared, and b/w infrared film. We have supplemented the archive photos with purchases from EROS Data Center and have made substantial use of the NAPP and NHAP programs. 360 of the photos were already in digital (but not rectified) form from the Landscan digital CD from the MSU Center for Remote Sensing and GIS. All other photos have been scanned at a ground resolution of approximately 2 meters, and rectified to a 1:24,000 scale digital reference product. In Michigan and Minnesota the reference products were digitized road networks acquired from state governments. In Wisconsin the reference product was scanned topographic quads in the form of the digital raster graphics (DRGs). For the 1970s, we have only partial photo coverage for 13 sites and no photo coverage for 5 sites. For the 1980s we have complete photo coverage for all sites. For the 1990s, 13 sites have only partial coverage. We are currently exploring alternative sources for photos of sites that have no or only partial coverage.

The aerial photography will serve two purposes in the study, a slight modification of the proposed activities and designed following comments made at the first meeting of the LCLUC science team. First, aerial photography will be overlain with ownership parcels and used in an interpretation of land use for each parcel. This process will involve primarily manual interpretation and will be aided by an AML-based interface (mostly complete) for updating parcel attributes. We have defined a three-tiered land use classification scheme suitable for such interpretation and subsequent modeling. Secondly, the photos will serve as a reference against which Landsat data will be compared for land cover class labeling and accuracy assessment.

In addition to interpreted land use, the study uses multi-date regional information on land cover. For this purpose we have acquired North American Landscape Characterization (NALC) data for the entire region, 24 scenes in all. We have processed all images associated with two of the scenes, covering Northern Lower Michigan, and performed a pilot study to investigate approaches for regional scale classification and analysis (Brown and Duh, 1998). Given the lessons from that study we have made some decisions about how to use the data in this project:

1. Given difficulties in radiometric correction and normalization, especially for historical scenes (we implemented the method presented by Hall et al., 1991, with no success), we have decided to use post-classification change analysis;

2. Because our research objectives focus on the effects of parcel fragmentation and land use change on forest cover and pattern, and given the spectral limitations of the sensor, we have decided to distinguish only forest / non-forest classes region-wide;

3. Radiometric normalization between two neighboring scenes, followed by mosaic creation, resulted in similar assessments of forest cover and pattern to those based on analysis of the two scenes separately. For this reason, scenes will be mosaiced and classified over as large an area as is ecologically reasonable for any given time frame;

4. The presence of atmospheric haze resulted in substantial changes from image to image in the estimates of forest cover and pattern. Metrics of forest fragmentation were particularly sensitive to haze. Although we will mask out areas of cloud and cloud shadow, we are also developing a procedure to minimize the effects on our analysis of atmospheric haze.

Although we have performed some analyses, the results are preliminary at this stage (Brown et al., 1998; Drzyzga and Brown, 1998). The results are empirical assessments of relationships between parcel size change and forest cover and fragmentation. They are ambiguous and describe only small portions of the study area. It seems clear that the land use and changes in use will affect the type and strength of relationship between land ownership and land cover. Given that the land use data are not yet ready, we will not report further on the preliminary results.

Model Development and Programming

There have been several noteworthy accomplishments with regard to the development of our spatial-temporal model for this project. First, we have reprogrammed Pijanowski's pilot Land Transformation Model into ArcView's Avenue scripting language (using Spatial Analyst). To date, approximately 350 Avenue scripts and 15-20 associated interfaces have been developed and tested for errors. In addition, new model capabilities have been added including a new parcel generation routine that will simulate parcel maps for any region. This capability will allow us to move the pilot LTM from a completely raster based model to a hybrid raster-vector model. All scripts for the model have been documented using flowcharts to illustrate the relationship of all scripts in the model. Second, high-resolution data (e.g., STF3A 1990 TIGER blocks) have been obtained for all counties in our sampling frame. These data will be used to explore methods of disaggregation/aggregation that are required in the Land Transformation Model. Third, two papers (Pijanowski et al. 1997, Pijanowski et al., In Press) have been published on the model in the last 9 months and the revision of a third paper is in progress.

Plans for the coming year include testing the entire model compared to the original pilot LTM for Michigan's Saginaw Bay Watershed. We will also investigate new ways to introduce stochastic events into this model; we will increase the number of land use/cover transitions into this model; and change the way the temporal driver of the model (regional population change) is used to forecast land use change. In particular, we will examine the way different per capita land use requirements can be altered in the model over space and time so that demographic effects on land use change (e.g., the effect of education level on residential parcel size) can be modeled.

Educational Impact

This project has been an important catalyst for graduate and undergraduate education. Three graduate students and four undergraduates, so far, have been involved to the mutual benefit of the project and to the practical education of the students. Students do much of the repetitive work, but are also included and encouraged to participate in discussions of research strategy.

Three graduate research assistants were hired to work on the project. Two PhD students (Mr. Jiunn-Der Duh and Mr. Bradley A. Shellito) are working on the project and anticipate developing thesis research that is related to the objectives of the project. Mr. Scott A. Dryzyga (M.A. Candidate) has been and will be working on the project through August 1998. Mr. Drzyzga is completing a thesis on the relationships between parcel size change and changes in forest cover and pattern in three adjacent counties of Northern Lower Michigan. Four undergraduate students have worked on the project to date (Ms. Emily Clark, Mr. Aron Thomas, Ms. Marianne Van Kerckhove, and Mr. Robert Goodwin). All undergraduate students have been working under the supervision of Mr. Duh to rectify scanned aerial photographs.

References

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