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 implemented a conceptual framework based on landscape ecology, linking the human drivers of forest fragmentation with the biodiversity impacts of related spatial changes in tree cover. The project developed models of household deforestation, landscape evolution, and road-building in forest frontiers, as well as statistical analyses of the effects of land cover change on bird species richness. Remote sensing products were also developed and tested. The project study area included sites 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, Biophysical Attributes

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

SCIENTIFIC QUESTIONS POSED BY STUDY:

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:

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

GOALS for the Project:

Remote Sensing Activities
Remote Sensing product development and application

Human Drivers Modeling
Models of lot-level deforestation and landscape evolution at regional scale
Model of road expansion and logger decision-making

Biodiversity Activities
Field work measuring species richness
Statistical analysis linking species richness to remotely-sensed, land cover indicators

Narrative Statement of Project Developments and Products

The **Remote Sensing Activities** consisted of development and experimentation of new satellite-based projects for land cover change analysis, and incorporation of remote sensing into landscape ecology studies of biodiversity impacts. The project developed, refined, and implemented algorithms for the measurement of fractional cover through linear mixture modeling – LMM, and deployed landscape indices using different sensors, in the interest of comparative assessment (patch density, edge density, Shannon's Diversity, IJI, and contagion). Fragmentation metrics were calculated using ETM+ and IKONOS imagery to assess scale dependency effects. Finally, remote sensing was used to generate variables for the statistical models assessing the impact of land cover change on biodiversity. Landsat ETM+ images were classified, and proportions of land cover types were determined for the routes along which bird species richness was sampled.

Project research on the **Human Drivers** of landscape change led to the development and application of three models. The first model details the optimization behavior of colonists households and predicts associated forest dynamics, both deforestation and reforestation (Walker 2003a). The second model introduces elements of the household model into two-dimensional space, and describes landscape evolution as a function of colonization and household attributes at regional scale (Walker et al. 2004). The third model uses GIS to generate routes of logging roads, also in two-dimensional space (Arima et al., submitted). In addition to modeling efforts, Human driver research on the project developed an approach to assessing the accuracy of spatial model prediction (Walker 2003a.).

The **Biodiversity Activities** of the project involved (1) developing a data base of the occurrence and relative abundance of bird species along 45, three kilometer sampling routes in Costa Rica; and (2) using these data, together with information generated by remote sensing, to test hypotheses about the relationships between land cover change and overall bird species richness and abundance, as well as the richness and abundance of various ecological guilds. Significant project findings include (1) a characterization of the types of birds most able to resist agricultural encroachment of tropical forests (Lindell et al. In press a), and (2) identification of the importance of forest edge and elevation gradients in sustaining species richness given land cover change (Lindell et al. In preparation).

► ***New Product:*** Field-tested Fractional Cover Algorithm and Forest Fragmentation

► ***New Model 1:*** Optimization Model of Household Forest Dynamics

► ***New Model 2:*** Model of Landscape Change, at regional scale (~10,000 Km^2)

► ***New Model 3:*** GIS-based Model of Logging Road Extension

► ***New Model 4:*** Statistical Models of Bird Species Richness and Abundance

► ***New Technique for Error Assessment:***

Adaptation of Map Accuracy to Spatial Models

Conclusions Our project achieved it primary goals. We developed a fractional cover algorithm, and used it to test scale dependency in measurement with ETM+ and IKONOS imagery. We also used remote sensing products in quantifying independent variables used in statistical assessments of the impacts of land cover change on biodiversity. We published two papers describing models developed with project support: the colonist household model, and the behavioral model of landscape evolution, both for the Amazon Basin. The later model was applied at regional scale in the Basin's eastern sector along the Transamazon Highway. We developed a third model describing the path selection of loggers, also for the Amazonian case, and submitted a paper describing it. We collected bird species richness data in Costa Rica and have several papers *In press* detailing our efforts to quantify the effects of land cover change on various aspects of the ecology of birds. We have a manuscript *In preparation* that addresses the proposal objective of statistically linking bird species richness and abundance to land cover measures (produced through remote sensing applications). Finally, we developed an approach for assessing the accuracy of spatial models, and published a paper that describes and applies the method.

Project papers published or *in press*:

Walker, R.T., Drzyzga, S., Li, Y., Qi, J., and Caldas. M., Qi, J., Arima, E., and Vergara, D. 2004. A Behavioral Model of Landscape Change in the Amazon Basin: The Colonist Case. *Ecological Applications*. 14(3): 299-312 (In press).

Walker, R.T. 2003a. Mapping Process to Pattern in the Landscape Change of the Amazonian Frontier. *Annals of the Association of American Geographers,* Vol. 93(2): 376-398.

Walker, R.T. 2003b. Evaluating the Performance of Spatially Explicit Models. 2003. *Photogrammetric Engineering and Remote Sensing,* Vol. 69(11): 1271-1278.

Lindell, C. A., W. H. Chomentowski, and J. R. Zook. In press a. Characteristics of bird species using forest and agricultural land covers in southern Costa Rica. *Biodiversity and Conservation*.

Lindell, C. A., E. B. Cohen, and J. S. Fritz. In press b. Are daily mortality rates for real and artificial clutches comparable? *Ornitología Neotropical*.

Cohen, E. B. and C. A. Lindell. In press. Survival, habitat use, and movements of fledgling white-throated robins in a Costa Rican agricultural landscape. *The Auk*.

Project papers submitted:

Arima, E., Walker, R.T., Perz, S., and Caldas, M. Theorizing Land-Cover and Land-Use change: loggers and forest fragmentation in the Amazon Basin. Submitted to *Annals of the Association of American Geographers.*

Project papers in preparation:

Lindell, C. A., W. H. Chomentowski, J. R. Zook, and S. A. Kaiser. Bird species richness and land-cover: Models for mid-elevation Central America. In preperation for *Ecological Applications.*

Walker, R.T., Caldas, M., Perz, S., Arima, E., Qi, J. Theorizing Land Cover and Land Use Change: the Peasant Economy of Colonization. In preparation for the *Annals of the Association of American Geographers*.

Wang, C., Qi, J., Skole, D., Cochrane, M., Samek, J., Chomentowski, W., and Matricardi, E. Canopy Degradation and Recovery: Estimation and Validation of Tropical Forest Fractional Cover with Landsat and IKONOS Imagery. In preparation for *Ecological Applications.*

Project Dissertation:

Wang. C. 2004. Estimation of tropical forest biophysical attributes with synergistic use of optical and microwave remote sensing techniques. PhD dissertation. Michigan State University (also with support from another NASA-funded project led by Dr. Jiaguo Qi).