# LCLUC

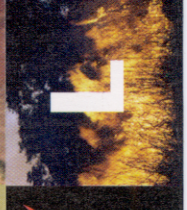
## Land Cover Land Use Change

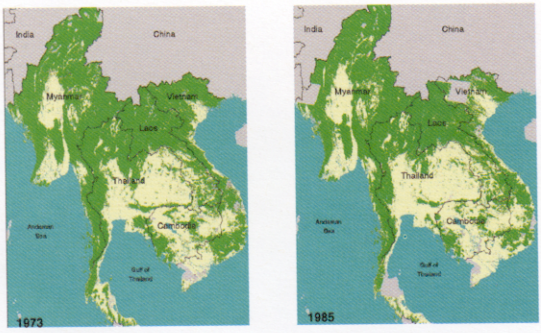
*An interdisciplinary research program addressing questions of societal relevance using remotely sensed data*

MODIS 250m Tulare County, CA, 5.27.01, J Descloitres

LCLUC is a research element of NASA's Earth Science Enterprise (ESE) which is studying the earth as an integrated system.

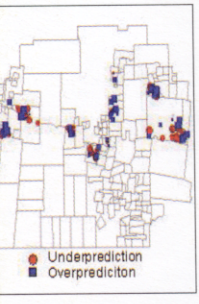
Land Cover Land Use Change






*Diagnostic Models of the Inter-annual Dynamics of Deforestation in Southeast Asia.* D. Skole, MSU

**Regional Forest Cover Change for Southeast Asia** was developed using time series of Landsat data. Landsat imagery and diagnostic models of the deforestation process were used to quantify the significant socio-economic drivers. It was determined that the area of deforestation in Northern Thailand increased by 36% from 1980–90 and decreased in the 90s. Agricultural expansion is the main driver of deforestation in the region.




*conometric modeling of eforestation, Southern ucatan Peninsular Region.* . Turner II, et. al., Clark niv.

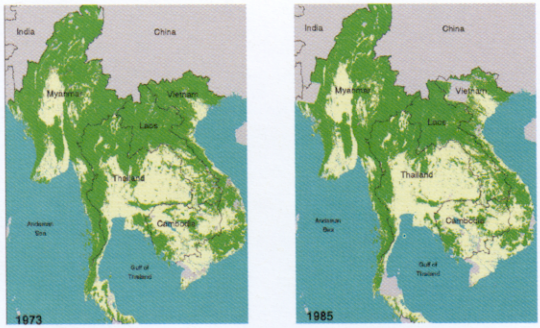
**LCLUC Processes in Mexico** were scaled from household to regional scale. LCLUC techniques were developed linking *in-situ* data collection (household surveys, individual plot mapping) to remote sensing data by econometric analysis and GIS validation for enhanced classification. Developed level of classification detail required for modeling and predicting land-use/land cover changes in the region.

**Responses and Consequences of Land Use** were determined for the Yaqui Valley, Mexico. Remote sensing data were used to evaluate off-site consequences of agricultural intensification. In the past 30 years, irrigated land area expanded by 6%. Winter wheat yields increased significantly due in part to subsidized increases in fertilizer use. This intensification altered coastal ecosystems by the transfer of nitrogen from the irrigated valley.

*Terra ASTER image showing intensive agriculture sandwiched between coastal ecosystems and the Sea of Cortez to the left and inland desert ecosystems to the right.* P Matson, Stanford

## Satellite Remote Sensing and LCLUC

**Satellite data provide** an important source of information for characterizing and monitoring land cover and land use change. In some regions it is the only feasible way to provide timely and reliable assessments. NASA satellite systems supplement operational satellites providing systematic measurements to study long-term trends. Measurements of limited duration are needed to better understand processes and experimental measurements to test new technologies. In-situ data collection is needed for product validation and to quantify those characteristics unobservable from space. NASA currently has a variety of sensing systems that meet the needs of the LCLUC program. NASA has also been exploring partnerships with industry for the commercial provision of data to meet the needs of its science community.

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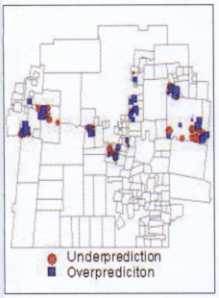


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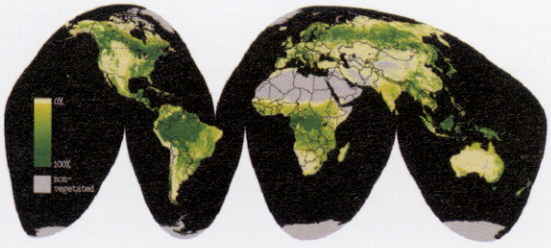
*Shenzhen, China. Landsat 1988 and 1996.* R. Kaufmann, et. al., BU

**Rapid Land Use Change Monitored in China.** Developed a process incorporating satellite imagery and socioeconomic data to quantify land conversion rates and model land use change. The amount of urban land in the Pearl River Delta tripled between 1988 and 1996. Most new urban land converted from agriculture.




*% tree cover derived from 1992–93 1km AVHRR.* R. Defries, UMd.

**Global Land Cover** characterization methods and map developed depicting continuous fields of vegetation properties to improve representation of land cover heterogeneity. This product is being used in terrestrial carbon cycle models to obtain more consistent and reliable estimates of carbon stocks and net primary production.

*IKONOS, Jiparana, Space Imaging L.P. (NASA's Scientific Data Purchase)*

## Systematic Measurements for LCLUC

**High Resolution** The Landsat series started in 1972 and provides a long term high-resolution data record for monitoring land cover change. Through its high quality data, a global acquisition strategy and an open data policy, *Landsat 7* has provided a major advance for land cover characterization. LCLUC requires continuation of all these aspects of the Landsat program. The *Landsat Data Continuity Mission* (LDCM) is being designed to continue the data record with LCLUC as one of the main science drivers.

**Moderate Resolution** The MODIS instrument on the TERRA platform is providing daily global data and derived products on land cover, Leaf Area Index, fire, snow cover, and albedo. This instrument extends the twenty year data record of the AVHRR, providing improved capabilities and a testbed for the next generation of operational imagers which will be started with NASA's NPP VIIRS in 2005.

## Experimental Measurements for LCLUC

**ASTER** (Advanced Spaceborne Thermal Emission & Reflection Radiometer) a joint NASA/METI mission on the TERRA platform is providing new high resolution thermal data sets.

**MISR** (Multiangle Imaging SpectroRadiometer) on the TERRA platform is providing multiangle measurements to characterize the directional properties of the land surface and the atmosphere.

**ALI** (Advanced Land Imager) and Hyperion are on board the **EO1** (Earth Observer One), which is a NASA Pathfinder Mission. Hyperion is currently providing the high resolution spaceborne hyperspectral data.

**IKONOS**, a hyperspatial resolution sensor, (1–4m resolution) is useful for identifying land use and scaling up from field data. NASA is making these data available through its Scientific Data Purchase Project.

**VCL** (Vegetation Canopy Lidar) is currently being developed to provide information on vegetation structure.

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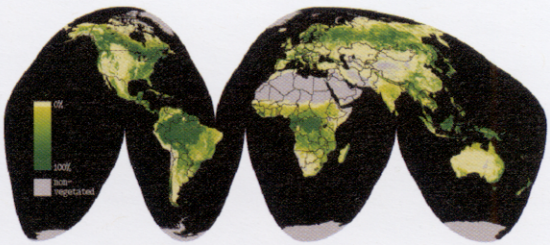


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# LCLUC and the Global Observation of Forest Cover (GOFC) Program

**Repeated inventories of** land cover are essential for LCLUC science and understanding the land use term within the Carbon Cycle. Undertaking repeated global inventories from space requires the active involvement of operational agencies in the collection and analysis of satellite data. The GOFC Program, which is part of the Global Terrestrial Observing System (GTOS), has as one of its major goals, improvement of the availability and flow of data to operational users. The LCLUC program is contributing to GOFC through research activities developing new techniques and methods for spaceborne monitoring of land cover and land use change and improving data flows to operational users. A number of LCLUC research projects are collaborating with GOFC regional science networks in regional case studies of land cover change in Central and Southern Africa, Southeast Asia, South America, and Russia.

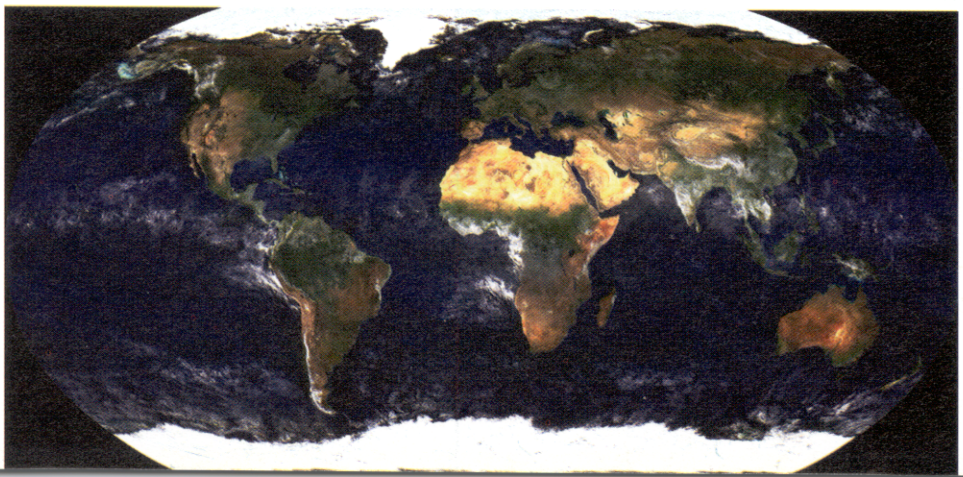
PHOTO: A. SOJA

*Modeling Siberian Boreal Forest Land—Cover Change and Carbon Under Changing Economic Paradigms,*
K. Bergen, U. Michigan

# LCLUC and Data Management

**The unprecedented volumes** of data being generated by NASA satellites require innovative approaches to data management and analysis. New technologies using the internet are being developed and applied to provide easy access to researchers and users of NASA satellite data and information on land use and land cover. New methods are being developed for archiving and distributing data and desktop data analysis and management. All LCLUC investigators are encouraged to provide both their results and data for broad use. Land cover and land use data sets are being made available from the NASA Distributed Active Archive Centers (DAAC's) and Earth Science Information Partners (ESIPS). ESIPS on the web at *http://www.esipfed.org*

*MODIS Surface Reflectance.* E. Vermote/N. El Saleous



# Science Themes

**With an emphasis** on the use of satellite remote sensing, the LCLUC Program combines physical and social science to study the current distributions of land cover and land use, to understand how patterns of land use and land cover have changed, how they will change in the future and the implications of these changes; for example, by impacts on biogeochemical and hydrological cycles, human livelihood and resource management.

**Process Studies** To understand how land cover will change in the future and to be able to better manage land use, it is important to understand the drivers of change. These include the local and proximate physical, socioeconomic and demographic causes of change, as well as the broader global and regional climatic or macroeconomic forces of change. Quantifying processes is undertaken by a series of regional and local case studies.

**Understanding Consequences and Impacts** The consequences of land use change can be biophysical and socio-economic. Changes in forest cover can affect carbon sources and sinks, local water resources and biodiversity through landscape fragmentation. Overuse of marginal lands leads to degradation and impoverishment affecting human livelihood. Agricultural intensification through the use of fertilizer can affect water quality. Changes in land use can affect human health by changing insect habitat or disease vectors. Agricultural abandonment can lead to changes in land cover. Urban expansion and suburban development can result in a loss of agricultural land or wetlands.

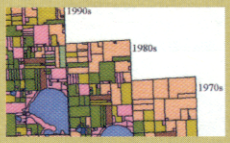
**Modeling Responses and Feedbacks** Modeling of land use change provides a means to understand the consequences of different land management options. Recent trends in land use change and an understanding of the processes of change provide a point of departure for predictive modeling. Coupled land use and dynamic vegetation models are needed to understand the impacts of land management on carbon budgets. Understanding the impacts of land use change on climate and the impacts of climate change on land use will need improved spatially explicit modeling.

**LCLUC Key Science Questions**

- Where are land cover and land use changing, what is the extent and over what time scale?
- What are the causes and what are the consequences of LCLUC?
- What are the projected changes of LCLUC and their potential impacts?
- What are the impacts of climate variability and changes on LCLUC and what is the potential feedback?

**Techniques and Method Development** The program supports the research and development of new algorithms, methods and techniques for characterizing, monitoring and modeling land cover and land use change and validating derived products. This includes developing new procedures for land cover classification and change detection, combining remote sensing and GIS and improved land use modeling. Development of techniques for data management and analysis are needed to handle the large volumes of data needed for global and regional monitoring and analyses. Global and regional data sets of land cover characteristics developed within this program support the modeling activities and provide the long-term data records needed to study trends.

# LCLUC and Societal Relevance

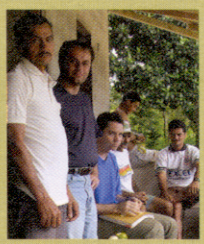



*Grand Traverse County, MI. Transition out of agriculture (beige) to forest (green) and residential (pink).* D. Brown, Univ. Michigan

**Land use change** is one of the most pervasive and visible forms of environmental change. Made by people, usually for economic reasons, land use changes can have a positive or negative impact on human livelihood. Societal impacts occur at the local level, for example through changes in water availability or air quality. Such local changes compound to raise serious concerns about land use change and biodiversity loss at the global scale. A scientific understanding of the process and impacts of different land use decisions provides an underpinning for improved land management and decision-making over a range of scales. Integrated assessments provide a means to model the linkages between land use and climate to better determine potential societal impacts of land use change.

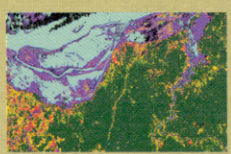
Spatial patterns of regional land cover change and the socioeconomic drivers of land use change were observed and modeled on a decadal scale for Grand Traverse County, Michigan. Abandonment of agricultural activities has been an important driver of forest regrowth in the Upper Midwest. Forest cover has increased as agricultural land is converted to recreational, conservation, residential uses. (D. Brown, Univ. Michigan)

# LCLUC and Intensive Field Campaigns



*Field team interviewing farmers.*

NASA has supported a number of Intensive Field Campaigns (IFC's) to provide a better understanding of regional scale processes. These campaigns commonly involve a combination of satellite, airborne and ground measurements. The LCLUC program has supported research as part of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) to understand the process of tropical deforestation, the fate of deforested land and impacts of land use change on biogeochemistry and hydrology. LCLUC has also contributed to a recent IFC in Southern Africa (SAFARI) addressing land use change and the impact of fire on atmospheric chemistry and nutrient cycling. SAFARI also provides a testing ground for new land cover related products being generated by NASA's Earth Observing System (EOS).



*Landsat time series of Santarem area.* E. Moran, U. of Indiana

Human dimensions of LCLUC in Amazonia is a project that integrates analysis of Landsat time-series images with interviews with individuals on their land use to create detailed sets of physical and socioeconomic variables that affect decisions people make about their use of the land. (E. Moran, Univ. Indiana)

A land use project in Ecuador linking decisions made on farms (50 hectares) and remote sensing found that decisions regarding deforestation and agricultural intensification are influenced by geographic access to roads and market towns. (R. Bilsborrow, UNC)

# LCLUC Program Partnerships

**LCLUC research provides** a unique human dimension component within the NASA science program and has common interests with other parts of the NASA program. The LCLUC program has developed close partnerships with the NASA Terrestrial Ecology and Surface Hydrology programs, particularly in the areas of land use change and the carbon cycle.

On the Seward Peninsula in Alaska, remote sensing is being used to evaluate potential influences of climate change on historical vegetation dynamics and the implications for carbon budgets of North America. Pink and blue regions of the image depict shrub advancement (approx. 100m.) in valleys north of the Bendeleben Mountains during the last two decades. (A.D. McGuire, U. Alaska)

*Change vector analysis overlaid on infrared aerial photograph indicating shrub advancement.*

### LCLUC Program Goals

- To develop the capability to perform repeated global inventories of land-use and land-cover from space.
- To develop the scientific understanding and models necessary to simulate the processes taking place.
- To evaluate the consequences of observed and predicted changes.
- To further the understanding of the consequences of land-use and land-cover changes on environmental goods and services, the carbon and water cycles and the management of natural resources.
- To improve understanding of human interaction with the environment, and thus provide a scientific foundation for sustainability, vulnerability and resilience of land systems and their use.

A partnership has been developed with the NASA Applications program transferring scientific findings to the resource management community and transferring testbed methods to the operational domain. The LCLUC program has benefited the NASA graduate fellowship and new investigator programs which support young scienctists to undertake LCLUC related research. The LCLUC program is playing an active role in the US Global Change Research Program (USGCRP) working in concert with other agencies, e.g. USDA, USGS and EPA, to address critical land use questions.

NASA has developed a longterm relationship with the international IDHP/IGBP Land Use and Cover Change (LUCC) program. Scientists from the NASA program are active members of the LUCC program and a number of LCLUC projects have been endorsed by the LUCC program. NASA has also been working with the SysTem for Analysis, Research and Training (START) program to help involve developing country scientists with the regional research activities.

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LCLUC Website *http://lcluc.gsfc.nasa.gov*

ESE Website *http://www.earth.nasa.gov*