



NASA Land Cover and Land Use Change (LCLUC) Program

Land Cover and Land Use Change and Global Change

- **LCLUC is the most immediate and visible form of environmental change**
- **Little has been developed in terms of the underpinning science of LCLUC, understanding the processes, impacts of LCLUC and predicting LCLUC**
- **LCLUC will continue to be important for the foreseeable future, driven by the demand for land, world population growth, the need for an increased food supply and wood products and socio economic forces**
- **LCLUC plays an important role in the global carbon cycle**
- **LCLUC contributes to climate change e.g. source of greenhouse gases**
- **LC and LU are impacted by climate change - effect of interannual, decadal and centennial climate variability and trends on land cover and land use**
- **LC and LUC can have an impact on the provision of ecological goods and services e.g. food supply, water quality, biodiversity**



NASA Land Cover and Land Use Change



- LCLUC is an interdisciplinary scientific theme within NASA's Earth Science Enterprise (ESE). The ultimate vision of this program is 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, and evaluate the consequences of observed and predicted changes.*** The underlying philosophy of the ESE LCLUC Program is to further the understanding of the consequences of land-use and land-cover changes for continued provision of ecological goods and services.
- <http://lcluc.gecp.virginia.edu/>

Rationale for the NASA Land Cover Land Use Research Program

- Land use change contributes to climate change
- Land use change is impacted by climate change and variability
- The process of land use change is driven by physical and socioeconomic drivers
- Satellite data can be used to quantify the pattern of land cover change and contribute to an understanding of the processes

Selected Policy Dimensions of Land Cover and Land Use Change

Scientific underpinning to provide policy relevant information on :

- Carbon Sources and Land Use
- Carbon Sinks and Land Use
- Habitat Loss and Fragmentation
- Food Production and Distribution
- Management of Ecosystems for Goods and Services
- water supply and quality
- Human Health

Example of LCLUC Policy Relevance: Carbon Sources, Sinks and Land Use

- **Carbon Sources**
 - Land-use change in tropics roughly 20-30% of total anthropogenic flux to atmosphere
 - Non-Annex I countries have no formal commitments under Kyoto Protocol
 - What are appropriate incentives to reduce this flux without adverse impacts on local livelihoods?
- **Carbon Sinks**
 - Roughly 1-2 GtC per year are taken up by terrestrial ecosystems in north temperate/boreal latitudes
 - Are there ways to maintain or enhance this sink?
 - Implications of Kyoto for land use - IPCC special report on Land Use
 - Can carbon offset or trading programs result in real gains and revenue streams for other policy goals, e.g. biodiversity conservation?

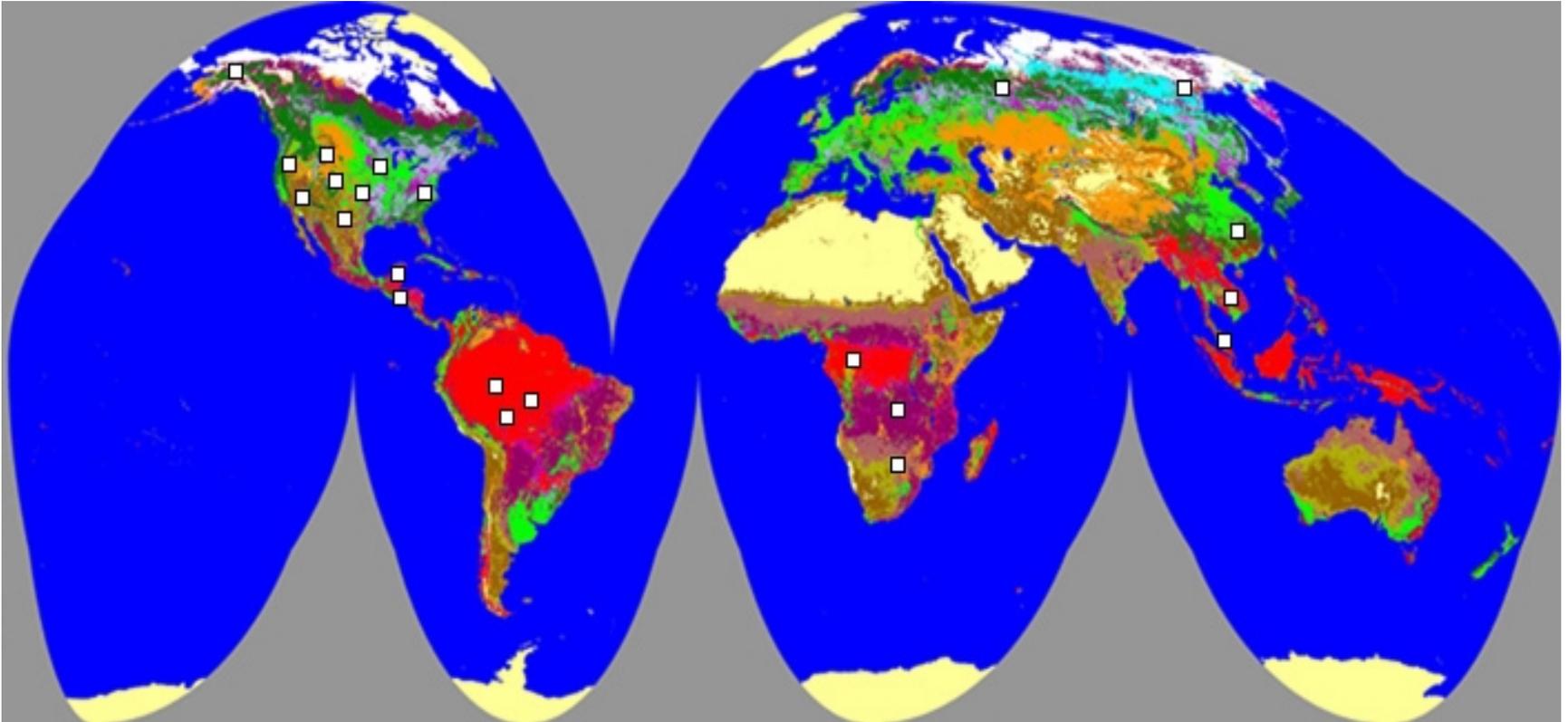


NASA LCLUC Program Components

- **Forcing Factors**
 - **Climate and Ecological Drivers**
 - **Socioeconomic Drivers**
- **Responses and Consequences**
 - **Land cover conversion, abandonment**
 - **Land use intensification**
 - **Land degradation**
 - **Landscape fragmentation**
- **Modeling and Implications**
 - **LCLUC modeling**
 - **coupled modeling of biogeochemistry e.g. carbon**
 - **modeling land atmosphere interactions**
- **Technique Development**
 - **Remote Sensing R and D**
 - **In-situ data collection - surveys / validation / process studies**
 - **Data Management**
- **Satellite Observations**
 - **Long -term measurements**
 - Landsat series
 - AVHRR.>MODIS>NPP>VIIRS
 - **Experimental missions**
 - EO-1 - hyperspectral
 - Vegetation Canopy Lidar (VCL)
 - Vegetation Recovery Mission
 - **Commercial Data Buy**
 - Ikonos - hyperspatial
 - Geocorrected Global Landsat Database



NASA LCLUC case study locations



*** 22 research projects, combining satellite remote sensing, physical and social science**

Summary of Achievements

- **Process Case Studies**
 - 22 regional process studies combining satellite data, physical and social science - understanding causes and impacts of land cover change
- **Science Data Sets**
 - global land cover (1km) mapping and validation (AVHRR)
 - regional deforestation maps tropic (Landsat)
 - regional microwave land cover data sets for tropical regions (JERS)
 - CD's of regional land cover data sets - southeast Asia, southern Africa
- **Technique Development**
 - land cover classification and characterization / change detection
 - fusion of social and physical science / LCLUC modeling
- **Model intercomparison**
 - VEMAP contribution to the national assessment
- **Outreach Initiatives**
 - World Fire Monitoring Web Site (OSTP)
 - Global % Tree Cover Poster (OSTP)
 - LCLUC WEB Site

Program Linkages

(LCLUC initially envisioned as an ESE cross cutting theme)

- **Internal Program Linkages**
 - **Ecology / Biogeochemistry - Disturbance / LBA**
 - **Applications Program**
 - **NASA / NGO Biodiversity**
 - **Contribution to Regional Field Programs - LBA / SAFARI-2000**
 - **Validation Program**
 - Global 1km Land Cover Validation
 - EOS Validation - land cover, % tree cover, fire,
 - **Data Systems**
 - ESIPS e.g. Land Cover (UMd) / Rainforest Report Card (MSU)
- **External Program Linkages**
 - **National Assessment**
 - **USGCRP Carbon Initiative**
 - **USAID - CARPE**
 - **CEOS - GOFC and CEOS -Validation**
 - **IGBP/IHDP LUCC**
 - **GTOS - NPP**

USGCRP - New Carbon Cycle Initiative

- **Land use currently has been given a relatively minor emphasis to date compared to atmosphere and ocean science**
- **Proposed Research Areas concerned with Land Use**
 - **Effect of past and current land use changes on carbon storage**
 - **Inventory and long term monitoring of carbon stocks**
 - **Quantify spatial and temporal distribution of sources and sinks on a regional scale and understand processes that control distribution**
 - **Understand land management factors that regulate net sequestration of anthropogenic CO₂**
 - **Lifetime, sustainability and variability of sources and sinks of CO₂**
- **Agency roles and specific contributions in the area of land use research have yet to be determined - e.g. USDA, USFS, USGS, NASA, NSF-Human Dimensions**

NASA Satellite Missions for LCLUC Science

- **Systematic Measurements**

- MODIS (land cover, land cover change, fire and burn scars)
- Landsat 7 (quantifying land cover extent and rates of change)
- Ikonos - commercial data buy (land use characterization, validation)
- Landsat Follow-On (monitoring land cover change)
- NPP-VIIRS(monitoring land cover, land characterization, fire)

- **Experimental Missions**

- EO1 (hyperspectral cover characterization, vegetation composition)
- VCL (vegetation structure and biomass, carbon studies)
- Vegetation recovery (vegetation regrowth, carbon studies)
- LightSAR (vegetation structure, biomass mapping)

Current and Future Directions for LCLUC

- **Satellite based process studies on causes and impacts of land cover change - blending physical and social science - developing predictive capabilities.**
- **Land cover - land use component of the Carbon Cycle - contributing to the emerging USGCRP Carbon initiative**
 - **CEOS GOF C - operational data for LCLUC Carbon research**
 - **LCLUC disturbance initiative**
 - **Integrating satellite based LCLUC data into regional and global models**
 - **Incorporating satellite data in science assessments (national /regional)**
- **Developing new methods and techniques for satellite land cover characterization using existing systems AVHRR/ Landsat/ JERS.**
- **Preparation for new land cover related satellite missions Terra / EO1 / VCL / Lightsar / Landsat follow-on / Transition of NPP into NPOESS.**
- **Highlighting and demonstrating policy relevance of LCLUC science re.-biogeochemistry - carbon cycle, land atmosphere interactions, water and food supply, human health, biodiversity.**
- **Science underpinning to sustainability questions.**

Global Fire Monitoring Web Site

Chris Justice, University of Virginia / David Herring, Goddard Space Flight Center



GLOBAL FIRE MONITORING
SCIENCE • SYSTEMS • REGIONS • RESEARCH • EOS • INITIATIVES • LINKS

Roughly 175 million acres of forest and grassland are burned each year world-wide.¹



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[acronym](#) NEW!

The average surface temperature of the globe has increased over the last 100 years by almost one degree celsius. Increases in greenhouse-gas concentrations appear to be at least partially responsible for the warming trend. Due to large-scale deforestation activities, grassland fires and naturally occurring wildfires around the world, biomass burning is a major source of greenhouse gases and aerosols. While the increase in temperature may seem insignificant, the uncertainty in the emissions from the burning process is a major concern. These emission products impact atmospheric chemistry, cloud properties and the Earth's radiant energy budget (heat and sunlight) in ways that influence climate on a regional and global scale.^{2,3}

Fire has always been and continues to be an integral part of land use and culture around the World. Greater emphasis is being placed on obtaining more accurate assessments of emissions from biomass burning. Remote sensing of fires, smoke and even burn scars allows for improved detection of fire characteristics as well as their short and long-term effects on ecosystems.

New Images



Fires in Florida
Spring 1999 NEW!



Fires in Canada
May 1999 NEW!



Fires in Mexico
May 1999 NEW!



Fires in Russia
May 1999 NEW!

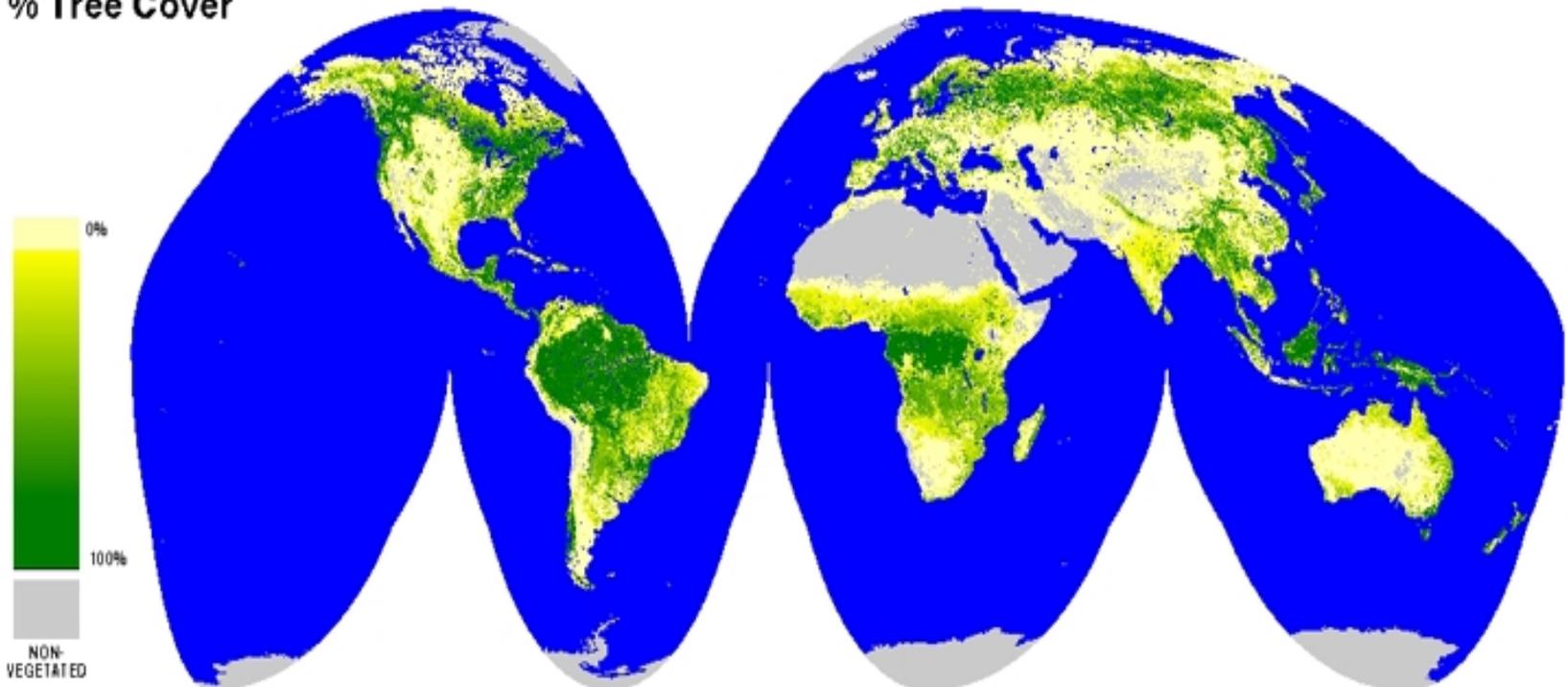


**Global AVHRR
Vegetation
Fires**

Global Percentage Tree Cover Product derived from AVHRR data

John Townshend / Ruth Defries, University of Maryland

% Tree Cover



A prototype data set estimating percent tree cover from 10 to 40 percent based on satellite data acquired by the Advanced Very High Resolution Radiometer in 1992-95. Percent tree cover is likely to be underestimated in areas with significant cloud cover throughout the year. The spatial resolution of 1 km precludes the detection of finer forest fragments. Future satellites with higher spatial resolution will improve detection of forest patches as well as areas undergoing land cover change. Note that this is an equal area map projection and hence tree cover in high latitudes appears less extensive than in conventional maps.