Evolution and Priorities for NASA Land Cover and Land Use Change Program

NASA LCLUC Science Team Meeting
15th Anniversary
University of Maryland
28 March 2011

Anthony C. Janetos, Director
Joint Global Change Research Institute
Former Program Manager: NASA LCLUC Program
Critical Issues

- How does our scientific understanding inform decision-making in a wide variety of domains?
- We are now the dominant force affecting many environmental conditions – land-cover, air quality, and increasingly, the climate system itself.
- So it is critically important to understand how human decisions and resource use interact with natural processes to shape landscapes and the Earth system itself.
The State of the Near Future Defines Important Scientific Issues

► A planet with 6.5 billion people headed towards 9 or 10 billion in the next several decades
► Most of those new people will be in the developing world
► Food demand will approximately double, and energy demand likely to roughly triple in the same time period, as people seek to raise standards of living
► Implications for water, habitat, natural ecosystems
► And the physical climate system is also changing, and impacts of that are being felt more rapidly than we had originally thought
► Enormous challenges for long-term sustainability
My Four Principles about Interdisciplinary Science and the Environment

- We should study the world we have, not the world we wished or imagine we have.
- Science should be interesting AND useful.
- There is no bright line between “basic” or “fundamental” and “applied” research.
- All the really interesting, important, and challenging problems in the environment are intrinsically interdisciplinary.
Evolving Over 15 Years

- Review the original goals and structure of the program
- Did we succeed?
- What challenges remain from the original set?
- What new challenges have emerged that should be pursued?
Where my history starts
The View from 1999
Land-Cover and Land-Use Change: Program Vision

- Capability to perform repeated global inventories from space
- Evaluate consequences of observed change
Land-Cover and Land-Use Change: Program Goals

► Land-cover conversion
  ▪ Identify current distribution of land-cover types
  ▪ Track conversion to other land-cover types
  ▪ Primary interest in conversion of forest ecosystems to other types

► Land-use intensification
  ▪ Understand consequences of intensified management of agricultural and agroforestry systems in tropics and sub-tropics
  ▪ Measure the long-term in situ degradation of forest ecosystems
Land-Cover and Land-Use Change: Program Goals

▶ Verification
- Understand consequences of international agreements
- Investigate forestry and agriculture in temperate and boreal climates

▶ Modeling
- Develop techniques to incorporate actual land-cover
Interactions of Land-Cover/Land-Use Change

Economic Drivers

Land-Use/Land-Cover Change
Conversion Intensification

Agricultural, Forestry
Other Goods and Services
to Humans

Biogeochemical Changes

Ecosystem Function

Biophysical Changes

Gas Fluxes to/from Atmosphere

Export to Oceans

Water/CO2 Fluxes to/from Atmosphere

Overland Water Flow
Erosion
Soil Stability

Carbonaceous Aerosols & Direct Gas Emissions

Climate Drivers

Fig. 1
Satellite Studies & Assessments

Current Activities (AVHRR/Landsat)
- 8 km LandCover
- 1 km LandCover
- FASIR NDVI

Land-Use/Land-Cover Status and Changes
- NALC
- HTF: SA SE Asia Africa
- GLCTS
- LS Pathfinder

Assessments for Carbon/Trace Gases from LC Change

Assessments for Land Surface Parameters
- Case Studies for Characterization & Processes
  - ERS-1/2 SIRC
  - Lewis HSR/ASTER & Clark

Periodic Assessments for Land Surface Condition and Change
- Possible High Spectral Resolution Mission
- Possible SAR Mission

Integrated Products
- EOS AM-1/Landsat 7 Era
  - MODIS MISR
  - Indices & Landcover Experimental Integration
  - Landsat 7 Periodic Refresh
  - Indices & Change

EOS/Landsat Follow-Ons
- EOS/Landsat Follow-Ons
Land-Cover/Land-Use Change: Field Studies & Campaigns

Amazonia/South America
- Case Studies
- Process Projects
- In Situ Transects
- Biomass Burning Emissions

Southeast Asia
- HTF Validation
- GLCTS Site Characterization

Africa
- Biomass Burning Emissions
- Process Projects

Russia (Siberia)
- Fire Studies

Current Activities → EOS AM-1 Era → EOS Future Era

LBA Integrated Field Campaigns
- Ecology
- Hydrometeorology
- Atmospheric Chemistry

Periodic Monitoring

Integrated Field Campaigns
Deforestation rates for Brazilian Amazon quantified for late 1970’s-1980’s

Estimates of regrowth in Amazon as high as 30% of the area

Satellite observations of distribution and frequency of fires in southern African savannas

Increases in boreal fire frequencies could potentially contribute another 0.3-0.8 GtC/yr to the atmosphere as a consequence of increased greenhouse warming
Land-Cover and Land-Use Change: A View Ahead

► Premier example of interdisciplinary study of land-use in the USGCRP
► Important contributor to US National Assessment of Potential Consequences of Climate Variability and Change
► Important contributor to international scientific assessments related to land-cover and land-use
► Must now incorporate new measurement and modeling capabilities
► Must now become major contributor to policy-relevant issues internationally and domestically
Did We Succeed?

- Premier example of interdisciplinary study of land-use in the USGCRP
  - Yes, no question about it
- Important contributor to US National Assessment of Potential Consequences of Climate Variability and Change
  - One of many programs
- Important contributor to international scientific assessments related to land-cover and land-use
  - Yes, through contributions in the broader literature and also through the MA and IPCC
- Must now incorporate new measurement and modeling capabilities
  - Continually…
- Must now become major contributor to policy-relevant issues internationally and domestically
  - Partially…
So What is Next?

- Enhancing operational capabilities
- Synthesis of individual case studies for broader perspective
- Land science at the interfaces
- Towards prospective, process-based modeling of land-use
Possibilities for Advancement

- The first bullet is really the province of GEO, GOFC-GOLD, National and International Space Agencies, etc.
- The second is an outgrowth of various scientific assessment and synthesis processes, e.g. the synthesis phase of IGBP
- The others are at the cutting edge of what we are capable of in research, and here is where I think we can make significant progress in the coming years
Interface with Human Needs and Ecosystem Services

- **Economic Drivers**
- **Land-Use/Land-Cover Change**
  - Conversion
  - Intensification
- **Environmental Drivers**
  - Overland Water Flow
  - Erosion
  - Soil Stability
- **Agricultural, Forestry Other Goods and Services to Humans**
- **Ecosystem Function**
- **Biogeochemical Changes**
- **Biophysical Changes**
  - Gas Fluxes to/from Atmosphere
  - Water/CO2 Fluxes to/from Atmosphere
- **Climate Drivers**
  - Carbonaceous Aerosols
  - Direct Gas Emissions

Export to Oceans
Interface with a Changing Climate System

Fig. 1

- Economic Drivers
- Agricultural, Forestry Other Goods and Services to Humans
- Biogeochemical Changes
- Gas Fluxes to/from Atmosphere
- Water/CO2 Fluxes to/from Atmosphere

- Land-Use/Land-Cover Change Conversion Intensification
- Ecosystem Function

- Biophysical Changes
- Overland Water Flow Erosion Soil Stability
- Export to Oceans

- Climate Drivers
- Carbonaceous Aerosols & Direct Gas Emissions
What Could be Done?

- Need to interact with modeling communities which already simulate changing human demands for agricultural productivity, energy, and water.
- Begin to adapt those models to deal with other human factors affecting land-use.
- Confront those models with observational data on land-cover and land-use.
- Experiment with modeling interactions with the physical climate system.
- Explore alternative futures in a way that illustrates the joint effects of meeting societal demands, sustaining ecosystem services, and interacting with a changing climate system.
- Understand the consequences of those potential futures from the standpoint of adaptive capacity and vulnerability – these are very different worlds from today.
Could We Be Successful?

- There are many reasons to think we can
- Collaborations are beginning to emerge
Agriculture, Land-use and Energy in GCAM
The Land Use Implications of Stabilizing at 450 ppm When Terrestrial Carbon is Valued

450 ppm Stabilization Scenario When Terrestrial Carbon is NOT Valued (FFICT)

450 ppm Stabilization Scenario When ALL Carbon is Valued (UCT)
Develop down-scaling algorithms for land cover

Thomson et al., 2010 *PNAS*
Integrated modeling biofuels and feedbacks

Objectives of iESM team:

• Investigate biofuel sustainability under future climate change.
• Study feedbacks from climate and CO$_2$ to the energy markets (phases 2 and 3)
• Quantify irrigation demand/costs for biofuels and energy markets.
Conclusion

- Even though early efforts are still experimental, have the capability to expand to other forcing factors
- Observational record for land-cover is good, but of course its sustainability must be secured
- Starting to think about what a similar record for land-use would look like
- We should be optimistic
- NASA LCLUC Program can and should still be one of the places where really new ideas and approaches are incubated and tested