Advances in Measuring and Monitoring Carbon and other Ecosystem Services

Beyond Carbon - Emerging Markets for Ecosystem Services
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Sandra Brown
Winrock International
sbrown@winrock.org
Measuring and Monitoring

- For market confidence, need accurate and precise estimates of the “commodity”
  - Projects must make a difference
    - Baselines for all ecosystem services
  - Need minimum set of standards
  - Techniques must be cost efficient
  - Easily understandable and transparent
  - Verifiable
Topics

- Approach for identifying where to locate projects and how to develop baselines
- Aerial digital imagery for measuring carbon
- Aerial digital imagery for change detection and monitoring of carbon and other ecosystem services
Baselines

- A baseline has two components:
  - a projection of changes in land use through time
  - the corresponding changes in carbon stocks

- These two components can be treated separately
Location of project areas

- Calakmul, Mexico
- Noel Kempff Mercado National Park, Bolivia
- Guaraquecaba, Brazil
- Rio Bravo Conservation and Management Area, Belize
Spatial modeling approach (GEOMOD)

Maps of potential “drivers” of land-use change

Calibration Procedure

Extrapolation Procedure

Validation Procedure

Kappa statistic

Time 1

Time 2

Factor 1
Factor 2
Factor 3
Factor 4

PLUC map

Agriculture
Forest
River

Predicted T2 Landuse Map

Predicted time 2

Extrapolation Procedure

Validation Procedure

Kappa statistic

Maps of potential “drivers” of land-use change
Baselines—way forward

- Develop spatially explicit baselines to incorporate factors that influence the way people use the land and other conservation and development goals
- Develop baseline at regional scales before start of project
- Recognize that baseline projections beyond a 10-year period are not likely to be realistic—rates of land-use change are subject to many factors which are difficult to predict over the long term
Implementation of spatial approach for baseline setting:

- **A three-step approach:**
  1. Use spatial model to develop the “potential land-use change map” rescaled to three levels of potentiality for change—high, medium, and low.
  2. Project land-use change over a 10-year period based on either:
     - Simple projection of past rates (past 5-10 year) determined from remote sensing, or...
     - A simple model of human population and deforestation

(https://www.winrock.org/what/ecosystem_pubs.cfm)
Example of a rescaled PLUC map

Campeche

Chiapas

Belize
Implementation of spatial approach for baseline setting:

3. Convert the PLUC map to a carbon baseline at the potential project site
   
   - Identify project area and measure its carbon using standard approaches (e.g., http://www.winrock.org/what/ecosystem_pubs.cfm)

   - Re-assess potentiality for land-use change and rates of change on a 10 yr cycles for updated baselines
Combine the projected rate of change with the project specific carbon stocks to generate a carbon baseline.
Multispectral 3D aerial digital imagery system

- Measuring and monitoring carbon
- Monitoring other ecosystem services
Multispectral 3D aerial digital imaging system

- Fits in a portable camera pod
- Will fit into commercial airline luggage
- Attaches to any Cessna in about an hour
The laser accurately measures a profile of crown height along each strip.
Noel Kempff Mercado National Park, Bolivia

This 3D approach provides new methods for studying and mapping forest canopies and individual trees.
Noel Kempff Mercado National Park, Bolivia

• These can be re-flown to monitor change in the forest on an individual tree level.
• Produces a virtual forest for later analyses
Application of M3DADI to measure carbon in forests

- **Two steps involved:**
  - Collect and analyze digital imagery of ecosystem
  - Collect and analyze ground data to use in combination with imagery
Flight paths for collecting M3DADI of the pine savanna in Belize
From M3DADI the following data are measured (in Stereo Analyst)

- **Trees**: crown areas and tree heights, by pines and broadleaf
- **Shrubs**: crown area and height class for all species combined
- **Palmettos**:
  - Thickets—aerial extent and average height class
  - Clumps (associated with pine woodlands)—crown area and height class
- **Grasses**: aerial extent by sparse and dense classes
Models of biomass carbon and measures of crown area and height by plant types based on field data

\[ r^2 = 0.94 \quad p < 0.0005 \]

Pine trees
Total biomass carbon is a function of pine tree crown area

\[ Y = 6.02 + 0.0055 \times X \]

\[ R^2 = 0.90 \]
Change Detection and Monitoring
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