Remote Sensing of Regenerating Vegetation
LBA-ECO
October, 2006
Plan for today’s meeting

1. Brief look at what’s been done
2. Resolve definitional issues
3. Identify gaps in research (geographical coverage, approaches, questions that remain unanswered)
4. Construct a plan of future work
Synthesis Products

a) Comprehensive review paper
   – Modeled on D. Lu’s RS of Biomass paper

b) Methodologically consistent multi-site estimates of extent and persistence of regenerating vegetation
   – Modeled on D. Zarin et al. biomass accumulation paper
Regenerating vegetation

- geographical extent
- rate of change
  - rate of agriculture abandonment
  - persistence

There are several studies that provide these types of estimates, but can we do it in a methodologically consistent way?
Remote sensing of regenerating vegetation: Sample of studies

- Mausel et al. 1993
- Li et al. 1994
- Moran et al. 1994
- Skole et al. 1994
- Foody and Curran, 1994
- Sant’Anna et al. 1995
- Alves and Skole, 1996
- Steininger, 1996
- Bohlman et al. 1998
- Kimes et al. 1999a
- Kimes et al. 1999b
- Steininger, 2000
- Nelson et al. 2000
- Salas PhD chapter 2000
- Lucas et al. 2000
- Lucas et al. 2002a
- Lucas et al. 2002b
- Roberts et al. 2002
- Alves et al. 2003
- Vieira et al. 2003
- Batistella et al. 2003
- Foody et al. 2003 (transferability of refl. biomass models)
- Lu et al. 2003
- Lu et al. 2004
- Perz and Skole, 2004
- Steininger 2004
- Hirsch et al. 2004
- Arroyo-Mora et al. 2005
- Freitas et al. 2005
- Ferraz et al. 2005
- Morton et al. 2006
- Broadbent et al. 2006 (selective logging recovery)
- Carreiras et al. 2006
Sample of studies

• Provide explicit **definition** of regenerating vegetation: 52% (17 of 33)
  – Common Definition: Secondary vegetation are those areas that have been abandoned and that have become re-vegetated after all or a significant portion of the original forest has been removed.

• Three basic types of studies:
  – Single date information extraction (19)
  – Time series of land cover transitions (7)
  – Regional mapping (3)
Sample of studies: Information extracted

- **Single Date Characterization** of regenerating vegetation:
  - Continuous Structure, such as biomass (7 of 19)
  - Discrete Stage, usually three stages (9 of 19)
  - Age (4 of 19)
  - Species or Regeneration Pathway (2 of 19)

- **Time series** of images
  - Land cover transitions (6 of 7)
  - Persistence of regenerating vegetation (2 of 7)
  - Patterns (e.g. proximity to highways) (4 of 7)
Sample of Studies: Extent and Persistence

- Basin wide estimates (~150,000 km$^2$?)
  - Lucas et al., (2000): 35.8% of cleared lands prior to 1992
    - Combines AVHRR analysis with INPE estimates of cleared lands
  - Fearnside (1996): 47%

- Regional variability
  - The amount of cleared land in second growth varies considerably
  - Moran et al. (1994): Western Altimira, 46% (1985), 82% (1991)
  - Skole et al. (1994): Rondonia, 30%
  - Roberts et al., (2002): Rondonia, 22%
  - Ballester et al. (2003): Jiparana Basin, ~ 11%

- Persistence
  - Rarely quantified, but probably varies regionally
Extent of regenerating vegetation

1996 MSU TRFIC (Skole)
Extent of regenerating vegetation

From 2006 Carreiras, et al.
Persistence of Regenerating Vegetation

From W.A.Salas, PhD Thesis. Averaged from three sites in Amazonia.
Preliminary survey results

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Respondent Key:

1. Ane Alencar & Ima Vieira
2. Diogenes Alves
3. Eduardo Brondizio
4. S. Hagen & W. Salas
5. Richard Lucas
6. Dar Roberts
7. Marc Steininger

IPAM
Instituto Nacional De Pesquisas Espaciais
Indiana University
University of New Hampshire, Applied Geosolutions, LLC
University of Wales, Aberystwyth
UC Santa Barbara
Conservation International
Study Locations

- Brondizio/Moran
- Lucas, Roberts, Steininger
- Vieira
- Alencar
- Hagen/Salas
- Roberts
- Steininger
- Hagen/Salas
- Roberts
- Alves
- Steininger
- Hagen/Salas
What is missing?

- Site level estimates of **persistence** (fluxes):
  - regenerating vegetation
  - pasture/agriculture

- Since gaps in annual time series of Landsat are common, estimation of **regeneration stage** is useful. Can we find a method that is **transferable** in space & time?

- Updated map of regenerating forest **extent** (pool).
Proposal

1. Consolidate image data from participating groups (3-10 geographic locations; time series)
   a) Geo-registered
   b) Radiometrically calibrated
   c) Atmospherically corrected (?)

2. Classify imagery
   a) Apply consistent methodology (mixture modeling or maximum likelihood)
   b) Include successional stages (?)

3. Identify persistence (rates of change) in stands of regenerating vegetation
Points of Discussion

• Definition of regenerating vegetation
• Successional stages
• Persistence (Time series of Landsat)
• Pasture/Regenerating confusion
• Regenerating/Mature confusion
• Common methodology
  – Mixture modeling vs. maximum likelihood
• Scaling up to Basin/Legal Amazon
  – Landsat (Asner) vs. MODIS (Carreira)
Definition of Regenerating Vegetation

- Swidden agriculture?
- Dirty pasture?
- Structurally complex regenerating forest?
Successional stages

- Two, three, or four stages?
- Spectral or structural information?
Successional Stages

Conceptual diagram relating biomass recovery (Bormann and Likens 1979) to forest structural stages (Oliver 1981) following disturbance.
Successional Stages

<table>
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<tr>
<th>Successional Stages</th>
<th>Visible Reflectance</th>
<th>NIR Reflectance</th>
<th>MIR Reflectance</th>
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<td>Pasture/crop areas*</td>
<td>High</td>
<td>Variable, &lt; SS1</td>
<td>High (dry soils)</td>
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<tr>
<td>SS1</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
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<tr>
<td>SS2</td>
<td>Moderate, higher green/red ratio</td>
<td>Moderate</td>
<td>Low-Moderate</td>
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<tr>
<td>SS3</td>
<td>Low, with higher green/red than SS1, SS2</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Mature Forest</td>
<td>Low</td>
<td>Lowest</td>
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Model transferability

• If we are to have a cross-site study, we need:
  – consistency in definitions and methods
  – methods that are less sensitive to atm. correction, seasonality, etc.
"young" (< 4 y.o.)
"medium"
"old" (> 10 y.o.)
Ariquemes, Rondonia  
(-9.95, -63.05)
Pasture
Old Forest
Secondary Forest
24 AUG 2003
20 MAY 2003

secondary or pasture?
The diagrams show reflectance data for different bands over time:

- **AUGUST**: Reflectance data for a similar time period.

The graphs plot reflectance values against different bands, including VIS (Visible), NIR (Near Infrared), SWIR1, and SWIR2, with distinct markers for each date.
Pasture
Old Forest
Secondary Forest
In sites that have burned repeatedly, the observed rates of secondary forest regrowth fall below expectations based on a previously validated empirical model that predicts growth from climate and soil properties. From Zarin et al. Front. Ecol. & Environ. 2005. 3:365-369.
Land cover classification
R-Green Veg.   G-Shade   B-Soil
Fraction of Green Vegetation
Fraction of Shade
Resources and Limitations

• Resources
  – processed Landsat scenes from >10 locations
  – ground truth data (class validation, structure)
  – knowledge base

• Limitations
  – limited time
  – limited funds