Remote sensing for forest degradation

Objectives

1. Provide a background of forest and carbon definitions as they relate to MRV
2. Define degradation
3. Provide examples of forest mapping and change detection
4. Frame issues and obstacles to assessing and monitoring forest degradation

Reduction +

Reduction
Emissions from
Deforestation and Forest Degradation
+ the role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks.

The top-level land categories for greenhouse gas (GHG) inventory reporting are:

(i) Forest land
(ii) Cropland
(iii) Grassland
(iv) Wetlands
(v) Settlements
(vi) Other land
**REDD Degradation**

“Lack of a universally agreed-upon definition of forest degradation will cause complications when REDD projects are implemented,”

Sasaki and Putz, in *Conservation Letters*

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**Degradation**

Incremental decline of forest structure and function over time, measured in terms of declining canopy cover, recovery rates from natural disturbances, species richness, and annual productivity, all compared to the same measures in natural mature (e.g., old-growth) forest stands of the same ecoregion. Chris Potter, NASA

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**What is a Tree to a Forester?**

The IPCC, UNFCCC, FAO and others all have their own definitions of a tree, something that has the potential to grow to somewhere between 6 and 15 feet (3-5 meters) tall and may or may not include planted rubber trees and oil palms.

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**What is a forest?**

The IPCC definition of a forest:

“All lands with woody vegetation consistent with thresholds used to define forest land in the national greenhouse gas inventory…”
What is a forest?

The Marrakesh Accords of 2002 definition of a forest:

A "Forest" is a minimum area of land of 0.05-1.0 hectares (0.1-2.5 acres) with tree crown cover... of more than 10-30 per cent with the potential to reach a minimum height of 2-5 metres (6.6-16.4 feet) at maturity in situ.

And...

A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10 – 30 per cent or tree height of 2 – 5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.

What is deforestation?

The UN Food and Agriculture Organization (FAO) defines deforestation as:

"The removal of tree cover to less than 10 percent."
Forest Mapping

1. Fractional Forest Cover – Continuous Fields
   - Advantage of allowing users to set their own thresholds

2. Forest Classifications
   - Problems with classification systems and cross-walking (translating) class names

Forest Change Detection

1. Post-Classification
   - Problem of map error propagation
   - Problems with classification systems and cross-walking (translating) class names

2. Direct Change Detection: Image
   - Difference, Image Ratio, Principal Component Analysis
   - Need to determine nature of change

In general, change detection is a function of the forest types, type and level of change and definition

Remote Sensing for Forest Degradation

1. Sampling
   - sampling
   - multi-sensor and/or aerial and in situ

2. Direct Mapping
   - wall-to-wall

3. Inferential
   - fragmentation, distance-to roads, population

4. Change detection

5. Vegetation stress/damage

Cambodia Landsat Mosaic
Scientific and operational challenges

- Optical data acquisition in the tropics
- Data integration: in situ, aerial and satellite; optical, radar and lidar
- Database management
- Accurately estimating forest cover, volume, biomass, and carbon stocks and flows
- Accuracy and precision requirements against costs and benefits
- Accuracy assessments and requirements for verification
- Time dependence

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THANK YOU!
Measuring global forest canopy reduction: A forest degradation proxy for FRA2015

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Senior Forestry Officer

Erik Lindquist
Forestry Officer

Today’s Presentation

• Degradation, more than carbon...
• Looking for a global proxy that takes a first global step
• FRA2015 remote sensing approach
• How this data will be used in FRA 2015

How many kinds of value-laden forest degradation are there?

• Many, many
• These fit into four general categories:
  – Lack of ability to sustain production
  – Reduction in biodiversity
  – Soil erosion
  – Carbon stocks
• Clearly what is one man’s degradation is another man’s sustainable forest management
• There is no single way to properly address each of these at the same time (at least not yet)

Looking for a proxy...

• We evaluated many approaches, including:
  – Do nothing, it is too difficult
  – Seek the perfect solution
  – Do something imperfect, recognizing it is a first step and will need refinement over time
    • This is what we chose
• We wanted a proxy that was above all of the general categories of degradation, but could be used by all
Looking for a proxy...

- A reduction in canopy area density was chosen because:
  - It relates to all categories of degradation
  - It can be measured, albeit crudely, from space
  - Countries can review and add improvements when they are available

The method

- Time-series MODIS 250m VCF from 2000 – 2011
- 2 main criteria
  - linear trend of time-series < -1
  - range between VCF crown cover in 2000 and 2011 > 20
- Can be further constrained by Intact Forest Landscapes and Wetlands databases
- MODIS canopy cover loss product (VCC)

The method

- 62 MODIS VCF annual phenologic metrics
  - For bands 1-7
    - Minimum reflectance
    - Eighth darkest reflectance
    - Mean 3 darkest reflectances
    - Mean 5 darkest reflectances
    - Mean 8 darkest reflectance
    - Reflectance at peak NDVI
  - Mean reflectance of values corresponding to 3 greenest composites
  - For NDVI:
    - Maximum NDVI
    - Eighth highest NDVI
    - Mean of minimum and 5th highest NDVI
    - Mean of 3 highest NDVI values
    - Mean of 5 highest NDVI values
    - Mean of 8 highest NDVI values

The method

- Tracking change at pixel scale using MODIS
- Deforestation
  - Unambiguous signal
  - Low VCF values (< 30) and
  - Constant
- Partial overstory removal
  - Ambiguous
  - High to low VCF values
  - Decreasing trend over time
Canopy reduction from MODIS

- Example of likely degradation resulting from nearly complete overstory removal in 2004
- If pixel detected as degraded meets definition of non-forest, will be labeled as deforestation and year

Mapping canopy reduction

- Canopy cover removal by year of first disturbance
- Masked with MODIS-derived forest cover loss

The method: Limitations

- Serve as an indicator... maybe not for precise area calculations
- Big pixels are limited by their nature and cannot detect all fine-scale changes
- Method depends on relatively large areas of change

Measures of confidence

As for other FRA 2015 variables we will use a tier classification approach:

- Tier 3: Direct, recent measurement including field observations
- Tier 2: MODIS methods as described or other remote sensing as documented
- Tier 1: Other
Summary

• Forest degradation is a value-laden minefield
• Global estimates from country-level analysis will by definition be approximations
• Pixel-scale tracking of a reasonable threshold of canopy loss over a 10 year period is promising with aggregations at country, regional, ecozone and global levels
Synthesis Workshop on Options for Monitoring Forest Degradation at Sub-National Levels in the Mekong

Jeffrey Himel, Managing Director, Aruna Technology Ltd.
Bangkok – 13 November 2012

Introduction

Context

- **Historical Development** – Sida, MRC, JICA, World Bank (FOMACOP, SUFORD), FIM, CliPAD, LEAF
- **Progressive Experience and Feedback Loop** – Continuity of advisors, leadership from Department of Forestry, careful consideration of issues
- **Coordination** – Informal REDD Task Force, donor cooperation, experience sharing

Objectives

- **Importance of Degradation** – Selective logging and rotational agriculture
- **Seasonal Change** – Looks like forest loss or degradation, variability by species and year
- **Time Frame** – Annual or Semi-Annual, scaling up ability to process information
Tools & Resources


- VHR Satellite Imagery, Aerial Photography, LIDAR and New Technologies – QuickBird, IKONOS, GeoEye, NGD, Pilot Testing of LIDAR, RADAR

- Software – (Pixels) ERDAS, ENVI, PCI, (Objects) eCognition, (GIS) ArcGIS

- Hardware – Garmin handheld GPS for Road Network and Field Survey, Forestry Tools

Comparison of GPS and 1:5,000 Surveyed Map
Implementation – Challenges

- **Data: Imagery** – ALOS AVNIR-2/PRISM Quality and Availability, SPOT5 Coverage and Cost, RapidEye Policy Changes = “Data-versity”

- **Data: Haze** – Critical issue to resolve access to data at key times, seasonality. ENVI and PCI only options, PCI more robust solution

The enhanced original image mosaic from several dates on left, and the same images after haze correction on the right (no enhancement)
**Implementation – Challenges**

- **Analysis: Consistency** – Amazing increase in amount and resolution of data available, but how to maintain quality over large areas with large number of relatively untrained staff?
- **Analysis: Information Management** – HUGE problem including file naming conventions and storage, backups, network speeds, documentation

**Implementation – Lessons**

- **Training** – Continuous and ongoing capacity development including HRM as well as HRD
- **Standards** – Development of appropriate and “do-able” standards, tools to assist that
- **Technical Assistance** – Will be needed for an indefinite period

**Processes**

- **Annual and Semi-Annual Coverage** – Enables current and post-facto analyses countrywide
- **Licensing** – Stop “stop-gap” or project-based approach and contribute to sector as a whole
- **National Participation** – Complicated and difficult issues but through engagement can observe improvement, buy-in and increased understanding

**Feasibility**

- **Training** – Will remain a constant requirement, but needs to be more effectively done
- **Cost** – RapidEye 5m coverage of ALL of Lao PDR at <10% cloud cover = 172,000 Euros = 0.73 Euro/km² **CHEAP!**
- **Coordination** – Staff continuity among donors and DOF has enabled, less waste of time and money
Next Steps

- **Action Plan** – CliPAD work in Xayabouli, CliPAD-LEAF work in Houaphan Provinces to build on previous work and focus on degradation.

Upland agriculture in change image – note new fields are yellow-green while old fields left fallow are purple-blue. 1:25,000 scale image.
The 2010/11 dry season image (top left) and 2011/12 dry season image are toggled to identify areas of change (indicated with black arrows). The aerial orthophoto is then observed in these locations (white arrows, lower left) and then individual tree canopies identified that appear to correspond to the missing canopy (lower right with yellow dots identifying individual trees).
Next Steps

Typical patterns seen in identification of tree targets. A main trail gets loggers to the area, with branch trails leading to rich stands where much of the harvesting occurs. Valuable trees along the trail on the way are also taken, for harvesting and to clear the path.

Next Steps

Comparison of study logging trails and tree stumps (yellow) with actual field survey GPS tracks (pink) and identified tree stumps (blue). The GPS tracks confirmed the location of logging trails, and tree stumps were found where individual tree targets had been identified from the image analysis.

Next Steps

Comparison of RIL area at different scales, some locations of change in vegetation marked with yellow arrows.

Next Steps

Comparison of identified tree targets from remote sensing analysis (yellow points) versus actual tree stumps found in field (light blue circles).
Next Steps

- **Capacity Building** – Difficult task now expanded to two ministries
- **Policy Reform** – Classification schema, reorganization of REDD sector

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Natural Forest</th>
<th>Plantation Forest</th>
<th>Classification</th>
<th>Management</th>
<th>Use</th>
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**Classification schema migration 1992 to 2010**

Field Survey Data on Plot Structure, Density, Species Linked to Remote Sensing Data

1. **Managed Use Forest** (not specified) FZ_101
2. **Managed Use Forest - general** FZ_102
3. **Managed Use Forest - for Bamboo** FZ_103
4. **Managed Use Forest - for Timber** FZ_104
5. **Managed Use Forest - for Livestock** FZ_105
6. **Private Managed Use Forest** FZ_106
7. **Protection/Conservation Forest** FZ_2
8. **Village Biodiversity Conservation Forest** FZ_201
9. **Village Watershed Protection Forest** FZ_301
10. **Riparian Protection Forest** FZ_302
11. **Other Protection Forest** FZ_4
12. **Other Protection Forest (not further specified) FZ_401
13. **Roadside Protection Forest** FZ_402
14. **Border Protection Forest** FZ_403

**Tree Plantation (industrial)** FPZ_5

- **Tree Plantation (not further specified)** FZ_501
- **Tree plantation: village/communal** FZ_502
- **Tree plantation: private** FZ_503

**Forest Management Zones**

1. **Heavy Vegetation**
   - Very Dense Forest (VD)
2. **Moderately Dense Forest**
   - Managed Use Forest - general (MD)
   - Village Managed Use Forest - for Timber (OF)
   - Village Managed Use Forest - for Livestock (SC)
3. **Low Vegetation**
   - Non-Vegetation Non-Forest (NON)

**Production/Use Forest**

1. **Managed Use Forest (not specified) FZ_101**
2. **Managed Use Forest - general** FZ_102
3. **Managed Use Forest - for Bamboo** FZ_103
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Thank you!

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