LEAF Technical Training on Reference Level Development

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Estimating Degradation and Calculating Emission Factors
Overview

- Monitoring degradation
- IPCC emission estimation approaches
- Developing emission factors
- Example: selective logging
- Example calculations
Difficult to monitor forest degradation

• Need to know magnitude and cause so can design a system for degradation
  • Not all agents of degradation can be monitored with same approach
• Procedures for estimating impact on C stocks already exist in IPCC for some agents, such as logging
• Other agents require development of procedure
• Only need EFs if activity data can be estimated
Degradation emission factors

- Define drivers of degradation
- Stratify forest and determine extent of degradation
- Assess suitability of existing data for deriving emission factors
- Develop and implement a sampling design (for each driver)
- Develop activity-specific emission factors for degradation
Stratify forest and determine extent of degradation

Define drivers of degradation

- Timber harvesting/Selective logging
- Fuelwood collection
- Human induced fires
- Shifting cultivation
- Overgrazing

Assess suitability of existing data

Develop and implement sampling design (for each driver)

Develop activity-specific emission factors for degradation
Are resources available to obtain these data for a recent time period?

Q. DEGRADATION SOURCE
What is the extent of the X activity in your country?
(Timber volume; fuelwood collected; area burned; area grazed; area of land use change)

Collect Data

Does the resulting value represent a significant proportion of emissions from deforestation?

NO

Are resources available to obtain these data for a recent time period?

NO

No, do not include degradation from X activity, consider other forms of degradation

YES

Yes, include degradation from X activity in RL/REL.
Location of Degradation / Enhancements

- Develop Activity Data
  - Different methods are used for different agents of degradation
- Remote Sensing of canopy cover change
- Other spatial and non-spatial data can inform location
  - Forest concession delineation
  - FSC certified volume data
  - Charcoal production
  - Plantations
  - Centers of population
- Estimate / monitor
  - RS from space
  - Using high resolution imagery
Monitoring degradation needs to be frequent.

From Carlos Souza, IMazon, Brazil,

Rate of forest recovery after logging and fires is fast and needs frequent monitoring.
Existing Data

- Define drivers of degradation
- Stratify forest and determine extent of degradation
- Assess suitability of existing data
- Develop and implement sampling design (for each driver)
- Develop activity-specific emission factors for degradation

• Timber inventories, scientific studies, and socio-economic records may be useful

• Unit of measure must agree with activity data

• Data availability may determine which approach is used

• Most likely new data will be needed for degradation EFs
Estimating Emission from Degradation

- Define drivers of degradation

- Stratify forest and determine extent of degradation

- Assess suitability of existing data

- Develop and implement sampling design (for each driver)

- Develop activity-specific emission factors for degradation

• Field measurements of carbon stock of each degradation class using standard forest carbon plots

• Field measurements specific to type of degradation (e.g. charcoal, large scale logging)

• Remote sensing technologies may be useful in combination with ground-truthing

• Need to determine carbon stocks at time 1 and time 2 (pre- and post-degradation) or carbon stock gains and losses

• Socio-economic statistics such as population and economic data may be most relevant
Emission Estimation Approaches

**Stock-Change Approach:**
- Difference in C stocks in a particular pool at two points in time
- Difference in C stocks between forest and post-deforestation land use

**Gain-Loss Approach**
- Net balance of additions to and removals to a carbon pool
- Annual data needed
  - Gains: annual rates of growth
  - Losses: data on timber harvests

1. Define drivers of degradation
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Stock Change Approach

Stock Difference Method:

\[ \Delta C = \frac{(C_{t2} - C_{t1})}{(t_2 - t_1)} \]

Where:

- \( \Delta C \) = annual carbon stock change in pool (t C/yr)
- \( C_{t1} \) = carbon stock in pool in at time \( t_1 \) (t C)
- \( C_{t2} \) = carbon stock in pool in at time \( t_2 \) (t C)

- Pool is product of deforested area (Activity Data) and C stock (Emission Factors) = area x C/ha
Gain-Loss Approach

- Use Gain-Loss Method:
  \[ \Delta C = \Delta C_G - \Delta C_L \]

Where:
- \( \Delta C \) = annual carbon stock change (t C/yr)
- \( \Delta C_G \) = annual gain in carbon (t C/yr)
- \( \Delta C_L \) = annual loss of carbon (e.g. from timber and fuelwood harvest) (t C/yr)
## Developing EFs for Degradation Drivers

<table>
<thead>
<tr>
<th>Driver</th>
<th>Stock-Change</th>
<th>Gain-Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber harvesting/Selective logging</td>
<td>Pre- and post-harvest data</td>
<td>Timber harvest data&lt;br&gt;Estimate of growth following harvest</td>
</tr>
<tr>
<td>Fuelwood collection</td>
<td>Pre- and post-harvest data</td>
<td>(Estimated) Losses&lt;br&gt;Gains from standard growth estimates</td>
</tr>
<tr>
<td>Human-induced fires</td>
<td>Pre- and post-fire data</td>
<td>Losses (area * EF)&lt;br&gt;Gains from standard growth estimates</td>
</tr>
<tr>
<td>Shifting cultivation and Overgrazing</td>
<td>Time 1 and time 2 data</td>
<td>(Estimated) Losses&lt;br&gt;Gains from standard growth estimates</td>
</tr>
</tbody>
</table>
Example of data needs to estimate carbon stock change for logging IPCC method of gains-losses

1. Area logged in a given year
2. Amount of timber selectively extracted per unit area per year, and area of infrastructure (roads etc.)
3. Amount of dead wood produced per unit area per year (from tops and stump of the harvested tree, mortality of the surrounding trees caused by the logging)
4. Tree mortality from the skid trails, roads, and logging decks
5. Amount going into long term storage as wood products
6. Regrowth rate of stand after logging per unit area per year for multiple years
Calculate Emission Factor

- Each forest stratum must have an activity-specific emission factor
- Uncertainty estimates must be included with EF
- Stock-change: EF = pre-degradation (time 1) carbon stocks minus post-degradation (time 2) carbon stocks
- Gain-loss: EF = lost carbon stocks minus increased carbon stocks
Example: Selective Logging

1. Define drivers of degradation
2. Stratify forest and determine extent of degradation
3. Assess suitability of existing data
4. Develop and implement sampling design (for each driver)
5. Develop activity-specific emission factors for degradation

Q1. TIMBER EXTRACTION
What volume of timber does your country produce on an annual basis that originates from natural forests?

- DON'T KNOW
- COLLECT DATA
- YES
- NO

Does the resulting value represent a significant proportion of emissions from deforestation?

- NO
- YES
- NO
- YES

Are resources available to obtain these data for a recent time period?

- NO
- YES

No, do not include degradation from timber harvesting, consider other forms of degradation

Yes, include degradation from timber harvesting in RL/REL.
Example: Selective Logging

- Define drivers of degradation
- Stratify forest and determine extent of degradation
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- High resolution aerial imagery: measure all gaps, skid trails, roads
- Create relationship between gaps and emissions
Example: Selective Logging

- Define drivers of degradation
- Stratify forest and determine extent of degradation
- Assess suitability of existing data
- Develop and implement sampling design (for each driver)
- Develop activity-specific emission factors for degradation

- Existing data from logging concessions
- Field measurements on: tree cut, other trees killed, skid trails, roads, logging decks
- Estimate impact per volume wood

↓ Live biomass

↑ Dead wood

Extracted

Damage

↑ Wood products

Wood Products

ATMOSPHERE
Logging Example: timber volume extracted and reduction in live biomass pool

Based on measurements of >530 logging gaps from selective logging sites around the tropics

\[
y = 0.3663x \\
R^2 = 0.70
\]

Combine with timber extraction rates
Example: Estimating emissions from removals in selective logging

\[
C \text{ emissions, t C/yr} = [\text{vol} \times WD \times CF \times (1 - LTP)] + [\text{vol} \times LDF] + [\text{vol} \times LIF]
\]

*Where:*

- Vol = volume timber extracted over bark per logging block (m³)
- WD = wood density (t/m³)
- CF = carbon fraction
- LTP = proportion of extracted wood in long term products still in use after 100 yr (dimensionless)
- LDF = logging damage factor (t C/m³)—dead wood left behind in gap
- LIF = logging infrastructure factor (t C/m³)—dead wood produced by construction
Logging example: carbon emissions from selective logging in tropical regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Emissions (Pg C yr⁻¹)</th>
<th>Timber Extraction</th>
<th>Incidental Damage</th>
<th>Logging Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0.05</td>
<td>53%</td>
<td>16%</td>
<td>31%</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.11</td>
<td>52%</td>
<td>25%</td>
<td>23%</td>
</tr>
<tr>
<td>Asia</td>
<td>0.05</td>
<td>44%</td>
<td>31%</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.22</strong></td>
<td><strong>50%</strong></td>
<td><strong>25%</strong></td>
<td><strong>25%</strong></td>
</tr>
</tbody>
</table>
Example: Outstanding issues related to carbon gains in logged forests

• Delayed mortality in gaps
• Assume dead wood decomposes in year of production or track decomposition—if track what rate of decomposition
• Regrowth of forest after logging—zone of influence and longevity; need only difference between around gap versus no gap
• Proportion of timber extracted going into long lived wood products?
Recap: Degradation emission factors

1. Define drivers of degradation
2. Stratify forest and determine extent of degradation
3. Assess suitability of existing data for deriving emission factors
4. Develop and implement a sampling design (for each driver)
5. Develop activity-specific emission factors for degradation
Calculating Degradation EFs

• Example
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