# IPCC Expert Meeting on National Forest GHG Inventories
# 23-25 February 2010
# Yokohama, Japan

## *Emission factors for selective logging and update on default C stocks for tropical forests*


**Sandra Brown**

sbrown@winrock.org

WINROCK INTERNATIONAL


## Change in carbon stocks of forests remaining forests (gain-loss)

**Common AFOLU method used for dealing with <u>timber removals</u> (also fuel and disturbance)**

EQUATION 2.7
ANNUAL CHANGE IN CARBON STOCKS IN BIOMASS
IN LAND REMAINING IN A PARTICULAR LAND USE CATEGORY (GAIN LOSS METHOD)

$$\Delta C_B = \Delta C_G - \Delta C_L$$

Where:

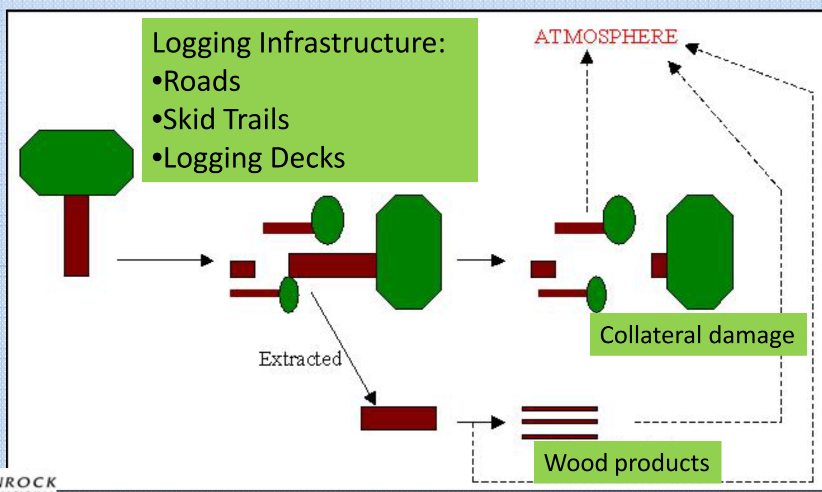
$\Delta C_B$ = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass terms in Equation 2.3) for each land sub-category, considering the total area, tonnes C $yr^{-1}$

$\Delta C_G$ = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tonnes C $yr^{-1}$

$\Delta C_L$ = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tonnes C $yr^{-1}$

## Estimating emissions from removals by selective logging in the tropical forests

- Impacts of selective logging on removals:




## Proposed equation for estimating emissions from removals in selective logging

C emissions, t C/yr = [vol timber extracted x WD x CF x (1-LTP)] +
[vol timber extracted x LDF ] +
[vol timber extracted x LIF ]

Where:

Vol = volume over bark (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)

LIF = logging infrastructure factor (t C/m3)

# Impact on carbon stocks of selective logging in Republic of Congo

| | Total carbon impact | | Impact per ha of concession | |
|---|---|---|---|---|
| | t C | 95% CI | t C/ha | 95% CI |
| Extracted biomass carbon | 3,824 | ± *248* | 2.60 | ± *0.17* |
| Damaged biomass carbon in logging gap | 5,698 | ± *343* | 4.01 | ± *0.23* |
| Damaged biomass carbon in skid trails | 126 | ± *10* | 0.09 | ± *0.007* |
| Biomass carbon impact of logging roads | 3,194 | ± *598* | 2.17 | ± *0.41* |
| **TOTAL** | **13,042** | **± *1,199*** | **8.86** | **± *0.81*** |

Pearson et al. 2004

# Parameters used in emission estimates:

| Region | Over-bark volume of timber extracted ($m^3$/yr) | WD-Wood density (t dry mass/$m^3$) | LDF-Logging damage factor (t C/$m^3$ extracted) | LIF-Logging infrastructure factor (t C/$m^3$ extracted) | LTP-Proportion of extracted wood still in use after 100 yr |
|---|---|---|---|---|---|
| Africa | Average of period 2000-2005 x 1.15 | 0.58 | 0.38 | 0.29 | 0.11 |
| America | Average of period 2000-2005 x 1.15 | 0.60 | 0.71 | 0.29 | 0.10 |
| Asia | Average of period 2000-2005 x 1.15 | 0.57 | 0.63 | 0.29 | 0.11 |

- Factors developed from data for Bolivia, Brazil, ROC, Indonesia
- Industrial roundwood data from FAO FRA2005 & Forest Products
- FAO data do not distinguish between production from native forests versus plantations in most cases

WINROCK INTERNATIONAL

# Pantropical estimate of carbon emissions from selective logging

| Region | Total Emissions (Pg C yr-1) | Timber Extraction | Incidental Damage | Logging Infrastructure |
|---|---|---|---|---|
| Africa | 0.05 | 53% | 16% | 31% |
| Latin America | 0.11 | 52% | 25% | 23% |
| Asia | 0.05 | 44% | 31% | 25% |
| **Total** | **0.22** | **50%** | **25%** | **25%** |

**Emission estimates based on AFOLU guidance**

# Change in carbon stocks of forests remaining forests: outstanding issues

- Use of FAO Forest Products or FRA reports for Tier 1 data—generally does not distinguish between plantations and native forests
- Total emissions underestimated because not all sources included
- Gains by growth—need improved guidance as most apply growth factor to all forests not just those under concessions or active logging
  - Regrowth occurs in gaps and maybe not enhanced by logging (smaller trees and gap closure)
  - Occurs over limited time frame
  - Many tropical countries report C sink for forests as a result
- Further investigation needed on all sources of emissions and guidance on how to apply growth

**Example.** The following example shows Gain-Loss Method (Tier 1) calculations of annual change in carbon stocks in biomass ($\Delta C_B$), using Chapter 2, Equation 2.7 ($\Delta C_B = (\Delta C_G - \Delta C_L)$), for a hypothetical country in temperate continental forest zone of Europe (Table 4.1, Section 4.5):

- the area of *Forest Land Remaining Forest Land* (A) within the country is 100,000 ha (see Chapter 3 for area categorization);
- it is a 25-year-old pine forest, average above-ground growing stock volume is 40 $m^3\ ha^{-1}$;
- the merchantable round wood harvest over bark (H) is 1,000 $m^3\ yr^{-1}$;
- whole trees fuel wood removal ($FG_{trees}$) is 500 $m^3\ yr^{-1}$;
- area of insect disturbance is 2,000 ha $yr^{-1}$ with above-ground biomass affected 4.0 tonne d.m. $ha^{-1}$.

**Annual gain in biomass** ($\Delta C_G$) is a product of mean annual biomass increment ($G_{TOTAL}$), area of land (A) and carbon fraction of dry matter (CF); Equation 2.9 in Chapter 2 ($\Delta C_G = \Sigma_{ij}$ (A • $G_{TOTAL}$ • CF). $G_{TOTAL}$ is calculated using Chapter 2, Equation 2.10 for given values of annual above-ground biomass growth ($G_W$), below-ground biomass to above-ground biomass ratio (R), and default data tables in Section 4.5.

For the hypothetical country,

$G_W$ = 4.0 tonnes d.m. $ha^{-1}\ yr^{-1}$ (Table 4.9);

R = 0.29 tonne d.m. (tonne d.m.)$^{-1}$ for above-ground biomass of 50 to 150 t $ha^{-1}$ (Table 4.4 with reference to Table 4.7 for above ground biomass);

$G_{TOTAL}$ = 4.0 tonnes d.m. $ha^{-1}\ yr^{-1}$ • (1 + 0.29) = 5.16 tonnes d.m. $ha^{-1}\ yr^{-1}$ (Equation 2.10); and

CF = 0.47 tonne C (tonne d.m.)$^{-1}$ (Table 4.3).

Consequently, (Equation 2.9): $\Delta C_G$ = 100,000 ha • 5.16 tonnes d.m. $ha^{-1}\ yr^{-1}$ • 0.47 tonne C (tonne dm)$^{-1}$ = 242,520 tonnes C $yr^{-1}$.

**Biomass loss** ($\Delta C_L$) is a sum of annual loss due to wood removals ($L_{wood\text{-}removals}$), fuel wood gathering ($L_{fuelwood}$) and disturbances ($L_{disturbance}$), Equation 2.11 in Chapter 2.

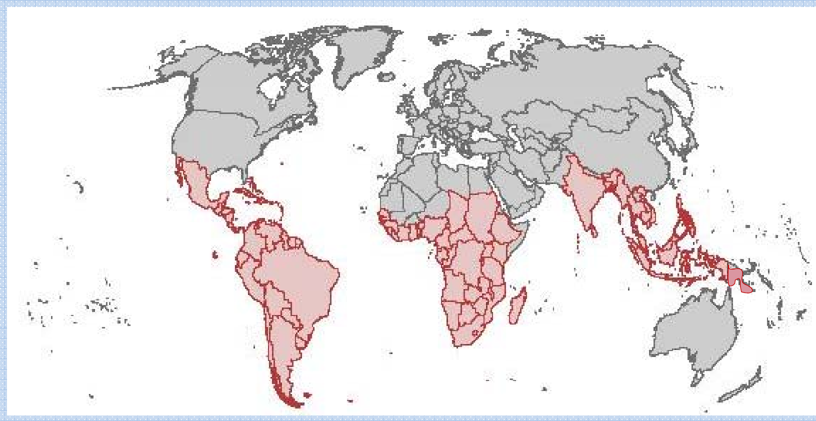
*Wood removal* ($L_{wood\text{-}removals}$) is calculated with Equation 2.12, Chapter 2, merchantable round

## Classic example from AFOLU

## Revisit default EFs for pantropics

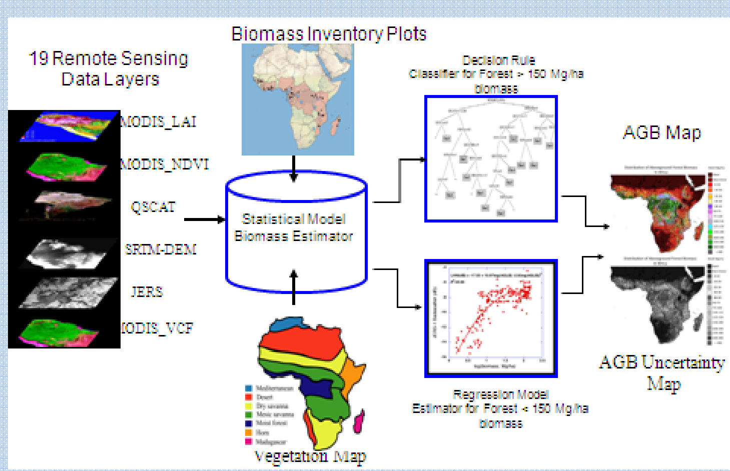
- Root of Efs is 1996 Guidance—one value per each of 6 ecoregions per region (Africa, America, continental and insular Asia) based on a combination of inventory data and forest C maps
- Or partial national estimate based on inventory of forests with potential commercial value and default biomass expansion factors (either FAO Forestry 134 [Brown 1997-equation] or GPG-range of factors)
- Updated in 2003 GPG –added a range but no guidance on how to use range

# Geographic scope of new effort
# Year ≈2000



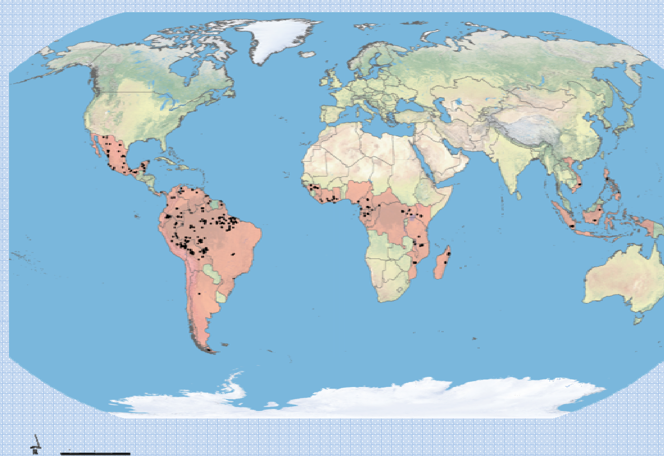
New analysis by Sassan Saatchi (JPL), Nancy Harris & Sandra Brown (Winrock), and Bill Salas (Applied Geosolutions) with support by World Bank

# Biomass prediction model



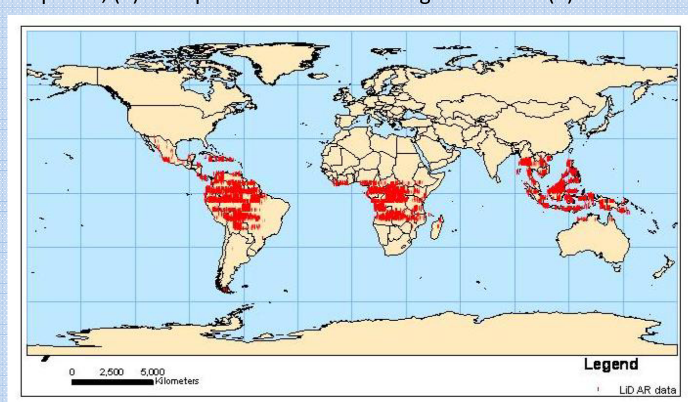

Sassan Saatchi et al 2010

## Biomass data from field plots (4,000+)

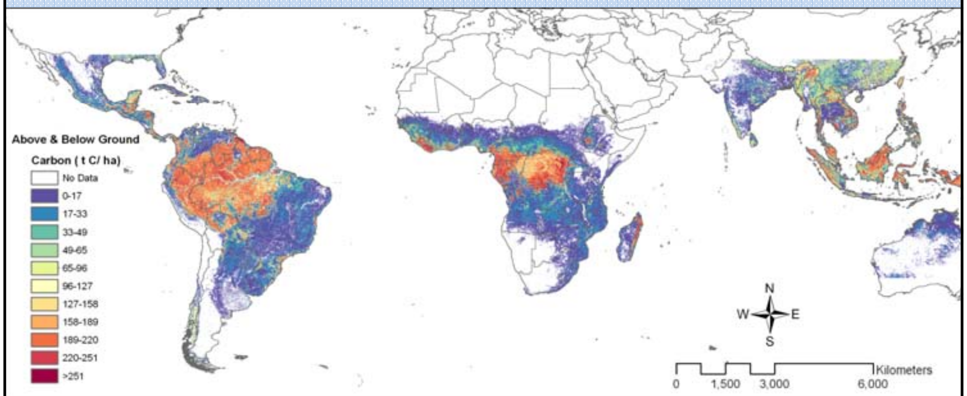


## Height derived from LIDAR points (150,000+) and

Used for 3 steps: (1) develop regression equations of field data with LIDAR points, (2) extrapolate C stocks over larger area and (3) validate map



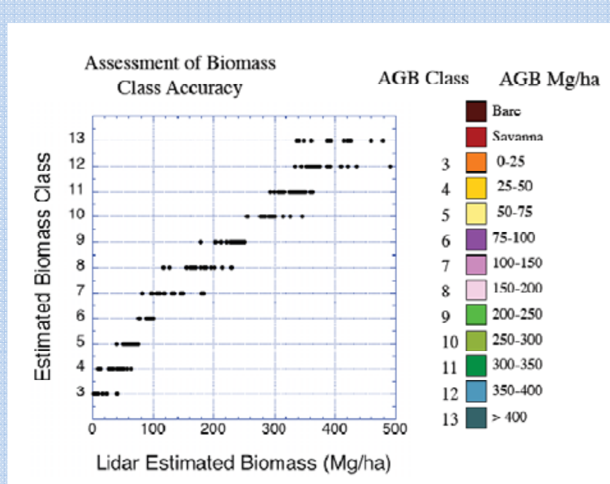
# Total Biomass Carbon Stocks




BGB was added to AGB using equation from Mokany et al. (2006)

WINROCK INTERNATIONAL

# Biomass Model Validation




**Overall Accuracy = 76%**
LA = 81% AF=86% SA=69%

WINROCK INTERNATIONAL

# Example of forest C stocks from map

| COUNTRY | Total Biomass Carbon AG+BG (t C/ha) | |
|---|---|---|
| | new data | FAO-FRA2005 |
| Brazil | 130 | 103 |
| Bolivia | 116 | 90 |
| Peru | 172 | no data |
| DRC | 140 | 173 |
| ROC | 159 | 231 |
| Cameroon | 155 | 90 |
| Indonesia | 144 | 67 |
| Malaysia | 163 | 168 |
| Vietnam | 108 | 91 |
| PNG | 149 | no data |