LEAF Technical Training on Reference Level Development

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Calculating Carbon Stocks
Steps for Emission Factor (EF) Creation

1. Assess Existing Data
2. Stratify Forests
3. RL Design
4. Carbon Stock Field Sampling: Design, Implement, and Analyze Data
5. Create Deforestation Emission Factors
Calculating carbon stocks

- After field work has been completed, need to calculate carbon per hectare in each pool
- For plots:
  - Perform calculations needed for each pool
  - Scale plot measurements to per hectare
  - Average across plots per stratum for each carbon pool
  - Sum across pools
Calculate carbon stocks for key pools

- Soil and Peat
- Above Ground (AG) non-tree woody
- Above Ground (AG) non-tree non-woody
- Belowground Live Biomass
- Litter
- Wood products
- Dead wood
- Standing deadwood
- Lying deadwood
- Soil and Peat Carbon
Carbon versus Biomass

• Carbon estimated to be a constant proportion of biomass (e.g. IPCC defaults)
  – Live biomass, standing + lying dead wood: 
    Biomass * 0.47 = Carbon
  – Litter: Biomass * 0.37 = Carbon

• OR: project can measure proportion in laboratory using selection of subsamples taken
**Calculating Plot Area**

- Trees were measured in different NEST sizes
- Area of a circle: \( A = \pi r^2 \)
  - 4 m radius = 50.3 m²
  - 14 m radius = 615.8 m²
  - 20 m radius = 1256.6 m²
Correcting Plot Area for Slope

• If plot is sloped, need to correct plot area because actual measurement of plot radius on slope will be larger than horizontal projection

• If distance is not corrected for slope, biomass will be underestimated
Scaling Factor: How Many Plots Per Ha?

• Measure trees in different nest sizes
• Need to standardize all measurements to a per-hectare basis
• 1 ha = 10,000 m²
• How many of each size plot are in 1 ha?
  – 4 m radius = 50.3 m² = 198.9 (10,000 / 50.3)
  – 14 m radius = 615.8 m² = 16.2 (10,000 / 615.8)
  – 20 m radius = 1256.6 m² = 8.0 (10,000 / 1256.6)
• Each tree measured in a nest should be multiplied by the appropriate scaling factor for its nest size
• Need scaling factors for clip plots and litter plots also
Live Tree Carbon

- Use regression or allometric equation to estimate biomass from DBH
  - Relationship between tree diameter and mass (‘biomass’) of tree
  - Many equations published for forests worldwide
  - Local regression equations may exist in literature

**Chave AG Biomass**

\[ \text{Chave AG Biomass} = \text{wood density} \times \exp(-1.499 + 2.148 \times \ln(DBH) + 0.207 \times \ln(DBH)^2 - 0.0281 \times \ln(DBH)^3) \]

Equation: Chave et al. 2005
Wood density from Reyes et al. 1992
Live Tree Carbon

- Calculate biomass of each tree (kg)
- Multiply biomass by scaling factor for appropriate nest size
- Sum biomass/ha of all trees for total plot biomass per ha
- Example
Belowground Tree Carbon

• Use Root-Shoot ratios
  – From literature (Mokany et al 2006)
    • $B_{GB} = 0.235 \times A_{GB}$, if $A_{GB} > 62.5$ $tC/ha$
    • $B_{GB} = 0.205 \times A_{GB}$, if $A_{GB} \leq 62.5$ $tC/ha$
  – From fieldwork

• Example

Non-tree pools

• Deadwood
  – Standing and lying
  – Requires deadwood density

• Non-tree vegetation
  – Saplings
  – Shrubs
  – Grasses
  – Herbaceous vegetation
  – Litter

• Methods described in SOPs
Calculating Uncertainty In Each Pool

• Standard deviation = measurement of variation from the average value

• Calculate average ("mean") and standard deviation across all plots within a stratum
  – Mean = \[
  \text{sum of all carbon values} \div \text{number of samples (N)}
  \]
  – Standard deviation:
    • Calculate the difference of each data point from the mean
    • Square the result of each
    • Calculate the average of these values and take the square root
95% Confidence Interval

• For normally distributed data, we expect that 95% of data points will fall within 1.96 standard deviations of the mean.

• Calculate the 95% confidence interval using
  – Standard deviation (σ)
  – Sample size (n)

• Report C stock as mean ± 95%CI

• Uncertainty can also be estimated as a percentage of the mean (95% CI / mean) x 100 → should be <10%

\[
95\% CI = 1.96 \left( \frac{\sigma}{\sqrt{n}} \right)
\]
Estimating total uncertainty

- Calculate % uncertainty in each pool
- Quantify total uncertainty across all pools using IPCC Tier 1 “Simple Propagation of Errors” method

\[
U_{total} = \sqrt{(U_1 \times x_1)^2 + (U_2 \times x_2)^2 + \ldots + (U_n \times x_n)^2} / (x_1 + x_2 + \ldots + x_n)
\]

Where:
- \(U_{total}\) = total uncertainty
- \(U_1\) = uncertainty associated with each pool
- \(x_1\) = average (mean) of each pool
Estimating total uncertainty

• Monte Carlo analysis (commercial software available)
  – Complex but should be used if there are correlations between datasets or if error (>100 %)
  – Correlations will exist between various measured carbon pools and between estimates at different times
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