Estimating Carbon Impacts and Emissions from Selective Logging

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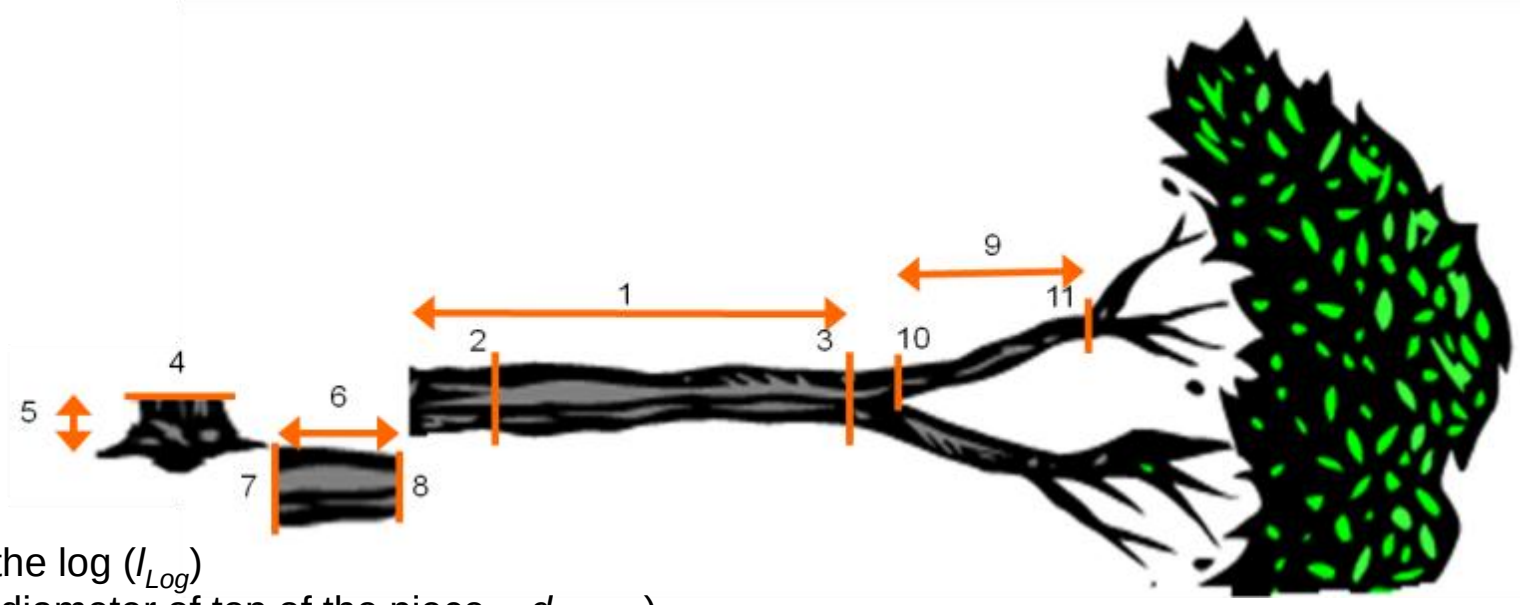
Field measurements: what is the goal?

- Take measurements in logging gaps to relate total carbon emissions to easily measurable parameters
  - Area of logging gap (m^2)
  - **Volume of timber extracted (m^3)**
- Components of carbon impact:
  - Log volume → convert to biomass using wood density
  - Incidental damage→ relate to m^3 volume extracted
  - Infrastructure damage → relate to m^3 volume extracted

Different parts of the tree have different fates:

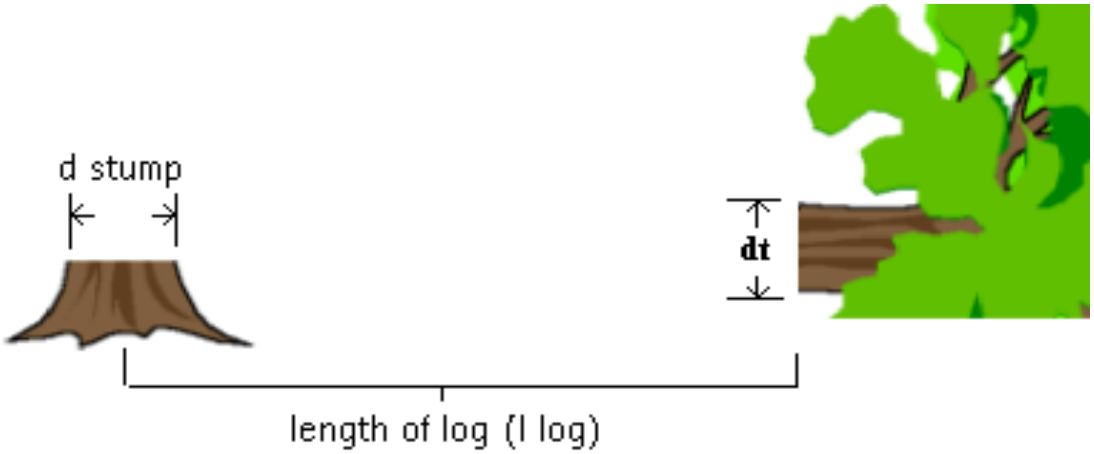
- Timber log:
  - Some of this carbon (~10%) ends up as long-lived (>100 yr) wood products
  - Assume remaining carbon (~90%) is emitted immediately to atmosphere (committed emission - simplifies accounting)
- Rest of timber tree (crown, stump, pieces left behind)
- Other trees damaged by felling
- Trees killed for construction of roads, skid trails and decks
  - All left in the forest to decompose - assume all C emitted immediately (committed emission - simplifies accounting)

Field measurements on timber tree



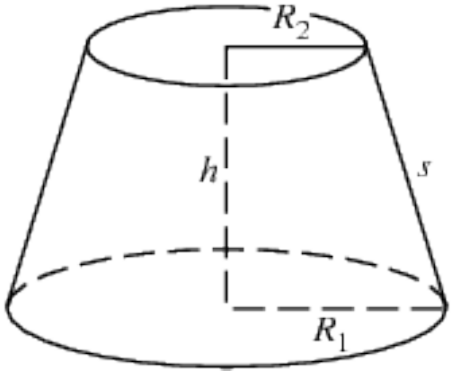
1. Length of the log (l_{Log})
2. DBH (and diameter of top of the piece – $d_{Piece\text{-}T}$)
3. Diameter at the top cut (d_{Top})
4. Diameter of the stump (D_{Stump})
5. Height of the stump (H_{Stump})
6. Length of the piece (l_{Piece})
7. Diameter of the bottom of the piece ($d_{Piece\text{-}B}$)
8. Diameter of the top of the piece ($d_{Piece\text{-}T}$)
9. Length of avoidable merchantable waste (l_{AMW})
10. Diameter at the bottom of the avoidable merchantable waste ($d_{AMW\text{-}B}$)
11. Diameter at the top of the avoidable merchantable waste ($d_{AMW\text{-}T}$)

Biomass of LOG EXTRACTED: HOW TO ESTIMATE?



What shape best approximates a tree trunk?

Conical Frustum
(cone with top sliced off)



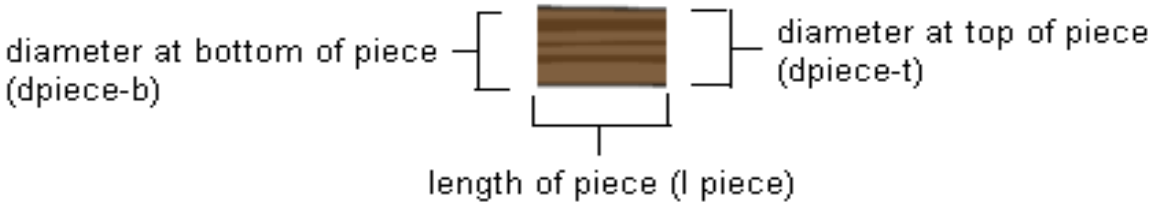
$$V = \frac{1}{3} \times \pi \times L_{bole} \times \left[\left(\frac{D_{bottom}}{200} \right)^2 + \left(\frac{D_{top}}{200} \right)^2 + \left(\frac{D_{bottom}}{200} \times \frac{D_{top}}{200} \right) \right]$$

Final units are in m^3

WHY ÷ by 200?

÷ by 2
Convert DIAMETER to RADIUS
÷ by 100
Convert units from CM to M

What if there are pieces of log left behind?



$$V = \frac{1}{3} \times \pi \times L_{\log} \times \left[\left(\frac{D_{bottom}}{200} \right)^2 + \left(\frac{D_{top}}{200} \right)^2 + \left(\frac{D_{bottom}}{200} \times \frac{D_{top}}{200} \right) \right]$$

L_{log} must be reduced by the sum of the length of log pieces left behind, or else log volume extracted will be overestimated.

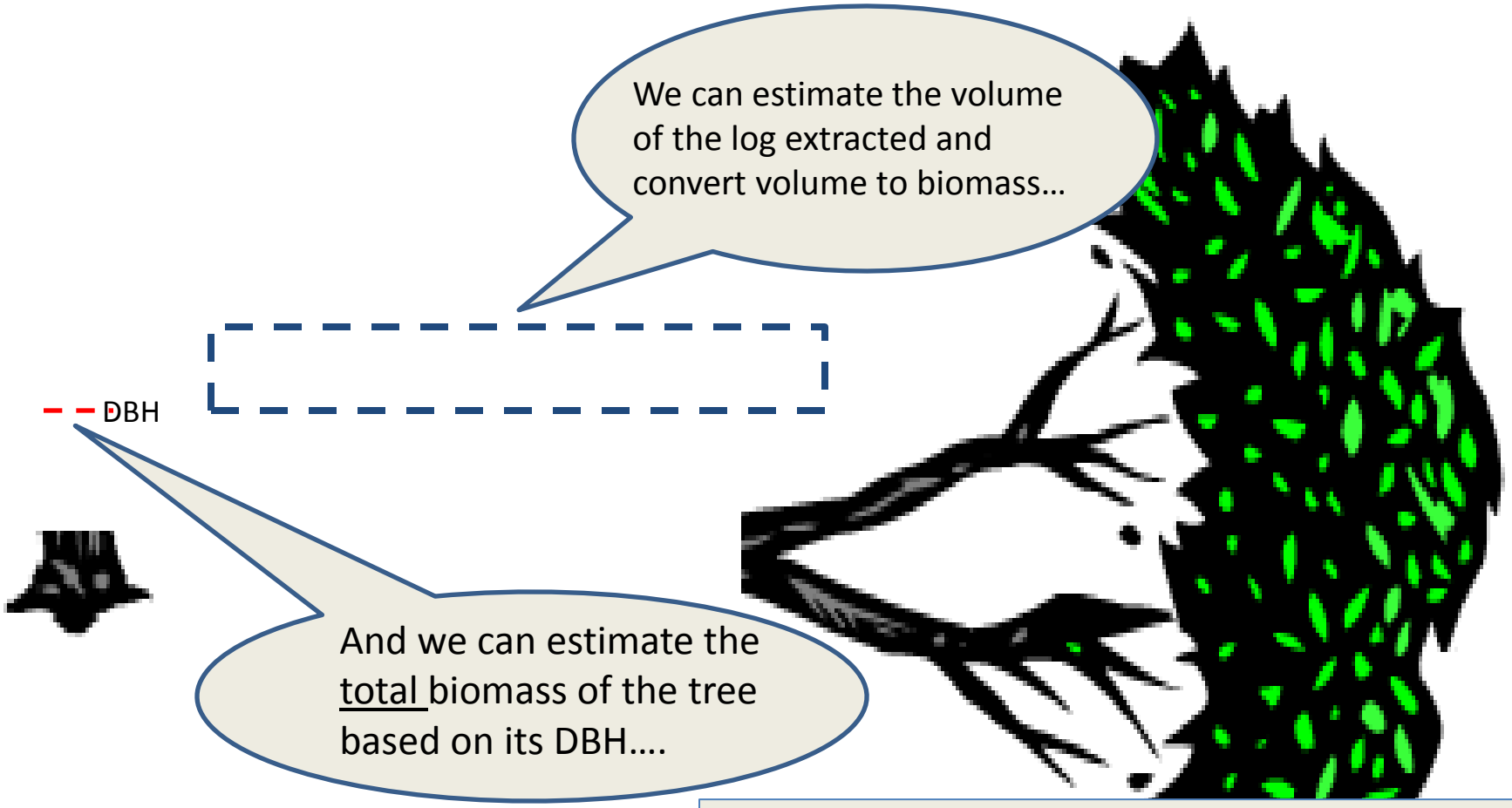
Estimating log biomass

- **Density = $\frac{\text{Mass}}{\text{Volume}}$**

Therefore: Biomass = Density x Volume

- Once log volume is estimated, easy to convert to biomass
- Average Wood Density for South American forests = 0.60 t m^{-3} (Brown 1997)
- If the timber species is known, use species-specific wood density

Biomass left behind: how to estimate?



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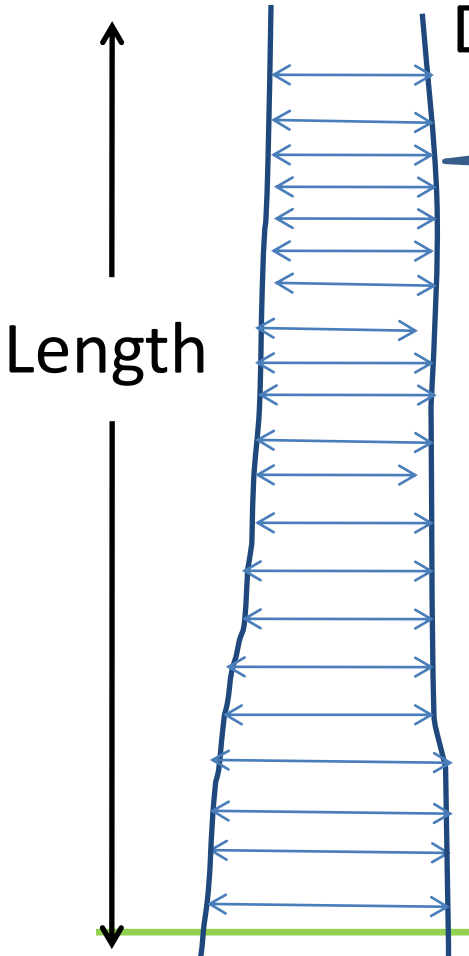
Therefore:
Biomass Remaining in Forest =
Total Biomass – Timber Biomass Extracted

How to estimate DBH if it can't be measured in the field?

--- DBH

If log is cut <u>above</u> DBH, then DBH is easy to measure in the field.
But if the log was cut <u>below</u> DBH, how can we estimate it?

Key concept: tree taper



Tree trunks get narrower with height – how can we calculate how much narrower?

$$\text{Tree taper} = \frac{\text{Change in diameter } (\Delta D)}{\text{Change in length } (\Delta L)}$$

$$\text{Tree taper} = \frac{D_{bottom} - D_{top}}{\text{Length}}$$

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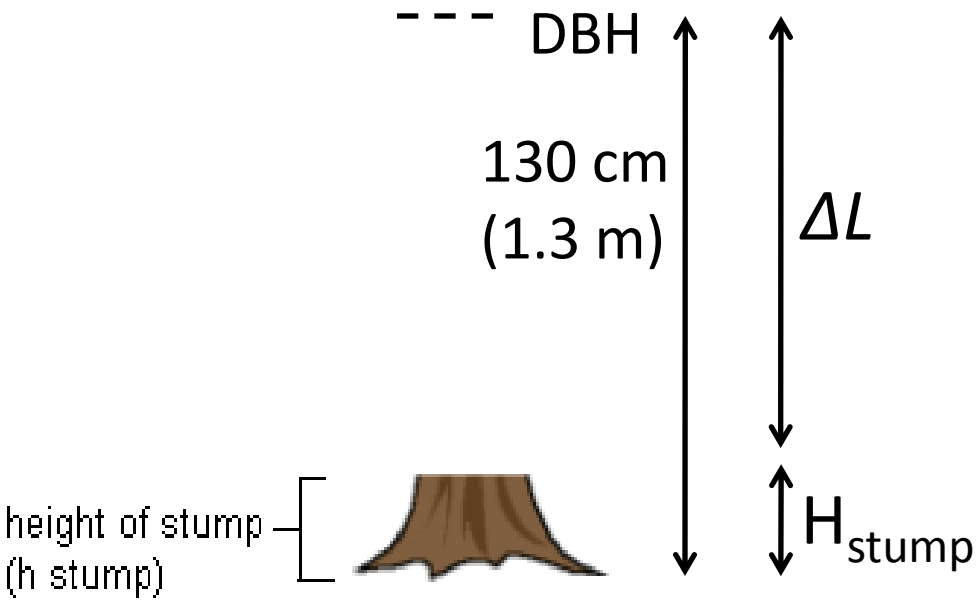
Estimating Δlength

From field measurements, we can calculate a taper factor that tells us how much diameter decreases per centimeter of a tree's length. Now: how many centimeters are between the stump (where diameter was measured) and DBH?



ΔL (cm) = 130 - H_{stump}

Estimating DBH: PUTTING IT ALL TOGETHER

TAPER (ΔD/ΔL) **x CHANGE IN LENGTH (ΔL) FROM STUMP TO DBH**

$$DBH = D_{stump} - \left[\frac{D_{stump} - D_{top}}{L_{\log} \times 100} \times \left(130 - H_{stump}\right) \right]$$

DBH is estimated as the **stump diameter modified by a reduction factor.** The reduction factor is based on the tree's **taper** and the **distance between the measured stump height and DBH (130 cm).**

Example of estimating DBH

Field Measurements:

Dstump = 70.8 cm

Dtop = 49.7 cm

Length = 19.9 m

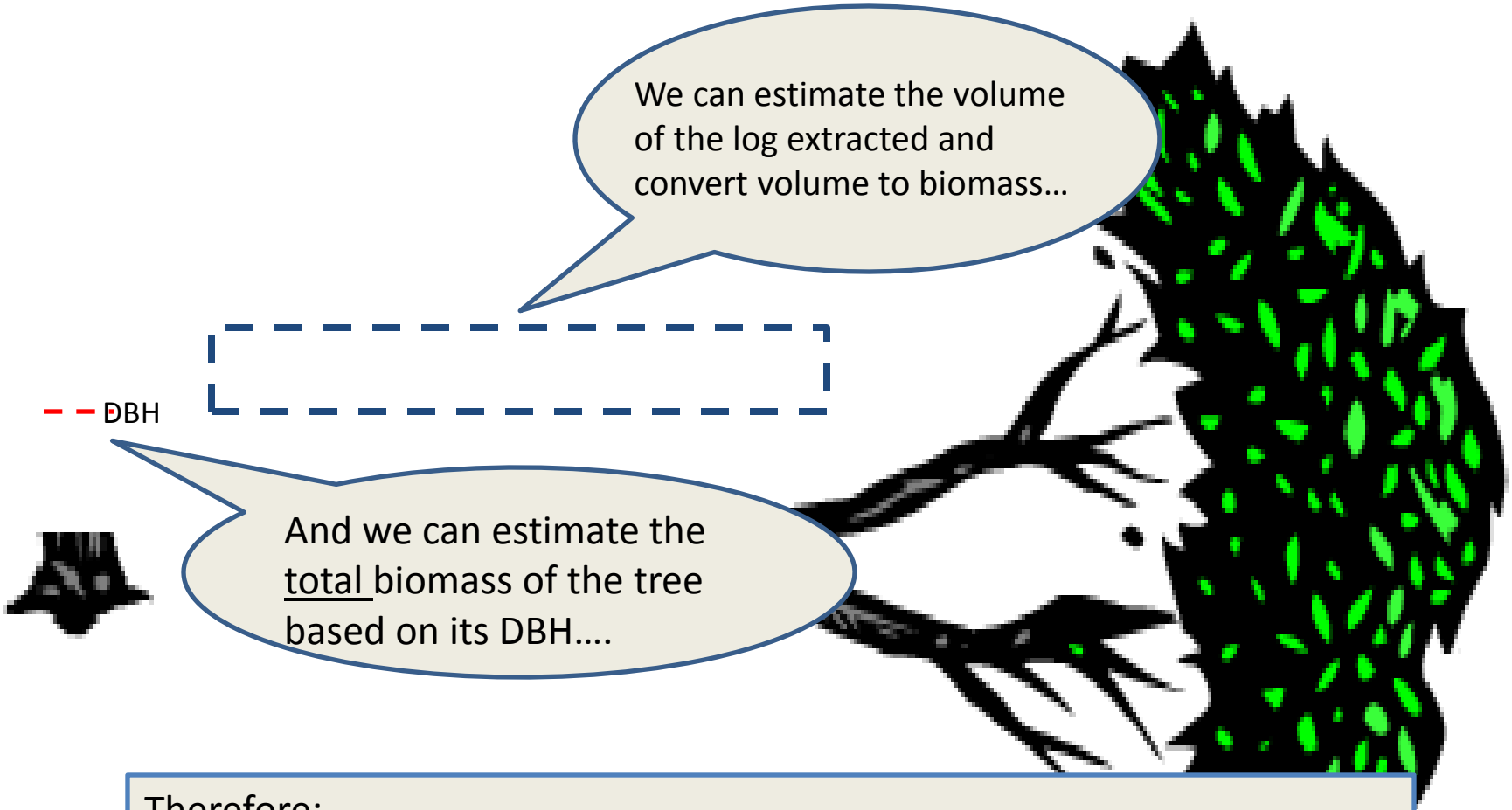
Hstump = 80 cm

Tree taper = $\frac{70.8 - 49.7}{19.9}$ = 1.06 cm/m

Change in length = 130 – 80 = 50 cm

$$DBH = 70.8 - \left[\frac{70.8 - 49.7}{19.9 \times 100} \times (130 - 80) \right] = 70.27$$

biomass left behind: how to estimate?



Therefore:
Biomass Remaining in Forest (crown, stump, pieces left behind) =
Total Biomass – Timber Biomass Extracted

Incidental damage

- Biomass of timber tree left in the forest will be emitted as CO_2 as it decomposes through time – this is part of incidental damage
- Other trees damaged as a result of felling operations will also decompose and emit CO_2
- Biomass of damaged trees estimated based on DBH using allometric equations
- Estimate total incidental damage as t C per m^3 extracted

Carbon impacts of logging infrastructure

Roads, Skid Trails, and Decks
- ✓ Length
- ✓ Width

Infrastructure Emission Factor
(Skid Trails+Decks+Roads)

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Carbon impacts of logging infrastructure

- Need estimates of average forest carbon stocks per stratum
- Calculate area of roads, logging decks, skid trails
- Multiply area by average forest carbon stocks to estimate carbon impact of logging infrastructure
- Estimate total logging infrastructure impact (t C) per m^3 extracted

Summary: Equation for estimating emissions from selective logging

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

Different Tool

ECO-Winrock Tool for Estimating Carbon Emissions Factors from Selective Logging

General Instructions:

Use this Excel file to enter measurements recorded from from LOGGING PLOTS.
This file is used for calculating carbon emission factors from tropical selective logging practices.
The intelectual knowledge in this file is proprietary of Winrock International.
Read all the instructions carefully before using this tool
NOTE: THIS IS A DRAFT VERSION, NOT FULLY ERROR CHECKED. USE WITH CAUTION.

WINROCK INTERNATIONAL

Direct any questions to:
carbonservices@winrock.org
Do not distribute this file without prior approval of a Winrock International - Ecosystem Services' staff

Instructions:

1. Enter data only in **BLUE CELLS**.
2. Enter data for each Concession into a separate excel worksheet. A separate file should be created for each Concession.
3. Do not make any changes to this spreadsheet without consulting a member of the ECO-Winrock team (carbonservices@winrock.org).
4. Enter one plot at a time until all worksheets related to the plot are completed. Make sure measurement units and column heading units are corresponding to each other.
5. Enter plot information accordingly in all worksheets
6. This spreasheet is programmed to use biomass allometric equations that do not require height data.
7. Save work in progress constatly to avoid losing entered data.

Plot_info

8. Enter general information about the plot.

Timber-Tree_Emissions

9. If the buttress extends above the measurable diameter, respond "Y" in column J. This could be either the diameter of the stump, or top diameter of piece, if piece was cut immediately above the stump.
10. Aboveground biomass in this tool is estimated using the allometric equation for "tropical moist forests" developed by Chave et al. (2005).
11. Belowground biomass in this tool is estimated using the relationship developed by Mokany (2006).
12. When DBH is unavailable in buttressed trees, DBH is conservatively estimated to be equal to the diameter at the top cut.

Incidental_Damage

13. Aboveground biomass in this tool is estimated using the allometric equation for "tropical moist forests" developed by Chave et al. (2005).
14. Belowground biomass in this tool is estimated using the relationship developed by Mokany (2006).
15. Damaged branches are conservatively assumed to represent small trees and their biomass is estimated using the "tropical moist forest" allometric equation from Chave et al. (2005). No belowground biomass

Summary_Felled-Tree_Emissions

16. Copy "Plot_ID" and columns indicated in v

Summary sheet per concession

	Extracted Volume (m3/gap)	Felled Tree Carbon (t C/gap)	Carbon Extracted (t C/ gap)	Carbon Stored in Long Term Wood Products (t C/tree)	Carbon Left in the Forest (t C/gap)	Top & stump of felled tree (t C/m3/gap)	Incidental Damage (t C/gap)	Incidental Damage per Volume Extracted (t C/m3/gap)	Total Carbon Damage Left in Forest (t C/gap)	Total Carbon Damage per Volume Extracted (t C/m3)	Carbon Emissions per Carbon Extracted (t C/t C)	Carbon Emissions from Skid Trail (t C/km)
Mean	3.908	3.743	1.386	0.149	2.186	0.567	1.283	0.337	3.469	0.949	2.674	32.839
Std_Dev	2.316	2.535	0.828	0.077	1.768	0.313	1.424	0.355	2.735	0.514	1.431	5.977
90% CI	0.346	0.379	0.124	0.011	0.264	0.047	0.213	0.053	0.409	0.077	0.214	1.404

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LEAF Technical Training on Forest Carbon Assessment

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