Atelier sur : L'APRÈS NAGOYA/CANCUN POUR LES PAYS DE LA ZONE COMIFAC en marge du CCR

(Agro)Forest Carbon Monitoring System

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Presentation outline

- ASB Historical bacground Research
- Ongoing initiatives to support the RPP process in COMIFAC countries
- Carbon assessment: ASB Methodology overview
- Practicality on (agro)forestry C-Measurement

ASB Historical bacground Research

- ASB partnership is a platform for Research in the Forest tropic margins, hosted by the World Agroforestry Centre in Nairobi
- Other partners in Africa /Cameroon: ICRAF, IITA, IRAD
- 15 years of Research to generate knowledge on Land uses dynamics and C-assessment in Cameroon and other tropical countries such as Peru, Indonesia, Philippines, Vietnam

Ongoing initiatives to support the RPP process in COMIFAC

- Generating knowledge on C-stocks and policy challenges for REDD process
- Capacity Building for national and African partners: Opp cost analysis and Support to UN REDD Negotiators
- Supporting UNFCC /REDD negociation process (case of the Douala worshop : REDD+ after Cancun), 20 african countries

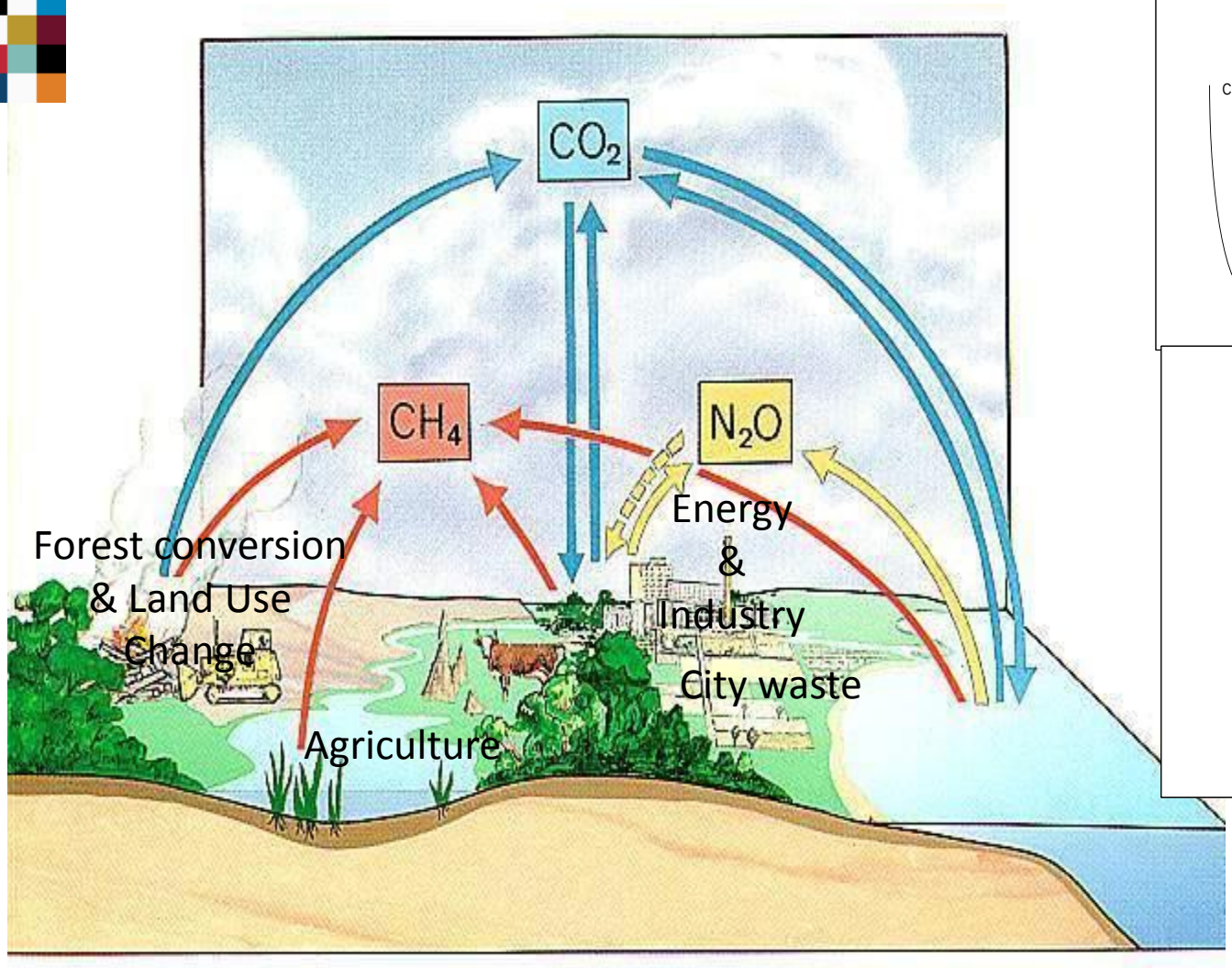
Training National partners on C-assessment methodology, Limbé 10 March 2011

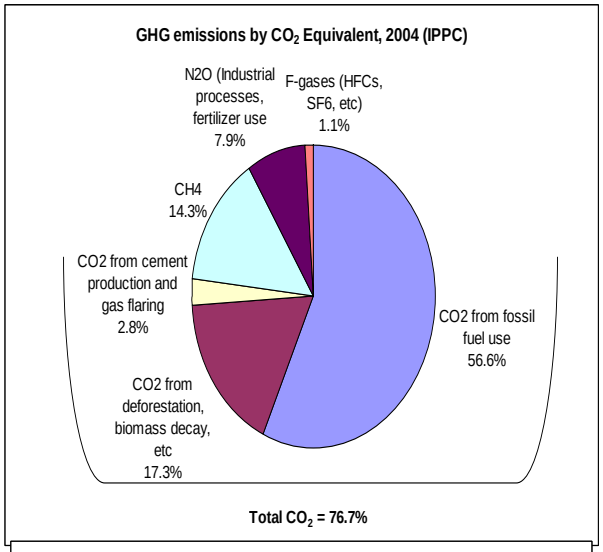
Carbon assessment: ASB Methodology overview

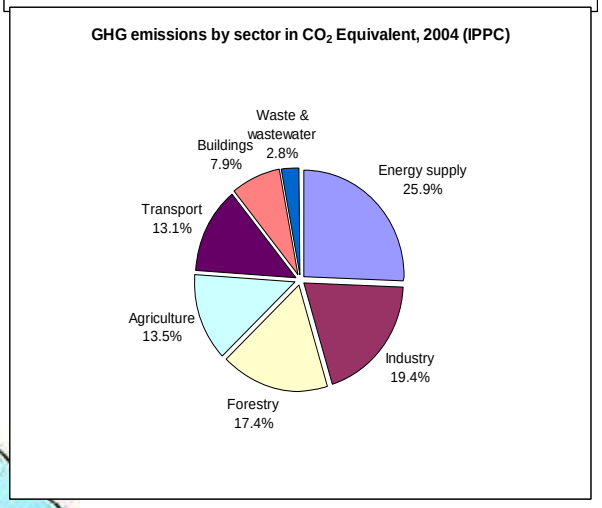
- Please consult reference documents produced by ASB platform and ICRAF
- Several manuals are available on the ASB website (Just google ASB , Alternative for Slash and Burn Partnership):
  - Carbon assessment Manual; ICRAF, 2008
  - Estimating opportunity Cost for REDD +, ASB-WB, 2010

Role of C in climate change

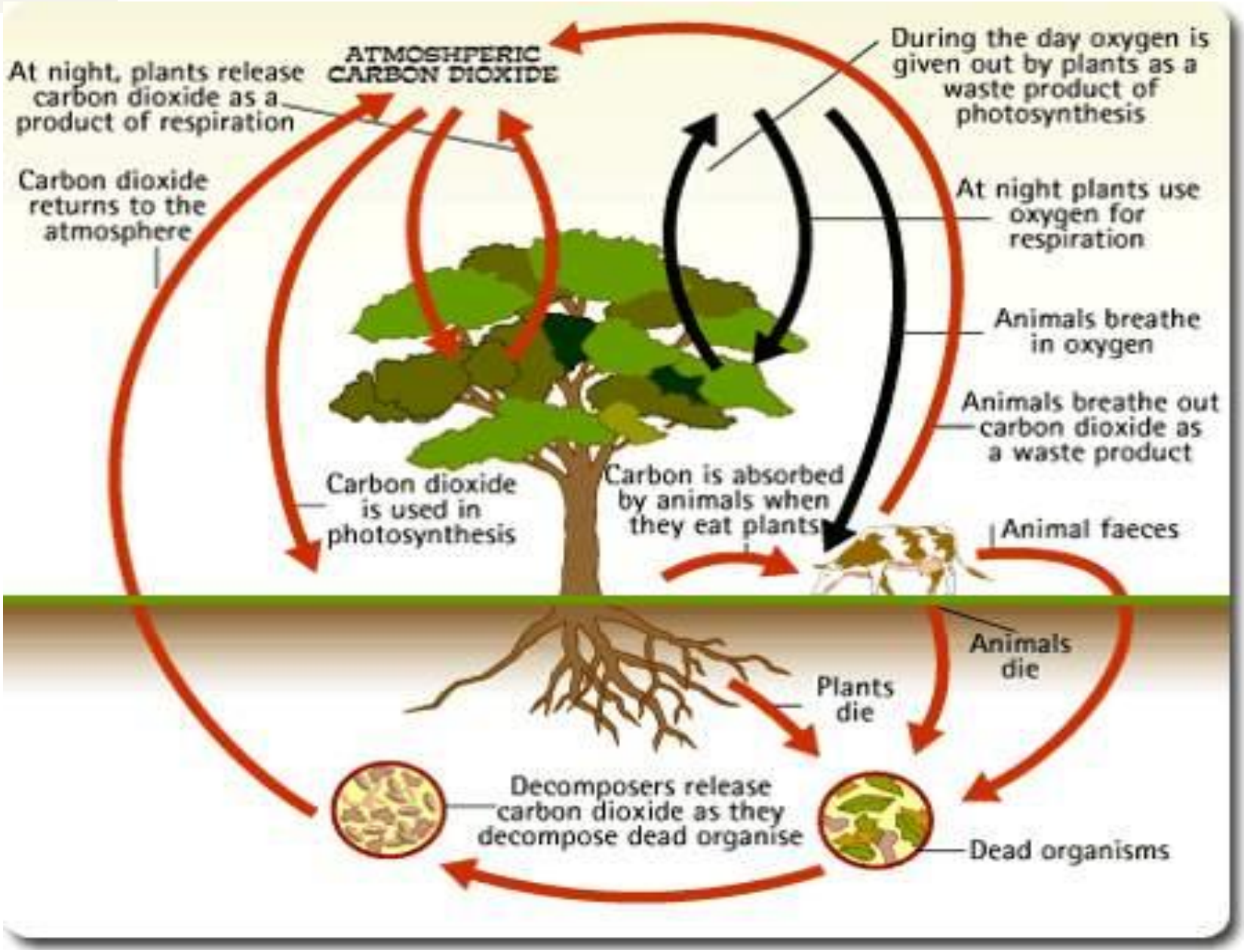
Contribution of Greenhouse Gases to Global Warming







Carbon cycle



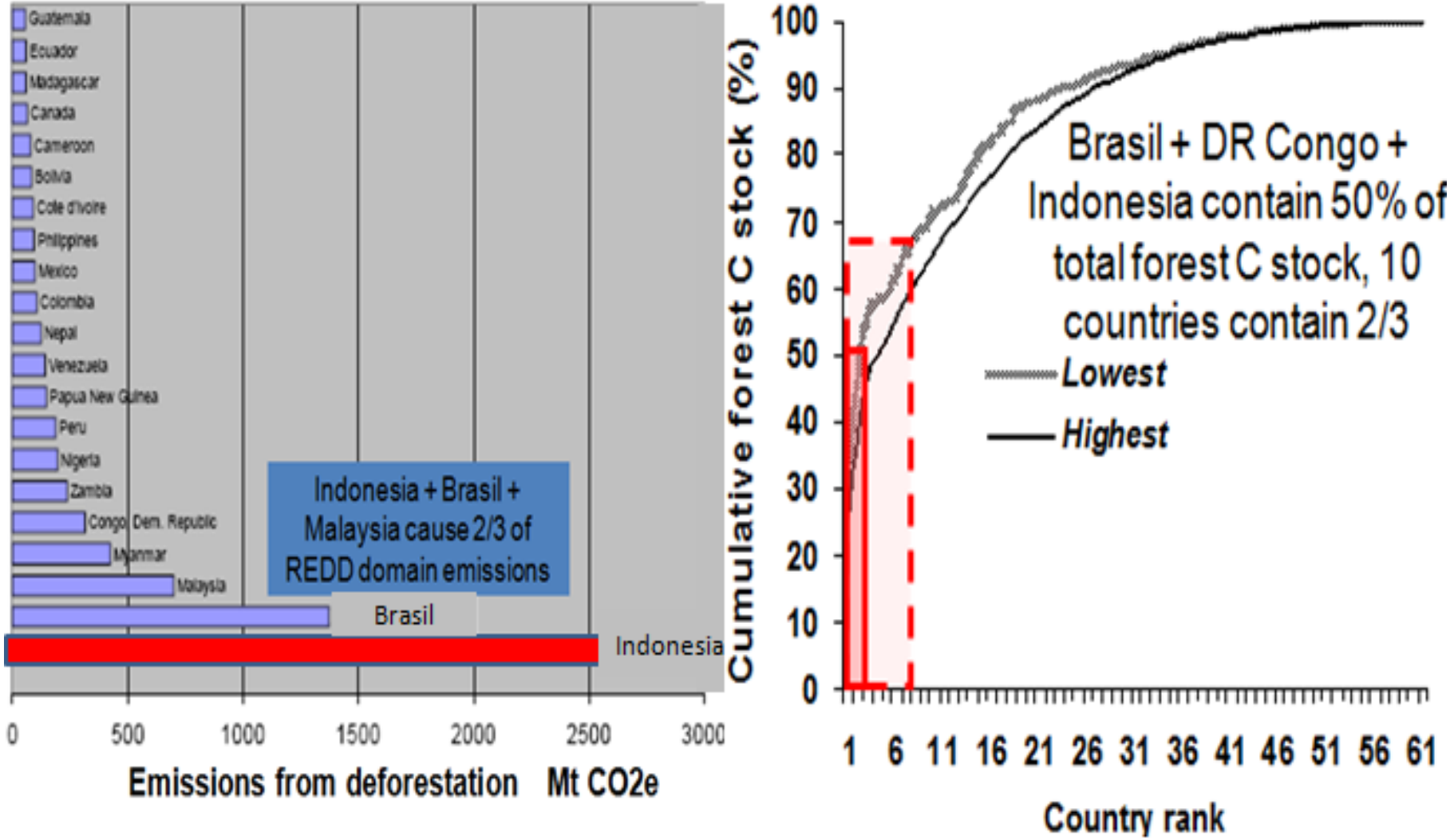


Figure 2. A) Estimates of current emission levels from forest + peat at national scale, B) cumulative total forest C stock (excluding peat) by ranked countries

5. Carbon Measurement Context and practice

1. Decide on a classification system for land uses
2. Measure the C stock densities of the land use systems
3. Measure the changes in area fraction
4. Integrating the data to a landscape level C balance

Measuring Carbon in different Pools and Land Uses

C Pools	Measurement Method
Tree biomass	DBH and allometric
Understorey biomass	Destructive sampling
Crop	Literature or destructive sampling
Necromass	Non destructive
Litter	Destructive
Soil C	Destructive, density et C content

Determine Number of Plots

1. Identify the desired precision level, e.g. =/- 10% of the mean value (0.1)
2. Identify area where to collect preliminary data for each stratum. About 6-10 plots, plot size determined adequately
3. Estimate carbon stock average and standard deviation from preliminary data
4. Calculate the required number of plots

Reference: Pearson, Walker, Brown 2005: Sourcebook for Land Use, Land-Use Change and Forestry Projects. BioCF, Winrock International

Equation Elements

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n}$$ *Average*

$$S^2 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}$$ *Variance*

$$S = \sqrt{S^2}$$ *Std. deviation*

t : Sample statistic from the probability t-distribution for a chosen confidence level, e.g. 95%.
Initially, for an unknown sample size: t = 2

Example: Determine the No. of Plots

For a single-stratum project:

$$n = \frac{(N \times s)^2}{\frac{N^2 \times E^2}{t^2} + N \times s^2}$$

Single-stratum project

Area	=	5,000 ha
Plot size	=	0.08 ha
Mean stock	=	101.6 t C/ha
Standard deviation	=	27.1 t C/ha
N **(number of possible sample units)**	=	5,000/0.08 = 62,500
Desired precision	=	10 %
E **(allowable error)**	=	101.6 x 0.1 = 10.16

$$n = \frac{(62{,}500 \times 27.1)^2}{\frac{62{,}500^2 \times 10.16^2}{2^2} + 62{,}500 \times 27.1^2}$$

= 29 plots

Reference: Pearson, Walker, Brown 2005: Sourcebook for Land Use, Land-Use Change and Forestry Projects. BioCF, Winrock International

Current work in ASB Benchmarks in Cameroon

- ICRAF: Homegardens : 96 Plots (5 sites:)
- IITA: Cocoa Agroforests systems: 76 plots
- IRAD: Natural Forest and Peatlands: 64 Plots

The same methodology is applied globally in Peru, Vietnam and Indonesia

Land uses currently under C assess by ASB teams

Land Use	Area Sampled per / village	Total Sample
Old Growth Forest, open access in the NPFD – (*foret villageoise*)	2000 m * 4 = 0.8ha	5 ha
Secondary forest corresponding to very old fallows (> 20 years)	2000 m * 4 = 0.8ha	5 ha
Trees fallows: 11-20 years	2000 m * 4 = 0.8ha	5 ha
Bush fallows: 6-10 years	Variable *	Variable * 0.48 – 5ha
Young fallows: 3-5 years	Variable *	Variable * 0.48 – 5ha
Cocoa		20 ha
young (1-7years),	2000 m * 4 = 0.8ha	5 ha
mature (8-15 years),	2000 m * 4 = 0.8ha	5 ha
old (15-30)	2000 m * 4 = 0.8ha	5 ha
very old (> 30 years);	2000 m * 4 = 0.8ha	5 ha

Accounting for C-stock changes from land use sectors

$$\Delta C = \sum_{ij} A_{ij} [\Delta C_{ij\ LB} + \Delta C_{ij\ DOM} + \Delta C_{ij\ SOILS}] / T_{ij}$$

LUC *Biomass* *Necromass* *Soil*

ΔC Annual change in **C stocks** in the landscape, ton C yr^{-1}

Aij **area** of land use type *i* that change to *j*, ha

ΔCij LB Change in C stocks in **living biomass** from changes of land use type *i* to *j* , tons C ha^{-1}

ΔCij DOM Change in C stocks in **dead organic matter** from changes of land use type *i* to *j* , ton C ha^{-1}

ΔCij SOILS Change in C stocks in **soils** from changes of land use type *i* to *j,* ton C ha^{-1}

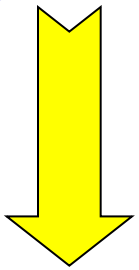
Tij **Period** of the transition from land use type *i* to land use type *j*, yr

- Classification scheme for land cover mapping
- Stratification - zoning
- Look-up table – landcover x land use systems

$$\Delta C = \sum_{ij} A_{ij} [\Delta C_{ij\ LB} + \Delta C_{ij\ DOM} + \Delta C_{ij\ SOILS}] / T_{ij}$$

- Sampling design
- Field measurement
- Modelling (allometric, growth, decay rate)

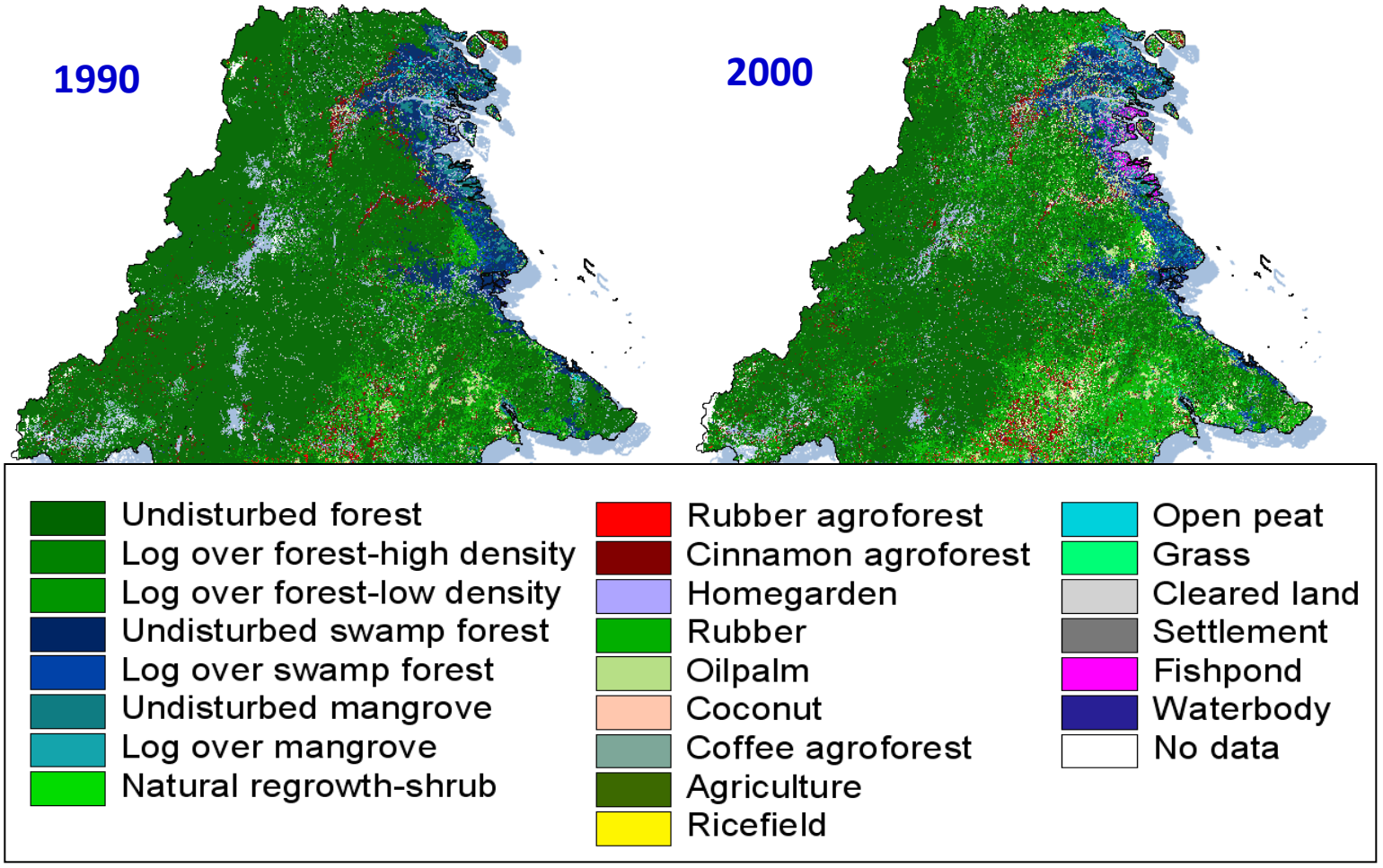
- Image interpretation
- Groundtruthing



Uncertainty/error

Accounting for C-stock changes from land use sectors

$$\Delta C = \sum_{ij} A_{ij} \left[\Delta C_{ij\ LB} + \Delta C_{ij\ DOM} + \Delta C_{ij\ SOILS}\right] / T_{ij}$$



Accounting for C-stock changes from land use sectors

$$\Delta C = \sum_{ij} A_{ij} [\Delta C_{ij\ LB} + \Delta C_{ij\ DOM} + \Delta C_{ij\ SOILS}] / T_{ij}$$

Modelling

Plot level measurement

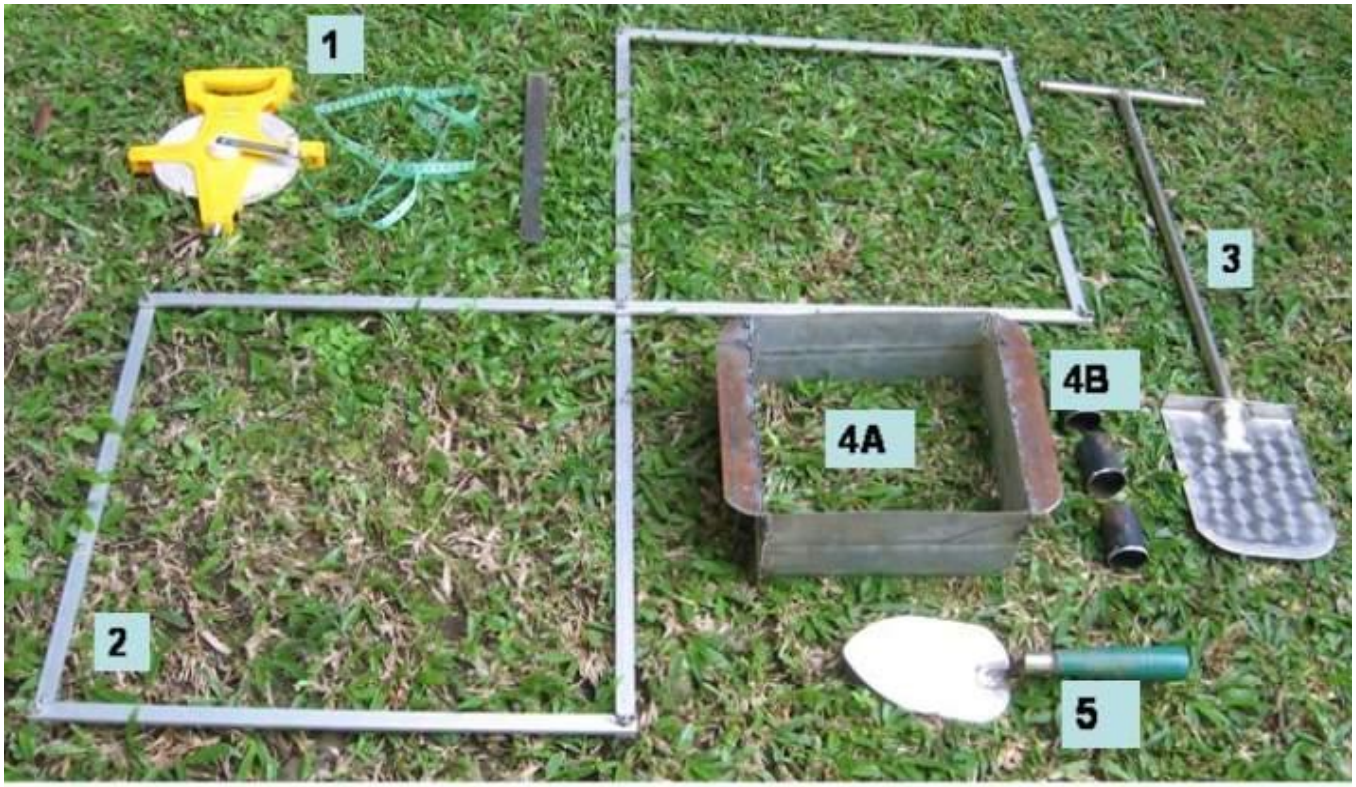
Measurement of C stock of

Bio-mass

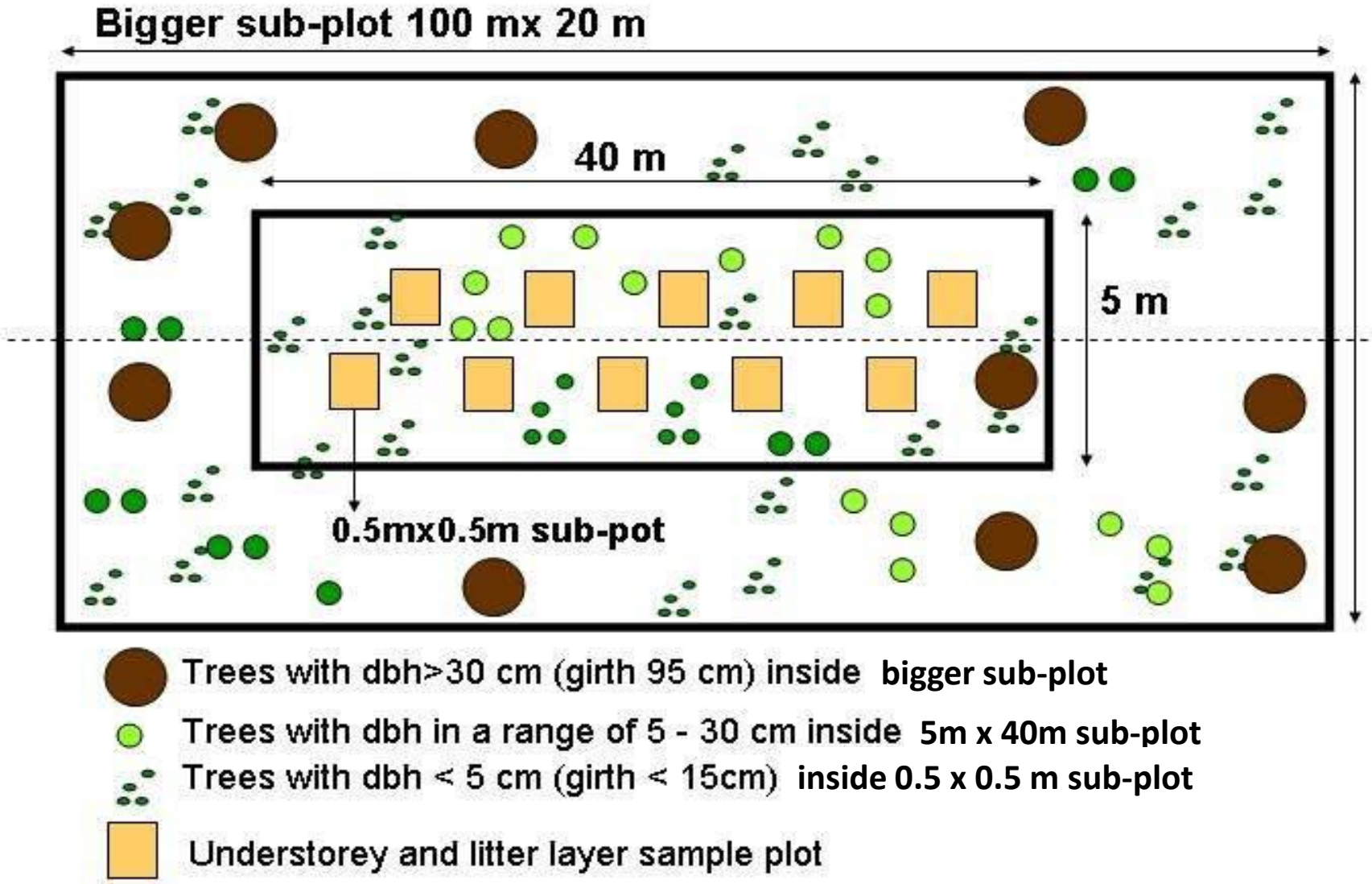
Soil

Equipments needed

-Measuring Tapes (5m, 50m
- Clinometer
- Sampling bags
- Etc

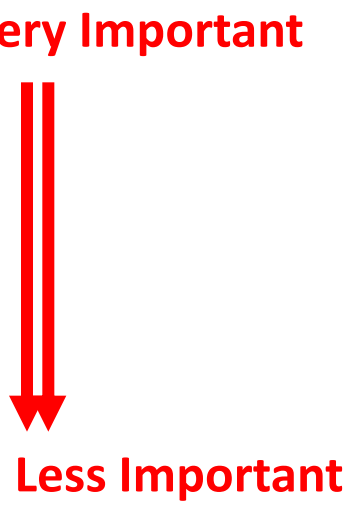


Nested Plot Design for Sampling



Important parameters for aboveground tree biomass

1. Tree trunk diameter
2. Wood specific gravity
3. Total height
4. Forest type (dry, moist or wet)



$$AGB = \rho D^2 H \ldots\ldots\ kg/tree$$

Chave *et al.* (2005)

Estimation of tree biomass

(Chave et al., 2005)

- **Branching pattern**
- **Diameter at breast height (dbh at 1.3 m)**
- **Wood density**

  - **Light (< 0.6 Mg m^{-3})**
  - **Medium (0.6 - 0.75 Mg m^{-3}),**
  - **Heavy (0.75 - 0.9 Mg m^{-3})**
  - **Very heavy (> 0.9 Mg m^{-3}) (*Anonymous, 1981*)**

Relation of tree size to carbon stocks

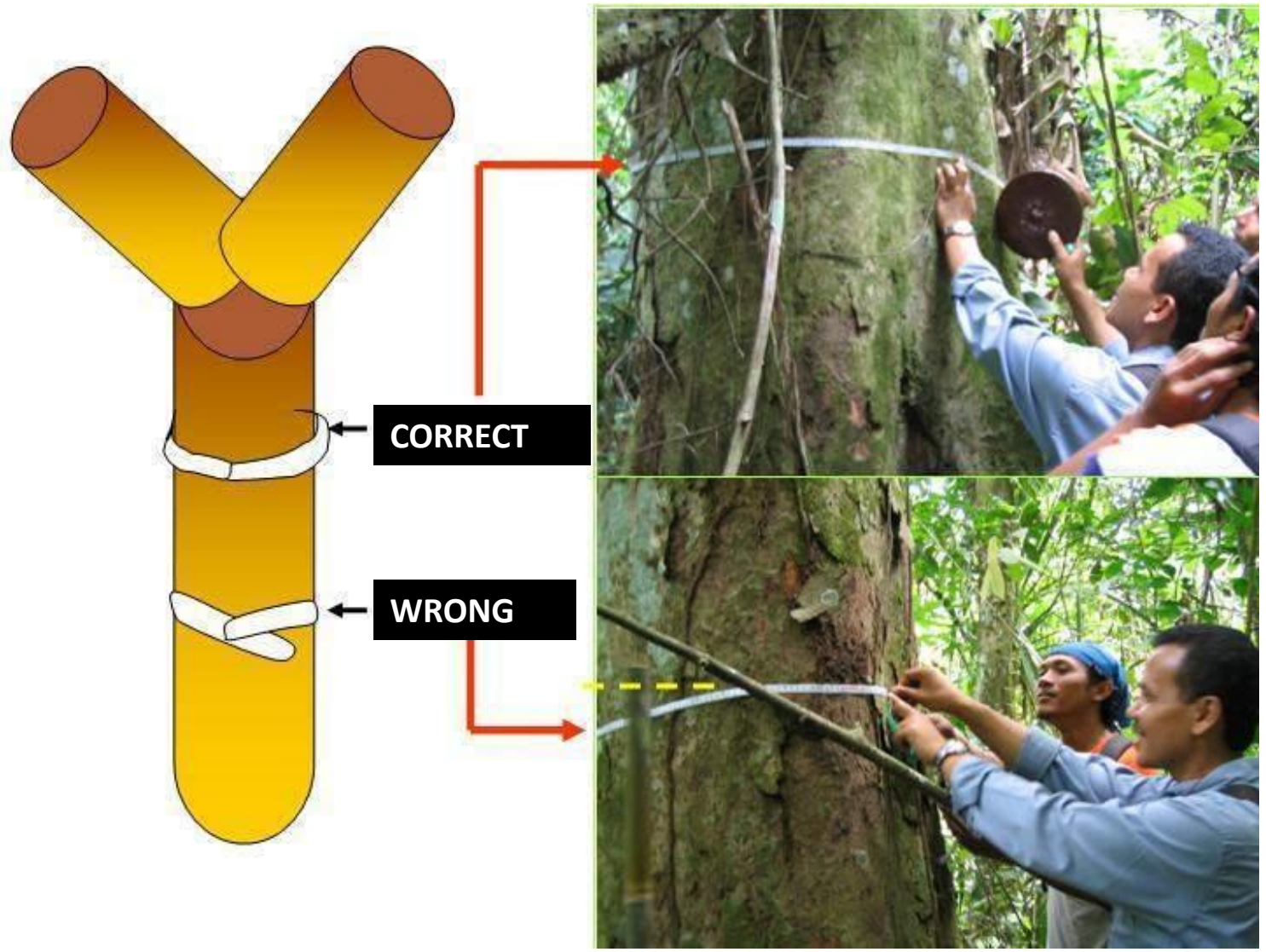
Stem diameter DBH (cm)	Biomass DM per tree (Mg)	No. of tree per hectare	Carbon per ha (Mg/ha)	Carbon (%)
10	0.13	900	53	19
30	2.25	70	71	24
50	8.50	20	76	26
70	20	10	90	31
Total	-	1000	290	100

Rainfall, mm/yr	Allometric	Diameter, cm	No tree	R^2
Dry (<1500)	**$W = 0.139\ D^{2.32}$** *(Brown, 1997)*	5-40	28	0.89
Moist (1500-4000)	**$W = 0.118\ D^{2.53}$** *(Brown, 1997)* **$W = 0.049\ D^2\ H$** *(Brown et al., 1995)* **$W = 0.11\ \rho\ D^{2+c}$** (c=0.62) *(Ketterings et al., 2001)*	5-148	170	0.90
Wet (>4000)	**$W = 0.037\ D^{1.89}\ H$** (Brown, 1997)	4-112	160	0.90
W = Tree Biomass, kg/tree; D=dbh, cm; ρ = wood density, g cm^{-3}				

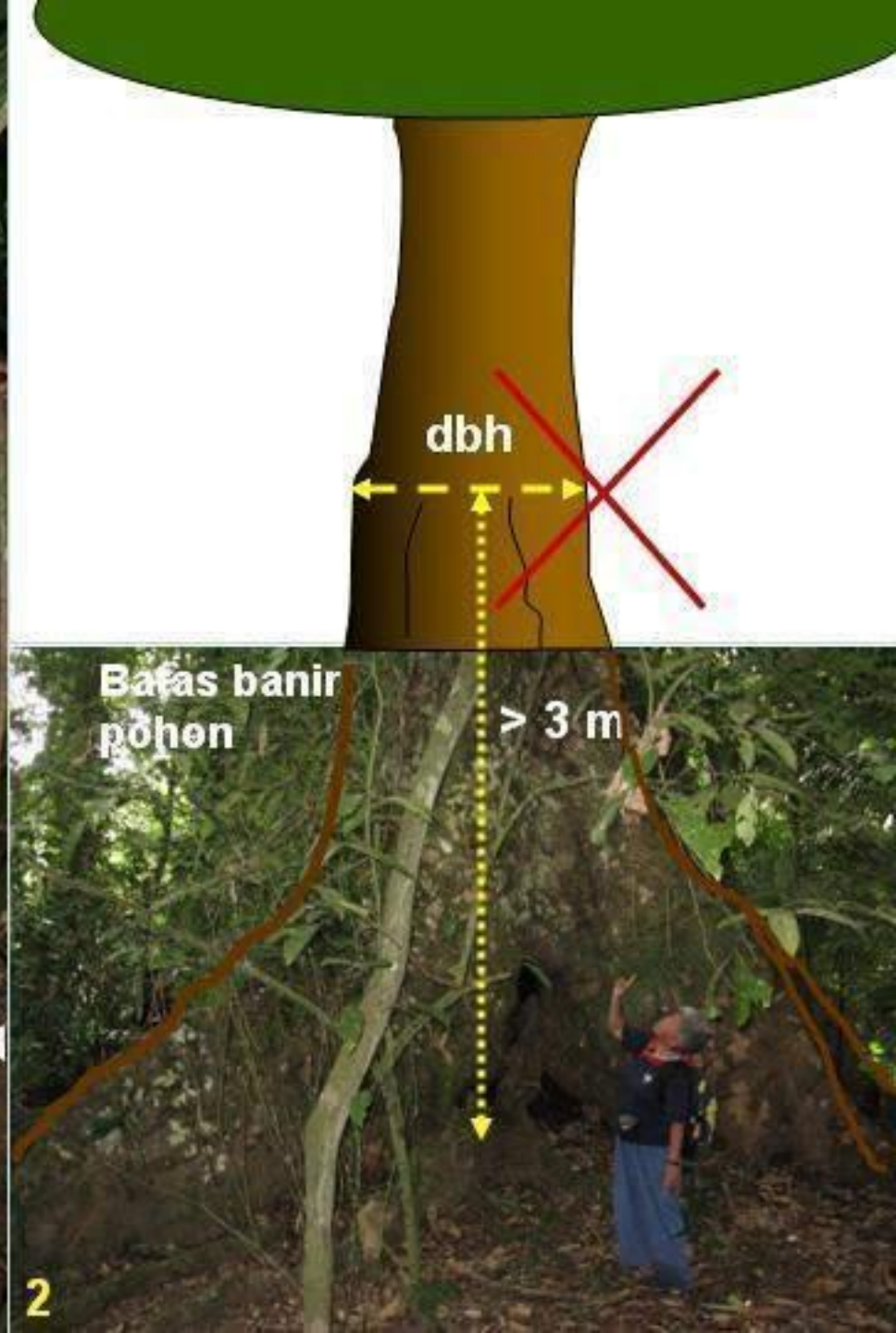
Biomass equations for 'woody' species

Vegetation	Equations	R^2
Coffee (Arifin, 2001)	$W = 0.2811\ D^{2.0635}$	0.9455
Banana (Arifin, 2001)	$W= 0.0303\ D^{2.1345}$	0.9887
Bamboo (Priyadarsini,1998)	$W= 0.1312\ D^{2.2784}$	0.9541
Paraserianthes (Sugiarto, 2001)	$W= 0.0272\ D^{2.831}$	0.8161
Tea (*Camelia sinensis*) (Hariyadi, 2005)	$W = 0.1594\ D^{1.1517}$	
Pinus (Waterloo, 1995)	$W= 0.0417\ D^{2.6576}$	0.9085

Measuring tree diameter at plot level for estimating C stock




dbh
0.5 m
1.3 m
1


dbh
Batas banir pohon
> 3 m
2

Abnormal condition

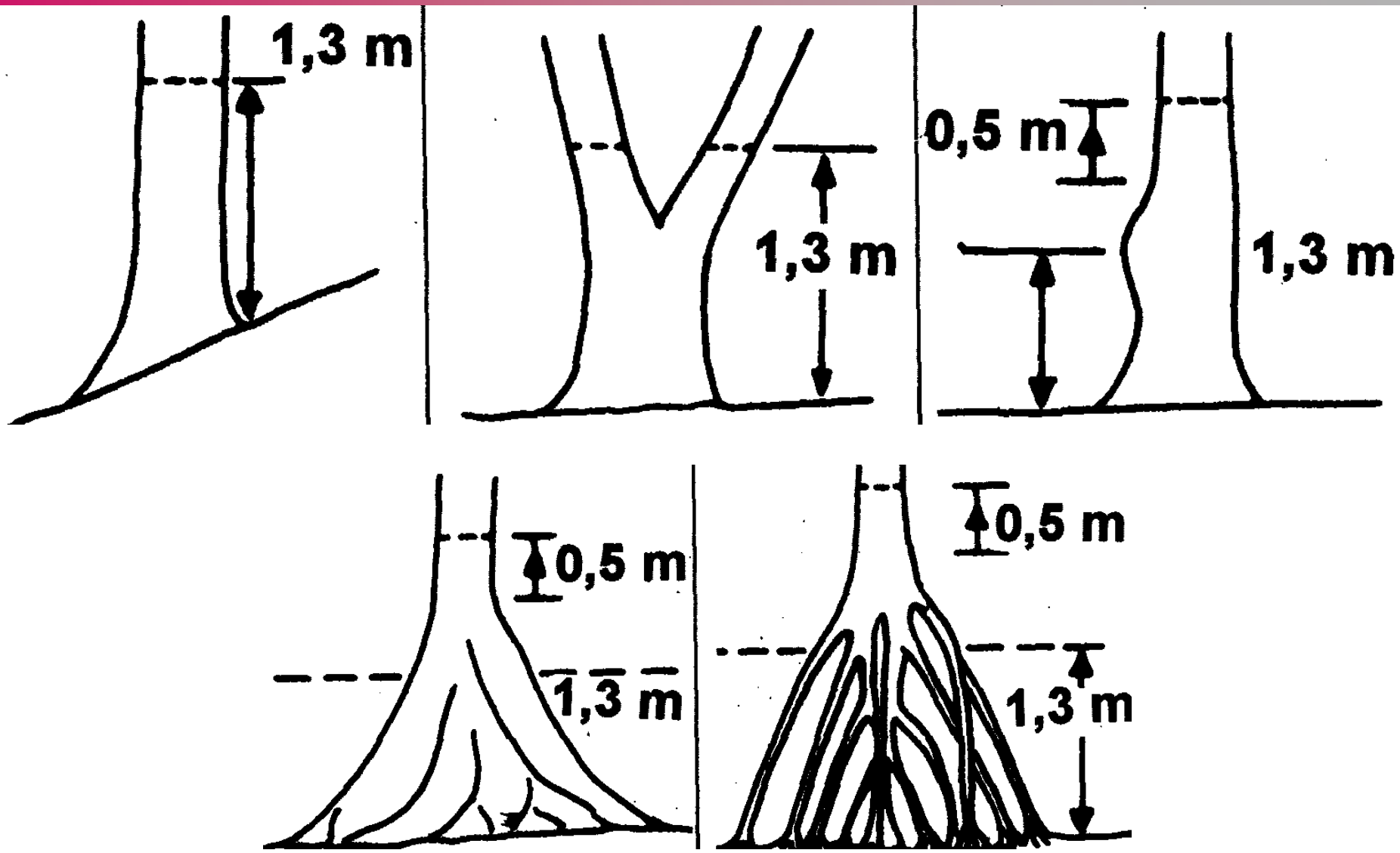


Table for total biomass of trees > 5 cm DBH

No	Local/Scientific name	Branched? Y/N	G	D	H	ρ*)	Biomass, kg/tree**)	Note
1							.....	
2							.....	
3							.....	
4							.....	
…							.....	
100							.....	
	TOTAL TREE BIOMASS						.....	

Note:
G=girth, cm, D = dbh= G/π, cm where π =3.14 ; H= tree height, cm, ρ = Wood density, g cm^{-3}

*)Estimated wood density: **H**igh, **M**edium, **L**ow (0.6, 0.4, 0.2 g cm^{-3})

***** *) Estimate AGB using specific allometric equation for tree growing in the tropical forest, and for trees growing in the agroforestry and plantation system

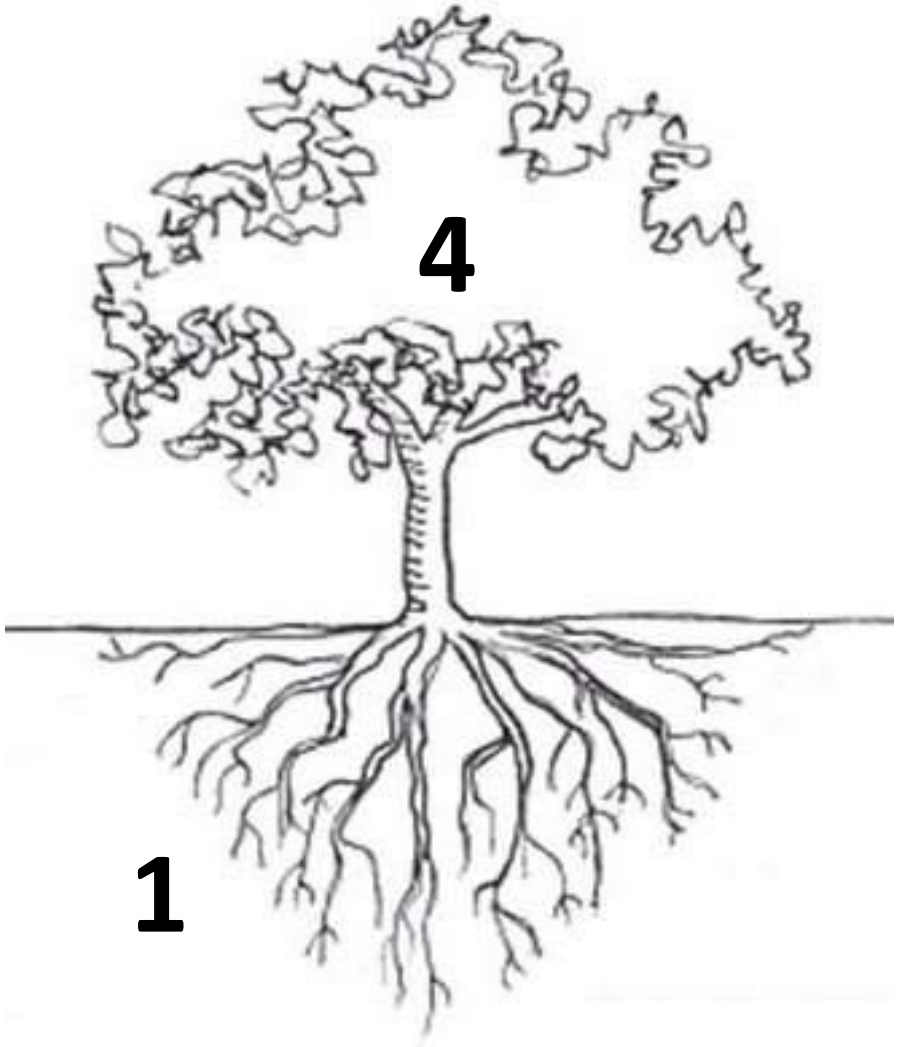
Table for total biomass of understorey

C stock = DW (kg) x total C (0.46)

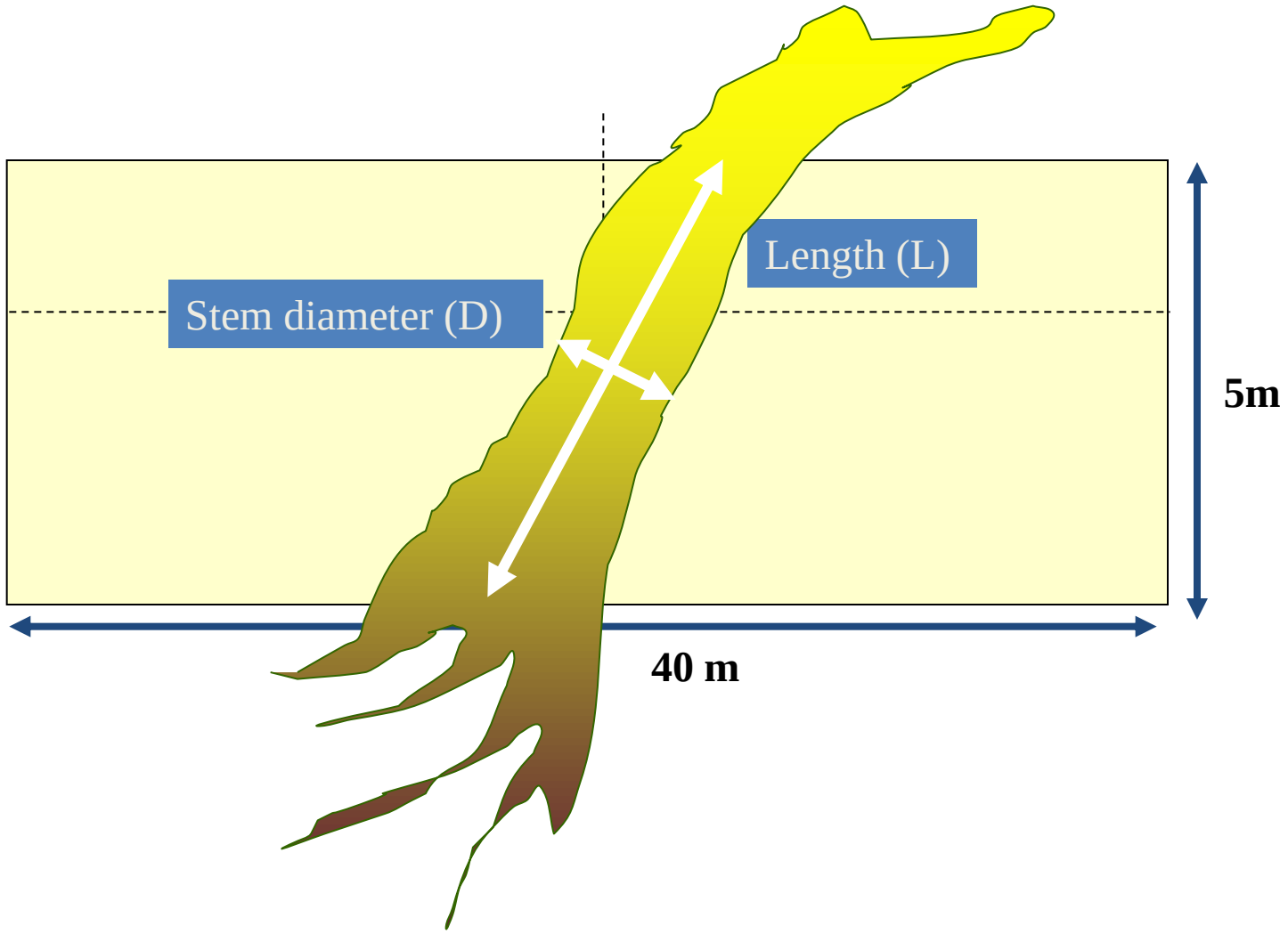
No.	Total FW (kg)	Sub-sample FW (g)	Sub-sample DW (g)	Total DW fine litter		Total C, %	Total C-stock, ton/ha
				kg/0.25 m^2	kg/m^2		
1							
2							
3							
4							
5							
6							
				Total DW	.....		
				Avg. DW	.....		

C stocks of Tree Root System

- Default values for the shoot/root ratio (SR-ratio) are **4:1** for humid tropical forest on normal upland soils
- up to **10:1** on continuously wet sites
- around **1:1** at very low soil fertility, long dry seasons



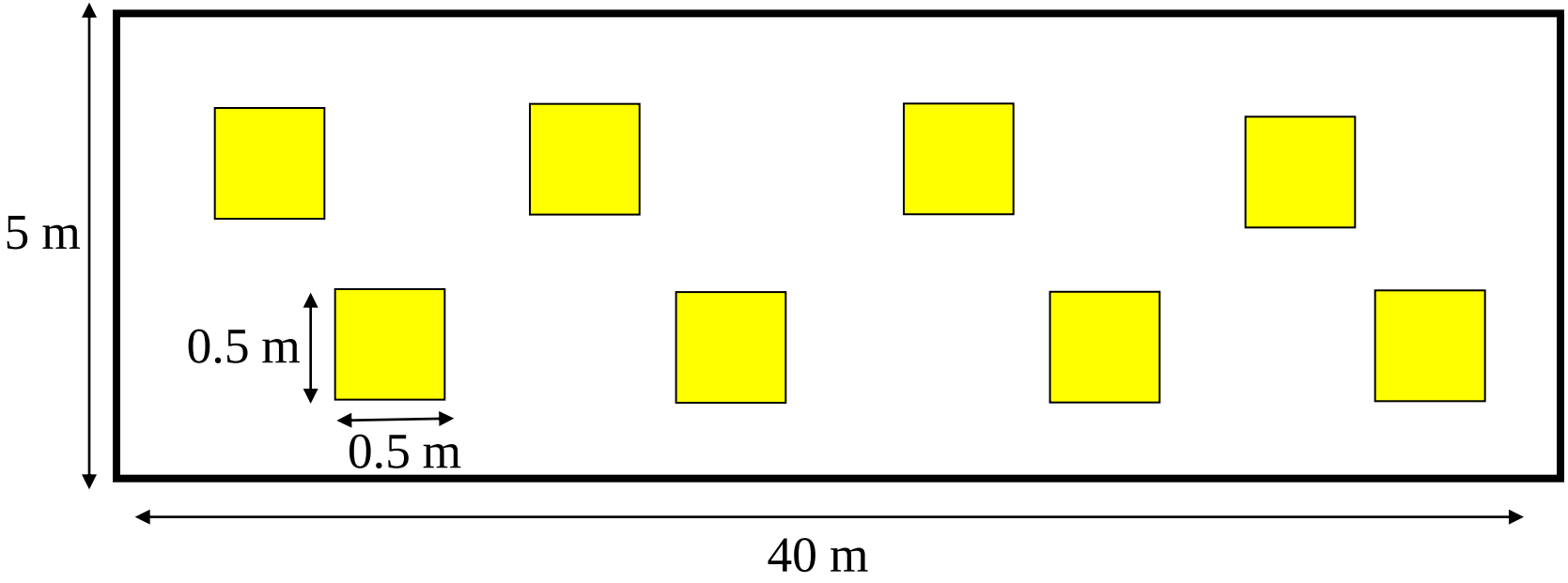
Estimation of Necromass: Laying trees



$DW = \pi/4 \times D^2\ [cm^2] \times length\ [cm] \times wood\ density\ [g\ cm^{-3}]$

NECROMASS: Undisturbed sampling

Destructive sampling: understorey and litter



Sample handling: Separating roots and soil

Estimation of total C stock in soil

Example of C calculation in soils

- **C stock (ton/ha) = *f(depth of the soil layer, bulk density and C concentration)***

Estimation of Total C stock per plot

LUS	Rep	Tree*) ton/ha	Understorey ton/ha	Litter ton/ha	Root**) ton/ha	Soil 0-5 cm ton/ha	Soil 5-15 cm ton/ha	Total C-stock ton/ha
		1	2	3	4	5	6	1+2+3+4 +5+6
	1							
	2							
	3							
	4							
	5							
	6							
								Σ ….

Problems in C measurement

- Difficulties working in long fallow vegetation and secondary forest
- Determination of effective survey area
- Selection of different sampling plots
- etc

Carbon stocks of different LUS

Land use system (LUS)	C stock time-averaged (tC/ha)	CO_2 stock time-averaged (tCO_2/ha)
Natural forest	250	918
Logged forest	200	734
Heavily logged forest	120	440
Agroforest 1	80	294
Agroforest 2	60	220
Cocoa	50	184
Oil palm plantations	41	150
Improved pastures	5	18
Low-productivity pastures	2	7
Agriculture 8yr fallow	15	55
Agriculture 3yr fallow	5	18

Sources: Palm, et al. 2004; White, et al. 2005.

Land use systems targeted by ASB in Cameroon

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Old Growth Forest, open access in the NPFD – (*foret villageoise*)	2000 m * 4 = 0.8ha	5 ha
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ASBResearch Perspectives in Africa for the COP 17 in Durban 2011

- **ASB-REALU Project**:
  1. Participatory development of country level REALU-REDD readiness framework including non forest sectors for addressing deforestation
  2. Review and update of landscape REDD+/REALU data on Land uses and rights (also in links with RRI funds)
  3. Assess institutional structure and governance for REDD+
  4. Review land use options (existing and new) to project their impact on ES
  5. Assess drivers of deforestation in target sites
  6. Testing PES mechanisms in West and central Africa

Our partners

We acknowledge with thanks the collaboration of:

Donors

- Norwegian Government through NORAD
- American Goverment
- The EU and IFAD
- RRG

Technical and institutional

COMIFAC, CBFP, CG Centers, Universities, NARS, NGOs and CBOS


Merci beaucoup de votre attention