National University of Mongolia

DEPARTMENT OF FOREST SCIENCES

SOME RESULTS OF FOREST CARBON STOCK CALCULATION IN NORTHERN MONGOLIA

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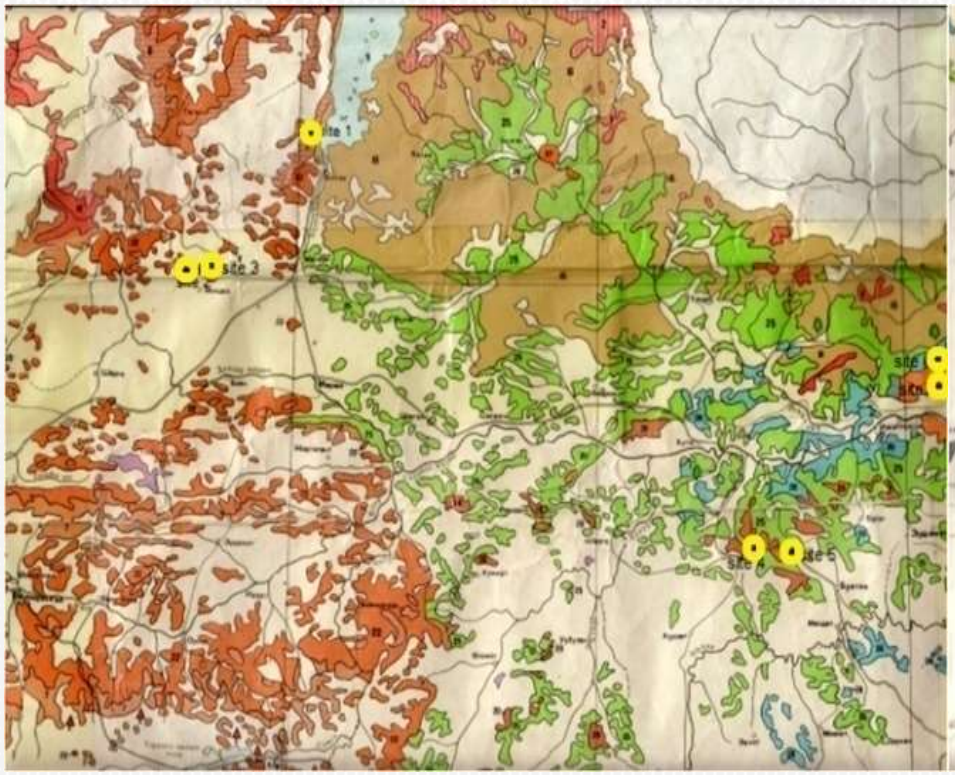
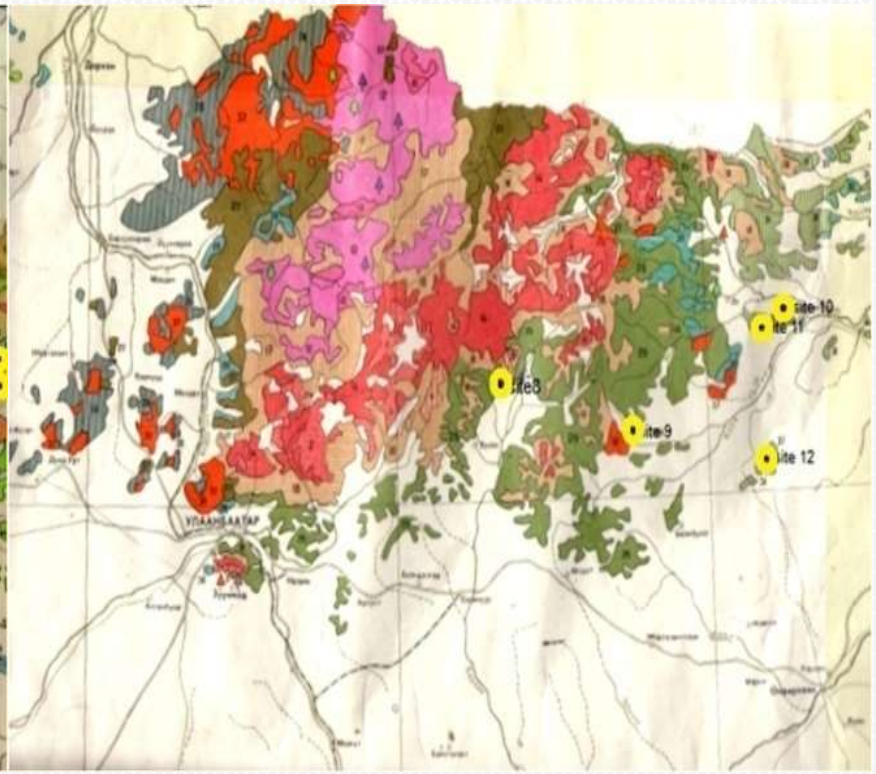
2013

LOCATION OF SAMPLE PLOTS AND DATE OF MEASUREMENTS

№	Site name		Location	Duration	Date	Forest type
	Province	Sum	Latitude			
1	Khuvusgul	Khatgal	50°34'29.50"	3:15	August 18	8
2	Khuvusgul	Ar Bulag	50° 2'46.00"	2:55	August 19	7
3	Khuvusgul	Ar Bulag	50° 2'51.20"	2:40	August 19	22
4	Bulgan	Khutag Undur	48°57'8.50"	2:50	August 21	20
5	Bulgan	Khutag Undur	48°56'54.30"	3:15	August 22	25
6	Bulgan	Khyalgant	49°36'12.10"	2:50	August 23	26
7	Bulgan	Khyalgant	49°34'52.10"	2:50	August 24	39
8	Tuv	Mungun Morit	48°26'59.00"	3:00	September14	4
9	Khentii	Umnu Delger	48°13'32.00"	3:00	September 16	29
10	Khentii	Binder	48°38'2.70"	3:40	September 17	37
11	Khentii	Binder	48°33'40.00"	2:40	September17	31
12	Khentii	Khurkh	48° 9'25.20"	3:05	September 18	32

LOCATION OF SAMPLE PLOTS

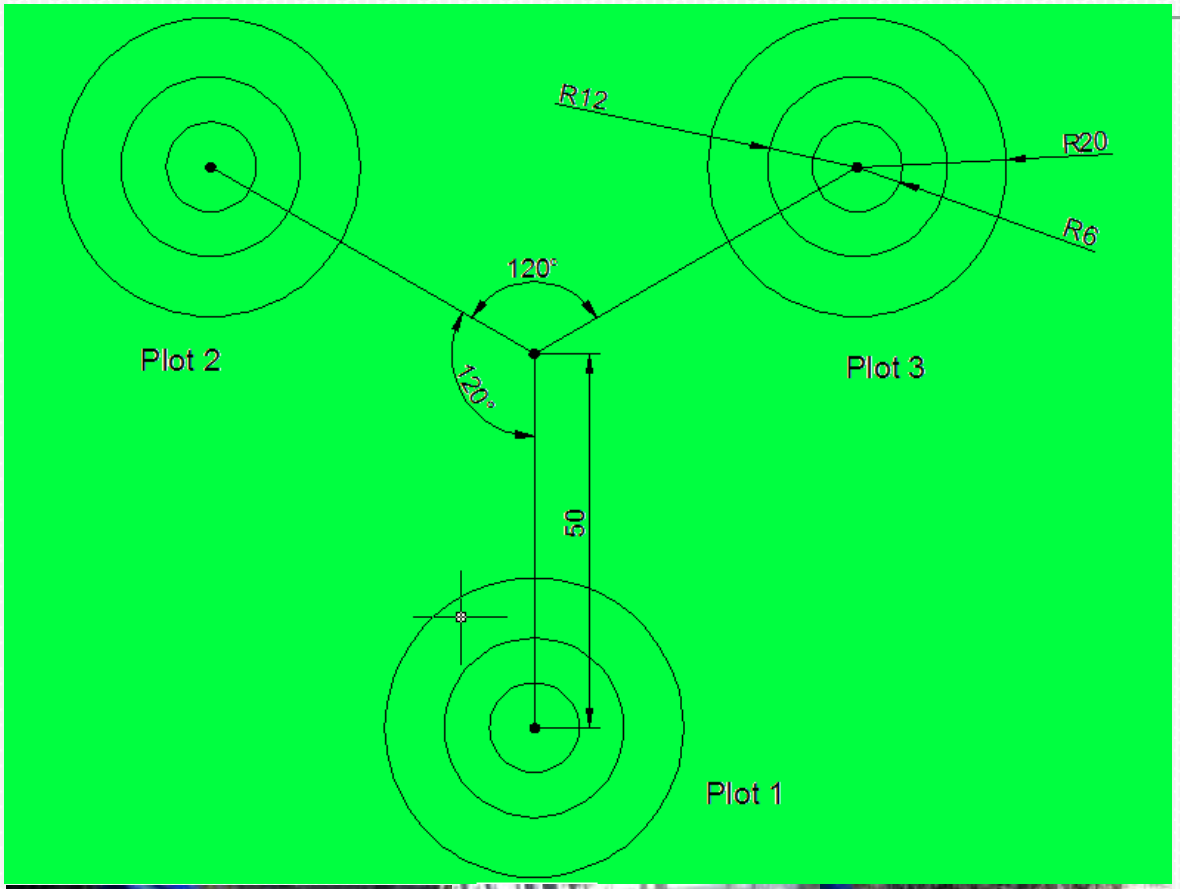




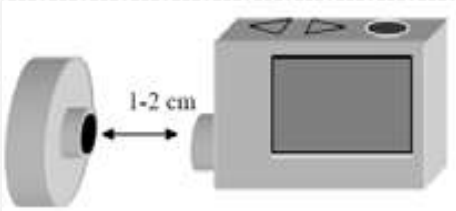
VOLUME OF COLLECTED DATA AND MEASUREMENTS IN THE FIELD SURVEY

№	Province	Forest type	Number of sample plots	Living trees	Standing dead wood	Down dead wood	Stump	Understory vegetation saplings/ha	Soil samples
1	Khuvsgul	8	1 (3 plot)	54	31	10	0	17	15
2		7	1 (3 plot)	94	19	0	0	18	15
3		22	1 (3 plot)	26	1	2	82	4	15
4	Bulgan	20	1 (3 plot)	82	22	1	45	14	15
5		25	1 (3 plot)	58	11	6	20	30	15
6		26	1 (3 plot)	47	20	3	0	24	15
7		39	1 (3 plot)	54	1	5	0	2565	15
8	Tuv	4	1 (3 plot)	77	21	7	0	281	15
9	Khentii	29	1 (3 plot)	48	1	2	32	150	15
10		37	1 (3 plot)	90	7	2	95	1288	15
11		31	1 (3 plot)	52	1	3	46	119	15
12		32	1 (3 plot)	85	77		12	103	15
	Total		**12 (36)**	**767**	**212**	**41**	**332**	**4613**	**180**

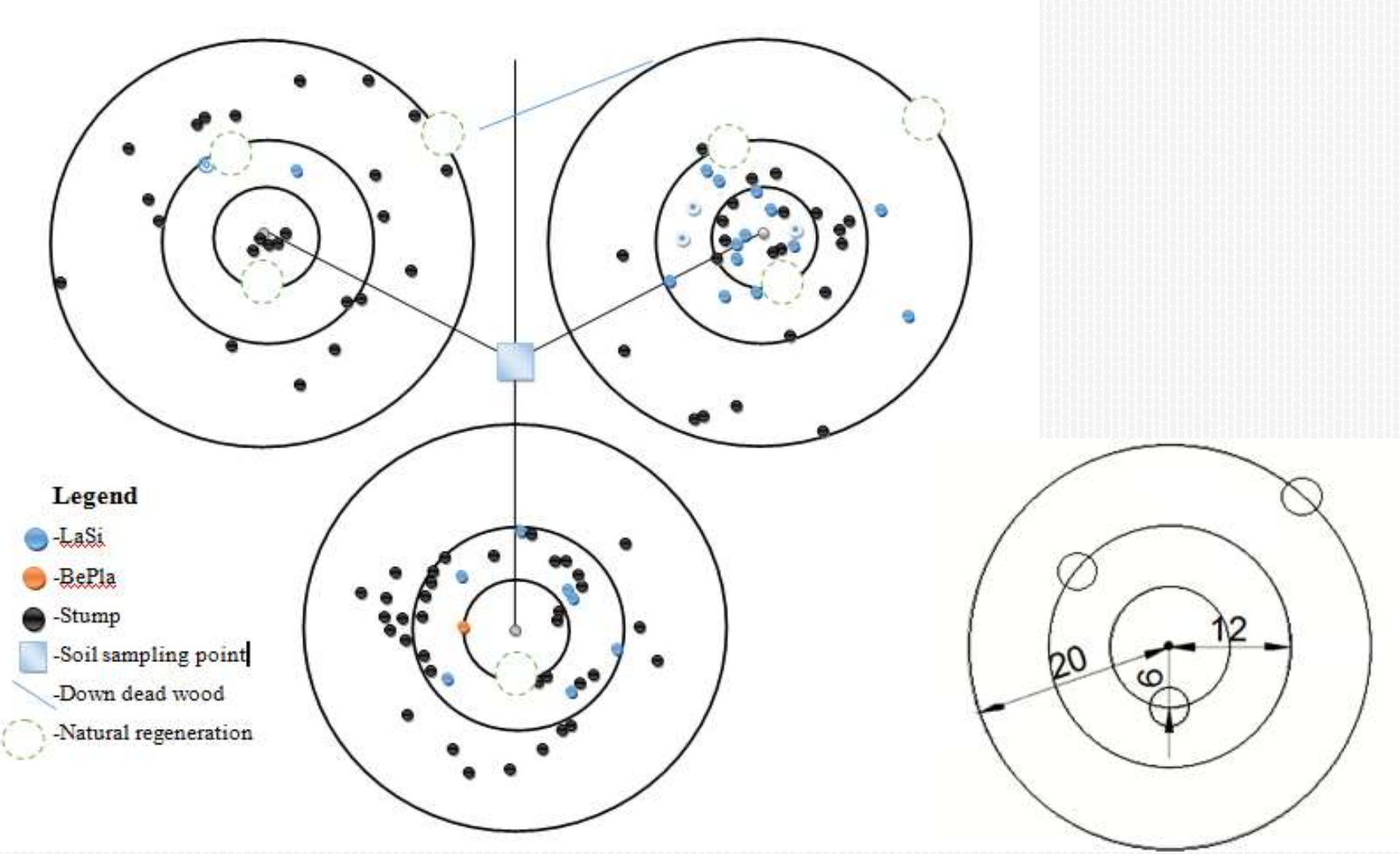
SAMPLING DESIGN AND MEASUREMENTS



Plot name	Radius (m)	Diameter at breast height (cm)
Large plot	20	30 <
Intermediate plot	12	15-30
Small plot	6	5-15



SAMPLING DESIGN AND MEASUREMENTS



CARBON STOCK CALCULATION OF LIVING TREES

Biomass Expansion Factor method

$$AGB = GSV * BEF$$

Where: AGB – Aboveground biomass (ton/ha)
GSV – growing stock volume (m^3/ha)
BEF – biomass expansion factor (t/m^3)

BEF =[total above-ground biomass of all living trees]/ [growing stock volume]

Source: Jenkins, J.C.; Chojnacky, D.C.; Heath, L.S.; Birdsey, R.A. 2003.National-scale biomass estimation for United States tree species. Forest Science. 49: 12-35.

Biomass equation $y = Exp(\beta_0 + \beta_1 Ln\ x)$

Where: y – total aboveground biomass (kg) for trees 2.5 cm and larger in d.b.h.
x - d.b.h.(cm)
exp – 'e' to power of
ln – base of natural log 'e' (2.7178282)

	β_0	β_1
Pine	-2.5356	-2.4349
Betula	-1.9123	-2.3651

7.3.2 Estimation and forecasting

A. Above ground biomass:

Following recommendations from FRA guidelines the following assumptions and calculations have been made:

The ecological zone of forest is assumed to correspond to the boreal, and one of OWL is to the temperate. From appendix 5, table 5.4 page 6 of the FRA guidelines and considering an ecological zones, the Biomass Conversion and Expansion Factor (BCEF) of 0.50 (pines in forest), 0.77 (larch in forest), 0.53 (firs and spruces in forest) ,0.55 (hardwoods in forest) and 3.0 (OWL) have been applied to the growing stock:

Source: Global Forest Resources assessment , 2010. Country report of Mongolia, Forestry Department Food and Agriculture Organization of the United Nations, 29p.

CARBON STOCK CALCULATION OF LIVING TREES

Carbon calculation from biomass

$$C_b = B * \%C \text{ organic}$$

Where:

C_b – carbon content from biomass (kg)

B – total biomass (kg)

%C organic – percentage value of carbon content, amounting to 0.47 or using the value obtained in measurement in the laboratory

№	Forest type	Volume m^3/ha	AGB ton/ha	Carbon stock ton/ha
1	8	61.78	47.57	21.88
2	7	100.59	77.46	35.63
3	22	52.50	38.35	17.64
4	20	205.62	158.32	72.83
5	25	100.58	72.92	33.54
6	26	82.30	45.27	20.82
7	39	52.24	26.12	12.02
8	4	55.11	42.39	19.50
9	29	89.85	69.19	31.83
10	37	155.94	88.90	40.89
11	31	105.02	80.86	37.20
12	32	6.03	4.65	2.14

CARBON STOCK CALCULATION OF DEAD WOOD

Biomass of standing dead wood

$$B_{SDW,sp,I,t} = * \pi * \left(\frac{B_{SDW,sp,I,t}}{200}\right)^2 * H_{SDWl,I,t} * D_{DWdc}$$

Where:

$B_{SDW,sp,I,t}$ – Biomass of standing dead wood from sample plot

$BDia_{SDWL,sp,I,}$t – Basel diameter of standing dead wood

$H_{SDWl,I,t}$ – Height of standing dead wood

D_{DWdc} – Mean wood density

$$B_{SDWsp,i,t} = \sum_{l=1}^{Nsp,i,t} B_{SDWL,sp,I,i,t}$$

Where:

$B_{SDWsp,i,t}$ -Biomass of standing dead wood in sample plot

$B_{SDWL,sp,I,i,t}$ – Biomass of standing dead tree

$$C_{DWi,t} = B_{SDWi,t} + B_{LDWi,t} * CF_{DW} * \quad (44/12)$$

Where:

$C_{DWi,t}$ - Mean carbon stock of dead wood

$B_{SDWi,t}$ – Biomass of standing dead wood in stratum

$B_{LDWi,t}$ – Biomass of lying dead wood in stratum

CF_{DW} – Carbon fraction of dry matter in dead wood

(44/12) - Ratio of molecular weight of CO_2 to carbon, t CO_2 –e tC^{-1}

Source: Estimation of carbon stocks in the dead wood pool, 2010, REDD Methodological Module, 3-8 p.

CARBON STOCK CALCULATION OF DEAD WOOD

Biomass of downed dead wood

$$\textbf{Volume } (m^3/ha) = \pi^2 * [(d1^2 + d2^2 \ldots\ldots\ldots dn^2)/8L]$$

Where:

d1, d2, …dn (cm) – tree diameter in the transect (cm)

L – length of transect (100 m)

Source: Heath, Linda S.; Chojnacky, David C. 2001. Down dead wood statistics for Maine timberlands, 1995.Resour. Bull. NE-150. Newtown Square, PA: U.S. Department of Agriculture, ForestService, Northeastern Research Station. 80p.

Calculation of carbon from dead organic material (litter, dead wood, dead tree)

$$C_m = B_o * \%C\ organic$$

Where:

C_m – carbon content of dead organic material (kg)

B_o – total biomass of dead wood (kg)

%C organic – percentage value of carbon content, amounting to 0.47 or using the value obtained in measurement in the laboratory

CARBON STOCK CALCULATION OF DEAD WOOD

№	Forest type	Wood volume m3/ha	Biomass ton/ha	Carbon stock (ton/ha)
1	8	99.51	33.353	21.346
2	7	0	0	0.000
3	22	26.86	11.1	7.104
4	20	2.49	1.842	1.179
5	25	18	5.061	3.239
6	26	16.74	1.95	1.248
7	39	16.040	10.278	6.578
8	4	31.66	7.469	4.780
9	29	6.24	3.698	2.367
10	37	4.19	1.208	0.773
11	31	10.67	3.986	2.551
12	32	7.42	2.861	1.431

CARBON STOCK CALCULATION OF SOIL

Calculation of soil carbon stock

$$C_t = K_d * \rho * \%\ \text{Corganic}$$

Where:

C_t – is the soil carbon stock, expressed in gram per square cm (g/cm^2)

K_d – is the depth of the soil sample, expressed in centimeter (cm)

ρ – is the soil bulk density, expressed in grams per cubic centimeter (g/cm^3)

$\%C_{organic}$ –is the percentage value of organic carbon content, amounting to 0.47 *LOI (loss on ignition in percent)

Source: *Lal, R.; Kimble, J.M.; Follett, R.F.; Stewart, B.A., eds. 2001.Assessment methods for soil carbon.Boca Raton, FL: Lewis Publishers.Robertson, G.P.; Coleman, D.C.; Bledsoe, C.S.; Sollins, P. 1999. Standard methods for long-term ecological research. Oxford, U.K: Oxford University Press.*

Calculate the bulk density of the mineral soil core

$$\text{Bulk density } (g/cm^3) = \frac{\text{Oven dry mass } (g/cm3)}{corevolume\,(cm3) - \frac{mass\ of\ course\ fragments\ (g)}{density\ of\ rock\ fragments\ (\frac{g}{cm3})}}$$

Source: Integrating Carbon Benefit Estimates into GEF projects, 2005. Capacity Development and Adaptation Group Guidelines, 27 p.

CARBON STOCK CALCULATION OF SOIL

Calculation of organic soil carbon content per hectare

$$C_{soil} = C_t * 100$$

Where:

C_{soil}– is the organic soil carbon content of organic soil per hectare, expressed in tons (ton/ha)

C_t–is the soil carbon content, expressed in gram per square cm (g/cm^2)

100 - is the conversion factor from g/cm^2 to ton/ha

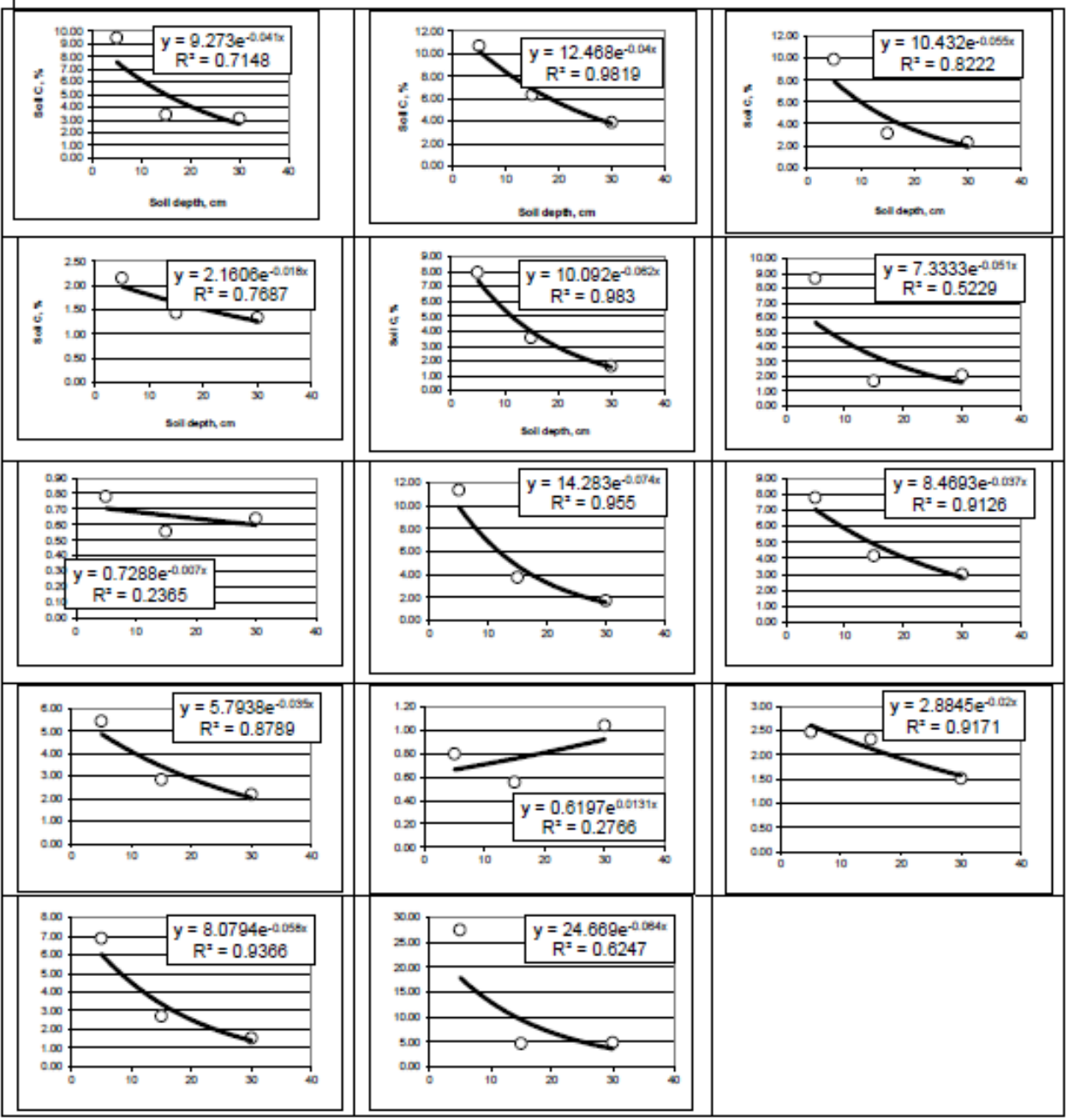
Source: *Measurement and calculation of carbon stocks – Field measurement for estimating for forest carbon stocks (ground based forest carbon accounting), 2011. Centre for Standardization and Environment Ministry of Forestry, Indonesia,16p.*

Forest floor oven-dry weight (g) / sampling frame area (cm^2)*100

Where multiplying by 100 converts the units to metric t/ha. Multiplying by 0.5 gives the amount of carbon.

Source: Timothy R.H. Pearson, Sandra L. Brown, Richard A. Birdsey, 2007. Measurement Guidelines for the Sequestration of Forest Carbon, USDA, General Technical Report NRS-18, 24 p.

Forest type	Depth, cm	SOMa (g/kg)		C, g/kg	C, %	Db, g/cm3		SummarisedC_{soil}, ton/ha
		Mean	SD			Mean	SD	
8	5	201.16	23.22	94.55	9.45	0.90	0.05	15139.34
	15	73.07	4.71	34.34	3.43	1.16	0.04	
	30	66.65	6.75	31.33	3.13	1.47	0.37	
20	5	227.74	62.86	107.04	10.70	0.58	0.25	20694.53
	15	134.82	17.07	63.36	6.34	1.55	0.77	
	30	82.67	7.45	38.85	3.89	1.33	0.02	
25	5	210.32	27.27	98.85	9.88	0.89	0.01	13131.16
	15	66.80	6.91	31.39	3.14	`1.30	0.06	
	30	48.99	2.65	23.03	2.30	1.34	0.14	
29	5	45.77	6.57	21.51	2.15	1.27	0.11	6229.06
	15	30.60	2.26	14.38	1.44	1.38	0.03	
	30	28.55	4.84	13.42	1.34	1.43	0.07	
22	5	169.08	18.48	79.47	7.95	0.92	0.02	11156.46
	15	75.46	11.66	35.47	3.55	1.24	0.15	
	30	35.16	2.06	16.52	1.65	1.25	0.23	
16	5	184.48	9.84	86.70	8.67	1.26	0.29	12458.32
	15	35.75	3.78	16.80	1.68	1.44	0.00	
	30	44.55	1.73	20.94	2.09	1.46	0.02	
39	5	16.62	2.47	7.81	0.78	1.39	0.18	2777.85
	15	11.86	0.60	5.57	0.56	1.56	0.00	
	30	13.63	2.30	6.41	0.64	1.42	0.12	
7	5	241.45	46.07	113.48	11.35	0.79	0.17	12521.38
	15	79.87	4.74	37.54	3.75	1.16	0.11	
	30	36.53	3.04	17.17	1.72	1.44	0.09	
26	5	165.56	10.07	77.81	7.78	0.90	0.08	13551.12
	15	88.51	6.37	41.60	4.16	1.15	0.08	
	30	64.31	2.67	30.22	3.02	1.16	0.08	
31	5	115.80	20.45	54.43	5.44	1.01	0.15	10358.67
	15	60.47	4.33	28.42	2.84	1.19	0.06	
	30	46.51	5.00	21.86	2.19	1.29	0.01	
37	5	16.91	8.06	7.95	0.79	1.33	0.10	3516.08
	15	11.82	1.20	5.56	0.56	1.36	0.11	
	30	22.08	9.90	10.38	1.04	1.43	0.14	
32	5	52.57	2.92	24.71	2.47	1.22	0.07	7485.71
	15	49.39	7.74	23.22	2.32	1.24	0.22	
	30	32.16	3.62	15.11	1.51	1.37	0.13	
25	5	146.48	13.10	68.85	6.88	0.97	0.13	9046.79
	15	57.61	3.71	27.08	2.71	1.06	0.06	
	30	32.66	1.77	15.35	1.53	1.23	0.03	
	5	585.52	16.76	275.19	27.52	0.36	0.09	



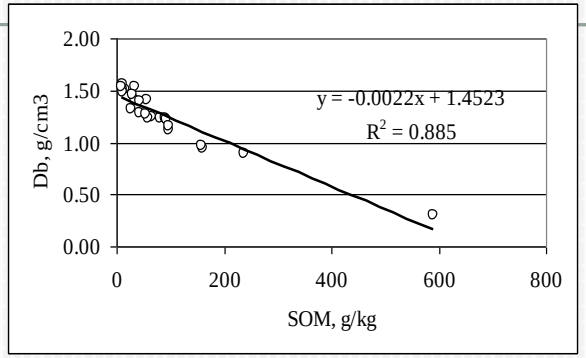


Figure 11. Relationships between soil carbon concentration and soil depth

CALCULATION OF TOTAL CARBON STOCK

$$C_{plot} = (C_{bar} + C_{bbp} + C_{litter} + C_{km} + C_{pm} + C_{soil})$$

Where:

C_{plot}– total carbon content in the plot (ton/ha)

C_{bar} - total carbon content of above-ground biomass per hectare in the plot (ton/ha)

C_{bbp}- total carbon content of below-ground biomass per hectare in the plot (ton/ha)

C_{litter}-total carbon content of the litter biomass per hectare in the plot (ton/ha)

C_{km}- total carbon content of standing dead wood biomass per hectare in the plot (ton/ha)

C_{pm}-total carbon content of downed dead tree biomass per hectare in the plot (ton/ha)

C_{soil}-total carbon content of soil per hectare in the plot (ton/ha)

CALCULATION OF TOTAL CARBON STOCK

№	Forest type	Forest carbon pools (ton/ha)					Total carbon stock (ton/ha)
		live tree	Standing dead tree	Downed dead tree	Forest floor	Soil carbon	
1	Kh.Khat 8	21.88	4.83	21.346	calculating	151.39	199.45
2	Kh.ArBu 7	35.63	2.49	0	0	125.21	163.33
3	Kh.ArBu 22	17.64	0.70	7.104	0	111.56	137.01
4	Bu.Khu 20	72.83	2.50	1.179	0	206.95	283.46
5	Bu.Khu 25	33.54	0.31	3.239	0	131.31	168.40
6	Bu.Khya 26	20.82	0.41	1.248	0	135.51	157.99
7	Bu.Khya 39	12.02	0.00	6.578	0	27.78	46.38
8	Tu.Mm 4	19.5	3.01	4.78	0	181.14	208.43
9	Kh.Ud 29	31.83	0.03	2.367	0	62.29	96.52
10	Kh.Bi 37	40.89	0.29	0.773	0	35.16	77.12
11	Kh.Bi 31	37.2	0.04	2.551	0	103.59	143.38
12	Kh.Khu 32	2.14	0.17	1.431	0	74.86	78.60

CALCULATION OF TOTAL CARBON STOCK

Calculating total carbon in stratum

$$C_{stratum} = \left(\sum Cplot \middle| Nplot\right) \text{ *area of stratum}$$

Where:

$C_{stratum}$ - total carbon stock in stratum (ton)

N_{plot} – number of plots in the stratum

C_{plot} – total carbon content per hectare in plots

Calculating the total carbon stock in an area

$$C_{total} = \Sigma C_{stratum}$$

Where:

C_{total} – carbon stock in an area (ton)

$C_{stratum}$ – total carbon stock in stratum (ton)

Source: *Measurement and calculation of carbon stocks – Field measurement for estimating for forest carbon stocks (ground based forest carbon accounting), 2011. Centre for Standardization and Environment Ministry of Forestry, Indonesia,16p.*

THANK YOU FOR YOUR ATTENTION