Supplementary Information

Table S1: Summary of eco zones and vegetation types used for computing the forest area according to the legend of GEZ FAO map and GLC 2000 map.

FAO GEZ map			GLC 2000 map	
Eco zones	**Symbol**	**Forest type**	**Classes**	
Tropical	TAr	Tropical rain forest	1	Tree Cover, broadleaved, evergreen
	TAwa	Tropical moist deciduous forest	2	Tree Cover, broadleaved, deciduous, closed
	TAwb	Tropical dry forest	3	Tree Cover, broadleaved, deciduous, open
	TBSh	Tropical shrubland	4	Tree Cover, needle-leaved, evergreen
	TBWh	Tropical desert	5	Tree Cover, needle-leaved, deciduous
	TM	Tropical mountain systems	6	Tree Cover, mixed leaf type
Subtropical	SCf	Subtropical humid forest		
	SCs	Subtropical dry forest	**Other possible forest classes (not used in this study)**	
	SBSh	Subtropical steppe	7	Tree Cover, regularly flooded, fresh water
	SBWh	Subtropical desert	8	Tree Cover, regularly flooded, saline water
	SM	Subtropical mountain systems	9	Mosaic: Tree Cover / Other natural vegetation
Temperate	TeDo	Temperate oceanic forest	11	Shrub Cover, closed-open, evergreen
	TeDc	Temperate continental forest	12	Shrub Cover, closed-open, deciduous
	TeBSk	Temperate steppe		
	TeBWk	Temperate desert		
	TeM	Temperate mountain systems		
Boreal	Ba	Boreal coniferous forest		
	Bb	Boreal tundra woodland		
	BM	Boreal mountain systems		
Polar	P	Polar		

S1. GPG LULUCF methodology IPCC 2003

GAINS

We refer to Equations contained by the Chapter 3.2. of IPCC 2003 methodology

http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_2_Forest_Land.pdf

We refer to Tables contained by the Annex 3A.1 of IPCC 2003 methodology

http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

Step 1

The year 2000 was chosen as base year for this study. The main reason was the use of GLC 2000 map which was developed for this particular year to be used by countries in the FRA 2000 reporting process. The activity data was categorized as forest area (1000 ha) and each country was subdivided into spatial units (polygons) that resulted from the integration of the following data sources (layers): country, eco zones forest types and vegetation classes, using the two maps as described in paragraph 2.1.

Step 2

The annual average increment (i.e. growth) in biomass (G_{total}) and was estimated using equation 3.2.5 (IPCC, 2003):

$$G_{total} = G_w * (1+R) \quad (1)$$

where:

G_{total} = average annual biomass increment above and below ground, t d.m. ha^{-1} yr^{-1}

G_w = average annual aboveground biomass increment, t d.m. ha^{-1} yr^{-1} Table 3A.1.5. , values for forests > 20 years

R = root to shoot ratio appropriate to increments (ratio of below-ground biomass to above-ground biomass), dimensionless, Table 3A.1.8.

G_w value was determined from relevant IPCC table for each forest type and climate zone for each administrative boundary of each country.

Step 3

Annual increase in country's C stocks due to biomass increment was calculated based on equation 3.2.4. (IPCC, 2003):

$$\Delta C_{FFG} = \sum_{ij} (G_{total,ij} * A_{ij}) * CF \quad (2)$$

where:

ΔC_{FFG} = annual increase in C stocks due to biomass increment in forest land remaining forest land by forest type and climatic zones, t C yr^{-1}

$G_{total, ij}$= average annual biomass increment above and below ground by forest type (i = 1 to n) and climatic zone (j = 1 to m), t d.m. ha^{-1} yr^{-1}

A_{ij} = total country area of forest land remaining forest land by forest type (i = 1 to n) and climatic zone (j = 1 to m), ha

CF = carbon fraction of dry matter (default = 0.5) t C $(t\ d.m.)^{-1}$

HARVEST

C losses were computed for Annex I Parties same as for Non-Annex I Parties by applying the following formula:

$$\Delta C_{FFL} = H * BEF2 * D * CF \quad (3)$$

ΔC_{FFL} = annual carbon loss, t C yr^{-1}

H= annually extracted volume, R_w + Wf, m^3 yr^{-1}

R_w (total) roundwood volume, m^3 yr^{-1}

W_f = wood fuel annual volume, m^3 yr^{-1}

D = basic wood density, t d.m. m^{-3}, Table 3A.1.9

CF = carbon fraction of dry matter (default = 0.5) t C $(t\ d.m.)^{-1}$

BEF2 = biomass expansion factor for converting merchantable volume to total above ground biomass (including bark), dimensionless, Table 3A.1.10

The above formula is the combination of Eq. 3.2.7 and 3.2.8 where $H = R_w + W_f$

We changed the initial Eq. 3.2.7 as following: the term 1-fBL which is the fraction of biomass left to decay in forest (transferred to dead organic matter) was not used and is assumed to be 0 when applying Tier 1 (IPCC, 2003).

For all countries it is assumed a high efficiency in wood use, so from one tree the harvested part is used in industry (reported as "roundwood") and the rest is used as wood fuel (then reported under "wood fuel") (INESTENE, 2011). Therefore we applied BEF2 to the total harvest volume H of wood fuel statistics which is composed by total roundwood (R_w) and wood fuel (W_f) due to the entire usage of the tree.

$$\Delta C_{FFL1} = (R_w + W_f) * BEF2 * D * CF \quad (4)$$

D was used as average of all default values per eco region and forest type which is provided in the IPCC Table 3A.1.9, while BEF2 is already provided as an average of growing stock and age. The values are shown in Table S2.

Table S2: Mean D and BEF2 per eco region and forest type (IPCC, 2003)

Eco region	Mean D	Climate zone	Forest type	Mean BEF2
Tropical Asia	0.56	Boreal	Needle-leaved	1.35
Tropical America	0.60		Broadleaved	1.3
Tropical Africa	0.59	Temperate	Needle-leaved	1.3
Boreal/Temperate needle-leaved	0.40		Broadleaved	1.4
Boreal/Temperate broadleaved	0.48	Tropical	Pines	1.3
			Broadleaved	3.4

To convert FAO statistical roundwood data without bark into merchantable wood removals including bark, multiply by default expansion factor 1.12 (12%).

FIRES

The data from GFEDv3 was used and losses due to fires were calculated based on the following formula:

$$L_{ForestFires} = \text{Biomass burned} \bullet CF \quad (5)$$

Biomass burned = from GFED v3, t d.m. yr^{-1}

CF = carbon fraction of dry matter as defined by van der Werf, 2010 for each partition and specie (for tropical forests 0.48 and for temperate forests 0.47 t C (t d.m.)$^{-1}$

NET DEFORESTATION

The C losses due to Net Deforestation were calculated based on the stock change method as following:

$$\text{LNet Deforestation} = AGb_{i,j} \bullet \text{Forest area change}_{i,j} \bullet CF \quad (6)$$

$AGb_{i,j}$ = Above–Ground Biomass stock in forest by vegetation type and climatic zone (t d.m. ha^{-1}) (Table 3A.1.2 and Table 4.7)

Forest area change in ha yr^{-1} by vegetation type and climatic zone (from GEZ FAO map and GLC 2000 map) as:

$$\text{Forest area change}_{i,j} = (A_{ij2}-A_{ij1})/n \quad (7)$$

n = number of years

i = ecological zone

j = climate domaine

A_{ij1} and A_{ij2} = forest areas in two different years in time for each ecological zone and climate domain

Data for forest area in 1980 was not available, therefore we assumed that the % of change between 1980 - 1990 is equal to the one from 1990-2000.

S2. IPCC 2006 methodology

GAINS

We refer to Equations in the Chapter 4.2.1 of IPCC2006

http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

We refer to Tables in the Chapter 4.5 of IPCC2006

http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

Step 1

The year 2000 was chosen as base year for this study. The main reason was the use of GLC 2000 map which was developed for this particular year to be used by countries in the FRA 2000 reporting process. The activity data was categorized as forest area (1000 ha) and each country was subdivided into spatial units (polygons) that resulted from the integration of the following data sources (layers): country, eco zones forest types and vegetation classes, using the two maps as described in paragraph 2.1.

Step 2

The annual average increment (i.e. growth) in biomass (G_{total}) and was estimated using equation 2.10 (IPCC, 2006):

$$G_{total} = \Sigma\{G_W \bullet (1+R)\} \quad (8)$$

where:

G_{total} = average annual biomass increment above and below ground, t d.m. ha^{-1} yr^{-1}

G_w = average annual above-ground biomass growth for a specific woody vegetation type, t d.m. ha^{-1} yr^{-1} ,Table 4.9, values for forests > 20 years

R = root to shoot ratio appropriate to increments (ratio of below-ground biomass to above-ground biomass), dimensionless

For Tier 1 approach no change of below-ground biomass is assumed, therefore R=0

G_w value was determined from relevant IPCC table for each forest type and climate zone for each administrative boundary of each country.

Step 3

Annual increase in country's C stocks due to biomass increment was calculated based on equation 2.9 (IPCC, 2006):

$$\Delta C_G = \sum_{ij} (G_{total,ij} * A_{ij}) * CF \quad (9)$$

where:

ΔC_G = annual increase in biomass carbon stocks due to biomass growth by vegetation type and climatic zone, t C yr^{-1}

$G_{total, ij}$= average annual biomass increment above and below ground by forest type (i = 1 to n) and climatic zone (j = 1 to m), t d.m. ha^{-1} yr^{-1}

A_{ij} = total country area of forest land remaining forest land by forest type (i = 1 to n) and climatic zone (j = 1 to m), ha

CF = carbon fraction of dry matter (default CF = 0.47) t C $(t\ d.m.)^{-1}$

For Tier 1 approach: no change of below-ground biomass is assumed. R=0

HARVEST

C losses for harvest from wood removal were computed for Annex I countries same as for Non-Annex I countries by applying the Eq. 2.12 as following:

$$L_{wood\ removals} = \{R_w \bullet BCEFr \bullet (1+ R) \bullet CF\} \quad (10)$$

$L_{wood\ removals}$= annual carbon loss, t C yr^{-1}

R_w = annual wood removals, roundwood, m^3 yr^{-1} (data from FORESTAT, 2010)

CF = carbon fraction of dry matter (default CF=0.47), t C $(t\ d.m.^{-1})$

BCEFr = biomass conversion and expansion factor for conversion of roundwood removals volume to total biomass removals (including bark). t d.m. m^{-3} (Table 4.5)

R = root to shoot ratio appropriate to increments (ratio of below-ground biomass to above-ground biomass), dimensionless

For Tier 1 approach: no change of below-ground biomass is assumed. R=0

To convert FAO statistical roundwood data without bark into merchantable wood removals including bark, multiply by default expansion factor 1.15 (15%)

The loss for C from wood fuel was calculated using the Eq. 2.13 as following:

$$Lfuelwood = [\{FGtrees \bullet BCEFr \bullet (1+ R)\} + FGpart \bullet D] \bullet CF \quad (11)$$

Lfuelwood = annual carbon loss due to fuelwood removals, t C yr^{-1}

FGtrees = annual volume of fuelwood removal of whole trees, m^3 yr^{-1} (data from FORESTAT, 2010)

FGpart = annual volume of fuelwood removal as tree parts, m^3 yr^{-1}

R = root to shoot ratio appropriate to increments (ratio of below-ground biomass to above-ground biomass), dimensionless

CF = carbon fraction of dry matter, (default CF=0.47), t C (t d.m.)$^{-1}$

D = basic wood density, t d.m. m^{-3}

BCEFr = biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark), t d.m. m^{-3} (Table 4.5)

For Tier 1 approach: no change of below-ground biomass is assumed. R=0

FGpart is considered included in FGtrees according to the fuelwood Forestat definition. FGpart=0

By combining these two formulas the total C loss dues to harvest results as:

$$\text{Loss harvest} = (R_w + W_F) \bullet BCEFr \bullet CF \quad (12)$$

A comparison between BCEF and BEF2 is shown in Tab. S4.

FIRES

Same as in S1.

NET DEFORESTATION

Same as in S1.

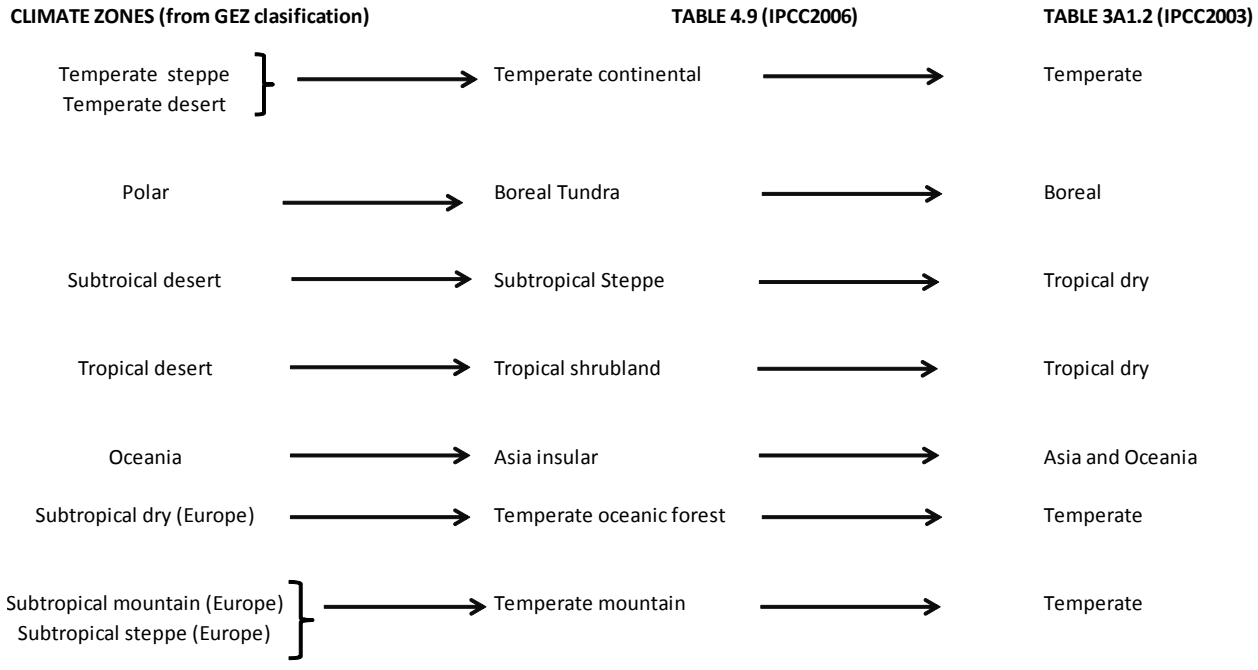
Tab. S3. Difference between above ground biomass stock in the two IPCC guidelines. Global weighted averaged values per country, climate and vegetation type (t d.m. ha^{-1}).

IPCC 2006			IPCC 2003		
Climate zone	**Vegetation (forest) type**	**Averaged regional above ground biomass (t d.m. ha^{-1})**	**Climate zone**	**Vegetation (forest)type**	**Averaged regional above ground biomass (t d.m. ha^{-1})**
TROPICAL	Tropical rain	308.61	TROPICAL	Wet	335.25
	Tropical moist deciduous	242.54		Moist with short or long dry season	180.52
	Tropical desert	65.00		Dry	66.03
	Tropical dry	159.65			71.58
	Tropical shrubland	66.67			61.89
	Tropical mountain systems	150.54		Mountain moist or mountain dry	164.21
SUBTROPICAL	Subtropical humid	209.96	TROPICAL*	Moist with short or long dry season	203.85
	Subtropical dry	144.35		Dry	99.95
	Subtropical desert	70.00			66.57
	Subtropical steppe	72.29			71.20
	Subtropical mountain	136.08		Tropical mountain moist or mountain dry	115.56
TEMPERATE	Temperate oceanic	202.56	TEMPERATE	Coniferous	128.05
	Temperate continental	124.64			129.81
	Temperate steppe	127.00		Broadleaf	129.60
	Temperate desert	130.00		Mixed broadleaf-coniferous	126.48
	Temperate mountain	129.97			127.98
BOREAL	Boreal coniferus	50.00	BOREAL	Coniferous	56.73
	Boreal tundra	18.00		Forest-tundra	16.14
	Boreal mountain	45.00		Mixed broadleaf-coniferous	57.22
POLAR	Polar	18.00	POLAR	Not existing (same as for boreal)	49.41

* IPCC 2003 does not include Subtropical zone, therefore we assume that Subtropical in IPCC 2006 corresponds to Tropical in IPCC 2003 (with assumptions for each country depending on the vegetation type, see below)

Averaged above ground biomass values represent weighted averages per country and vegetation type for > 20yr. (taken from Tables 4.9 IPCC 2006 and 3A1.2 IPCC 2003).

Figure S1: Representation of climate zones in the two IPCC reports



231 Tab. S4. Difference between BEFs factors (BEF2 and BCEF) in the two IPCC guidelines. Global averaged
232 values per main regions.

Region	IPCC 2003	IPCC 2006	Difference	
	BEF*D (t m^{-3})	BCEF (t m^{-3})	Absolute	%
Africa	2.01	1.99	0.02	0.77%
Asia	1.45	2.11	0.66	45.51%
Europe	0.57	0.92	0.34	59.80%
North America	1.29	0.85	0.44	51.94%
Central America	2.04	1.34	0.70	51.82%
South America and Caribbean	1.78	1.39	0.40	28.59%
Oceania	1.75	1.36	0.40	29.13%
World	1.56	1.42	0.13	9.48%

233 Tab. S5: Regional C stock estimates based on IPCC 2006 calculations for the four subsets: Gains, Harvest,
234 Fires and Net Deforestation, in Mt C yr^{-1}

Region	Gains (Mt C yr^{-1})				Harvest (Mt C yr^{-1})			
	1990	2000	2005	2010	1990	2000	2005	2010
Africa	-658.87	-628.22	-614.29	-600.68	720.94	1109.43	1199.64	1264.92
Asia	-568.46	-556.91	-570.18	-584.21	1313.19	1213.72	1206.75	1178.21
Russia	-559.07	-559.29	-558.73	-558.95	118.84	76.38	95.40	87.18
Europe-Russia	-246.62	-257.17	-260.65	-264.53	196.22	238.01	266.73	277.56
Central America	-41.16	-35.54	-33.66	-31.80	49.16	55.64	57.98	59.75
North America	-691.01	-693.23	-694.63	-696.42	374.29	352.11	346.56	273.68
South America and Caribbean	-1025.35	-983.26	-950.17	-922.17	255.02	292.87	324.19	337.50
Oceania	-154.18	-153.21	-151.70	-147.81	20.01	24.35	25.40	25.92
World	-3944.73	-3866.82	-3834.00	-3806.58	3047.67	3362.50	3522.65	3504.72
Region	**Fires (Mt C yr^{-1})**				**Net Deforestation (Mt C yr^{-1})**			
	1990	2000	2005	2010	1990	2000	2005	2010
Africa	152.45	78.38	80.26	70.27	374.05	374.05	336.79	333.99
Asia	52.62	15.12	10.91	18.06	348.85	348.85	122.06	154.46
Russia	36.33	116.96	37.73	70.90	0.00	0.00	4.27	0.00
Europe-Russia	12.37	1.48	2.63	0.49	0.32	0.32	3.48	3.79
Central America	0.82	3.78	6.08	0.22	59.68	59.68	44.60	44.25
North America	47.82	25.34	93.38	92.15	32.75	32.75	22.24	14.56
South America and Caribbean	11.12	19.66	49.20	37.46	465.13	465.13	698.83	597.28
Oceania	96.21	7.08	3.78	2.11	20.80	20.80	29.47	65.11
World	409.74	267.81	283.97	291.67	1301.57	1301.57	1261.75	1213.45

235 Reference

236 INESTENE, 2011: Rapport national d'inventaire pour la France au titre de la convention cadre des nations
237 unies sur les changements climatique et du protocol de Kyoto, Centre Interprofessionnel Technique
238 d'Etudes de la pollution Atmosphérique CITEPA/rapport CCNUCC – edition de mars 2011.