Annex 4A.1 Tool for Estimation of Changes in Soil Carbon Stocks associated with Management Changes in Croplands and Grazing Lands based on IPCC Default Data

(see the attached CD-ROM)

Annex 4A.2 Examples of allometric equations for estimating aboveground biomass and belowground biomass of trees

TABLE 4.A.1
ALLOMETRIC EQUATIONS FOR ESTIMATING ABOVEGROUND BIOMASS (KG DRY MATTER PER TREE) OF TROPICAL AND TEMPERATE HARDWOOD AND PINE SPECIES

Equation	Forest type[a]	R^2/sample size	DBH range (cm)
$Y = \exp[-2.289 + 2.649 \bullet \ln(DBH) - 0.021 \bullet (\ln(DBH))^2]$	Tropical moist hardwoods	0.98/226	5 - 148
$Y = 21.297 - 6.953 \bullet (DBH) + 0.740 \bullet (DBH)^2$	Tropical wet hardwoods	0.92/176	4 - 112
$Y = 0.887 + [(10486 \bullet (DBH)^{2.84}) / ((DBH^{2.84}) + 376907)]$	Temperate/tropical pines	0.98/137	0.6 - 56
$Y = 0.5 + [(25000 \bullet (DBH)^{2.5}) / ((DBH^{2.5}) + 246872)]$	Temperate US eastern hardwoods	0.99/454	1.3 - 83.2

Where

Y = aboveground dry matter, kg $(tree)^{-1}$
DBH =diameter at breast height, cm
ln = natural logarithm
exp = "e raised to the power of"

[a] Tropical moist generally represent areas with rainfall of between 2000 to 4000 mm/year in the lowlands; tropical wet is suited for areas with rainfall greater than 4000 mm/year in the lowlands (see Brown, 1997 for further discussion).

Sources: Updated from Brown, 1997; Brown and Schroeder, 1999; Schroeder *et al.*, 1997

TABLE 4.A.2
ALLOMETRIC EQUATIONS FOR ESTIMATING ABOVEGROUND BIOMASS OF PALM TREES (KG DRY MATTER PER TREE) COMMON IN TROPICAL HUMID FORESTS OF LATIN AMERICA. THE NUMBER OF HARVESTED TREES WAS 15 FOR EACH SPECIES

Equation	Palm species	R^2	Height range (HT in m)
$Y = 0.182 + 0.498 \bullet HT + 0.049 \bullet (HT)^2$	*Chrysophylla* sp	0.94	0.5-10.0
$Y = 10.856 + 176.76 \bullet (HT) - 6.898 \bullet (HT)^2$	*Attalea cohune*	0.94	0.5-15.7
$Y = 24.559 + 4.921 \bullet HT + 1.017 \bullet (HT)^2$	*Sabal* sp	0.82	0.2-14.5
$Y = 23.487 + 41.851 \bullet (\ln(HT))^2$	*Attalea phalerata*	0.62	1-11
$Y= 6.666 + 12.826 \bullet (HT^{0.5}) \bullet \ln(HT)$	*Euterpe precatoria & Phenakospermun guianensis*	0.75	1-33

Where

Y = aboveground dry matter, kg $(tree)^{-1}$
HT = height of the trunk, meters (for palms this is the main stem, excluding the fronds)
ln = natural logarithm

Source: Delaney *et al.*, 1999; Brown *et al.*, 2001

TABLE 4.A.3
EXAMPLES OF ALLOMETRIC EQUATIONS FOR ESTIMATING ABOVEGROUND BIOMASS (KG OF DRY MATTER PER TREE) OF SOME INDIVIDUAL SPECIES COMMONLY USED IN THE TROPICS

Equation	Species	R^2	Height for DBH/BA (cm)[a]	Diameter range (cm)	Source
$Y = 0.153 \bullet DBH^{2.382}$	*Tectona grandis* [b]	0.98	130	10-59	1
$Y = 0.0908 \bullet DBH^{2.575}$	*Tectona grandis* [c]	0.98	130	17-45	2
$Y = 0.0103 \bullet DBH^{2.993}$	*Bombacopsis quinatum* [d]	0.97	130	14-46	3
$Y = 1.22 \bullet DBH^2 \bullet HT \bullet 0.01$	*Eucalyptus sp.* [e]	0.97	130	1-31	4
$Y = 0.08859 \bullet DBH^{2.235}$	*Pinus pinaster* [f]	0.98	10	0-47	5
$Y = 0.97 + 0.078 \bullet BA - 0.00094 \bullet BA^2 + 0.0000064 \bullet BA^3$	*Bactris gasipaes* [g]	0.98	100	2-12	6
$Y = -3.9 + 0.23 \bullet BA + 0.0015 \bullet BA^2$	*Theobroma grandiflora* [g]	0.93	30	6-18	6
$Y = -3.84 + 0.528 \bullet BA + 0.001 \bullet BA^2$	*Hevea brasiliensis* [g]	0.99	150	6-20	6
$Y = -6.64 + 0.279 \bullet BA + 0.000514 \bullet BA^2$	*Citrus sinensis* [g]	0.94	30	8-17	6
$Y = -18.1 + 0.663 \bullet BA + 0.000384 \bullet BA^2$	*Bertholletia excelsa* [g]	0.99	130	8-26	6

Where

Y = aboveground dry matter, kg $(tree)^{-1}$
DBH =diameter, cm
HT = total height of the tree, meters
BA = basal area, cm^2

[a] Height for DBH/BA is height above ground where diameter or basal area was measured, cm

[b] 87 individuals at ages of 5-47 years.

[c] 9 individuals at age of 20 years.

[d] 17 individuals at ages of 10-26 years.

[e] Pooled values for 458 individuals of *Eucalyptus ovata*, *E. saligna*, *E. globulus* and *E. nites* at ages of 2-5 years.

[f] 148 individuals at ages of 1-47 years.

[g] 7-10 individuals at age of 7 years.

Sources: (1) Pérez and Kanninen, 2003; (2) Kraenzel *et al.*, 2003; (3) Pérez and Kanninen, 2002; (4) Senelwa and Sims, 1998; (5) Ritson and Sochacki, 2003; (6) Schroth *et al.*, 2002.

TABLE 4.A.4
ALLOMETRIC EQUATIONS FOR ESTIMATING BELOWGROUND OR ROOT BIOMASS OF FORESTS
ALTHOUGH ADDITION OF AGE AND LATITUDE DID NOT INCREASE THE R^2 BY VERY MUCH, THE COEFFICIENTS WERE HIGHLY SIGNIFICANT

Conditions and independent variables	Equation	Sample size	R^2
All forests, ABD	Y=exp[–1.085 + 0.9256 • ln(ABD)]	151	0.83
All forests, ABD and AGE	Y=exp[–1.3267+0.8877•ln(ABD)+0.1045•ln(AGE)	109	0.84
Tropical forests, ABD	Y=exp[–1.0587 + 0.8836 • ln(ABD)]	151	0.84
Temperate forests, ABD	Y=exp[–1.0587 + 0.8836 • ln(ABD) + 0.2840]	151	0.84
Boreal forests, ABD	Y=exp[–1.0587 + 0.8836 • ln(ABD) + 0.1874]	151	0.84

Where

Y= root biomass in Mg ha^{-1} of dry matter
ln = natural logarithm
exp = "e to the power of"
ABD = aboveground biomass in Mg ha^{-1} of dry matter
AGE = age of the forest, years

Source: Cairns et al., 1997