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Table 3A.1.3 Aboveground Biomass Stock in plantation forests by broad category	To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in equation in Equation 3.3.8 in Cropland section and for $L_{conversion}$ in Equation 3.4.13 in Grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3
Table 3A.1.4 Average Growing stock volume (1) and aboveground biomass (2) content (dry matter) in forest in 2000	(1) To be used for V in Equation 3.2.3. (2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13 in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.
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Table 3A.1.7 Annual Average Above ground volume Increment in plantations by species	To be used for I_v in Equation 3.2.5
Table 3A.1.8 Average Belowground to Aboveground Biomass ratio in Natural Regeneration by broad category	To be used for R in Equation 3.2.5
Table 3A.1.9 –1 Basic wood densities of stemwood for boreal and temperate species	To be used for D in Equations 3.2.3., 3.25, 3.2.7, 3.2.8
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Table 3A.1.13 Biomass consumption values for fires in a range of vegetation types	To be used in Equation 3.2.9. for the part of the equation: '$B_W \bullet (1- f_{BL})$' , i.e. an absolute amount
Table 3A.14 Combustion Efficiency(proportion of available fuel actually burnt) relevant to land-clearing burns, and burns in heavy logging slash for a range of vegetation types and burning conditions.	To be used in sections 'forest lands converted to cropland', 'converted to grassland', or 'converted to settlements or other lands'
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TABLE 3A.1.1
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

a. AFRICA

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Algeria	1 879	2 145	27	1.3
Angola	70 998	69 756	-124	-0.2
Benin	3 349	2 650	-70	-2.3
Botswana	13 611	12 427	-118	-0.9
Burkina Faso	7 241	7 089	-15	-0.2
Burundi	241	94	-15	-9.0
Cameroon	26 076	23 858	-222	-0.9
Cape Verde	35	85	5	9.3
Central African Republic	23 207	22 907	-30	-0.1
Chad	13 509	12 692	-82	-0.6
Comoros	12	8	n.s.	-4.3
Congo	22 235	22 060	-17	-0.1
Côte d'Ivoire	9 766	7 117	-265	-3.1
Dem. Rep. of the Congo	140 531	135 207	-532	-0.4
Djibouti	6	6	n.s.	n.s.
Egypt	52	72	2	3.3
Equatorial Guinea	1 858	1 752	-11	-0.6
Eritrea	1 639	1 585	-5	-0.3
Ethiopia	4 996	4 593	-40	-0.8
Gabon	21 927	21 826	-10	n.s.
Gambia	436	481	4	1.0
Ghana	7 535	6 335	-120	-1.7
Guinea	7 276	6 929	-35	-0.5
Guinea-Bissau	2 403	2 187	-22	-0.9
Kenya	18 027	17 096	-93	-0.5
Lesotho	14	14	n.s.	n.s.
Liberia	4 241	3 481	-76	-2.0
Libyan Arab Jamahiriya	311	358	5	1.4

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

a. AFRICA (Continued)

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Madagascar	12 901	11 727	-117	-0.9
Malawi	3 269	2 562	-71	-2.4
Mali	14 179	13 186	-99	-0.7
Mauritania	415	317	-10	-2.7
Mauritius	17	16	n.s.	-0.6
Morocco	3 037	3 025	-1	n.s.
Mozambique	31 238	30 601	-64	-0.2
Namibia	8 774	8 040	-73	-0.9
Niger	1 945	1 328	-62	-3.7
Nigeria	17 501	13 517	-398	-2.6
Réunion	76	71	-1	-0.8
Rwanda	457	307	-15	-3.9
Saint Helena	2	2	n.s.	n.s.
Sao Tome and Principe	27	27	n.s.	n.s.
Senegal	6 655	6 205	-45	-0.7
Seychelles	30	30	n.s.	n.s.
Sierra Leone	1 416	1 055	-36	-2.9
Somalia	8 284	7 515	-77	-1.0
South Africa	8 997	8 917	-8	-0.1
Sudan	71 216	61 627	-959	-1.4
Swaziland	464	522	6	1.2
Togo	719	510	-21	-3.4
Tunisia	499	510	1	0.2
Uganda	5 103	4 190	-91	-2.0
United Republic of Tanzania	39 724	38 811	-91	-0.2
Western Sahara	152	152	n.s.	n.s.
Zambia	39 755	31 246	-851	-2.4
Zimbabwe	22 239	19 040	-320	-1.5

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

b. ASIA				
Country	**Total Forest area**		**Forest Area Change 1990-2000**	
	1990	**2000**	**Annual Change**	**Change Rate**
	000 ha	**000 ha**	**000 ha /yr**	**% / yr**
Afghanistan	1 351	1 351	n.s.	n.s.
Armenia	309	351	4	1.3
Azerbaijan	964	1 094	13	1.3
Bahrain	n.s.	n.s.	n.s.	14.9
Bangladesh	1 169	1 334	17	1.3
Bhutan	3 016	3 016	n.s.	n.s.
Brunei Darussalam	452	442	-1	-0.2
Cambodia	9 896	9 335	-56	-0.6
China	145 417	163 480	1 806	1.2
Cyprus	119	172	5	3.7
Dem People's Rep. of Korea	8 210	8 210	n.s.	n.s.
East Timor	541	507	-3	-0.6
Gaza Strip	-	-	-	-
Georgia	2 988	2 988	n.s.	n.s.
India	63 732	64 113	38	0.1
Indonesia	118 110	104 986	-1 312	-1.2
Iran, Islamic Rep.	7 299	7 299	n.s.	n.s.
Iraq	799	799	n.s.	n.s.
Israel	82	132	5	4.9
Japan	24 047	24 081	3	n.s.
Jordan	86	86	n.s.	n.s.
Kazakhstan	9 758	12 148	239	2.2
Kuwait	3	5	n.s.	3.5
Kyrgyzstan	775	1 003	23	2.6
Lao People's Dem. Rep	13 088	12 561	-53	-0.4
Lebanon	37	36	n.s.	-0.4
Malaysia	21 661	19 292	-237	-1.2
Maldives	1	1	n.s.	n.s.
Mongolia	11 245	10 645	-60	-0.5
Myanmar	39 588	34 419	-517	-1.4
Nepal	4 683	3 900	-78	-1.8
Oman	1	1	n.s.	5.3
Pakistan	2 755	2 361	-39	-1.5
Philippines	6 676	5 789	-89	-1.4
Qatar	n.s.	1	n.s.	9.6

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

b. ASIA (Continued)				
Country	**Total Forest Area**		**Forest Area Change 1990-2000**	
	1990	**2000**	**Annual Change**	**Change Rate**
	000 ha	**000 ha**	**000 ha /yr**	**% / yr**
Republic of Korea	6 299	6 248	-5	-0.1
Saudi Arabia	1 504	1 504	n.s.	n.s.
Singapore	2	2	n.s.	n.s.
Sri Lanka	2 288	1 940	-35	-1.6
Syrian Arab Republic	461	461	n.s.	n.s.
Tajikistan	380	400	2	0.5
Thailand	15 886	14 762	-112	-0.7
Turkey	10 005	10 225	22	0.2
Turkmenistan	3 755	3 755	n.s.	n.s.
United Arab Emirates	243	321	8	2.8
Uzbekistan	1 923	1 969	5	0.2
Viet Nam	9 303	9 819	52	0.5
West Bank	-	-	-	-
Yemen	541	449	-9	-1.9
c. OCEANIA				
American Samoa	12	12	n.s.	n.s.
Australia	157 359	154 539	-282	-0.2
Cook Islands	22	22	n.s.	n.s.
Fiji	832	815	-2	-0.2
French Polynesia	105	105	n.s.	n.s.
Guam	21	21	n.s.	n.s.
Kiribati	28	28	n.s.	n.s.
Marshall Islands	n.s.	n.s.	n.s.	n.s.
Micronesia	24	15	-1	-4.5
Nauru	n.s.	n.s.	n.s.	n.s.
New Caledonia	372	372	n.s.	n.s.
New Zealand	7 556	7 946	39	0.5
Niue	6	6	n.s.	n.s.
Northern Mariana Isl.	14	14	n.s.	n.s.
Palau	35	35	n.s.	n.s.
Papua New Guinea	31 730	30 601	-113	-0.4
Samoa	130	105	-3	-2.1
Solomon Islands	2 580	2 536	-4	-0.2
Tonga	4	4	n.s.	n.s.
Vanuatu	441	447	1	0.1

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

d. EUROPE

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Albania	1 069	991	-8	-0.8
Andorra	-	-	-	-
Austria	3 809	3 886	8	0.2
Belarus	6 840	9 402	256	3.2
Belgium & Luxembourg	741	728	-1	-0.2
Bosnia & Herzegovina	2 273	2 273	n.s.	n.s.
Bulgaria	3 486	3 690	20	0.6
Croatia	1 763	1 783	2	0.1
Czech Republic	2 627	2 632	1	n.s.
Denmark	445	455	1	0.2
Estonia	1 935	2 060	13	0.6
Finland	21 855	21 935	8	n.s.
France	14 725	15 341	62	0.4
Germany	10 740	10 740	n.s.	n.s.
Greece	3 299	3 599	30	0.9
Hungary	1 768	1 840	7	0.4
Iceland	25	31	1	2.2
Ireland	489	659	17	3.0
Italy	8 737 [1]	10 003	30	0.3
Latvia	2 796	2 923	13	0.4

[1] The value for Italy was provided by Italy and is referred to in their Third National Communication to the UNFCCC.

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

d. EUROPE

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Liechtenstein	6	7	n.s.	1.2
Lithuania	1 946	1 994	5	0.2
Malta	n.s.	n.s.	n.s.	n.s.
Netherlands	365	375	1	0.3
Norway	8 558	8 868	31	0.4
Poland	8 872	9 047	18	0.2
Portugal	3 096	3 666	57	1.7
Republic of Moldova	318	325	1	0.2
Romania	6 301	6 448	15	0.2
Russian Federation	850 039	851 392	135	n.s
San Marino	-	-	-	-
Slovakia	1 997	2 177	18	0.9
Slovenia	1 085	1 107	2	0.2
Spain	13 510	14 370	86	0.6
Sweden	27 128	27 134	1	n.s.
Switzerland	1 156	1 199	4	0.4
The FYR of Macedonia	906	906	n.s.	n.s.
Ukraine	9 274	9 584	31	0.3
United Kingdom	2 624	2 794	17	0.6
Yugoslavia	2 901	2 887	-1	-0.1

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

e. NORTH AND CENTRAL AMERICA

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Antigua and Barbuda	9	9	n.s.	n.s.
Bahamas	842	842	n.s.	n.s.
Barbados	2	2	n.s.	n.s.
Belize	1 704	1 348	-36	-2.3
Bermuda	-	-	-	-
British Virgin Is.	3	3	n.s.	n.s.
Canada	244 571	244 571	n.s.	n.s.
Cayman Islands	13	13	n.s.	n.s.
Costa Rica	2 126	1 968	-16	-0.8
Cuba	2 071	2 348	28	1.3
Dominica	50	46	n.s.	-0.7
Dominican Republic	1 376	1 376	n.s.	n.s.
El Salvador	193	121	-7	-4.6
Greenland	-	-	-	-
Grenada	5	5	n.s.	0.9
Guadeloupe	67	82	2	2.1
Guatemala	3 387	2 850	-54	-1.7
Haiti	158	88	-7	-5.7
Honduras	5 972	5 383	-59	-1.0
Jamaica	379	325	-5	-1.5
Martinique	47	47	n.s.	n.s.
Mexico	61 511	55 205	-631	-1.1
Montserrat	3	3	n.s.	n.s.
Netherlands Antilles	1	1	n.s.	n.s.
Nicaragua	4 450	3 278	-117	-3.0
Panama	3 395	2 876	-52	-1.6
Puerto Rico	234	229	-1	-0.2
Saint Kitts and Nevis	4	4	n.s.	-0.6
Santa Lucia	14	9	-1	-4.9
Saint Pierre & Miquelon	-	-	-	-
Saint Vincent & Grenadines	7	6	n.s.	-1.4
Trinidad and Tobago	281	259	-2	-0.8
United States	222 113	225 993	388	0.2
US Virgin Islands	14	14	n.s.	n.s.

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.1 (CONTINUED)
FOREST AREA CHANGE
(To be used for verification of 'A' in Equation 3.2.4)

f. SOUTH AMERICA

Country	Total Forest Area		Forest Area Change 1990-2000	
	1990	2000	Annual Change	Change Rate
	000 ha	000 ha	000 ha /yr	% / yr
Argentina	37 499	34 648	-285	-0.8
Bolivia	54 679	53 068	-161	-0.3
Brazil	566 998	543 905	-2 309	-0.4
Chile	15 739	15 536	-20	-0.1
Colombia	51 506	49 601	-190	-0.4
Ecuador	11 929	10 557	-137	-1.2
Falkland Islands	-	-	-	-
French Guiana	7 926	7 926	n.s.	n.s.
Guyana	17 365	16 879	-49	-0.3
Paraguay	24 602	23 372	-123	-0.5
Peru	67 903	65 215	-269	-0.4
Suriname	14 113	14 113	n.s.	n.s.
Uruguay	791	1 292	50	5.0
Venezuela	51 681	49 506	-218	-0.4

n.s. - not specified
Source: FRA 2000 and Working Paper 59, FRA Programme, Forestry Department of FAO, Rome 2001, 69p (www.fao.org/forestry/fo/fra/index.jsp)

TABLE 3A.1.2
ABOVEGROUND BIOMASS STOCK IN NATURALLY REGENERATED FORESTS BY BROAD CATEGORY (tonnes dry matter/ha)

(To be used for Bw in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in Cropland section and for $L_{conversion}$ in Equation 3.4.13. in Grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3)

Tropical Forests [1]

	Wet	Moist with Short Dry Season	Moist with Long Dry Season	Dry	Montane Moist	Montane Dry
Africa	310 (131 - 513)	260 (159 – 433)	123 (120 - 130)	72 (16 - 195)	191	40
Asia & Oceania:						
Continental	275 (123 - 683)	182 (10 – 562)	127 (100 - 155)	60	222 (81 - 310)	50
Insular	348 (280 - 520)	290	160	70	362 (330 - 505)	50
America	347 (118 - 860)	217 (212 - 278)	212 (202- 406)	78 (45 - 90)	234 (48 - 348)	60

Temperate Forests

Age Class	Coniferous	Broadleaf	Mixed Broadleaf-Coniferous
Eurasia & Oceania			
≤20 years	100 (17 - 183)	17	40
>20 years	134 (20 - 600)	122 (18 -320)	128 (20-330)
America			
≤20 years	52 (17-106)	58 (7-126)	49 (19-89)
>20 years	126 (41-275)	132 (53-205)	140 (68-218)

Boreal Forests

Age Class	Mixed Broadleaf-Coniferous	Coniferous	Forest-Tundra
Eurasia			
≤20 years	12	10	4
>20 years	50	60 (12.3-131)	20 (21- 81)
America			
≤20 years	15	7	3
>20 years	40	46	15

Note: Data are given in mean value and as range of possible values (in parentheses).

[1] The definition of forest types and examples by region are illustrated in Box 2 and Tables 5-1, p 5.7-5.8 of the *IPCC Guidelines* (1996).

TABLE 3A.1.3
ABOVEGROUND BIOMASS STOCK IN PLANTATION FORESTS BY BROAD CATEGORY (tonnes dry matter/ha)

(To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in equation in Equation 3.3.8 in Cropland section and for $L_{conversion}$ in Equation 3.4.13. in Grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3)

Tropical and sub-tropical Forests

	Age Class	Wet	Moist with Short Dry Season	Moist with Long Dry Season	Dry	Montane Moist	Montane Dry
		R > 2000	2000>R>1000		R<1000	R>1000	R<1000
Africa							
Broadleaf spp	≤20 years	100	80	30	20	100	40
	>20 years	300	150	70	20	150	60
Pinus sp	≤20 years	60	40	20	15	40	10
	>20 years	200	120	60	20	100	30
Asia:							
Broadleaf	All	220	180	90	40	150	40
other species	All	130	100	60	30	80	25
America							
Pinus	All	300	270	110	60	170	60
Eucalyptus	All	200	140	110	60	120	30
Tectona	All	170	120	90	50	130	30
other broadleaved	All	150	100	60	30	80	30

Temperate Forests

	Age class	Pine	Other coniferous	Broadleaf
Eurasia				
Maritime	≤20 years	40	40	30
	>20 years	150	250	200
Continental	≤20 years	25	30	15
	>20 years	150	200	200
Mediterranean & steppe	≤20 years	17	20	10
	>20 years	100	120	80
S. America	All	100	120	90
N America	All	175 (50–275)	300	–

Boreal Forests

	Age class	Pine	Other coniferous	Broadleaf
Eurasia	≤20 years	5	5	5
	>20 years	40	40	25
N. America	All	50	40	25

TABLE 3A.1.4
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

a. AFRICA

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Algeria	44	75	NI
Angola	39	54	NI
Benin	140	195	PI
Botswana	45	63	NI
Burkina Faso	10	16	NI
Burundi	110	187	ES
Cameroon	135	131	PI
Cape Verde	83	127	ES
Central African Republic	85	113	PI/EX
Chad	11	16	ES
Comoros	60	65	ES
Congo	132	213	EX
Côte d'Ivoire	133	130	PI
Dem. Rep. of the Congo	133	225	NI
Djibouti	21	46	ES
Egypt	108	106	ES
Equatorial Guinea	93	158	PI
Eritrea	23	32	NI
Ethiopia	56	79	PI
Gabon	128	137	ES
Gambia	13	22	NI
Ghana	49	88	ES
Guinea	117	114	PI
Guinea-Bissau	19	20	NI
Kenya	35	48	ES
Lesotho	34	34	ES
Liberia	201	196	ES
Libyan Arab Jamahiriya	14	20	ES

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

a. AFRICA (Continued)

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Madagascar	114	194	NI
Malawi	103	143	NI
Mali	22	31	PI
Mauritania	4	6	ES
Mauritius	88	95	ES
Morocco	27	41	NI
Mozambique	25	55	NI
Namibia	7	12	PI
Niger	3	4	PI
Nigeria	82	184	ES
Réunion	115	160	ES
Rwanda	110	187	ES
Saint Helena			
Sao Tome and Principe	108	116	NI
Senegal	31	30	NI
Seychelles	29	49	ES
Sierra Leone	143	139	ES
Somalia	18	26	ES
South Africa	49	81	EX
Sudan	9	12	ES
Swaziland	39	115	NI
Togo	92	155	PI
Tunisia	18	27	NI
Uganda	133	163	NI
United Republic of Tanzania	43	60	NI
Western Sahara	18	59	NI
Zambia	43	104	ES
Zimbabwe	40	56	NI

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

b. ASIA

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Infor-mation Source
Afghanistan	22	27	FAO
Armenia	128	66	FAO
Azerbaijan	136	105	FAO
Bahrain	14	14	FAO
Bangladesh	23	39	FAO
Bhutan	163	178	FAO
Brunei Darussalam	119	205	FAO
Cambodia	40	69	FAO
China	52	61	NI
Cyprus	43	21	FAO
Dem People's Rep. of Korea	41	25	ES
East Timor	79	136	FAO
Gaza Strip			
Georgia	145	97	FAO
India	43	73	NI
Indonesia	79	136	FAO
Iran, Islamic Rep.	86	149	FAO
Iraq	29	28	FAO
Israel	49	-	FAO
Japan	145	88	FAO
Jordan	38	37	FAO
Kazakhstan	35	18	FAO
Kuwait	21	21	FAO
Kyrgyzstan	32	-	FAO
Lao People's Dem. Rep	29	31	NI
Lebanon	23	22	FAO
Malaysia	119	205	ES
Maldives	-	-	-
Mongolia	128	80	NI
Myanmar	33	57	NI
Nepal	100	109	PI
Oman	17	17	FAO
Pakistan	22	27	FAO
Philippines	66	114	NI

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

b. ASIA (Continued)

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Infor-mation Source
Qatar	13	12	FAO
Republic of Korea	58	36	NI
Saudi Arabia	12	12	FAO
Singapore	119	205	FAO
Sri Lanka	34	59	FAO
Syrian Arab Rep.	29	28	FAO
Tajikistan	14	10	FAO
Thailand	17	29	NI
Turkey	136	74	FAO
Turkmenistan	4	3	FAO
United Arab Emirates	-	-	-
Uzbekistan	6		FAO
Viet Nam	38	66	ES
West Bank	-	-	-
Yemen	14	19	FAO

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

c. OCEANIA

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Infor-mation Source
American Samoa			
Australia	55	57	FAO
Cook Islands	-	-	-
Fiji	-	-	-
French Polynesia	-	-	-
Guam	-	-	-

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.
(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

c.OCEANIA (Continued)

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Kiribati	-	-	-
Marshall Islands	-	-	-
Micronesia	-	-	-
Nauru	-	-	-
New Caledonia	-	-	-
New Zealand	321	217	FAO
Niue	-	-	-
Northern Mariana Isl.	-	-	-
Palau	-	-	-
Papua New Guinea	34	58	NI
Samoa	-	-	-
Solomon Islands	-	-	-
Tonga	-	-	-
Vanuatu	-	-	-

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.
(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

d. EUROPE

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Albania	81	58	FAO
Andorra	0	0	FAO
Austria	286	250	FAO
Belarus	153	80	FAO
Belgium & Luxembourg	218	101	FAO
Bosnia & Herzegovina	110	-	FAO
Bulgaria	130	76	FAO

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.
(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

d. EUROPE (Continued)

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Croatia	201	107	FAO
Czech Republic	260	125	FAO
Denmark	124	58	FAO
Estonia	156	85	FAO
Finland	89	50	NI
France	191	92	FAO
Germany	268	134	FAO
Greece	45	25	FAO
Hungary	174	112	FAO
Iceland	27	17	FAO
Ireland	74	25	FAO
Italy	145	74	FAO
Latvia	174	93	FAO
Liechtenstein	254	119	FAO
Lithuania	183	99	FAO
Malta	232		FAO
Netherlands	160	107	FAO
Norway	89	49	FAO
Poland	213	94	FAO
Portugal	82	33	FAO
Republic of Moldova	128	64	FAO
Romania	213	124	FAO
Russian Federation	105	56	FAO
San Marino	0	0	FAO
Slovakia	253	142	FAO
Slovenia	283	178	FAO
Spain	44	24	FAO
Sweden	107	63	NI
Switzerland	337	165	FAO
The FYR of Macedonia	70	-	FAO
Ukraine	179	-	FAO
United Kingdom	128	76	FAO
Yugoslavia	111	23	FAO

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

e. NORTH AND CENTRAL AMERICA

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Antigua and Barbuda	116	210	ES
Bahamas	-	-	-
Barbados	-	-	-
Belize	202	211	ES
Bermuda	-	-	-
British Virgin Islands	-	-	-
Canada	120	83	FAO
Cayman Islands	-	-	-
Costa Rica	211	220	ES
Cuba	71	114	NI
Dominica	91	166	ES
Dominican Republic	29	53	ES
El Salvador	223	202	FAO
Greenland	-	-	-
Grenada	83	150	PI
Guadeloupe	-	-	-
Guatemala	355	371	ES
Haiti	28	101	ES
Honduras	58	105	ES
Jamaica	82	171	ES
Martinique	5	5	ES
Mexico	52	54	NI
Montserrat	-	-	-
Netherlands Antilles	-	-	-
Nicaragua	154	161	ES
Panama	308	322	ES
Puerto Rico	-	-	-
Saint Kitts and Nevis	-	-	-
Saint Lucia	190	198	ES
Saint Pierre & Miquelon	-	-	-

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

e. NORTH AND CENTRAL AMERICA (Continued)

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Saint Vincent and Grenadines	166	173	NI
Trinidad and Tobago	71	129	ES
United States	136	108	FAO
US Virgin Islands	-	-	-

TABLE 3A.1.4 (CONTINUED)
AVERAGE GROWING STOCK VOLUME (1) AND ABOVEGROUND BIOMASS CONTENT (2) (DRY MATTER) IN FOREST IN 2000. (SOURCE FRA 2000)

(1) To be used for V in Equation 3.2.3.

(2) To be used for B_w in Equation 3.2.9, for $L_{conversion}$ in Equation 3.3.8 in cropland section and for $L_{conversion}$ in Equation 3.4.13. in grassland section, etc. Not to be applied for C_{t_2} or C_{t_1} in Forest section Equation 3.2.3.

f. SOUTH AMERICA

Country	Volume (aboveground) m³ / ha	Biomass (aboveground) t / ha	Information Source
Argentina	25	68	ES
Bolivia	114	183	PI
Brazil	131	209	ES
Chile	160	268	ES
Colombia	108	196	NI
Ecuador	121	151	ES
Falkland Islands	-	-	-
French Guiana	145	253	ES
Guyana	145	253	ES
Paraguay	34	59	ES
Peru	158	245	NI
Suriname	145	253	ES
Uruguay	-	-	-
Venezuela	134	233	ES

Information source: NI = National inventory; PI = Partial inventory; ES = Estimate; EX = External data (from other regions)

TABLE 3A.1.5
AVERAGE ANNUAL INCREMENT IN ABOVEGROUND BIOMASS IN NATURAL REGENERATION BY BROAD CATEGORY
(tonnes dry matter/ha/year)
(To be used for G_W in Equation 3.2.5)

Tropical and Sub-Tropical Forests

Age Class	Wet	Moist with Short Dry Season	Moist with Long Dry Season	Dry	Montane Moist	Montane Dry
	R > 2000	2000>R>1000		R<1000	R>1000	R<1000
Africa						
≤20 years	10.0	5.3	2.4 (2.3 – 2.5)	1.2 (0.8 – 1.5)	5.0	2.0 (1.0 – 3.0)
>20 years	3.1 (2.3 -3.8)	1.3	1.8 (0.6 – 3.0)	0.9 (0.2 – 1.6)	1.0	1. 5 (0.5 – 4.5)
Asia & Oceania						
Continental						
≤20 years	7.0 (3.0 – 11.0)	9.0	6.0	5.0	5.0	1.0
>20 years	2.2 (1.3 – 3.0)	2.0	1.5	1.3 (1.0 – 2.2)	1.0	0.5
Insular						
≤20 years	13.0	11.0	7.0	2.0	12.0	3.0
>20 years	3.4	3.0	2.0	1.0	3.0	1.0
America						
≤20 years	10.0	7.0	4.0	4.0	5.0	1.8
>20 years	1.9 (1.2 – 2.6)	2.0	1.0	1.0	1.4 (1.0 – 2.0)	0.4

Temperate Forests

Age Class	Coniferous	Broadleaf
≤20 years	3.0 (0.5 – 6.0)	4.0 (0.5 – 8.0)
>20 years	3.0 (0.5 – 6.0)	4.0 (0.5 – 7.5)

Boreal forests

Age Class	Mixed Broadleaf-Coniferous	Coniferous	Forest-Tundra	Broadleaf
Eurasia				
≤20 years	1.0	1.5	0.4 (0.2 – 0.5)	1.5 (1.0 – 2.0)
>20 years	1.5	2.5	0.4 (0.2 – 0.5)	1.5
America				
≤20 years	1.1 (0.7 – 1.5)	0.8 (0.5 – 1.0)	0.4 (0.2 – 0.5)	1.5 (1.0 – 2.0)
>20 years	1.1 (0.7 — 1.5)	1.5 (0.5 – 2.5)	0.4 (0.2 – 0.5)	1.3 (1.0 – 1.5)

Note: R= annual rainfall in mm/yr
Note: Data are given as mean value and as the range of possible values.

Table 3A.1.6
ANNUAL AVERAGE ABOVEGROUND BIOMASS INCREMENT IN PLANTATIONS BY BROAD CATEGORY
(tonnes dry matter/ha/year)

(To be used for G_W in Equation 3.2.5.
In case of missing values it is preferred to use stemwood volume increment data I_V from Table 3A.1.7)

Tropical and sub-tropical Forests							
	Age Class	**Wet**	**Moist with Short Dry Season**	**Moist with Long Dry Season**	**Dry**	**Montane Moist**	**Montane Dry**
		R >2000	**2000>R>1000**		**R<1000**	**R>1000**	**R<1000**
Africa							
Eucalyptus spp	≤20 years	-	20.0	12.6	5.1 (3.0-7.0)	-	-
	>20 years	-	25.0	-	8.0 (4.9-13.6)	-	-
Pinus sp	≤20 years	18.0	12.0	8.0	3.3 (0.5-6.0)	-	-
	>20 years		15.0	11.0	2.5	-	-
others	≤20 years	6.5 (5.0-8.0)	9.0 (3.0-15.0)	10.0 (4.0-16.0)	15.0	11.0	-
	>20 years	-	-	-	11.0	-	-
Asia							
Eucalyptus spp	All	5.0 (3.6-8.0)	8.0	15.0 (5.0-25.0)	-	3.1	-
other species	-	5.2 (2.4-8.0)	7.8 (2.0-13.5)	7.1 (1.6-12.6)	6.45 (1.2-11.7)	5.0 (1.3-10.0)	-
America	-	-	-	-	-	-	-
Pinus	-	18.0	14.5 (5.0 – 19.0)	7.0 (4.0 - 10.3)	5.0	14.0	-
Eucalyptus	-	21.0 (6.4 - 38.4)	16.0 (6.4 - 32.0)	16.0 (6.4 - 32.0)	16.0	13.0 (8.5 - 17.5)	-
Tectona	-	15.0	8.0 (3.8 - 11.5)	8.0 (3.8 - 11.5)	-	2.2	-
other broadleaved	-	17.0 (5.0 - 35.0)	18.0 (8.0 – 40.0)	10.5 (3.2 - 11.8)	-	4.0	-

Note 1 : R= annual rainfall in mm/yr

Note 2 : Data are given as mean value and as the range of possible values.

Note 3 : Some Boreal data were calculated from original values in Zakharov *et al.* (1962), Zagreev *et al.* (1993), Isaev *et al.* (1993) using 0.23 as belowground/aboveground biomass ratio and assuming a linear increase in annual increment from 0 to 20 years.

Note 4 : For plantations in temperate and boreal zones, it is good practice to use stemwood volume increment data (I_v in Equation 3.2.5) instead of above ground biomass increment as given in above table.

References for Tables 3A.1.2, 3A.1.3, 3A.1.4, 3A.1.5, and 3A.1.6

Tropical and subtropical

Brown, S. (1996). A primer for estimating biomass and biomass change of tropical forest. FAO, Rome, Italy. 55 pp.

Budowski, G. (1985). The place of Agroforestry in managing tropical forest. In La conservación como instrumento para el desarrollo. Antología. San José, Costa Rica. EUNED. 19 pp.

Burrows, W. H.; Henry, B. K.; Back, P. V., *et al.* (2002) Growth and carbon stock change in eucalypt woodlands in northeast Australia: ecological and greenhouse sink implications. Global Change Biology 8 (8): 769-784 2002

Chudnoff, M. (1980). Tropical Timbers of the World. US Department of Agriculture, Forest Service, Forest Products Laboratory. Madison, W1. 831 pp.

Clarke *et al.* (2001) NPP in tropical forests: an evaluation and synthesis of existing field data. Ecol. Applic. 11:371-384

Evans, J. (1982). Plantation forestry in the tropics. Oxford.

Favrichon, V. (1997). Réaction de peuplements forestiers tropicaux a des interventions sylvicoles. Bois et des forets des tropiques 254: 5-24

FBDS: FUNDACAO BRASILERA PARA O DESEMVOLVIMENTO SUSTENTAVEL. (1997). Avaliacao das emissoes de gases de efeito estufa devido as mudancas no estoques de florestas plantadas. Rio de Janeiro (Brasil). 44 pp.

Fearnside, P.M. (1997). Wood density for estimating forest biomass in Brazilian Amazonia. Forest Ecology and Management 90(1): 59-87.

FIA: Fundación para la Innovación Agraria. (2001). Potencial de proyectos forestales en el Mecansimo de Desarrollo Limpio en Chile. In IV Seminario Regional forestal del Cono Sur, elaboración de proyectos forestales en el Mecanismo de Desarrollo Limpio, realizado 06-07 de diciembre de 2001. Santiago de Chile. 26 pp.

GASTON G., BROWN S., LORENZINI M. & SING. (1998). State and change in carbon pools in the forests of tropical Africa.Global Change Biology 4 (1), 97-114.

Gower S.T., Gholz H.L, Nakane K.,Baldwin V.C. (1994). Production and carbon allocation patterns of pine forests Ecological bulletins 43:115-135 (data converted from aNPP values assuming litterfall =2 x L(-38)C foliage annual production)

Grace J., Malhi Y., Higuchi N., Meir P. (2001). Productivity of tropical Rain Forests in "Terrestrial Global productivity" Roy J, Saugier B., & Mooney H.Eds, Physiological Ecology Series, Academic Press, San Diego , 401-426

Hofmann-Schielle, C., A. Jug, *et al.* (1999). Short-rotation plantations of balsam poplars, aspen and willows on former arable land in the Federal Republic of Germany. I. Site-growth relationships. Forest Ecology and Management 121(1/2): 41-55.

IBDF. (1983). Potencial madereira do Grande Carajás. Instituto Brasileiro de Desenvolvimento Florestal. Brasilia, DF, Brazil. 134 pp.

IPCC Guidelines (1996). Workbook p 5.22. from Houghton etal. 1983, 1987.

Klinge, H.; Rodrigues, W.A. (1973). Biomass estimation in a central Amazonian rain forest. Acta Científica Venezolana 24:225-237

Laclau, J. P., J. P. Bouillet, *et al.* (2000). Dynamics of biomass and nutrient accumulation in a clonal plantation of Eucalyptus in Congo. Forest Ecology and Management 128(3): 181-196

Lamprecht, H. (1990). Silviculture in the tropics. GTZ. Rossdorf, Deutsche. 333 pp.

Mandouri T. *et al.* in "Annales de la recherche forestière (1951-1999); and Thesis from National High School of Forestry (ENFI); and Hassan II Agronomic Institut(IAVHII)

MDSP/PNCC: MINISTERIO DE DESARROLLO SOSTENIBLE Y PLANIFICACION; PROGRAMA NACIONAL DE CAMBIOS CLIMATICOS. (2002). Inventariación de Emisiones de Gases de Efecto Invernadero, Bolivia, 1990, 1994, 1998 y 2000. La Paz (Bolivia). 443 pp.

MINISTERIO DE MEDIOAMBIENTE Y RECURSOS NATURALES. (2000). Taller Regional Centro Americano sobre el Cambio Climático, 24-26 de junio de 2000. Ciudad de Panamá, Panamá.

Montagnini, F. (2000). Accumulation in above-ground biomass and soil storage of mineral nutrients in pure and mixed plantations in a humid tropical lowland. Forest Ecology and Management 134(1/3): 257-270.

Moreno, H. (2001). Estado de la Investigación sobre dinámica del carbono en proyectos Forestales de Colombia. Universidad Nacional de Colombia, Sede Medellín, Departamento de Ciencias Forestales. Medellín, Colombia.

Norgrove, L. and S. Hauser (2002). Measured growth and tree biomass estimates of Terminalia ivorensis in the 3 years after thinning to different stand densities in an agrisilvicultural system in southern Cameroon. Forest Ecology and Management 166(1/3): 261-270.

PAC-NK: NOEL KEMPFF CLIMATE ACTION PROJECT. (2000). Noel Kempff Climate Action Project: project case carbon inventory and offset benefits. Winrock Drive. Arlington, U.S.A. 45 pp.

Pandey, D (1982).

Parrotta, J. A. (1999). Productivity, nutrient cycling, and succession in single- and mixed-species plantations of Casuarina equisetifolia, Eucalyptus robusta, and Leucaena leucocephala in Puerto Rico. Forest Ecology and Management 124(1): 45-77

Peters, R. (1977). Fortalecimiento al sector forestal Guatemala inventarios y estudios dendrométricos en bosques de coniferas. FO:DP/GUA/72/006, Informe Técnico 2, FAO, Rome, Italy.

Ramírez, P.; Chacón, R. (1996). National Inventory of Sources and Sinks of Greenhouse Gases in Costa Rica. U.S. Contry Studies Program. Kluwer Academic Publishers. Boston, U.K. 357-365.

Russell, C.E. (1983). Nutrient cycling and productivity of native and plantation forest at Jari Florestal, Pará, Brazil. Ph.D. dissertation in ecology, University of Georgia, Athens, Georgia, U.S.A. 133 pp.

Saldarriaga, C.A.; Escobar, J.G.; Orrego, S. A.; Del Valle, I. (2001). Proyectos de Reforestación como parte del Mecanismo de Desarrollo Limpio: una aproximación preliminar para el análisis financiero y ambiental. Universidad Nacional de Colombia, Departamento de Ciencias Forestales. Medellín (Colombia). 61 pp.

Wadsworth, F.H. (1997). Forest production for tropical America. USDA Forest Service Agriculture Handbook 710. Washington, DC, USDA Forest Service.

Webb, D.B., Wood, P.J., Smith, J.P. & Henman, G.S. (1984). A guide to species selection for tropical and subtropical plantations. Tropical Forestry Papers No. 15 Oxford, UK, Commonwealth Forestry Institute.

Temperate

Data includes values compiled by DR. JIM SMITH, USDA FOREST SERVICE, DURHAM NH USA 03824. jsmith11@fs.fed.us, Lheath@fs.fed.us

Botkin D.B., Simpson L.G. (1990) Biomass of North American Boreal Forest. Biogeochemistry, 9: 161-174.

Brown S., Schroeder P., Kern J.S. (1999) Spatial distribution of biomass in forests of the eastern USA. Forest Ecology and Management, 123:81-90

Burrows, W. H.; Henry, B. K.; Back, P. V., *et al.* (2002) Growth and carbon stock change in eucalypt woodlands in northeast Australia: ecological and greenhouse sink implications. Global Change Biology 8 (8): 769-784 2002

Fang, S., X. Xu, *et al.* (1999). Growth dynamics and biomass production in short-rotation poplar plantations: 6-year results for three clones at four spacings. Biomass and Bioenergy 17(5): 415-425.

Götz S, D'Angelo SA , Teixeira W G, l Haag and Lieberei R (2002) Conversion of secondary forest into agroforestry and monoculture plantations in Amazonia: consequences for biomass, litter and soil carbon stocks after 7 years, For. Ecol. Manage 163 Pages 131-150

Gower S.T., Gholz H.L, Nakane K.,Baldwin V.C. (1994) Production and carbon allocation patterns of pine forests Ecological bulletins 43:115-135 (data converted from aNPP values assuming litterfall =2 x foliage annual production)

Grierson, P. F., M. A. Adams, *et al.* (1992). Estimates of carbon storage in the above-ground biomass of Victoria's forests. Australian Journal of Botany 40(4/5): 631-640.

Hall GMJ, Wiser SK, Allen RB, Beets PN and Goulding C J (2001).Strategies to estimate national forest carbon stocks from inventory data: the 1990 New Zealand baseline.Global Change Biology,7:389-403.

Hofmann-Schielle, C., A. Jug, *et al.* (1999). Short-rotation plantations of balsam poplars, aspen and willows on former arable land in the Federal Republic of Germany. I. Site-growth relationships. Forest Ecology and Management 121(1/2): 41-55.

Mitchell, C. P., E. A. Stevens, *et al.* (1999). Short-rotation forestry - operations, productivity and costs based on experience gained in the UK. Forest Ecology and Management 121(1/2): 123-136.

Santa Regina, I. and T. Tarazona (2001). Nutrient cycling in a natural beech forest and adjacent planted pine in northern Spain. Forestry (Oxford) 74(1): 11-28

Schroeder, P., S. Brown, *et al.* (1997). Biomass estimation for temperate broadleaf forests of the United States using inventory data. Forest Science 43(3): 424-434.

Shan, J Morris L A. & Hendrick, R L. (2001) The effects of management on soil and plant carbon sequestration in slash pine plantations. Journal of Applied Ecology 38 (5), 932-941.

Smith and Heath. Data includes values compiled by DR. JIM SMITH, USDA FOREST SERVICE, DURHAM NH USA 03824. jsmith11@fs.fed.us, Lheath@fs.fed.us

Son YH; Hwang JW; Kim ZS; Lee WK; Kim JS (2001) Allometry and biomass of Korean pine (Pinus koraiensis) in central Korea. Bioresource Technology 78 (3): 251-255 2001

Turnbull, C.R.A., McLeod, D.E., Beadle, C.L., Ratkowsky, D.A., Mummery, D.C. and Bird, T. (1993). Comparative growth of Eucalyptus species of the subgenera Monocalyptus and Symphyomyrtus in intensively managed plantations in southern Tasmania. Aust. For. 56, pp. 276–286.

UN-ECE/FAO (2000). Forest Resources of Europe, CIS, North America, Australia, Japan and new Zealand (industrialized temperate / boreal countries.UN-ECE/FAO contribution to th Global Forest Resources Assessment 2000, united nations, New-Ypork and Geneva, geneva Timber and Forest Study papers, No 17.446 p.

U'soltsev and Van Clay. (1995). Stand Biomass Dynamics of Pine plantations and natural forests on dry steppe in Kazakhstan Scan J For Res, 10, 305-312

Vogt K (1991). Carbon budgets of temperate forest ecosystems. Tree Physiology, 9:69-86.

Zhou, G., Y. Wang, *et al.* (2002). Estimating biomass and net primary production from forest inventory data: a case study of China's Larix forests. Forest Ecology and Management 169(1/2): 149-157.

Boreal

Finnish Forest Research Institute (2002). Finnish Statistical Yearbook of Forestry. SVT Agriculture and Forestry, Helsinki, Finland.

Isaev, A.S., Korovin, G.N., Utkin A.I., Pryazhnikov A.A., and D.G. Zamolodchikov (1993) *Estimation of Carbon Pool and Its Annual Deposition in Phytomass of Forest Ecosystems in Russia*, Forestry (*Lesovedenie*), 5: 3-10 (In Russian).

Kajimoto, T., Y. Matsuura, *et al.* (1999). Above- and belowground biomass and net primary productivity of a Larix gmelinii stand near Tura, central Siberia. Tree Physiology 19(12): 815-822.

Koivisto, 1959; Koivisto, P., (1959) Growth and Yield Tables. Commun. Inst. For. Fenn. Vol 51 no. 51.8: 1-49 (In Finnish with headings in English).

Kurz, W.A. and M.J. Apps. (1993): Contribution of northern forests to the global C cycle: Canada as a case study. Water, Air, and Soil Pollution, 70, 163-176.

Nilsson S., Shvidenko A., Stolbovoi V., Glick M., Jonas M., Obersteiner M. (2000). Full carbon account for Russia. Interim Report IR -00-021 Int Inst Appl Anal, 181 pages.

UN-ECE/FAO (2000). Forest Resources of Europe, CIS, North America, Australia, Japan and new Zealand (industrialized temperate / boreal countries.UN-ECE/FAO contribution to th Global Forest Resources Assessment 2000, United Nations, New-Ypork and Geneva, geneva Timber and Forest Study papers, No 17.446 p.

Vuokila, Y. and Väliaho, H. (1980). Growth and yield models for conifers cultures in Finland. Commun. Inst. For. Fenn. 99(2):1-271

Wirth C. , E.-D. Schulze, W. Schulze, D. von Stünzner-Karbe, W. Ziegler, I. M. Miljukova, A. Sogatchev, A. B. Varlagin, M. Panvyorov, S. Grigoriev, W. Kusnetzova, M. Siry, G. Hardes, R. Zimmermann, N. N. Vygodskaya (1999). Above-ground biomass and structure of pristine Siberian Scots pine forests as controlled by competition and fire. Oecologia 121 : 66-80

Zakharov, V.K., Trull, O.A., Miroshnikov, V.S., and V.E. Ermakov (1962) The Reference Book on Forest Inventory. Belarus State Publishing, Minsk, p. 368. (In Russian).

Zagreev, V.V., Sukhikh, B.I., Shvidenko, A.Z., Gusev, N.N., and A.G. Moshkalev (1993) *The All-Union Standards for Forest Inventory. Kolos*, Moscow, p. 495. (In Russian).

TABLE 3A.1.7
AVERAGE ANNUAL ABOVE GROUND NET INCREMENT IN VOLUME IN PLANTATIONS BY SPECIES
(m^3/ha/yr)
(To be used for I_v in Equation 3.2.5)

Species	I_V (m^3 ha^{-1} yr^{-1})	
	Range	Mean*
E. deglupta	14 - 50	32
E. globulus	10 - 40	25
E. grandis	15 - 50	32.5
E. saligna	10 - 55	32.5
E. camaldulensis	15 - 30	22.5
E. urophylla	20 - 60	40
E. robusta	10 - 40	25
Pinus caribaea var. caribaea	10 - 28	19
Pinus caribaea var. hondurensis	20 - 50	35
Pinus patula	8 - 40	24
Pinus radiata	12 - 35	23.5
Pinus oocarpa	10 - 40	25
Araucaria angustifolia	8 - 24	16
A. cunninghamii	10 - 18	14
Gmelina arborea	12 - 50	31
Swietenia macrophylla	7 - 30	18.5
Tectona grandis	6 - 18	12
Casuarina equisetifolia	6 - 20	13
C. junghuhniana	7 - 11	9
Cupressus lusitanica	8 - 40	24
Cordia alliadora	10 - 20	15
Leucaena leucocephala	30 - 55	42.5
Acacia auriculiformis	6 - 20	13
Acacia mearnsii	14 - 25	19.5
Terminalia superba	10 - 14	12
Terminalia ivorensis	8 - 17	12.5
Dalbergia sissoo	5 - 8	6.5

* For those parties that have reason to believe that their plantations are located on more than average fertile sites it is suggested to use the mean value + 50%, for those Parties that have reason to believe their plantations are located on poor sites, it is suggested to use the mean value -50%

Source: Ugalde,L. and Prez,O. Mean annual volume increment of selected industrial forest planatation species. Forest Plantation Thematic Papers, Working paper 1. FAO (2001)
Available at http://www.fao.org/DOCREP/004/AC121E/AC121E00.HTM

TABLE 3A.1.8
AVERAGE BELOWGROUND TO ABOVEGROUND BIOMASS RATIO (ROOT-SHOOT RATIO, R) IN NATURAL REGENERATION BY BROAD CATEGORY (tonnes dry matter/tonne dry matter)
(To be used for R in Equation 3.2.5)

	Vegetation type	Aboveground biomass (t/ha)	Mean	SD	lower range	upper range	References
Tropical/sub-tropical forest	Secondary tropical/sub-tropical forest	<125	0.42	0.22	0.14	0.83	5, 7, 13, 25, 28, 31, 48, 71
	Primary tropical/sub-tropical moist forest	NS	0.24	0.03	0.22	0.33	33, 57, 63, 67, 69
	Tropical/sub-tropical dry forest	NS	0.27	0.01	0.27	0.28	65
Conifer forest/ plantation	Conifer forest/plantation	<50	0.46	0.21	0.21	1.06	2, 8, 43, 44, 54, 61, 75
	Conifer forest/plantation	50-150	0.32	0.08	0.24	0.50	6, 36, 54, 55, 58, 61
	Conifer forest/plantation	>150	0.23	0.09	0.12	0.49	1, 6, 20, 40, 53, 61, 67, 77, 79
Temperate broadleaf forest/ plantation	Oak forest	>70	0.35	0.25	0.20	1.16	15, 60, 64, 67
	Eucalypt plantation	<50	0.45	0.15	0.29	0.81	9, 51, 59
	Eucalypt plantation	50-150	0.35	0.23	0.15	0.81	4, 9, 59, 66, 76
	Eucalypt forest/plantation	>150	0.20	0.08	0.10	0.33	4, 9, 16, 66
	Other broadleaf forest	<75	0.43	0.24	0.12	0.93	30, 45, 46, 62
	Other broadleaf forest	75-150	0.26	0.10	0.13	0.52	30, 36, 45, 46, 62, 77, 78, 81
	Other broadleaf forest	>150	0.24	0.05	0.17	0.30	3, 26, 30, 37, 67, 78, 81
Grassland	Steppe/tundra/prairie grassland	NS	3.95	2.97	1.92	10.51	50, 56, 70, 72
	Temperate/sub-tropical/ tropical grassland	NS	1.58	1.02	0.59	3.11	22, 23, 32, 52
	Semi-arid grassland	NS	2.80	1.33	1.43	4.92	17-19, 34
Other	Woodland/savanna	NS	0.48	0.19	0.26	1.01	10-12, 21, 27, 49, 65, 73, 74
	Shrubland	NS	2.83	2.04	0.34	6.49	14, 29, 35, 38, 41, 42, 47, 67
	Tidal marsh	NS	1.04	0.21	0.74	1.23	24, 39, 68, 80

NS = Not specified

References for Table 3A.1.8

1. Alban, D., D. Perala, and B. Schlaegel (1978) Biomass and nutrient distribution in aspen, pine, and spruce stands on the same soil type in Minnesota. *Canadian Journal of Forest Research* **8**: 290-299.
2. Albaugh, T., H. Allen, P. Dougherty, L. Kress, and J. King (1998) Leaf area and above- and below-ground growth responses of loblolly pine to nutrient and water additions. *Forest Science* **44**(2): 317-328.
3. Anderson, F. (1971) Methods and Preliminary results of estimation of biomass and primary production in a south Sweedish mixed deciduous woodland. In: *Productivity of forest ecosystems. Proccedings of the Brussels symposium, 1969, ecology and conservation 4*. UNESCO, Paris.
4. Applegate, G. (1982) *Biomass of Blackbutt (Eucalyptus pilularis Sm.) Forests on Fraser Island*. Masters Thesis. University of New England, Armidale.
5. Bartholomew, W., J. Meyer, and H. Laudelout (1953) Mineral nutrient immobilization under forest and grass fallow in the Yangambi (Belgian Congo) region. *Publications de l'Institut National Pour l'Etude Agronomique du Congo Belge Serie scientifique* **57**: 27pp total.
6. Baskerville, G. (1966) Dry-matter production in immature balsam fir stands: roots, lesser vegetation, and total stand. *Forest Science* **12**: 49-53.
7. Berish, C. (1982) Root biomass and surface area in three successional tropicl forests. *Canadian Journal of Forest Research* **12**: 699-704.
8. Braekke, F. (1992) Root biomass changes after drainage and fertilisation of a low-shrub pine bog. *Plant and Soil* **143**: 33-43.
9. Brand, B. (1999) *Quantifying biomass and carbon sequestration of plantation blue gums in south west Western Australia*. Honours Thesis. Curtin University of Technology,
10. Burrows, W. (1976) *Aspects of nutrient cycling in semi-arid mallee and mulga communities*. PhD Thesis. Australian National University, Canberra.
11. Burrows, W., M. Hoffmann, J. Compton, P. Back, and L. Tait (2000) Allometric relationships and community biomass estimates for some dominant eucalypts in Central Queensland woodlands. *Australian Journal of Botany* **48**: 707-714.
12. Burrows, W., M. Hoffmann, J. Compton, and P. Back (2001) *Allometric relationships and community biomass stocks in white cypress pine (Callitris glaucophylla) and associated eucalypts of the Carnarvon area - south central Queensland*. National Carbon Accounting System Technical Report No. 33. Australian Greenhouse Office, Canberra. 16 p.

13. Buschbacher, R., C. Uhl, and E. Serrao (1988) Abandoned pastures in eastern Amazonia. II. Nutrient stocks in the soil and vegetation. *Journal of Ecology* **76**: 682-701.

14. Caldwell, M. and L. Camp (1974) Belowground productivity of two cool desert communities. *Oecologia* **17**: 123-130.

15. Canadell, J. and F. Roda (1991) Root biomass of Quercus ilex in a montane Mediterranean forest. *Canadian Journal of Forest Research* **21**(12): 1771-1778.

16. Chilcott, C. (1998) *The initial impacts of reforestation and deforestation on herbaceous species, litter decomposition, soil biota and nutrients in native temperate pastures on the Northern Tablelands, NSW*. PhD Thesis. University of New England, Armidale.

17. Christie, E. (1978) Ecosystem processes in semiarid grasslands. I. Primary production and water use of two communities possessing different photosynthetic pathways. *Australian Journal of Agricultural Research* **29**: 773-787.

18. Christie, E. (1979) Eco-physiological studies of the semiarid grasses *Aristida leptopoda* and *Astrebla lappacea*. *Australian Journal of Ecology* **4**: 223-228.

19. Christie, E. (1981) Biomass and nutrient dynamics in a C_4 semi-arid Australian grassland community. *Journal of Applied Ecology* **18**: 907-918.

20. Cole, D., S. Gessel, and S. Dice (1967) Distribution and cycling of nitrogen, phosphorus, potassium, and calcium in a second-growth Douglas-fir ecosystem. In: *Symposium : Primary productivity and mineral cycling in natural ecosystems*. American Association for the Advancement of Science 13th Annual Meeting New York City, December 27, 1967: University of Maine Press.

21. Compton, J., L. Tait, M. Hoffmann, and D. Myles (1999) Root-shoot ratios and root distribution for woodland communities across a rainfall gradient in central Queensland. In: *Proceedings of the VI International Rangeland Congress*. Townsville, Australia.

22. Cooksley, D., K. Butler, J. Prinsen, and C. Paton (1988) Influence of soil type on *Heteropogon contortus - Bothrichloa bladhii* dominant native pasture in south-eastern Queensland. *Australian Journal of Experimental Agriculture* **28**: 587-591.

23. De Castro, E.A. and J.B. Kauffman (1998) Ecosystem structure in the Brazilian Cerrado: a vegetation gradient of aboveground biomass, root mass and consumption by fire. *Journal of Tropical Ecology* **14**(3): 263-283.

24. De la Cruz, A. and C. Hackney (1977) Energy value, elemental composition, and productivity of belowground biomass of a *Juncus* tidal marsh. *Ecology* **58**: 1165-1170.

25. Drew, W., S. Aksornkoae, and W. Kaitpraneet (1978) An assessment of productivity in successional stages from abandoned swidden (Rai) to dry evergreen forest in northeastern Thailand. *Forest Bulletin* **56**: 31 total.

26. Dylis, N. (1971) Primary production of mixed forests. In: *Productivity of forest ecosystems. Proceedings of the Brussels symposium, 1969*. Paris: UNESCO.

27. Eamus, D., X. Chen, G. Kelley, and L. Hutley (2002) Root biomass and root fractal analyses of an open *Eucalyptus* forest in a savanna of north Australia. *Australian Journal of Botany* **50**: 31-41.

28. Ewel, J. (1971) Biomass changes in early tropical succession. *Turrialba* **21**: 110-112.

29. Forrest, G. (1971) Structure and production of North Pennine blanket bog vegetation. *Journal of Ecology* **59**: 453-479.

30. Garkoti, S. and S. Singh (1995) Variation in net primary productivity and biomass of forests in the high mountains of Central Himalaya. *Journal of Vegetation Science* **6**: 23-28.

31. Golley, F., H. Odum, and R. Wilson (1962) The structure and metabolism of a Puerto Rican red mangrove forest in May. *Ecology* **43**(1): 9-19.

32. Graham, T. (1987) *The effect of renovation practices on nitrogen cycling and productivity of rundown buffel grass pasture*. PhD Thesis. University of Queensland,

33. Greenland, D. and J. Kowal (1960) Nutrient content of the moist tropical forest of Ghana. *Plant and Soil* **12**: 154-173.

34. Grouzis, M. and L. Akpo (1997) Influence of tree cover on herbaceous above- and below-ground phytomas in the Sahelian zone of Senegal. *Journal of Arid Environments* **35**: 285-296.

35. Groves, R. and R. Specht (1965) Growth of heath vegetation. 1. Annual growth curves of two heath ecosystems in Australia. *Australian Journal of Botany* **13**: 261-280.

36. Harris, W., R. Kinerson, and N. Edwards (1977) Comparison of belowground biomass of natural deciduous forest and loblolly pine plantations. *Pedobiologica* **17**: 369-381.

37. Hart, P., P. Clinton, R. Allen, A. Nordmeyer, and G. Evans (2003) Biomass and macro-nutrients (above- and below-ground) in a New Zealand beech (*Nothofagus*) forest ecosystem: implications for carbon storage and sustainable forest management. *Forest Ecology and Management* **174**: 281-294.

38. Hoffmann, M. and J. Kummerow (1978) Root studies in the Chilean matorral. *Oecologia* **32**: 57-69.

39. Hussey, A. and S. Long (1982) Seasonal changes in weight of above- and below-ground vegetation and dead plant material in a salt marsh at Colne Point, Essex. *Journal of Ecology* **70**: 757-771.

40. Johnstone, W. (1971) Total standing crop and tree component distributions in three stands of 100-year-old lodgepole pine. In: *Forest biomass studies. 15th IUFRO Congress* (Ed.^Eds. H. Young). University of Maine Press, Orono. p. 81-89.

41. Jones, R. (1968) Estimating productivity and apparent photosynthesis from differences in consecutive measurements of total living plant parts of an Australian heathland. *Australian Journal of Botany* **16**: 589-602.

42. Kummerow, J., D. Krause, and W. Jow (1977) Root systems of chaparral shrubs. *Oecologia* **29**: 163-177.

43. Linder, S. and B. Axelsson (1982) Changes in carbon uptake and allocation patterns as a result of irrigation and fertilisation in a young Pinus sylvestris stand. In: *Carbon Uptake and Allocation:Key to Management of Subalpine Forest Ecosystems* (Ed.^Eds. R. Waring). Forest Research Laboratory, Oregon State University, Corvallis, Oregon. p. 38-44.

44. Litton, C., M. Ryan, D. Tinker, and D. Knight (2003) Belowground and aboveground biomass in young postfire lodgepole pine forests of contrasting tree density. *Canadian Journal of Forest Research* **33**(2): 351-363.

45. Lodhiyal, L. and N. Lodhiyal (1997) Variation in biomass and net primary productivity in short rotation high density central Himalayan poplar plantations. *Forest Ecology and Management* **98**: 167-179.

46. Lodhiyal, N., L. Lodhiyal, and P. Pangtey (2002) Structure and function of Shisham forests in central Himalaya, India: dry matter dynamics. *Annals of Botany* **89**: 41-54.

47. Low, A. and B. Lamont (1990) Aerial and belowground phytomass of *Banksia* scrub-heath at Eneabba, South-Western Australia. *Australian Journal of Botany* **38**: 351-359.

48. Lugo, A. (1992) Comparison of tropical tree plantations with secondary forests of similar age. *Ecological Monographs* **62**: 1-41.

49. Menaut, J. and J. Cesar (1982) The structure and dynamics of a west African savanna. In: *Ecology of Tropical Savannas* (Ed.^Eds. B. Huntley and B. Walker). Springer-Verlag, Berlin. p. 80-100.

50. Milchunas, D. and W. Lauenroth (1989) Three-dimensional distribution of plant biomass in relation to grazing and topography in the shortgrass steppe. *Oikos* **55**: 82-86.

51. Misra, R., C. Turnbull, R. Cromer, A. Gibbons, and A. LaSala (1998) Below- and above-ground growth of *Eucalyptus nitens* in a young plantation. I. Biomass. *Forest Ecology and Management* **106**: 283-293.

52. Nepstad, D. (1989) *Forest regrowth in abandoned pastures of eastern Amazonia: limitations to tree seedling survival and growth*. PhD Dissertation. Yale University, New Haven.

53. Nihlgård, B. (1972) Plant biomass, primary production and distribution of chemical elements in a beech and a planted spruce forest in South Sweden. *Oikos* **23**: 69-81.

54. Ovington, J. (1957a) Dry matter production by *Pinus sylvestris* L. *Annals of Botany, London* **N.S. 21**: 287-314.

55. Ovington, J. and H. Madgwick (1959a) Distribution of organic matter and plant nutrients in a plantation of Scotts pine. *Forest Science* **5**: 344-355.

56. Ovington, J. (1963) Plant biomass and productivity of prairie, savanna, oakwood, and maize field ecosystems in central Minnesota. *Ecology* **44**(1): 52-63.

57. Ovington, J. and J. Olson (1970) Biomass and chemical content of El Verde lower montane rain forest plants. In: *A tropical rain forest. A study of irradiation and ecology at El Verde, Puerto Rico (Division of Technical Information TID 24270)* (Ed.^Eds. H. Odum and R. Pigeon). US Atomic Energy Commission, Washington DC. p. 53-77.

58. Pearson, J., T. Fahey, and D. Knight (1984) Biomass and leaf area in contrasting lodgepole pine forests. *Canadian Journal of Forest Research* **14**: 259-265.

59. Prasad, R., A. Sah, A. Bhandari, and O. Choubey (1984) Dry matter production by *Eucalyptus camaldulensis* Dehn plantationin Jabalpur. *Indian Forester* **110**: 868-878.

60. Rawat, Y. and J. Singh (1988) Structure and function of oak forests in Central Himalaya. I. Dry matter dynamics. *Annals of Botany* **62**: 397-411.

61. Ritson, P. and S. Sochacki (2003) Measurement and prediction of biomass and carbon content of *Pinus pinaster* trees in farm forestry plantations, south-western Australia. *Forest Ecology and Management* **175**: 103-117.

62. Ruark, G. and J. Bockheim (1988) Biomass, net primary production, and nutrient distribution for an age sequence of *Populus tremuloides. Canadian Journal of Forest Research* **18**: 435-443.

63. Shanmughavel, P., Z. Zheng, S. Liqing, and C. Min (2001) Floristic structure and biomass distribution of a tropical seasonal rain forest in Xishuangbanna, southwest China. *Biomass and Bioenergy* **21**: 165-175.

64. Simonovic, V. (1980) Root productivity studies in deciduous forest ecosystem. In: *Environment and root behaviour* (Ed.^Eds. N. David). Geobios International, Jodhour, India. p. 213-230.

65. Singh, K. and R. Misra (1979) *Structure and Functioning of Natural, Modified and Silvicultural Ecosystems in Eastern Uttar Pradesh*. Final Technical Report (1975-1978) MAB research project. Banras Hindu University, Varanasi. 160 p.

66. Singh, R. and V. Sharma (1976) Biomass estimation in five different aged plantations of *Eucalyptus tereticornix* Smith in western Uttar Pradesh. In: *Oslo Biomass Studies* (Ed.^Eds. University of Maine, Orono. p. 143-161.

67. Singh, S., B. Adhikari, and D. Zobel (1994) Biomass, productivity, leaf longevity, and forest structure in the central Himalaya. *Ecological Monographs* **64**: 401-421.

68. Suzuki, E. and H. Tagawa (1983) Biomass of a mangrove forest and a sedge marsh on Ishigaki Island, south Japan. *Japanese Journal of Ecology* **33**: 231-234.

69. Tanner, E. (1980) Studies on the biomass and productivity in a series of montane rain forests in Jamaica. *Journal of Ecology* **68**: 573-588.

70. Titlyanova, A., G. Rusch, and E. van der Maarel (1988) Biomass structure of limestone grasslands on Öland in relation to grazing intensity. *Acta phytogeographica suecica* **76**: 125-134.

71. Uhl, C. (1987) Factors controlling succession following slash-and-burn agriculture in Amazonia. *Journal of Ecology* **75**: 377-407.

72. van Wijk, M., M. Williams, L. Gough, S. Hobbie, and G. Shaver (2003) Luxury consumption of soil nutrients: a possible competitive strategy in above-ground and below-ground biomass allocation and root morphology for slow growing arctic vegetation? *Journal of Ecology* **91**: 664-676.

73. Werner, P.A. (1986) *Population dynamics and productivity of selected forest trees in Kakadu National Park*. Final report to the Australian National Parks and Wildlife Service. CSIRO Darwin, Tropical Ecosystems Research Centre, p.

74. Werner, P.A. and P.G. Murphy (2001) Size-specific biomass allocation and water content of above- and below-ground components of three *Eucalyptus* species in a northern Australian savanna. *Australian Journal of Botany* **49**(2): 155-167.

75. Westman, E. and R. Whitaker (1975) The pygmy forest region of northern California: studies on biomass and primary productivity. *Journal of Ecology* **63**: 493-520.

76. Westman, W. and R. Rogers (1977) Biomass and structure of a subtropical eucalypt forest, North Stradbroke Island. *Australian Journal of Botany* **25**: 171-191.

77. Whittaker, R. and G. Woodwell (1971) Measurement of net primary production in forests. In: *Productivity of Forest Ecosystems* (Eds.) Paris: UNESCO. p. 159-175.

78. Whittaker, R., F. Borman, G. Likens, and T. Siccama (1974) The Hubbard Brook ecosystem study: forest biomass and production. *Ecological Monographs* **44**: 233-252.

79. Will, G. (1966) Root growth and dry-matter production in a high-producing stand of *Pinus radiata. New Zealand Forestry Research Notes* **44**: 1-15.

80. Windham, L. (2001) Comparison of biomass production and decomposition between *Phragmites australis* (common reed) and *Spartina patens* (salt hay grass) in brackish tidal marshes of New Jersey, USA. *Wetlands* **21**(2): 179-188.

81. Zavitkovski, J. and R. Stevens (1972) Primary productivity of red alder ecosystems. *Ecology* **53**: 235-242.

TABLE 3A.1.9-1
BASIC WOOD DENSITIES OF STEMWOOD (tonnes dry matter/m^3 fresh volume)
FOR BOREAL AND TEMPERATE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

Species or genus	Basic wood density m_0/V_{wet}	Source
Abies	0.40	1
Acer	0.52	1
Alnus	0.45	1
Betula	0.51	1
Carpinus betulus	0.63	3
Castanea sativa	0.48	3
Fagus sylvatica	0.58	1
Fraxinus	0.57	1
Juglans	0.53	3
Larix decidua	0.46	1
Larix kaempferi	0.49	3
Picea abies	0.40	1
Picea sitchensis	0.40	2
Pinus pinaster	0.44	5
Pinus strobus	0.32	1
Pinus sylvestris	0.42	1
Populus	0.35	1
Prunus	0.49	1
Pseudotsuga menziesii	0.45	1
Quercus	0.58	1
Salix	0.45	1
Thuja plicata	0.31	4
Tilia	0.43	1
Tsuga	0.42	4

Source:

1. Dietz, P. 1975: Dichte und Rindengehalt von Industrieholz. Holz Roh- Werkstoff 33: 135-141
2. Knigge, W.; Schulz, H. 1966: Grundriss der Forstbenutzung. Verlag Paul Parey, Hamburg, Berlin
3. EN 350-2 (1994): Durability of wood and wood products - Natural durability of solid wood - Part 2: Guide to the natural durability and treatability of selected wood species of importance in Europe
4. Forest Products Laboratory: Handbook of wood and wood-based materials. Hemisphere Publishing Corporation, New York, London
5. Rijsdijk, J.F.; Laming, P.B. 1994: Physical and related properties of 145 timbers. Kluwer Academic Publishers, Dordrecht, Boston, London
6. Kollmann, F.F.P.; Coté, W.A. 1968: Principles of wood science and technology. Springer Verlag, Berlin, New York

TABLE 3A.1.9-2
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Acacia leucophloea	0.76	Albizia spp.	0.52	Afzelia spp.	0.67
Adina cordifolia	0.58, 0.59+	Alcornea spp.	0.34	Aidia ochroleuca	0.78*
Aegle marmelo	0.75	Alexa grandiflora	0.6	Albizia spp.	0.52
Agathis spp.	0.44	Alnus ferruginea	0.38	Allanblackia floribunda	0.63*
Aglaia llanosiana	0.89	Anacardium excelsum	0.41	Allophyllus africanus f. acuminatus	0.45
Alangium longiflorum	0.65	Anadenanthera macrocarpa	0.86	Alstonia congensis	0.33
Albizzia amara	0.70*	Andira retusa	0.67	Amphimas pterocarpoides	0.63*
Albizzia falcataria	0.25	Aniba riparia lduckei	0.62	Anisophyllea obtusifolia	0.63*
Aleurites trisperma	0.43	Antiaris africana	0.38	Annonidium mannii	0.29*
Alnus japonica	0.43	Apeiba echinata	0.36	Anopyxis klaineana	0.74*
Alphitonia zizyphoides	0.5	Artocarpus comunis	0.7	Anthocleista keniensis	0.50*
Alphonsea arborea	0.69	Aspidosperma spp. (araracanga group)	0.75	Anthonotha macrophylla	0.78*
Alseodaphne longipes	0.49	Astronium lecointei	0.73	Anthostemma aubryanum	0.32*
Alstonia spp.	0.37	Bagassa guianensis	0.68,0.69+	Antiaris spp.	0.38
Amoora spp.	0.6	Banara guianensis	0.61	Antrocaryon klaineanum	0.50*
Anisophyllea zeylanica	0.46*	Basiloxylon exelsum	0.58	Aucoumea klaineana	0.37
Anisoptera spp,	0.54	Beilschmiedia sp.	0.61	Autranella congolensis	0.78
Anogeissus latifolia	0.78, 0.79+	Berthollettia excelsa	0.59, 0.63+	Baillonella toxisperma	0.71
Anthocephalus chinensis	0.36,0.33+	Bixa arborea	0.32	Balanites aegyptiaca	0.63*
Antidesma pleuricum	0.59	Bombacopsis sepium	0.39	Baphia kirkii	0.93*
Aphanamiris perrottetiana	0.52	Borojoa patinoi	0.52	Beilschmiedia louisii	0.70*
Araucaria bidwillii	0.43	Bowdichia spp.	0.74	Beilschmiedia nitida	0.50*
Artocarpus spp.	0.58	Brosimum spp. (alicastrum group)	0.64, 0.66+	Berlinia spp.	0.58
Azadirachta spp.	0.52	Brosimum utile	0.41, 0.46+	Blighia welwitschii	0.74*
Balanocarpus spp.	0.76	Brysenia adenophylla	0.54	Bombax spp.	0.4
Barringtonia edulis *	0.48	Buchenauia capitata	0.61, 0.63+	Brachystegia spp.	0.52
Bauhinia spp.	0.67	Bucida buceras	0.93	Bridelia micrantha	0.47*
Beilschmiedia tawa	0.58	Bulnesia arborea	1	Calpocalyx klainei	0.63*
Berrya cordifolia	0.78*	Bursera simaruba	0.29, 0.34+	Canarium schweinfurthii	0.40*
Bischofia javanica	0.54,0.58,0.62+	Byrsonima coriacea	0.64	Canthium rubrocostratum	0.63*
Bleasdalea vitiensis	0.43	Cabralea cangerana	0.55	Carapa procera	0.59
Bombax ceiba	0.33	Caesalpinia spp.	1.05	Casearia battiscombei	0.5
Bombycidendron vidalianum	0.53	Calophyllum sp.	0.65	Cassipourea euryoides	0.70*
Boswellia serrata	0.5	Campnosperma panamensis	0.33,0.50+	Cassipourea malosana	0.59*
Bridelia squamosa	0.5	Carapa sp.	0.47	Ceiba pentandra	0.26
Buchanania latifolia	0.45	Caryocar spp.	0.69, 0.72+	Celtis spp.	0.59
Bursera serrata	0.59	Casearia sp.	0.62	Chlorophora ercelsa	0.55
Butea monosperma	0.48	Cassia moschata	0.71	Chrysophyllum albidum	0.56*
Calophyllum spp.	0.53	Casuarina equisetifolia	0.81	Cleistanthus mildbraedii	0.87*
Calycarpa arborea	0.53	Catostemma spp.	0.55	Cleistopholis patens	0.36*
Cananga odorata	0.29	Cecropia spp.	0.36	Coelocaryon preussii	0.56"
Canarium spp.	0.44	Cedrela spp.	0.40, 0.46+	Cola sp.	0.70"
Canthium monstrosum	0.42	Cedrelinga catenaeformis	0.41, 0.53+	Combretodendron macrocarpum	0.7
Carallia calycina	0.66*	Ceiba pentandra	0.23,0.24,0.25, 0.29+	Conopharyngia holstii	0.50*

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED) **BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES** (To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)					
TROPICAL ASIA	**D**	**TROPICAL AMERICA**	**D**	**TROPICAL AFRICA**	**D**
Cassia javanica	0.69	Centrolobium spp.	0.65	Copaifera religiosa .	0.50”
Castanopsis philippensis	0.51	Cespedesia macrophylla	0.63	Cordia millenii	0.34
Casuarina equisetifolia	0.83	Chaetocarpus schomburgkianus	0.8	Cordia platythyrsa	0.36”
Casuarina nodiflora	0.85	Chlorophora tinctoria	0.71,0.75+	Corynanthe pachyceras	0.63”
Cedrela odorata	0.38	Clarisia racemosa	0.53,0.57+	Coda edulis	0.78*
Cedrela spp.	0.42	Clusia rosea	0.67	Croton megalocarpus	0.57
Cedrela toona	0.43	Cochlospermum orinocensis	0.26	Cryptosepalum staudtii	0.70*
Ceiba pentandra	0.23	Copaifera spp.	0.46, 0.55+	Ctenolophon englerianus	0.78*
Celtis luzonica	0.49	Cordia spp. (gerascanthus group)	0.74	Cylicodiscus gabonensis	0.8
Chisocheton pentandrus	0.52	Cordia spp. (alliodora group)	0.48	Cynometra alexandri	0.74
Chloroxylon swietenia	0.76, 0.79, 0.80+	Couepia sp.	0.7	Dacryodes spp.	0.61
Chukrassia tabularis	0.57	Couma macrocarpa	0.50,0.53+	Daniellia ogea	0.40*
Citrus grandis	0.59	Couratari spp.	0.5	Desbordesia pierreana	0.87”
Cleidion speciflorum	0.5	Croton xanthochloros	0.48	Detarium senegalensis	0.63*
Cleistanthus eollinus	0.88	Cupressus lusitanica	0.43, 0.44+	Dialium excelsum	0.78*
Cleistocalyx spp.	0.76	Cyrilla racemiflora	0.53	Didelotia africana	0.78”
Cochlospermum gossypium+religiosum	0.27	Dactyodes colombiana	0.51	Didelotia letouzeyi	0.5
Cocos nucifera	0.5	Dacryodes excelsa	0.52, 0.53+	Diospyros spp.	0.82
Colona serratifolia	0.33	Dalbergia retusa.	0.89	Discoglypremna caloneura	0.32*
Combretodendron quadrialatum	0.57	Dalbergia stevensonii	0.82	Distemonanthus benthamianus	0.58
Cordia spp.	0.53	Declinanona calycina	0.47	Drypetes sp.	0.63*
Cotylelobium spp.	0.69	Dialium guianensis	0.87	Ehretia acuminata	0.51*
Crataeva religiosa	0.53*	Dialyanthera spp.	0.36, 0.48+	Enantia chlorantha	0.42”
Cratoxylon arborescens	0.4	Dicorynia paraensis	0.6	Endodesmia calophylloides	0.66”
Cryptocarya spp.	0.59	Didymopanax sp.	0.74	Entandrophragma utile	0.53
Cubilia cubili	0.49	Dimorphandra mora	0.99*	Eribroma oblongum	0.60*
Cullenia excelsa	0.53	Diplotropis purpurea	0.76, 0.77, 0.78+	Eriocoelum microspermum	0.50”
Cynometra spp.	0.8	Dipterix odorata	0.81,0.86,0.89+	Erismadelphus ensul	0.56*
Dacrycarpus imbricatus	0.45, 0.47+	Drypetes variabilis	0.69	Erythrina vogelii	0.25”
Dacrydium spp.	0.46	Dussia lehmannii	0.59	Erythrophleum ivorense	0.72
Dacryodes spp.	0.61	Ecclinusa guianensis	0.63	Erythroxylum mannii	0.5
Dalbergia paniculata	0.64	Endlicheria cocvirey	0.39	Fagara macrophylla	0.69
Decussocarpus vitiensis	0.37	Enterolobium schomburgkii	0.82	Ficus iteophylla	0.40”
Degeneria vitiensis	0.35	Eperua spp.	0.78	Fumtumia latifolia	0.45*
Dehaasia triandra	0.64	Eriotheca sp.	0.4	Gambeya spp.	0.56*
Dialium spp.	0.8	Erisma uncinatum	0.42, 0.48+	Garcinia punctata	0.78”
Dillenia spp.	0.59	Erythrina sp.	0.23	Gilletiodendron mildbraedii	0.87”
Diospyros spp.	0.7	Eschweilera spp.	0.71,0.79,0.95+	Gossweilerodendron balsamiferum	0.4
Diplodiscus paniculatus	0.63	Eucalyptus robusta	0.51	Guarea thompsonii	0.55”
Dipterocarpus caudatus	0.61	Eugenia stahlii	0.73	Guibourtia spp.	0.72
Dipterocarpus eurynchus	0.56	Euxylophora paraensis	0.68,0.70+	Hannoa klaineana	0.28”
Dipterocarpus gracilis	0.61	Fagara spp.	0.69	Harungana madagascariensis	0.45”
Dipterocarpus grandiflorus	0.62	Ficus sp.	0.32	Hexalobus crispiflorus	0.48”
Dipterocarpus kerrii	0.56	Genipa spp.	0.75	Holoptelea grandis	0.59”

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Dipterocarpus kunstlerii	0.57	Goupia glabra	0.67, 0.72+	Homalium spp.	0.7
Dipterocarpus spp.	0.61	Guarea chalde	0.52	Hylodendron gabonense.	0.78”
Dipterocarpus warburgii	0.52	Guarea spp.	0.52	Hymenostegia pellegrini	0.78”
Dracontomelon spp.	0.5	Guatteria spp.	0.36	Irvingia grandifolia	0.78”
Dryobalanops spp.	0.61	Guazuma ulmifolia	0.52, 0.50+	Julbernardia globiflora	0.78
Dtypetes bordenii	0.75	Guettarda scabra	0.65	Khaya ivorensis	0.44
Durio spp.	0.53	Guillielma gasipae	0.95, 1.25+	Klainedoxa gabonensis	0.87
Dyera costulata	0.36	Gwtavia sp.	0.56	Lannea welwitschii	0.45”’
Dysoxylum quercifolium	0.49	Helicostylis tomentosa	0.68, 0.72+	Lecomtedoxa klainenna	0.78”
Elaeocarpus serratus	0.40*	Hernandia Sonora	0.29	Letestua durissima	0.87”
Emblica officinalis	0.8	Hevea brasiliense	0.49	Lophira alata	0.87”
Endiandra laxiflora	0.54	Himatanthus articulata	0.40,0.54+	Lovoa trichilioides	0.45”
Endospermum spp.	0.38	Hirtella davisii	0.74	Macaranga kilimandscharica	0.40*
Enterolobium cyclocarpum	0.35	Humiria balsamifera	0.66,0.67+	Maesopsis eminii	0.41
Epicharis cumingiana	0.73	Humiriastrum procera	0.7	Malacantha sp. aff. alnifolia	0.45”
Erythrina subumbrans	0.24	Hura crepitans	0.36, 0.37, 0.38+	Mammea africana	0.62
Erythrophloeum densiflorum	0.65	Hyeronima alchorneoides	0.60,0.64+	Manilkara lacera	0.78”
Eucalyptus citriodora	0.64	Hyeronima laxiflora	0.59	Markhamia platycalyx	0.45*
Eucalyptus deglupta	0.34	Hymenaea davisii	0.67	Memecylon capitellatum	0.77”
Eugenia spp.	0.65	Hymenolobium sp.	0.64	Microberlinia brazzavillensis	0.7
Fagraea spp.	0.73	Inga sp.	0.49,0.52,0.58, 0.64+	Microcos coriaceus	0.42”
Ficus benjamina	0.65	Iryanthera spp.	0.46	Milletia spp.	0.72
Ficus spp.	0.39	Jacaranda sp.	0.55	Mitragyna stipulosa	0.47
Ganua obovatifolia	0.59	Joannesia heveoides	0.39	Monopetalanthus pellegrinii	0.47”
Garcinia myrtifolia	0.65	Lachmellea speciosa	0.73	Musanga cecropioides	0.23
Garcinia spp.	0.75	Laetia procera	0.68	Nauclea diderrichii	0.63
Gardenia turgida	0.64	Lecythis spp.	0.77	Neopoutonia macrocalyx	0.32”
Garuga pinnata	0.51	Licania spp.	0.78	Nesogordonia papaverifera	0.65
Gluta spp.	0.63	Licaria spp.	0.82	Ochtocosmus africanus	0.78’
Gmelina arborea	0.41,0.45+	Lindackeria sp.	0.41	Odyendea spp.	0.32
Gmelina vitiensis	0.54	Linociera domingensis	0.81	Oldfieldia africana	0.78*
Gonocaryum calleryanum	0.64	Lonchocarpus spp.	0.69	Ongokea gore	0.72
Gonystylus punctatus	0.57	Loxopterygium sagotii	0.56	Oxystigma oxyphyllum	0.53
Grewia tiliaefolia	0.68	Lucuma spp.	0.79	Pachyelasma tessmannii	0.70”
Hardwickia binata	0.73	Luehea spp.	0.5	Pachypodanthium staudtii	0.58”
Harpullia arborea	0.62	Lueheopsis duckeana	0.64	Paraberlinia bifoliolata	0.56”
Heritiera spp.	0.56	Mabea piriri	0.59	Parinari glabra	0.87”
Hevea brasiliensis	0.53	Machaerium spp.	0.7	Parkia bicolor	0.36”
Hibiscus tiliaceus	0.57	Macoubea guianensis	0.40*	Pausinystalia brachythyrsa	0.56”
Homalanthus populneus	0.38	Magnolia spp.	0.52	Pausinystalia cf. talbotii	0.56”
Homalium spp.	0.76	Maguira sclerophylla	0.57	Pentaclethra macrophylla	0.78”
Hopea acuminata	0.62	Mammea americana	0.62	Pentadesma butyracea	0.78”
Hopea spp.	0.64	Mangifera indica	0.55	Phyllanthus discoideus	0.76”
Intsia palembanica	0.68	Manilkara sp.	0.89	Pierreodendron africanum	0.70;”
Kayea garciae	0.53	Marila sp.	0.63	Piptadeniastrum africanum	0.56

\+ The wood densities specified pertain to more than one bibliographic source.

* Wood density value is derived from the regression equation in Reyes *et al.* (1992).

Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED) BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES (To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)					
TROPICAL ASIA	**D**	**TROPICAL AMERICA**	**D**	**TROPICAL AFRICA**	**D**
Kingiodendron alternifolium	0.48	Marmaroxylon racemosum	0.78*	Plagiostyles africana	0.70”
Kleinhovia hospita	0.36	Matayba domingensis	0.7	Poga oleosa	0.36
Knema spp.	0.53	Matisia hirta	0.61	Polyalthia suaveolens	0.66”
Koompassia excelsa	0.63	Maytenus spp.	0.71	Premna angolensis	0.63”
Koordersiodendron pinnatum	0.65, 0.69+	Mezilaurus lindaviana	0.68	Pteleopsis hylodendron	0.63*
Kydia calycina	0.72	Michropholis spp.	0.61	Pterocarpus soyauxii	0.61
Lagerstroemia spp.	0.55	Minquartia guianensis	0.76,0.79+	Pterygota spp.	0.52
Lannea grandis	0.5	Mora sp.	0.71	Pycnanthus angolensis	0.4
Leucaena leucocephala	0.64	Mouriria sideroxylon	0.88	Randia cladantha	0.78*
Litchi chinensis ssp. philippinensis	0.88	Myrciaria floribunda	0.73	Rauwolfia macrophylla	0.47*
Lithocarpus soleriana	0.63	Myristica spp.	0.46	Ricinodendron heudelotii	0.2
Litsea spp.	0.4	Myroxylon balsamum	0.74, 0.76, 0.78+	Saccoglottis gabonensis	0.74”
Lophopetalum spp.	0.46	Nectandra spp.	0.52	Santiria trimera	0.53*
Macaranga denticulata	0.53	O c o t e a spp.	0.51	Sapium ellipticum	0.50*
Madhuca oblongifolia	0.53	Onychopetalum amazonicum	0.64	Schrebera arborea	0.63*
Mallotus philippensis	0.64	Ormosia spp.	0.59	Sclorodophloeus zenkeri	0.68*
Mangifera spp.	0.52	Ouratea sp.	0.66	Scottellia coriacea	0.56
Maniltoa minor	0.76	Pachira acuatica	0.43	Scyphocephalium ochocoa	0.48
Mastixia philippinensis	0.47	Paratecoma peroba	0.6	Scytopetalum tieghemii	0.56”
Melanorrhea spp.	0.63	Parinari spp.	0.68	Sindoropsis letestui	0.56*
Melia dubia	0.4	Parkia spp.	0.39	Staudtia stipitata	0.75
Melicope triphylla	0.37	Peltogyne spp.	0.79	Stemonocoleus micranthus	0.56”
Meliosma macrophylla	0.27	Pentaclethra macroloba	0.65,0.68+	Sterculia rhinopetala	0.64
Melochia umbellata	0.25	Peru glabrata	0.65	Strephonema pseudocola	0.56*
Me&a ferrea	0.83,0.85+	Peru schomburgkiana	0.59	Strombosiopsis tetrandra	0.63”
Metrosideros collina	0.70,0.76+	Persea spp.	0.40, 0.47,0.52+	Swartzia fistuloides	0.82
Michelia spp.	0.43	Petitia domingensis	0.66	Symphonia globulifera	0.58”
Microcos stylocarpa	0.4	Pinus caribaea	0.51	Syzygium cordatum	0.59*
Micromelum compressum	0.64	Pinus oocarpa	0.55	Terminalia superba	0.45
Milliusa velutina	0.63	Pinus patula	0.45	Tessmania africana	0.85”
Mimusops elengi	0.72*	Piptadenia sp.	0.58	Testulea gabonensis	0.6
Mitragyna parviflora	0.56	Piranhea longepedunculata	0.9	Tetraberlinia tubmaniana	0.60”
Myristica spp.	0.53	Piratinera guianensis	0.96	Tetrapleura tetraptera	0.50”
Neesia spp.	0.53	Pithecellobium guachapele (syn. Pseudosamea)	0.56	Tieghemella heckelii	0.55”
Neonauclea bernardoi	0.62	Platonia insignis	0.70’	Trema sp.	0.40*
Neotrewia cumingii	0.55	Platymiscium spp.	0.71, 0.84+	Trichilia prieureana	0.63”
Ochna foxworthyi	0.86	Podocarpus spp.	0.46	Trichoscypha arborea	0.59”
Ochroma pyramidale	0.3	Pourouma aff. melinonii	0.32	Triplochiton scleroxylon.	0.32
Octomeles sumatrana	0.27, 0.32+	Pouteria spp.	0.64, 0.67+	Uapaca spp.	0.6
Oroxylon indicum	0.32	Prioria copaifera	0.40,0.41+	Vepris undulata	0.70”
Ougenia dalbergiodes	0.7	Protium spp.	0.53,0.64+	Vitex doniana	0.4
Palaquium spp.	0.55	Pseudolmedia laevigata	0.64	Xylopia staudtii	0.36*
Pangium edule	0.5	Pterocarpus spp.	0.44		
Parashorea malaanonan	0.51	Pterogyne nitens	0.66		
Parashorea stellata	0.59	Qualea albiflora	0.5		
Paratrophis glabra	0.77	Qualea cf. lancifolia	0.58		
Parinari spp.	0.68	Qualea dinizii	0.58		

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Parkia roxburghii	0.34	Qualea spp.	0.55		
Payena spp.	0.55	Quararibaea guianensis	0.54		
Peltophorum pterocarpum	0.62	Quercus alata	0.71		
Pentace spp.	0.56	Quercus costaricensis	0.61		
Phaeanthus ebracteolatus	0.56	Quercus eugeniaefolia	0.67		
Phyllocladus hypophyllus	0.53	Quercus spp.	0.7		
Pinus caribaea	0.48	Raputia sp.	0.55		
Pinus insularis	0.47,0.48+	Rheedia spp.	0.72		
Pinus merkusii	0.54	Rollinia spp.	0.36		
Pisonia umbellifera	0.21	Saccoglottis cydonioides	0.72		
Pittosporum pentandrum	0.51	Sapium ssp.	0.47,0.72+		
Planchonia spp.	0.59	Schinopsis spp.	1		
Podocarpus spp.	0.43	Sclerobium spp.	0.47		
Polyalthia flava	0.51	Sickingia spp.	0.52		
Polyscias nodosa	0.38	Simaba multiflora	0.51		
Pometia spp.	0.54	Simarouba amara	0.32, 0.34,0.38+		
Pouteria villamilii	0.47	Sloanea guianensis	0.79		
Premna tomentosa	0.96	Spondias mombin	0.30, 0.40,0.41+		
Pterocarpus marsupium	0.67	Sterculia spp.	0.55		
Pterocymbium tinctorium	0.28	Stylogyne spp.	0.69		
Pyge'um vulgare	0.57	Swartzia spp.	0.95		
Quercus spp.	0.7	Swietenia macrophylla	0.42,0.45,0.46, 0.54+		
Radermachera pinnata	0.51	Symphonia globulifera	0.68		
Salmalia malabarica	0.32,0.33+	Tabebuia spp. (lapacho group)	0.91		
Samanea saman	0.45, 0.46+	Tabebuia spp. (roble)	0.52		
Sandoricum vidalii	0.43	Tabebuia spp. (white cedar)	0.57		
Sapindus saponaria	0.58	Tabebuia stenocalyx	0.55,0.57+		
Sapium luzontcum	0.4	Tachigalia myrmecophylla	0.56		
Schleichera oleosa	0.96	Talisia sp.	0.84		
Schrebera swietenoides	0.82	Tapirira guianensis	0.47*		
Semicarpus anacardium	0.64	Terminalia sp.	0.50, 0.51, 0.58+		
Serialbizia acle	0.57	Tetragastris altisima	0.61		
Serianthes melanesica	0.48	Toluifera balsamum	0.74		
Sesbania grandiflora	0.4	Torrubia sp.	0.52		
Shorea assamica forma philippinensis	0.41	Toulicia pulvinata	0.63		
Shorea astylosa	0.73	Tovomita guianensis	0.6		
Shorea ciliata	0.75	Trattinickia sp.	0.38		
Shorea contorta	0.44	Trichilia propingua	0.58		
Shorea gisok	0.76	Trichosperma mexicanum	0.41		
Shorea guiso	0.68	Triplaris spp.	0.56		
Shorea hopeifolia	0.44	Trophis sp.	0.54		
Shorea malibato	0.78	Vatairea spp.	0.6		
Shorea negrosensis	0.44	Virola spp.	0.40, 0.44, 0.48+		
Shorea palosapis	0.39	Vismia spp.	0.41		
Shorea plagata	0.7	Vitex spp.	0.52,0.56, 0.57+		

+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m³ fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Shorea polita	0.47	Vitex stahelii	0.6		
Shorea polysperma	0.47	Vochysia spp.	0.40,0.47, 0.79+		
Shorea robusta	0.72	Vouacapoua americana	0.79		
Shorea spp. balau group	0.7	Warszewicsia coccinea	0.56		
Shorea spp. dark red meranti	0.55	Xanthoxylum martinicensis	0.46		
Shorea spp. light red meranti	0.4	Xanthoxylum spp.	0.44		
Shorea spp. white meranti	0.48	Xylopia frutescens	0 64”		
Shorea spp. yellow meranti	0.46				
Shorea virescens	0.42				
Sloanea javanica	0.53				
Soymida febrifuga	0.97				
Spathodea campanulata	0.25				
Stemonurus luzoniensis	0.37				
Sterculia vitiensis	0.31				
Stereospermum suaveolens	0.62				
Strombosia philippinensis	0.71				
Strychnos potatorum	0.88				
Swietenia macrophylla	0.49,0.53+				
Swintonia foxworthyi	0.62				
Swintonia spp.	0.61				
Sycopsis dunni	0.63				
Syzygium spp.	0.69, 0.76+				
Tamarindus indica	0.75				
Tectona grandis	0.50,0.55+				
Teijsmanniodendron ahernianum	0.9				
Terminalia citrina	0.71				
Terminalia copelandii	0.46				
Terminalia foetidissima	0.55				
Terminalia microcarpa	0.53				
Terminalia nitens	0.58				
Terminalia pterocarpa	0.48				
Terminalia tomentosa	0.73,0.76, 0.77+				
Ternstroemia megacarpa	0.53				
Tetrameles nudiflora	0.3				
Tetramerista glabra	0.61				
Thespesia populnea	0.52				
Toona calantas	0.29				
Trema orientalis	0.31				

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Trichospermum richii	0.32				
Tristania spp.	0.80				
Turpinia ovalifolia	0.36				
Vateria indica	0.47*				
Vatica spp.	0.69				
Vitex spp.	0.65				
Wallaceodendron celebicum	0.55, 0.57+				
Weinmannia luzoniensis	0.49				
Wrightia tinctorea	0.75				
Xanthophyllum excelsum	0.63				
Xanthostemon verdugonianus	1.04				
Xylia xylocarpa	0.73,0.81+				
Zanthoxylum rhetsa	0.33				
Zizyphus spp.	0.76				

+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).

Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

TABLE 3A.1.10
DEFAULT VALUES OF BIOMASS EXPANSION FACTORS (BEFS)
(BEF_2 to be used in connection with growing stock biomass data in Equation 3.2.3;
and BEF_1 to be used in connection with increment data in Equation 3.2.5)

Climatic zone	Forest type	Minimum dbh (cm)	BEF_2 (overbark) to be used in connection to growing stock biomass data (Equation 3.2.3)	BEF_1 (overbark) to be used in connection to increment data (Equation 3.2.5)
Boreal	Conifers	0-8.0	1.35 (1.15-3.8)	1.15 (1-1.3)
	Broadleaf	0-8.0	1.3 (1.15-4.2)	1.1 (1-1.3)
Temperate	Conifers: Spruce-fir	0-12.5	1.3 (1.15-4.2)	1.15 (1-1.3)
	Pines	0-12.5	1.3 (1.15-3.4)	1.05 (1-1.2)
	Broadleaf	0-12.5	1.4 (1.15-3.2)	1.2 (1.1-1.3)
Tropical	Pines	10.0	1.3 (1.2-4.0)	1.2 (1.1-1.3)
	Broadleaf	10.0	3.4 (2.0-9.0)	1.5 (1.3-1.7)

Note: BEF_2s given here represent averages for average growing stock or age, the upper limit of the range represents young forests or forests with low growing stock; lower limits of the range approximate mature forests or those with high growing stock. The values apply to growing stock biomass (dry weight) including bark and for given minimum diameter at breast height; Minimum top diameters and treatment of branches is unspecified. Result is above-ground tree biomass.

Sources: Isaev *et al.*, 1993; Brown, 1997; Brown and Schroeder, 1999; Schoene, 1999; ECE/FAO TBFRA, 2000; Lowe *et al.*, 2000; please also refer to FRA Working Paper 68 and 69 for average values for developing countries (http://www.fao.org/forestry/index.jsp)

TABLE 3A.1.11
DEFAULT VALUES FOR FRACTION OUT OF TOTAL HARVEST LEFT TO DECAY IN THE FOREST, f_{BL}
(To be used only for f_{BL} in Equation 3.2.7)

Region	f_{BL}
Boreal intensively managed	0.07
Temperate intensively managed	0.1
Temperate semi natural forests	0.15
Tropical plantation	0.25
Tropical selective logging in primary forests	0.4

TABLE 3A.1.12
COMBUSTION FACTOR VALUES (PROPORTION OF PREFIRE BIOMASS CONSUMED) FOR FIRES IN A RANGE OF VEGETATION TYPES.
(Values in column 'mean' are to be used for (1-f_{BL}) in Equation 3.2.9 and for $\rho_{burned\ on\ site}$ in Equation 3.3.10)

Vegetation Type	Sub-category	Mean	SD	No. m[1]	Range	No. r[2]	References
Primary Tropical Forest (slash and burn)	Primary tropical forest	0.32	0.12	14	0.20 – 0.62	17	7, 8, 15, 56, 66, 3, 16, 53, 17, 45,
	Primary open tropical forest	0.45	0.09	3	0.36 – 0.54	3	21
	Primary tropical moist forest	0.50	0.03	2	0.39 – 0.54	2	37, 73
	Primary tropical dry forest	-	-	0	0.78 – 0.95	1	66
All primary tropical forests		**0.36**	**0.13**	**19**	**0.19 – 0.95**	**23**	
Secondary tropical forest (slash and burn)	Young secondary tropical forest (3-5 yrs)	0.46	-	1	0.43 – 0.52	1	61
	Intermediate secondary tropical forest (6-10 yrs)	0.67	0.21	2	0.46 – 0.90	2	61, 35
	Advanced secondary tropical forest (14-17 yrs)	0.50	0.10	2	0.36 – 0.79	2	61, 73
All secondary tropical forests		**0.55**	**0.06**	**8**	**0.36 – 0.90**	**9**	56, 66, 34, 30
All Tertiary tropical forest		**0.59**	**-**	**1**	**0.47 – 0.88**	**2**	66, 30
Boreal Forest	Wildfire (general)	0.40	0.06	2	0.36 – 0.45	2	33
	Crown fire	0.43	0..21	3	0.18 – 0.76	6	66, 41, 64, 63
	surface fire	0.15	0.08	3	0.05 – 0.73	3	64, 63
	Post logging slash burn	0.33	0.13	4	0.20 – 0.58	4	49, 40, 18
	Land clearing fire	0.59	-	1	0.50 – 0.70	1	67
All Boreal Forest		**0.34**	**0.17**	**15**	**0.05 – 0.76**	**16**	45, 47
Eucalyptus forests	Wildfire	-	-	0	-	0	
	Prescribed fire – (surface)	0.61	0.11	6	0.50 – 0.77*	6	72, 54, 60, 9
	Post logging slash burn	0.68	0.14	5	0.49 – 0.82	5	25, 58, 46
	Felled and burned (land-clearing fire)	0.49	-	1	-	1	62
All Eucalyptus Forests		**0.63**	**0.13**	**12**	**0.49 – 0.82**	**12**	
Other temperate forests	Post logging slash burn	0.62	0.12	7	0.48 – 0.84	7	55, 19, 27, 14
	Felled and burned (land-clearing fire)	0.51	-	1	0.16 – 0.58	3	53, 24, 71
All "other" temperate forests		**0.45**	**0.16**	**19**	**0.16 – 0.84**	**17**	53, 56
Shrublands	Shrubland (general)	0.95	-	1	-	1	44
	Calluna heath	0.71	0.30	4	0.27 – 0.98	4	26, 56, 39
	Fynbos	0.61	0.16	2	0.50 – 0.87	2	70, 44
All Shrublands		**0.72**	**0.25**	**7**	**0.27 – 0.98**	**7**	
Savanna Woodlands (early dry season burns)*	Savanna woodland[@]	0.22	-	1	0.01 – 0.47	1	28
	Savanna parkland	0.73	-	1	0.44 – 0.87	1	57
	Other savanna woodlands	0.37	0.19	4	0.14 – 0.63	4	22, 29
All savanna woodlands (early dry season burns)		**0.40**	**0.22**	**6**	**0.01 – 0.87**	**6**	
Savanna Woodlands (mid/late dry season burns)*	Savanna woodland [@]	0.72	-	1	0.71 – 0.88	2	66, 57
	Savanna parkland	0.82	0.07	6	0.49 – 0.96	6	57, 6, 51
	Tropical savanna[#]	0.73	0.04	3	0.63 – 0.94	5	52, 73, 66, 12
	Other savanna woodlands	0.68	0.19	7	0.38 – 0.96	7	22, 29, 44, 31, 57
All savanna woodlands (mid/late dry season burns)*		**0.74**	**0.14**	**17**	**0.29 – 0.96**	**20**	

[1] No. m = the number of observations for the mean
[2] No. r = the number of observations for the range
* Surface layer combustion only, [#] campo cerrado, cerrado sensu stricto, [$] campo sujo, campo limpo, dambo, [@] miombo
[~] derived from slashed tropical forest (includes unburned woody material)

TABLE 3A.1.12 (CONTINUED)
COMBUSTION FACTOR VALUES (PROPORTION OF PREFIRE BIOMASS CONSUMED) FOR FIRES IN A RANGE OF VEGETATION TYPES.
(Values in column 'mean' are to be used for (1-f_{BL}) in Equation 3.2.9 and for $\rho_{burned\ on\ site}$ in Equation 3.3.10)

Vegetation Type	Sub-category	Mean	SD	No.m[1]	Range	No.r[2]	References
Savanna Grasslands / Pastures (early dry season burns)*	Tropical/sub-tropical grassland[$]	0.74	-	1	0.44 – 0.98	1	28
	Grassland	-	-	0	0.18 – 0.78	1	48
All savanna grasslands (early dry season burns)*		**0.74**	**-**	**1**	**0.18 – 0.98**	**2**	
Savanna Grasslands / Pastures (mid/late dry season burns)*	Tropical/sub-tropical grassland[$]	0.92	0.11	7	0.71 – 1.00	8	44, 73, 66, 12, 57
	Tropical pasture[~]	0.35	0.21	6	0.19 – 0.81	7	4, 23, 38, 66
	Savanna	0.86	0.12	16	0.44 – 1.00	23	53, 5, 56, 42, 50, 6, 45, 13, 44, 65, 66
All savanna grasslands (mid/late dry season burns)*		**0.77**	**0.26**	**29**	**0.19 – 1.00**	**38**	
Other Vegetation Types	Peatland	0.50	-	1	0.50 – 0.68	2	20, 44
	Tropical Wetlands	0.70	-	1	-	1	44

[1] No. m = the number of observations for the mean
[2] No. r = the number of observations for the range
* Surface layer combustion only, [#] campo cerrado, cerrado sensu stricto, [$] campo sujo, campo limpo, dambo, [@] miombo
[~] derived from slashed tropical forest (includes unburned woody material)

TABLE 3A.1.13
BIOMASS CONSUMPTION (t/ha) VALUES FOR FIRES IN A RANGE OF VEGETATION TYPES
(To be used in Equation 3.2.9. for the part of the equation: '$B_W \bullet (1- f_{BL})$' , i.e., an absolute amount)

Vegetation Type	Sub-category	Mean	SE	No. m[1]	Range	No. r[2]	References
Primary Tropical Forest (slash and burn)	Primary tropical forest	83.9	25.8	6	10 – 228	9	7, 15, 66, 3, 16, 17, 45
	Primary open tropical forest	163.6	52.1	3	109.9 – 214	3	21,
	Primary tropical moist forest	160.4	11.8	2	115.7 – 216.6	2	37, 73
	Primary tropical dry forest	-	-	0	57 – 70	1	66
All primary tropical forests		**119.6**	**50.7**	**11**	**10 – 228**	**15**	
Secondary tropical forest (slash and burn)	Young secondary tropical forest (3-5 yrs)	8.1	-	1	7.2 – 9.4	1	61
	Intermediate secondary tropical forest (6-10 yrs)	41.1	27.4	2	18.8 – 66	2	61, 35
	Advanced secondary tropical forest (14-17 yrs)	46.4	8.0	2	29.1 – 63.2	2	61, 73
All secondary tropical forests		**42.2**	**23.6**	**5**	**7.2 – 93.6**	**5**	66, 30
All Tertiary tropical forest		**54.1**	**-**	**1**	**4.5 – 53**	**2**	66, 30
Boreal Forest	Wildfire (general)	52.8	48.4	6	18 – 149	6	2, 33, 66
	Crown fire	25.1	7.9	10	15 – 43	10	11, 43, 66, 41, 63, 64
	Surface fire	21.6	25.1	12	1.0 – 148	13	43, 69, 66, 63, 64, 1
	Post logging slash burn	69.6	44.8	7	7 – 202	9	49, 40, 66, 18
	Land clearing fire	87.5	35.0	3	48 – 136	3	10, 67
All Boreal Forest		**41.0**	**36.5**	**44**	**1.0 – 202**	**49**	43, 45, 69, 47
Eucalypt forests	Wildfire	53.0	53.6	8	20 – 179	8	66, 32, 9
	Prescribed fire – (surface)	16.0	13.7	8	4.2 – 17	8	66, 72, 54, 60, 9
	Post logging slash burn	168.4	168.8	5	34 – 453	5	25, 58, 46
	Felled and burned (land-clearing fire)	132.6	-	1	50 – 133	2	62, 9
All Eucalypt Forests		**69.4**	**100.8**	**22**	**4.2 – 453**	**23**	

TABLE 3A.1.13 (CONTINUED)
BIOMASS CONSUMPTION (t/ha) VALUES FOR FIRES IN A RANGE OF VEGETATION TYPES
(To be used in Equation 3.2.9. for the part of the equation: '$B_W \bullet (1- f_{BL})$' , i.e., an absolute amount)

Vegetation Type	Sub-category	Mean	SE	No. m[1]	Range	No. r[2]	References
Other temperate forests	Wildfire	19.8	6.3	4	11 - 25	4	32, 66
	Post logging slash burn	77.5	65.0	7	15 – 220	8	55, 19, 14, 27, 66
	Felled and burned (land-clearing fire)	48.4	62.7	2	3 – 130	3	53, 24, 71
All "other" temperate forests		**50.4**	**53.7**	**15**	**3 – 220**	**18**	43, 56
Shrublands	Shrubland (general)	26.7	4.2	3	22 – 30	3	43
	Calluna heath	11.5	4.3	3	6.5 – 21	3	26, 39
	Sagebrush	5.7	3.8	3	1.1 – 18	4	66
	Fynbos	12.9	0.1	2	5.9 – 23	2	70, 66
All Shrublands		**14.3**	**9.0**	**11**	**1.1 – 30**	**12**	
Savanna Woodlands (early dry season burns)*	Savanna woodland[@]	2.5	-	1	0.1 – 5.3	1	28
	Savanna parkland	2.7	-	1	1.4 – 3.9	1	57
All savanna woodlands (early dry season burns)		**2.6**	**0.1**	**2**	**0.07 – 3.9**	**2**	
Savanna Woodlands (mid/late dry season burns)*	Savanna woodland [@]	3.3	-	1	3.2 – 3.3	1	57
	Savanna parkland	4.0	1.1	6	1 – 10.6	6	57, 6, 51
	Tropical savanna[#]	6	1.8	2	3.7 – 8.4	2	52, 73
	Other savanna woodlands	5.3	1.7	3	3.7 – 7.6	3	59, 57, 31
All savanna woodlands (mid/late dry season burns)*		**4.6**	**1.5**	**12**	**1.0 – 10.6**	**12**	
Savanna Grasslands / Pastures (early dry season burns)*	Tropical/sub-tropical grassland[$]	2.1	-	1	1.4 – 3.1	1	28
	Grassland	-	-	-	1.2 – 11	1	48
All savanna grasslands (early dry season burns)*		**2.1**	**-**	**1**	**1.2 – 11**	**2**	
Savanna Grasslands / Pastures (mid/late dry season burns)*	Tropical/sub-tropical grassland[$]	5.2	1.7	6	2.5 – 7.1	6	9, 73, 12, 57
	Grassland	4.1	3.1	6	1.5 – 10	6	43, 9
	Tropical pasture[~]	23.7	11.8	6	4.7 – 45	7	4, 23, 38, 66
	Savanna	7.0	2.7	6	0.5 – 18	10	42, 50, 6, 45, 13, 65
All savanna grasslands (mid/late dry season burns)*		10.0	10.1	24	0.5 – 45	29	
Other Vegetation Types	Peatland	41	1.4	2	40 – 42	2	68, 33
	Tundra	10	-	1	-	-	33

[1] No. m = the number of observations for the mean

[2] No. r = the number of observations for the range

* Surface layer combustion only, [#] campo cerrado, cerrado sensu stricto, [$] campo sujo, campo limpo, dambo,
[@] miombo[~] derived from slashed tropical forest (includes unburned woody material)

References to Tables 3A.1.12 and 3A.1.13

1. Alexander, M., *Calculating and interpreting forest fire intensities.* CANADIAN JOURNAL OF BOTANY, 1978. **60**: p. 349-357.

2. Amiro, B., J. Todd, and B. Wotton, *Direct carbon emissions from Canadian forest fires, 1959-1999.* CANADIAN JOURNAL OF FOREST RESEARCH, 2001. **31**: p. 512-525.

3. Araújo, T., J. Carvalho, N. Higuchi, A. Brasil, and A. Mesquita, *A tropical rainforest clearing experiment by biomass burning in the state of Pará, Brazil.* ATMOSPHERIC ENVIRONMENT, 1999. **33**: p. 1991-1998.

4. Barbosa, R. and P. Fearnside, *Pasture burning in Amazonia: Dynamics of residual biomass and the storage and release of aboveground carbon.* JOURNAL OF GEOPHYSICAL RESEARCH, 1996. **101**(D20): p. 25847-25857.

5. Bilbao, B. and E. Medina, *Types of grassland fires and nitrogen volatilization in tropical savannas of calabozo*, in *Biomass Burning and Global Change: Volume 2. Biomass burning in South America, Southeast Asia, and temperate and boreal ecosystems, and the oil fires of Kuwait*, J. Levine, Editor. 1996, MIT Press: Cambridge. p. 569-574.

6. Cachier, H., C. Liousse, M. Pertusiot, A. Gaudichet, F. Echalar, and J. Lacaux, *African fire Particulate emissions and atmospheric influence*, in *Biomass Burning and Global Change: Volume 1. Remote Sensing, Modeling and Inventory Development, and Biomass Burning in Africa*, J. Levine, Editor. 1996, MIT Press: Cambridge. p. 428-440.

7. Carvalho, J., N. Higuchi, T. Araujo, and J. Santos, *Combustion completeness in a rainforest clearing experiment in Manaus, Brazil.* JOURNAL OF GEOPHYSICAL RESEARCH, 1998. **103**(D11): p. 13195.

8. Carvalho, J., F. Costa, C. Veras*, et al.*, *Biomass fire consumption and carbon release rates of rainforest-clearing experiments conducted in northern Mato Grosso, Brazil.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 2001. **106**(D16): p. 17877-17887.

9. Cheyney, N., R. Raison, and P. Khana, *Release of carbon to the atmosphere in Australian vegetation fires*, in *Carbon Dioxide and Climate: Australian Research*, G. Pearman, Editor. 1980, Australian Academy of Science: Canberra. p. 153-158.

10. Cofer, W., J. Levine, E. Winstead, and B. Stocks, *Gaseous emissions from Canadian boreal forest fires.* ATMOSPHERIC ENVIRONMENT, 1990. **24A**(7): p. 1653-1659.

11. Cofer, W., E. Winstead, B. Stocks, J. Goldammer, and D. Cahoon, *Crown fire emissions of CO_2, CO, H_2, CH_4, and TNMHC from a dense jack pine boreal forest fire.* GEOPHYSICAL RESEARCH LETTERS, 1998. **25**(21): p. 3919-3922.

12. De Castro, E.A. and J.B. Kauffman, *Ecosystem structure in the Brazilian Cerrado: a vegetation gradient of aboveground biomass, root mass and consumption by fire.* Journal of Tropical Ecology, 1998. **14**(3): p. 263-283.

13. Delmas, R., *On the emission of carbon, nitrogen and sulfur in the atmosphere during bushfires in intertropical savannah zones.* GEOPHYSICAL RESEARCH LETTERS, 1982. **9**(7): p. 761-764.

14. Einfeld, W., D. Ward, and C. Hardy, *Effects of fire behaviour on prescribed fire smoke characteristics: A case study*, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, J. Levine, Editor. 1991, MIT Press: Massechusetts. p. 412-419.

15. Fearnside, P., N. Filho, and F. Fernandes, *Rainforest burning and the global carbon budget: biomass, combustion efficiency and charcoal formation in the Brazilian Amazon.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 1993. **98**(D9): p. 16733-16743.

16. Fearnside, P., P. Graca, N. Filho, J. Rodrigues, and J. Robinson, *Tropical forest burning in Brazilian Amazonia: measurement of biomass loading, burning efficiency and charcoal formation at Altamira, Para.* FOREST ECOLOGY AND MANAGEMENT, 1999. **123**: p. 65-79.

17. Fearnside, P., P. Graca, and J. Rodrigues, *Burning of Amazonian rainforests: burning efficiency and charcoal formation in forest cleared for cattle pasture near Manaus, Brazil.* FOREST ECOLOGY AND MANAGEMENT, 2001. **146**: p. 115-128.

18. Feller, M. *The influence of fire severity, not fire intensity, on understory vegetation biomass in British Columbia*. in *13th Fire and Forest Meteorology Conference*. 1998. Lorne, Australia: IAWF.

19. Flinn, D., P. Hopmans, P. Farell, and J. James, *Nutrient loss from the burning of Pinus radiata logging residue.* AUSTRALIAN FOREST RESEARCH, 1979. **9**: p. 17-23.

20. Garnett, M., P. Ineson, and A. Stevenson, *Effects of burning and grazing on carbon sequestration in a Pennine blanket bog, UK.* HOLOCENE, 2000. **10**(6): p. 729-736.

21. Graca, P., P. Fearnside, and C. Cerri, *Burning of Amazonian forest in Ariquemes, Rondonia, Brazil: biomass, charcoal formation and burning efficiency.* FOREST ECOLOGY AND MANAGEMENT, 1999. **120**: p. 179-191.

22. Griffin, G. and M. Friedel, *Effects of fire on central Australian rangelands. I Fire and fuel characteristics and changes in herbage and nutrients.* AUSTRALIAN JOURNAL OF ECOLOGY, 1984. **9**: p. 381-393.

23. Guild, L., J. Kauffman, L. Ellingson, and D. Cummings, *Dynamics associated with total aboveground biomass, C, nutrient pools, and biomass burning of primary forest and pasture in Rondonia, Brazil during SCAR-B.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 1998. **103**(D24): p. 32091-32100.

24. Gupta, P., V. Prasad, C. Sharma, A. Sarkar, Y. Kant, K. Badarinath, and A. Mitra, *CH4 emissions from biomass burning of shifting cultivation areas of tropical deciduous forests - experimental results from ground - based measurements.* CHEMOSPHERE - GLOBAL CHANGE SCIENCE, 2001. **3**: p. 133-143.

25. Harwood, C. and W. Jackson, *Atmospheric losses of four plant nutrients during a forest fire.* AUSTRALIAN FORESTRY, 1975. **38**(2): p. 92-99.

26. Hobbs, P. and C. Gimingham, *Studies on fire in Scottish heathland communities.* JOURNAL OF ECOLOGY, 1984. **72**: p. 223-240.

27. Hobbs, P., J. Reid, J. Herring*, et al.*, *Particle and trace-gas measurements from prescribed burns of forest products in the Pacific Northwest*, in *Biomass Burning and Global Change: Volume 2. Biomass burning in South America, Southeast Asia, and temperate and boreal ecosystems, and the oil fires of Kuwait*, J. Levine, Editor. 1996, MIT Press: Cambridge. p. 697-715.

28. Hoffa, E., D. Ward, W. Hao, R. Susott, and R. Wakimoto, *Seasonality of carbon emissions from biomass burning in a Zambian savanna.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 1999. **104**(D11): p. 13841-13853.

29. Hopkins, B., *Observations on savanna burning in the Olokemeji forest reserve, Nigeria.* JOURNAL OF APPLIED ECOLOGY, 1965. **2**(2): p. 367-381.

30. Hughes, R., J. Kauffman, and D. Cummings, *Fire in the Brazilian Amazon 3. Dynamics of biomass, C, and nutrient pools in regenerating forests.* OECOLOGIA, 2000. **124**(4): p. 574-588.

31. Hurst, D., W. Griffith, and G. Cook, *Trace gas emissions from biomass burning in tropical Australian savannas.* JOURNAL OF GEOPHYSICAL RESEARCH, 1994. **99**(D8): p. 16441-16456.

32. Jackson, W., *Nutrient stocks in Tasmanian vegetation and approximate losses due to fire.* Papers and proceedings of the Royal Society of Tasmania, 2000. **134**: p. 1-18.

33. Kasischke, E., N. French, L. Bourgeau-Chavez, and N. Christensen, *Estimating release of carbon from 1990 and 1991 forest fires in Alaska.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 1995. **100**(D2): p. 2941-2951.

34. Kauffman, J. and C. Uhl, *8 interactions of anthropogenic activities, fire, and rain forests in the Amazon Basin*, in *Fire in the Tropical Biota: Ecosystem Processes and Global Changes*, J. Goldammer, Editor. 1990, Springer-Verlag: Berlin. p. 117-134.

35. Kauffman, J., R. Sanford, D. Cummings, I. Salcedo, and E. Sampaio, *Biomass and nutrient dynamics associated with slash fires in neotropical dry forests.* ECOLOGY, 1993. **74**(1): p. 140-151.

36. Kauffman, J., D. Cummings, and D. Ward, *Relationships of fire, biomass and nutrient dynamics along a vegetation gradient in the Brazilian cerrado.* JOURNAL OF ECOLOGY, 1994. **82**: p. 519-531.

37. Kauffman, J., D. Cummings, D. Ward, and R. Babbitt, *Fire in the Brazilian Amazon: 1. Biomass, nutrient pools, and losses in slashed primary forests.* OECOLOGIA, 1995. **104**: p. 397-408.

38. Kauffman, J., D. Cummings, and D. Ward, *Fire in the Brazilian Amazon: 2. Biomass, nutrient pools and losses in cattle pastures.* OECOLOGIA, 1998. **113**: p. 415-427.

39. Kayll, A., *Some characteristics of heath fires in north-east Scotland.* JOURNAL OF APPLIED ECOLOGY, 1966. **3**(1): p. 29-40.

40. Kiil, A., *Fuel consumption by a prescribed burn in spruce-fir logging slash in Alberta.* THE FORESTRY CHRONICLE, 1969: p. 100-102.

41. Kiil, A., *Fire spread in a black spruce stand.* CANADIAN FORESTRY SERVICE BI-MONTHLY RESEARCH NOTES, 1975. **31**(1): p. 2-3.

42. Lacaux, J., H. Cachier, and R. Delmas, *Biomass burning in Africa: an overview of its impact on atmospheric chemistry*, in *Fire in the Environment: The Ecological, Atmospheric, and Climatic Importance of Vegetation Fires*, P. Crutzen and J. Goldammer, Editors. 1993, John Wiley & Sons: Chichester. p. 159-191.

43. Lavoue, D., C. Liousse, H. Cachier, B. Stocks, and J. Goldammer, *Modeling of carbonaceous particles emitted by boreal and temperate wildfires at northern latitudes.* JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES, 2000. **105**(D22): p. 26871-26890.

44. Levine, J., *Global biomass burning: a case study of the gaseous and particulate emissions released to the atmosphere during the 1997 fires in Kalimantan and Sumatra, Indonesia*, in *Biomass Burning and its Inter-relationships with the Climate System*, J. Innes, M. Beniston, and M. Verstraete, Editors. 2000, Kluwer Academic Publishers: Dordrecht. p. 15-31.

45. Levine, J. and W. Cofer, *Boreal forest fire emissions and the chemistry of the atmosphere*, in *Fire, Climate Change and Carbon Cycling in the Boreal Forest*, E. Kasischke and B. Stocks, Editors. 2000, Springer-Verlag: New York. p. 31-48.

46. Marsdon-Smedley, J. and A. Slijepcevic, *Fuel characteristics and low intensity burning inEucalyptus obliqua wet forest at the Warra LTER site.* TASFORESTS, 2001. **13**(2): p. 261-279.

47. Mazurek, M., W. Cofer, and J. Levine, *Carbonaceous aerosols from prescribed burning of a boreal forest ecosystem*, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, J. Levine, Editor. 1991, MIT Press: Massechusetts. p. 258-263.

48. McNaughton, S., N. Stronach, and N. Georgiadis, *Combustion in natural fires and global emissions budgets.* ECOLOGICAL APPLICATIONS, 1998. **8**(2): p. 464-468.

49. McRae, D. and B. Stocks. *Large-scale convection burning in Ontario*. in *Ninth Conference on Fire and Forest Metearology*. 1987. San Diego, California: American Meterological Society.

50. Moula, M., J. Brustet, H. Eva, J. Lacaux, J. Gregoire, and J. Fontan, *Contribution of the Spread-Fire Model in the study of savanna fires*, in *Biomass Burning and Global Change: Volume 1. Remote Sensing, Modeling and Inventory Development, and Biomass Burning in Africa*, J. Levine, Editor. 1996, MIT Press: Cambridge. p. 270-277.

51. Neil, R., N. Stronach, and S. McNaughton, *Grassland fire dynamics in the Serengeti ecosystem, and a potential method of retrospectively estimating fire energy.* JOURNAL OF APPLIED ECOLOGY, 1989. **26**: p. 1025-1033.

52. Pivello, V. and L. Coutinho, *Transfer of macro-nutrients to the atmosphere during experimental burnings in an open cerrado (Brazilian savanna).* JOURNAL OF TROPICAL ECOLOGY, 1992. **8**: p. 487-497.

53. Prasad, V., Y. Kant, P. Gupta, C. Sharma, A. Mitra, and K. Badarinath, *Biomass and combustion characteristics of secondary mixed deciduous forests in Eastern Ghats of India.* ATMOSPHERIC ENVIRONMENT, 2001. **35**(18): p. 3085-3095.

54. Raison, R., P. Khana, and P. Woods, *Transfer of elements to the atmosphere during low intensity prescribed fires in three Australian subalpine eucalypt forests.* CANADIAN JOURNAL OF FOREST RESEARCH, 1985. **15**: p. 657-664.

55. Robertson, K., *Loss of organic matter and carbon during slash burns in New Zealand exotic forests.* NEW ZEALAND JOURNAL OF FORESTRY SCIENCE, 1998. **28**(2): p. 221-241.

56. Robinson, J., *On uncertainty in the computation of global emissions from biomass burning.* CLIMATIC CHANGE, 1989. **14**: p. 243-262.

57. Shea, R., B. Shea, J. Kauffman, D. Ward, C. Haskins, and M. Scholes, *Fuel biomass and combustion factors associated with fires in savanna ecosystems of South Africa and Zambia.* JOURNAL OF GEOPHYSICAL RESEARCH, 1996. **101**(D19): p. 23551-23568.

58. Slijepcevic, A., *Loss of carbon during controlled regeneration burns in Eucalyptus obliqua forest.* TASFORESTS, 2001. **13**(2): p. 281-289.

59. Smith, D. and T. James, *Characteristics of prescribed burns andresultant short-term environmental changes in Populus tremuloides woodland in southern Ontario.* CANADIAN JOURNAL OF BOTANY, 1978. **56**: p. 1782-1791.

60. Soares, R. and G. Ribeiro. *Fire behaviour and tree stumps sprouting in Eucalyptus prescribed burnings in southern Brazil*. in *III International Conference on Forest Fire Research / 14th Conference on Fire and Forest Meteorology*. 1998. Luso.

61. Sorrensen, C., *Linking smallholder land use and fire activity: examining biomass burning in the Brazilian Lower Amazon.* FOREST ECOLOGY AND MANAGEMENT, 2000. **128**(1-2): p. 11-25.

62. Stewart, H. and D. Flinn, *Nutrient losses from broadcast burning of Eucalyptus debris in north-east Victoria.* AUSTRALIAN FOREST RESEARCH, 1985. **15**: p. 321-332.

63. Stocks, B., *Fire behaviour in immature jack pine.* CANADIAN JOURNAL OF FOREST RESEARCH, 1987. **17**: p. 80-86.

64. Stocks, B., *Fire behaviour in mature jack pine.* CANADIAN JOURNAL OF FOREST RESEARCH, 1989. **19**: p. 783-790.

65. Stocks, B., B. van Wilgen, W. Trollope, D. McRae, J. Mason, F. Weirich, and A. Potgieter, *Fuels and fire behaviour dynamics on large-scale savanna fires in Kruger National Park, South Africa.* JOURNAL OF GEOPHYSICAL RESEARCH, 1996. **101**(D19): p. 23541-23550.

66. Stocks, B. and J. Kauffman, *Biomass consumption and behaviour of wildland fires in boreal, temperate, and tropical ecosystems: parameters necessary to interpret historic fire regimes and future fire scenarios*, in *Sediment Records of Biomass Burning and Global Change*, J. Clark, *et al*., Editors. 1997, Springer-Verlag: Berlin. p. 169-188.

67. Susott, R., D. Ward, R. Babbitt, and D. Latham, *The measurement of trace emissions and combustion characteristics for a mass fire*, in *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*, J. Levine, Editor. 1991, MIT Press: Massechusetts. p. 245-257.

68. Turetsky, M. and R. Wieder, *A direct approach to quantifying organic matter lost as a result of peatland wildfire.* CANADIAN JOURNAL OF FOREST RESEARCH, 2001. **31**(2): p. 363-366.

69. Van Wagner, C., *Duff consumption by fire in eastern pine stands.* CANADIAN JOURNAL OF FOREST RESEARCH, 1972. **2**: p. 34-39.

70. van Wilgen, B., D. Le Maitre, and F. Kruger, *Fire behaviour in South African fynbos (macchia) vegetation and predictions from Rothermel's fire model.* JOURNAL OF APPLIED ECOLOGY, 1985. **22**: p. 207-216.

71. Vose, J. and W. Swank, *Site preparation burning to improve southern Appalachian pine-hardwood stands: aboveground biomass, forest floor mass, and nitrogen and carbon pools.* CANADIAN JOURNAL OF FOREST RESEARCH, 1993. **23**: p. 2255-2262.

72. Walker, J., *Fuel dynamics in Australian vegetation*, in *Fire and the Australian Biota*, A. Gill, R. Groves, and I. Noble, Editors. 1981, Australian Academy of Science: Canberra. p. 101-127.

73. Ward, D., R. Susott, J. Kauffman*, et al.*, *Smoke and fire characteristics for Cerrado and deforestation burns in Brazil: BASE-B Experiment.* JOURNAL OF GEOPHYSICAL RESEARCH, 1992. **97**(D13): p. 14601-14619.

TABLE 3A.1.14

COMBUSTION EFFICIENCY (PROPORTION OF AVAILABLE FUEL ACTUALLY BURNT) RELEVANT TO LAND-CLEARING BURNS, AND BURNS IN HEAVY LOGGING SLASH FOR A RANGE OF VEGETATION TYPES AND BURNING CONDITIONS

(To be used in sections 'forest lands converted to cropland', 'converted to grassland', or 'converted to settlements or other lands')

Forest Types	**Burn type and drying time (Months)**					
	Broadcast		**Windrow**		**Windrow+Stoking**	
	<6	>6	<6	>6	<6	>6
Tropical moist						
- primary [a]	0.15-0.3	~0.30				
- secondary [b]		0.40				
Tropical dry						
- Mixed species [c]		>0.9				
- Acacia [d]			-	0.8	-	~0.95
Temperate Eucalyptus [e]	0.3	0.5-0.6				
Boreal forest [f]	0.25					

Note: The combustion efficiency or fraction of biomass combusted, is a critical number in the calculation of emissions, that is highly variable depending on fuel arrangement (e.g. broadcast v heaped), vegetation type affecting the (size of fuel components and flammability) and burning conditions (especially fuel moisture).

Sources: [a]Fearnside (1990), Wei Min Hao *et. al* (1990); [b]Wei Min Hao *et. al* (1990); [c]Kauffmann and Uhl; *et. al* (1990); [d]Williams *et. al* (1970), Cheney (pers. comm. 2002); [e] McArthur (1969), Harwood & Jackson (1975), Slijepcevic (2001), Stewart & Flinn (1985); and [f]French *et. al* (2000)

TABLE 3A.1.15
EMISSION RATIOS FOR OPEN BURNING OF CLEARED FORESTS
(To be applied to Equation 3.2.19)

Compound	Emission Ratios
CH_4	0.012 (0.009-0.015)[a]
CO	0.06 (0.04-0.08)[b]
N_2O	0.007 (0.005-0.009)[c]
NO_x	0.121 (0.094-0.148)[c]

Source: [a]Delmas, 1993, [b]Lacaux *et al.*, 1993, and Crutzen and Andreae, 1990. Note: Ratios for carbon compounds, i.e. CH_4 and CO, are mass of carbon compound released (in units of C) relative to mass of total carbon released from burning. Those for the nitrogen compounds are expressed as the ratios of emission (in units of N) relative to total nitrogen released from the fuel.

TABLE 3A.1.16
EMISSION FACTORS (G/KG DRY MATTER COMBUSTED)
APPLICABLE TO FUELS COMBUSTED IN VARIOUS TYPES OF VEGETATION FIRES
(To be used in connection with Equation 3.2.20)

	CO_2	CO	CH_4	NO_x	N_2O*	NMHC [2]	Source
Moist/infertile broad-leaved savanna	1 523	92	3	6	0.11	-	Scholes (1995)
Arid fertile fine-leaved savanna	1 524	73	2	5	0.11	-	Scholes (1995)
Moist- infertile grassland	1 498	59	2	4	0.10	-	Scholes (1995)
Arid-fertile grassland	1 540	97	3	7	0.11	-	Scholes (1995)
Wetland	1 554	58	2	4	0.11	-	Scholes (1995)
All vegetation types [1]	1 403 -1 503	67-120	4-7	0.5-0.8	0.10	-	IPCC (1994)
Forest fires	1 531	112	7.1	0.6-0.8	0.11	8-12	Kaufman *et al.* (1992)
Savanna fires	1 612	152	10.8	-	0.11	-	Ward *et al.* (1992)
Forest fires	1 580	130	9	0.7	0.11	10	Delmas *et al.* (1995)
Savanna fires	1 640	65	2.4	3.1	0.15	3.1	Delmas *et al.* (1995)

[1] Assuming 41-45% C content, 85-100% combustion completeness.
[2] NMHC non methane hydrocarbons.
* Calculated from data of Crutzen and Andreae (1990) assuming an N/C ratio of 0.01, except for savanna fires.