Carbon Assessment Lab Guide – 500-Year Forest Foundation, Randolph College

This is a guide to completing the post-sampling procedures of estimating carbon storage in inventoried forests. Modified from Quintero (2023).

Area-Weighted Separation by Forest Plot

Using Google Earth Pro or another mapping software, determine the forest area represented by each sampling plot based on plot location and field observations of dominant stand types surrounding each plot. Record the area of each plot's representative area in acres for subsequent calculations.

Aboveground Biomass

For each plot, use the average of the measured values for basal area and stand height inputted into the USDA Forest Service's quick cruise computer (Fig. 1) to determine the plot's timber volume per acre. Convert from board feet to cubic meters by dividing the value by 423.8. Determine the BEF of each plot with the equation BEF = $a + b/x$, where a and b are parameters specific to forest type found in the table from Guo et. al (2010) (Table 1) and x is the calculated timber volume in cubic meters. Calculate the total AGB over the forest using the equation:

$$AGB = \sum_{i}^{n} A_i \cdot x_i \cdot \mathrm{BEF}_i$$

Where AGB is the AGB biomass in Mg, n is the number of plots i, A_i is the area of each plot i, x_i is the calculated timber volume per acre for each plot i, and BEF_i is the calculated BEF for each plot i.

Belowground Biomass

To calculate the BGB over the forest, use the equation:

$$BGB = \sum_{i}^{n} AGB_i \cdot RSR_i$$

Where BGB is the BGB biomass in Mg, n is the number of plots i, AGB_i is the calculated aboveground biomass for each plot i, and RSR_i is the root-shoot ratio for each plot i, found in the table from Luo et. al (2012) (Table 2).

Litter

Dry all samples in a drying oven at 110C until fully dry (at least 3 hours). Record the dry mass of each sample, then for each plot average the mass of the samples from the plot. Calculate the litter biomass using the equation:

$$L = \sum_{i}^{n} A_i \cdot \frac{m_i}{1.57} \cdot 0.04356$$

Where L is the litter biomass in Mg, n is the number of plots i, A_i is the area of each plot i, and m_i is the average litter sample mass for each plot i.

Soil Organic Carbon

Air dry the soil samples for 24-48 hours. Sift each soil sample to 2mm. For each sample, record the mass of 20cc of soil before and after drying at 110C for 3 hours. Determine the moisture content of the soil using the ratio of the mass difference and the original mass and determine the bulk density by dividing the final mass by 20cc.

Using the air-dried soil, record the mass of three subsamples per sample before and after firing in a muffle furnace for 3 hours at 500C. The original mass should be between 5 and 10 grams. Determine the OM% in the soil using the ratio of the mass difference and the original mass. To calculate the total soil organic carbon, use the equation:

$$SOC = \sum_{i}^{n} A_i \cdot d \cdot \mathrm{OM}_i \cdot p_i \cdot (1 - \mathrm{mc}_i) \cdot 0.5$$

Where SOC is the soil organic carbon in Mg, n is the number of plots i, A_i is the area of each plot i, d is the depth of the soil core taken, OM_i is the average organic matter content for each plot i, p_i is the bulk density for each plot i, and mc_i is the moisture content for each plot i.

Figures and Tables:

Fig.1: USDA Forest Service Quick Cruise Computer (USDA, 2016)

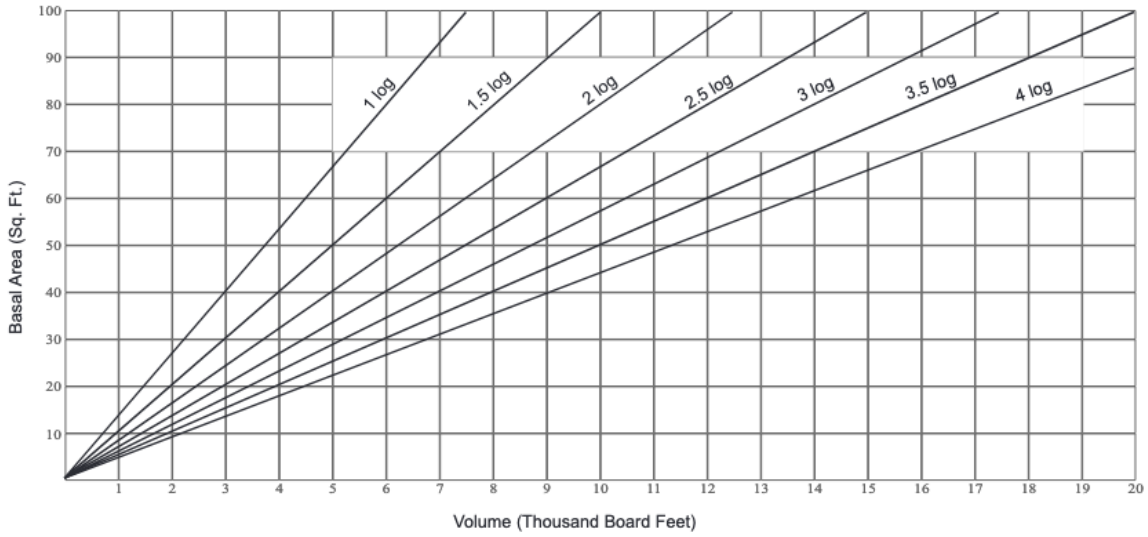

Table 1: Parameters for BEF = $a + b/x$ (Guo et. al, 2010)

Forest type	Parameters for equation: BEF = $a + b/x$				
	a	b	n	r^2	p
Abies, *Picea*	0.5519	48.861	24	0.7764	<0.001
Cunninghamia lanceolata	0.4652	19.141	90	0.9401	<0.001
Cypress	0.8893	7.3965	19	0.8711	<0.001
Larix	0.6096	33.806	34	0.8212	<0.001
Pinus koraiensis	0.5723	16.489	22	0.9326	<0.001
P. armandii	0.4581	32.666	10	0.7769	<0.001
P. massoniana, *P.yunnanensis*	0.5034	20.547	51	0.8676	<0.001
P. sylyestris var.*mongolica*	1.112	2.6951	15	0.8478	<0.001
P. tabulaefomis	0.869	9.1212	112	0.9063	<0.001
Other pines and conifer forests	0.5292	25.087	18	0.8622	<0.001
Tsuga, *Cryptomeria*, *Keteleeria*	0.3491	39.816	30	0.7899	<0.001
Mixed conifer and deciduous	0.8136	18.466	10	0.9953	<0.001
Betula	1.0687	10.237	9	0.7045	<0.005
Casuarina	0.7441	3.2377	10	0.9549	<0.001
Deciduous oaks	1.1453	8.547	12	0.9795	<0.001
Eucalyptus	0.8873	4.5539	20	0.802	<0.001
Lucidophyllous forests	0.9292	6.494	23	0.8259	<0.001
Mixed deciduous and *Sassafras*	0.9788	5.3764	32	0.9333	<0.001
Nonmerchantable woods	1.1783	5.5585	17	0.9483	<0.001
Populus	0.4969	26.973	13	0.9183	<0.001
Tropical forests	0.7975	0.4204	18	0.8715	<0.001

Table 2: Root-Shoot Ratios by Forest Type (Luo et. al, 2012)

Categories	**n**	**Mean RSR**	**SD**	**Max**	**Min**
All forests	649	0.233	0.082	0.07	0.73
Forest group					
Abies, *Picea* and *Sabina*	32	0.229	0.077	0.115	0.39
Cunninghamia	83	0.193	0.038	0.11	0.318
Cupressus and *Fokienia*	24	0.209	0.057	0.095	0.317
Larix	46	0.234	0.079	0.132	0.516
Pinus koraiensis	33	0.227	0.057	0.126	0.345
P. massoniana and *P. taiwanensis*	55	0.159	0.049	0.072	0.281
P. tabulaeformis	100	0.239	0.092	0.094	0.731
Other temperate pines and conifers	22	0.25	0.057	0.137	0.36
Other subtropical pines and conifers	24	0.207	0.051	0.104	0.33
Alnus, Betula and *Populus*	22	0.29	0.093	0.168	0.546
Quercus and other temperate deciduous broadleaved forests	66	0.323	0.097	0.153	0.573
Other subtropical deciduous broadleaved forests	10	0.205	0.046	0.15	0.274
Castanopsis, *Cyclobalanopsis* and *Lithocarpus*	23	0.265	0.064	0.157	0.433
Other evergreen broadleaved forests	46	0.265	0.078	0.131	0.435
Tropical forests	17	0.228	0.047	0.125	0.358
Temperate coniferous–broadleaved mixed forest	15	0.221	0.068	0.1	0.331
Subtropical coniferous–broadleaved mixed forest	31	0.208	0.04	0.137	0.303
Forest origin					
Natural forests	211	0.26	0.091	0.08	0.573
Planted forests	438	0.22	0.074	0.072	0.731
Phylogeny					
Coniferous forests	420	0.214	0.072	0.072	0.731
Broadleaved forests	183	0.283	0.088	0.131	0.573
Coniferous–broadleaved mixed forests	46	0.212	0.051	0.1	0.331
Leaf habit					
Deciduous forests	144	0.281	0.098	0.132	0.573
Evergreen forests	459	0.22	0.073	0.072	0.731

Sources:

Guo, Z., Fang, J., Pan, Y., & Birdsey, R. (2010). Inventory-based estimates of forest biomass carbon stocks in China: A comparison of three methods. Forest Ecology and Management, 259(7), 1225–1231. https://doi.org/10.1016/j.foreco.2009.09.047

Luo, Y., Wang, X., Zhang, X., Booth, T. H., & Lu, F. (2012). Root: shoot ratios across China's forests: Forest type and climatic effects. *Forest Ecology and Management*, *269*, 19-25.

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