Wood density – BCI (draft 3 December 2007)

This document describes the rationale, methods, calculations and equipment used to measure wood density for trees and lianas from central Panama. Wood density is use here to refer to wood specific gravity, which is defined as oven-dry mass divided by fresh volume.

Rationale

The CTFS plant traits working group identified wood density as a crucial functional trait to be measured across CTFS sites. Wood density underlies a well established tradeoff between rates of growth and survival (Muller-Landau 2004). Growth rates tend to be slower and survival rates tend to be higher for higher density woods. This tradeoff might reflect allocation of resources that could otherwise be used in growth to pest defenses and mechanical strength in species with high density wood. The final working group report is Appendix A at the end of this document.

Methods

Methods used to collect wood samples differed for trees versus lianas and shrubs (see below). All wood samples were processed identically once collected.

Methods – Selection of individuals

Wood collections are destructive and are prohibited on BCI. Expert botanists (Salomon Aguilar and Rolando Perez) therefore located plants off BCI. They went where rare trees and shrubs were already known. They collected lianas and the more common free-standing species opportunistically. Thus, opportunistic best describes the selection of individuals. We recorded the coordinates of each individual with a global positioning system (Garmin, Model X, city X, state X).

Methods – Collection of wood samples from trees

We collected wood samples with an increment borer. Cornelissen et al. (2003) describe this method under their subheading "Additional useful methods from forestry". Appendix E describes an increment borer and its use.

We only used increment borers for trees larger than 6 cm in diameter at breast height because we found that the increment borer sometimes caused the stems of smaller trees to split. This necessitated a second method to collect wood from lianas and shrubs.

Methods – Collection of wood samples from lianas and shrubs

We collected a 10-cm long stem segment from lianas and shrubs as recommended by Cornelissen et al. (2003). The stem segments were approximately 1 cm in diameter at their midpoints. This differs from the recommendation of Cornelissen et al. (2003) for

plants less than 6 cm in diameter. They recommend collecting segments "at about one-third of the stem height or length". We could not follow this recommendation for lianas because their stem lengths are unknown. We chose not to follow this recommendation for shrubs because the plant to the plant was too severe.

Methods – Determination of wood specific gravity

We sealed each wood sample in "Ziploc" bag and held the sealed samples on ice until they could be processed. We determined fresh volume within 48 hours of collection.

We followed the recommendations of Cornelissen et al. (2003) with one additional exception. The exception concerned bark. Cornelissen et al. (2003) recommend including "firmly attached bark". We removed bark because this is standard procedure for trees in both the forestry and ecological literature.

We used the water displacement method to determine fresh volume. We partially filled a graduated cylinder with water, placed the cylinder on a balance, and tared the balance to zero. We patted the wood sample dry, inserted a pin, and used the pin to hold the sample just beneath the surface. The balance then recorded the mass of water displaced by the wood sample. The sample was held beneath the surface for five seconds to permit water to fill large air spaces but not very small air spaces. Wood sample diameters varied between about 5.1 mm (the inner diameter of an increment borer) and 10 mm for lianas and shrubs. We used water filled cylinders whose diameters were slightly larger than sample diameters.

We placed each sample in a convection drying oven immediately after determining its fresh volume. The oven temperature was 60C, and each sample was dried for 72 or 96 hours. Samples were then weighed and stored in a dry room at 42-46 C for as much as one month. Appendix F shows that samples gained a small amount of weight in the dry room. Finally, the samples were placed in a convection drying oven at 100 C for 48 hours and weighed a second time. This permitted us to calculate oven dried wood specific gravity (or density) at 60 C and 100 C. Both drying temperatures are found in the literature (Muller-Landau 2004).

Calculation of wood specific gravity

For stem segments of lianas and shrubs, we calculated wood specific gravity (WSG_t) as follows: $WSG_t = M_t / V$,
where M_t, V and the subscript *t* represent oven-dry mass, fresh volume and the final temperature used to dry the sample, respectively.

We used the same formula weighted by cross sectional areas to estimate WSG for trees as follows:

$$WSG_t = \Sigma_{n=1 \text{ to max}} (M_{t,n} / V_n) \times (L_n^2 - L_{n-1}^2) / L_{max}^2,$$

Comment [S1]: Not checked.

where L_n represents the distance from the center of the tree to the distal end of fragment *n*, $L_0 = 0$, L_{max} = the radius of the tree, and the fragments are ordered from the center to the edge of the tree.

The weighting in the final equation is necessary because increment borers collect a fixed volume of wood at all distances through the stem while the actual volume of wood increases with distance from the center. The weighting in the last equation represents the proportion of stem cross sectional area in each successive concentric ring from the center of the tree to the inner edge of its bark.

Many samples collected with increment borers naturally break apart into fragments. Samples more than 5 cm long were purposefully broken so that no fragment was more than 5 cm long.

Equipment

To collect samples

- Data forms
- Increment borers
- Sharpeners for increment borers
- Lubricant for increment borers
- Rags to clean increment borers
- GPS
- 'Rite-in-rain' notebook to record comments
- Pencils
- Straws to store wood samples
- Sturdy clippers to collect 1-cm diameter samples for shrubs and lianas
- 'Ziploc' bags
- Ice chest

To process samples

- Balance
- Graduated cylinder or other narrow jar (an olive jar might do)
- Pin
- Data forms
- Drying oven at 60°C
- Drying oven at 100°C

Appendix E. The use of increment borers to extract wood samples from trees.

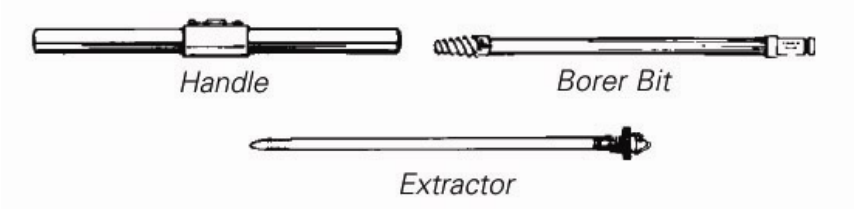

Figure E1. The parts of an increment borer (courtesy of J Chave).

Instructions for using an increment borer can be found at the following web sites:
http://www.plantbio.ohiou.edu/dendro/field_methods.htm
http://www.yale.edu/fes519b/totoket/treering/method1.html
http://www.yale.edu/fes519b/saltonstall/trmethods.htm

A summary of general rules associated with good quality coring follows:

- Protect your coring bit tip because the best increment corer for any tree is a really sharp, really clean, tenderly cared for increment corer. Steps to protect your tip include always putting it carefully back in the handle when going from tree to tree, cleaning it every day (or even every core for some species) and having available a good sharpening kit (and the knowledge to use it).
- Select a good spot on the tree to core - away from branches; away from tension or compression wood on slopes; away from cracks in lobate growing trees; where you can stand comfortably to operate the corer at breast height. If the stem is leaning, the upper side produces reaction wood (tension wood), the growth of which is more related to mechanical stress than to the normal growth of the tree and is also likely to differ in density.
- It is crucial that the cores are taken perpendicular to the stem axis.
- Start coring slowly and steadily, without wobbling the end of the handle around - if the handle is not held steadily, then the outer part of your core will not be straight. A corer starter/ breast plate will help to steady the corer. The starter is a plates you can put pressure on with your chest and a pin that holds the borer.
- Continue winding in the corer. In some harder species it may be necessary to back the corer off a quarter or half turn for every inward turn.
- **When you have reached the desired depth, carefully insert the extractor alongside the wooden core, pressing it firmly (but not too firmly) into place**. One of the more frequent corer breakages is snapping the head from your extractor by trying to push it in too hard.
- Back off the corer a turn or two (or half way out of the tree for some "grabby" hardwoods.)
- Remove and store the core, place the extractor somewhere safe, unwind the bit from the tree and then pack the bit and extractor into the handle before moving to the next coring place.

Key advice: "you should aim to keep the bit moving in or out and only stop for the minimum possible time to insert the extractor."

Appendix F. Check on the temporary storage of wood samples at 42-46 C.

After weighing samples dried at 60 C, many samples were stored for up to one month in the Tupper dry room. La temperatura del cuarto de secado esta entre 42 a 46 grados centigrados. The following data are from the file "Pesos cuarto de secado.xls".

60˚ C (g)	**Fecha de peso 60˚ C**	**Cuarto secado (g)**	**Fecha de peso Cuarto Secado**
0.3597	9/11/2007	0.3798	21/11/07
0.3843	9/11/2007	0.4069	21/11/07
0.2018	9/11/2007	0.2147	21/11/07
0.4703	9/11/2007	0.5013	21/11/07
0.2731	9/11/2007	0.2924	21/11/07
0.5055	9/11/2007	0.5335	21/11/07
0.6815	9/11/2007	0.7245	21/11/07
0.4172	9/11/2007	0.4451	21/11/07
0.5018	9/11/2007	0.5332	21/11/07
0.766	9/11/2007	0.8107	21/11/07
0.389	9/11/2007	0.4112	21/11/07
0.5706	9/11/2007	0.6083	21/11/07
0.66	9/11/2007	0.701	21/11/07
0.1746	9/11/2007	0.1851	21/11/07
0.435	9/11/2007	0.4603	21/11/07
0.3921	9/11/2007	0.4157	21/11/07
0.6684	9/11/2007	0.7071	21/11/07
0.5927	9/11/2007	0.6267	21/11/07
0.1547	9/11/2007	0.1637	21/11/07
0.8219	9/11/2007	0.8708	21/11/07
0.5461	9/11/2007	0.579	21/11/07

Podemos secar estas muestras por un dia a 60 C y para dos dias mas a 100 C antes de pesarlas por el ultimo vez.