Crown traits – BCI (draft 2 December 2007)

This document describes the rationale, methods, calculations and equipment used for BCI crown trait determinations.

Rationale

The CTFS plant traits working group selected four crown traits to be measured across CTFS sites. We were unable to measure one of these four traits, crown depth, in a repeatable manner on BCI. We therefore substituted crown openness (described below). Table 3 presents these crown traits, their rationale, and sample sizes recommended by Cornelissen et al. (2003). The final working group report is Appendix A at the end of this document.

Table 3. Crown functional traits. '+' marks denote well established associations with environmental gradients in climate or disturbance regime, competitive ability, and defense against herbivores and pathogens. Recommended sample sizes are numbers of individuals and numbers of leaves per individual from Cornelissen et al. (2003). NA indicates that Cornelissen et al. (2003) omitted the trait.

Trait (units)	Literature association of trait with				Sample Size Indi-viduals
	Response to		Com-petitive ability	Defense	
	Climate	Distur-bance			
Growth form (categorical)	+	+	+	+	-
Plant height (m)	+	+	+	+	10-25
Crown diameter (m)	NA	NA	NA	NA	NA
Crown openness (%)	NA	NA	NA	NA	NA

Methods

Methods follow the recommendations of Cornelissen et al. (2003) unless otherwise stated. Cornelissen et al. (2003) did not consider crown diameter or openness.

Methods – Selection of individuals

We measured plant height and crown diameter between August and December 2007 for the six largest individuals of each free-standing species in the BCI 50-ha plot. We used the 2005 census to identify these individuals and chose six individuals at random when several individuals were tied in size. We measured every individual for species with six or fewer individuals. We measured crown openness only when appropriate (see below). We also determined the crown exposure index described in Table 2 for each individual.

Methods – Plant height

We measured height to the highest meristem for palms and to the highest leaves for all other plants. We eliminated individuals who had lost their largest diameter branch or trunk. We used a telescoping measuring pole (Xcompany, city, state) to measure the heights of plants less than 15.25 m tall. One person extended the pole and another spotted when the pole reached the top of the crown.

We used a laser rangefinder (Nikon ProStaff Laser 440, Xcity, state) of 4 x 20 and 6.3º) and a clinometer (Brunton Clino Master, Xcity, state) to measure trees taller than 15.25 m (Fig. 3). We measured the angle and distance from the observer to the tree top for trees on level ground (Fig. 3). Most BCI trees are on level ground. We made several measurements from different sides of the tree to increase the chance that we observed the tree top. We avoided angles > 50º because the clinometer scale is most accurate at 45º (angles < 40º were rarely possible). We calculated tree height (H) as follows: H = sin(angle) x hypotenuse + observer height, where figure 3 defines angle and hypotenuse.

Comment [S1]: What is this?

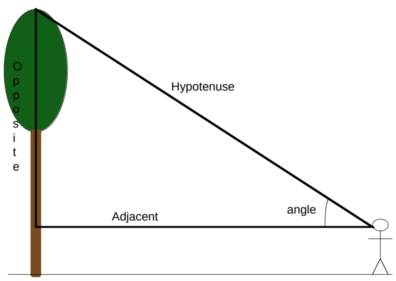

Figure 3. For trees on level ground, we measured the hypotenuse with a laser range finder and the angle with a clinometer. We then calculated tree height by multiplying the hypotenuse by the sin of the angle and adding the height of the observer.

On sloping ground, we measured a second angle to the base of the trunk (Fig. 4). We then estimated tree height as follows:

$$H = \sin(\text{angle1}) \times \text{hypotenuse} \pm \tan(\text{angle2}) \times \cos(\text{angle1}) \times \text{hypotenuse},$$

where figure 4 defines angle 1, angle 2 and hypotenuse. We added the second term if the observer was upslope from the tree as in figure 4. We subtracted the second term if the observer was down slope from the tree.

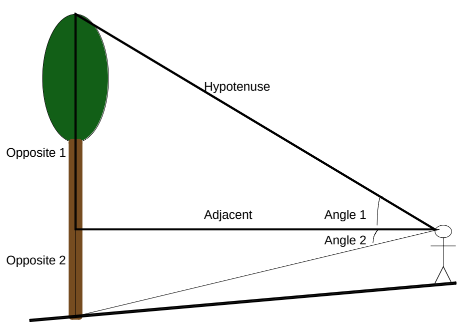

Figure 4. For trees on sloping ground, we measured the hypotenuse with a laser range finder and two angles with a clinometer.

For leaning trees, we used the telescopic measuring pole to measure the vertical height and a meter tape to measure the horizontal distance defined in figure 5. We then used the Pythagorean Theorem to estimate height (Fig. 5). For recently fallen trees whose leaves were still alive, we used a meter tape to measure height.

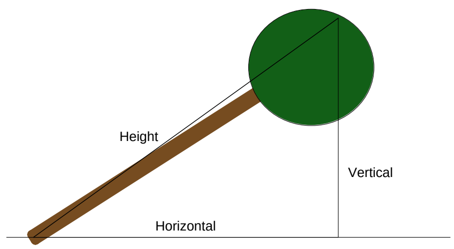

Figure 5. We measured the vertical height and horizontal distance to the base of fallen trees and used the Pythagorean Theorem to determine height as the square root of the sum of the squared vertical and squared horizontal distances.

A comment is in order about our decision to measure the hypotenuse and angles given in figures 3 and 4. The greatest source of error in measuring the heights of tall trees is locating the tallest part of the tree. To increase the chance of finding the tallest point on each tree, we made measurements from two or more positions for virtually every tall tree measured (excepting those whose crowns were clearly visible). We then discarded obvious outliers (more than X% larger than other heights) and used the largest of the remaining heights. Every measurement is available. Other investigators recommend methods that we found to be impractical or inefficient on BCI. Clark and Clark (2001), King et al. (2006a) and S. Bohlman (personal communication) recommend standing at the base of the tree and measuring height vertically with a laser rangefinder. We used this method whenever possible, but we found that foliage of the tree being measured usually blocked the line of sight to the tallest leaves or occasionally the tree being measured could not be distinguished from overtopping foliage including lianas. Cornellisen et al. (2003), Chave (2005) and Bohlman and O'Brien (2006) recommend measuring the adjacent and the angle as defined in figures 3 and 4. We found that the adjacent distance was (a) often impossible to measure with a laser range finder because understory vegetation blocked the line of sight, (b) time consuming to measure with a meter tape (which precluded measurements from multiple positions), and (c) occasionally impossible to measure with a meter tape on sloping ground. Cornellisen et al. (2003) also recommended a second method that included measuring three angles. We rejected this method because two of the angles are quite shallow and clinometers measure shallow angles with substantial error.

Comment [S2]: Tentative – must rewrite once data are processed.

Methods – Crown diameter

We measured crown diameters for the same individuals used to measure crown height. But, we eliminated all fallen individuals, individuals missing any part of their crown, and individuals whose crown was smothered by lianas.

We measured crown radii from the approximate center of the crown to the edge of the crown with a meter tape or when possible with the laser range finder. We attempted to measure crown radii in the eight principal directions (N, NE, E, SE, S, SW, W and NW) for each tree (Bohlman and O'Brien 2006). We located the edge of the crown by looking directly up while facing perpendicular to the radius being measured. We used the clinometer to confirm that we were indeed looking directly up. By facing perpendicular to the measurement, we minimized error along the radius being measured. We eliminated a radius if intervening vegetation blocked the line of site to the crown edge from directly beneath the crown edge. We measured radii from the approximate center of the crown when the crown was not located over the tree trunk. Figure 6 makes it clear why this is necessary. We averaged the available radii for each individual. The original measurements are also available.

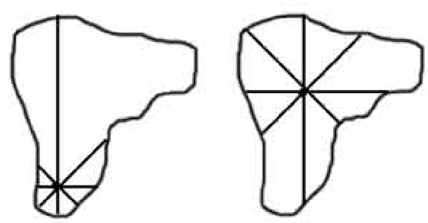

Figure 6. The horizontal projection of a hypothetical tree crown whose trunk is near the bottom of the projection (left) or near the center of the projection (right). The crown diameter is better reflected when radii are measured from near the center of the crown.

.

Methods – Crown openness

We took photographs to evaluate crown openness using a digital camera (Panasonic Lumix DMC – TZ3 with a 28-mm Leica lens, 7.2 megapixels). We took photographs on the 10X optical zoom setting. We took a photograph whenever a single tree free of lianas was between the observer and the sky. We recorded the angle of each photograph with the clinometer and attempted to take vertical photographs.

We have not yet processed these images. More images must be taken because the presence of other trees and lianas precluded taking photographs of most trees.

.

Methods – Growth form

We identified lianas (code L), shrubs (S, adult height < 5 m), understory treelets, (U, 5-10 m), midstory trees (M, 10-20 m) and canopy or emergent trees (C, > 20 m). The S, U, M and C growth forms are routinely used in publications by Condit and others. We will explore how these growth forms were determined. We will also explore the more quantitative measure of adult size given by King et al. (2006b).

Equipment

Bohlman, S., and S. O'Brien. 2006. Allometry, adult stature and regeneration requirement of 65 tree species on Barro Colorado Island, Panama. Journal Of Tropical Ecology 22:123-136.

Chave, J. 2005. Measuring tree height for tropical forest trees: a field manual. Pan Amazonia: Project for the Advancement of Network Science in Amazonia.

King, D., S. J. Wright, and J. H. Connell. 2006. The contribution of interspecific variation in maximum tree height to tropical and temperate diversity. Journal of Tropical Ecology 22:11-24.