The forest overstory density is important for understanding the conditions in which fauna and flora are established. In an environment where light is often a limiting resource, methods used to measure the openness of the canopy from the proportion of open sky are of great relevance to the estimation of brightness.

Many techniques for measuring brightness are available as direct measurements with light sensors, canopy aperture estimates with hemispherical photos, spherical densiometer or canopy scope, or visual classification of opening levels, but the estimation values can vary widely between each technique.

The spherical densiometer canopy opening techniques presented here can measure variations from enclosed canopy to small and large gaps, but will not be sufficient to detect subtle differences in light between areas with no gaps, where gaps are below 5%. For a general characterization of the brightness pattern of a research site, they may be appropriate, but for more detailed studies of the light niche of species, especially for plant species, it is better to use measurements based on light sensors. The measurements obtained with the spherical densiometer have high variability between each data collector. Thus, measurements must be performed by the same collector at all sampling points and the greater the collector's experience in the use of the equipment the greater the accuracy of the estimation (Werneck *et al*., 2004).

The Forest Densiometer or spherical densiometer was originally developed by Dr. Paul E. Lemmon in 1956. Lemmon published two articles disclosing simple and inexpensive equipment to measure the percentage of canopy opening (Lemmon, 1956, 1957). It consists of a concave or convex checkered piece of mirrored metal composed of 24 frames to reflect the incident light at an angle of 180 °. This mirror is fixed on a piece of wood with a level bubble to level the equipment at the time of its reading (Fig. 1). The canopy image is reflected in the metal piece and each frame must be divided into four parts, where each part has the value of 1 point making a total of 96. To correct the percentage we used the index of 1.04.

Figure 1: Model C of spherical densiometer, by Robert E. Lemmon, Bartlesville, USA. Picture: Gabriel Masseli.

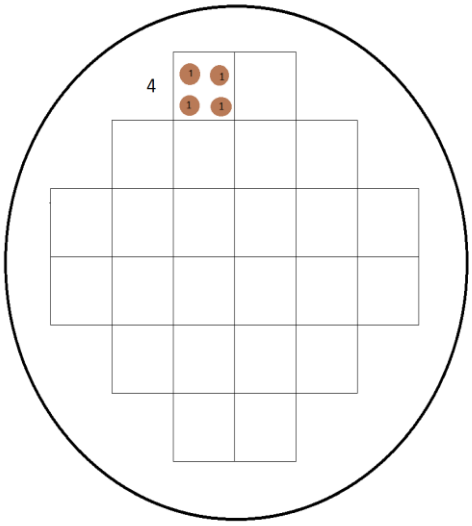

Figure 2: Reading surface of the spherical densiometer with the four imaginary reading points per frame. The points should be counted if the canopy opening illuminates them. Scheme: Gabriel Masseli.

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What to take?

Figure 3: Chart for recording measurements, clipboard, 2B pencil, rubber, plastic bags to protect the clipboard, compass, spherical densiometer metadata and site azimuth data. Picture: Sulamita Marques.

Instructions for spherical densiometer reading

Using the compass, position yourself on the 0 picket facing the first cardinal point (Fig. 4).

Position the leveled spherical densiometer at elbow height away from the body, so that the you don't affect the measurement (Fig. 5).

Figure 4: Picket 0 where the first measurement of the plot will be performed. Picture: M.A.Freitas.

Figure 5: Collector reading the equipment in the field, showing the position of the device in relation to the body. Picture: Gabriel Masseli.

In RAPELD plots, measurements should be made in a standardized way, 6 sites per plot, at the 0, 50, 100, 150, 200 and 250 pickets.

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With the elbows held at an angle of 90º to the body ensure that the apparatus is level (the bubble should be in the center of the circle) and count the number of illuminated points inside each of the four frames of the mirror (Fig. 2).

The data collector must decide whether the points of light reflected by the spherical densiometer are covering the four points of each frame. Small or spaced dots will be not counted. The collector must then sum the number of illuminated points in that position and record it on the worksheet. Repeat the procedure for each of the four cardinal points (North, South, East and West).

The worksheet looks like this:

Picket	Direction	Point	Observations
0	N	20	
0	E	18	
0	S	11	
0	W	17	
50	N		
50	L		
50	S		
50	O		
100	N		
100	L		
100	S		

How to obtain the canopy opening estimate value (%)

Sum up the illuminated points and take the average for the sampling picket. Multiply the mean of the points by 1.04 (correction factor of the device) and we have the estimated percentage value of the canopy opening.

Example: Picket 0 -

Total: 20+18+11+17 = **66;**

Average: 66/4 = 16.5;

Correction Factor 16.5x1.04 = 17.16%

The openness of the canopy of the plot is estimated as the average of each of the 6 points. And the coverage therefore, is the inverse of this: Coverage = 1/Openness.

REFERENCES

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Lemmon, P. E. 1957. **A new instrument for measuring forest overstory density**. Journal of Forestry 55: 667-669. http://www.forestry-suppliers.com/Documents/1450_msds.pdf
Werneck, F., Zuquim, G., Rodrigues, L. & Leitão, R. 2004. **Uso de esferodensiômetro e fotos digitais para estimar abertura de dossel: um teste metodológico.** http://pdbff.inpa.gov.br/cursos/efa/livro/2004/PDFs/pl1g4.pdf

WORKSHEET FOR TAKING CANOPY OPENNESS MEASUREMENTS

Date: **Time:**	**Site:**	**Module:**
Recorder:		**Trail:**
Measurer:		**Plot:**

picket	direction	points	Observations
0	N		
0	E		
0	S		
0	W		
50	N		
50	E		
50	S		
50	W		
100	N		
100	E		
100	S		
100	W		
150	N		
150	E		
150	S		
150	W		
200	N		
200	E		
200	S		
200	W		
250	N		
250	E		
250	S		
250	W		

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RECORD FOR OPENING CANOPY METADATA

Title

Team: (specify the function of each member)

Geographic scope:

Temporal scope:

Sampling methods:

Data file:

Atributes' information

Atribute´s name	Definition
Date	When the measure was taken mm/dd/yyyy
Time	Beginning and end of the sampling period
Site	Name of the site where data was collected
Module	Name of the trail
Trail	Name of the plot
Picket	Point where the opening canopy measures will be taken - 0, 50, 100, 150, 200, 250.
Direction	Direction in which will be taken the opening canopy measures - N (north), E (east), S (south) and W (west).
Points	Number of points not filled by the vegetation's projection in each square of spherical densiometer
Obs	Relevant observations