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Short communication

Gap size measurement: The proposal of a new field method

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Abstract

In the tropical Atlantic Forest, 42 canopy gaps had their areas estimated using four different field methods of measurement: Runkle, Brokaw and Green [Runkle, J.R., 1981. Gap formation in some old-growth forests of the eastern United States. Ecology 62, 1041–1051; Brokaw, N.V.L., 1982. The definition of treefall gap and its effect on measures of forest dynamics. Biotropica 14, 158–160; Green, P.T., 1996. Canopy Gaps in rain forest on Christmas Island, Indian Ocean: size distribution and methods of measurement. J. Trop. Ecol. 12, 427–434] and a new method proposed in this work. It was found that within the same gap delimitation, average gap size varied from 56.0 up to 88.3 m^2 while total sum of gap area varied from 2351.3 to 3707.9 m^2. Differences among all methods and between pairs of method proved to be statistically significant. As a consequence, gap size–class distribution was also different between methods. When one method is held as a standard, deviation on average values of gap size ranged between 11.8 and 59.7% as deviations on single gap size can reach 172.8%. Implications on forest dynamics were expressed by the forest turnover rate that was 24% faster or 15% slower depending on the method adopted for gap measurement. Based on my results and on methods' evaluation, the use of a new method is proposed here for future research involving the measure of gap size in forest ecosystems. Finally, it is concluded that forest comparisons disregarding the influence of different methods of gap measurement should be reconsidered.

Keywords: Atlantic rain forest; Canopy gaps; Methods of measurement; Turnover rate

1. Introduction

Disturbances caused by canopy gaps received much attention in the last decades [see reviews by Brokaw (1985), Denslow (1987) and Clark (1990)] and are regarded as important factors in tropical forest dynamics (Martínez-Ramos et al., 1989). Canopy openings as a result of tree or branch falls create an environment different from the adjacent forest (Hubbell and Foster, 1986) which influences not only plant regeneration (Brown, 1993) but also animal behavior (Schupp, 1988). In addition, gap processes partly determine forest structure and floristic composition (Runkle, 1985; Clark, 1990) and play an important role to maintain plant species richness (Denslow, 1987).

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For studies on forest disturbance regimes, both on tropical or temperate ecosystems, measuring gap size is an important issue (Runkle, 1985; van der Meer et al., 1994). Gap area is a good index to characterize light entrance and resource availability (Denslow, 1987). Area is also important for sampling procedures which involve parameters dependent on area such as species richness and density. In a wider context, gap size is used to characterize the gap size–frequency distributions and to calculate the forest turnover rate, both related to regeneration patterns (Brokaw, 1985; Clark, 1990). Currently, several methods are available to define and estimate gap size and no method seems to have been universally adopted (see Popma et al., 1988; Clark, 1990). This is a critical issue because the use of different methods can generate different values while measuring the same phenomenon. As an example, gap size depends on gap definition as values vary up to eight times depending on the definition used (van der Meer et al., 1994).

Considering only methods to define gap limits, the most widely used one is Brokaw (1982) or the vertical projection of the opening in forest canopy. Clark (1990) regard this definition as objective and workable, but it has been severely criticized for its lack of realism in determining canopy opening effects, especially on patterns of plant species regeneration (Popma et al., 1988; Lieberman et al., 1989; Brown, 1993). These authors pointed out that the real effect of higher light levels reaching the forest floor would not be restricted to the vertical projection of the 'hole' in the canopy. Other gap definitions have been proposed to define a gap (e.g., Runkle, 1981; Hubbell and Foster, 1986; Popma et al., 1988). Among them, van der Meer et al. (1994) affirm that the method proposed by Runkle (the extended gap) probably is the most workable and accurate one because it would include areas direct and indirectly affected by the canopy opening (also see Canham, 1988).

Once the gap limits are established the next step is to calculate gap area. To do so, one will need a measuring method for estimating the size of the defined gap. There are three basic methods to measure gap area proposed by different authors: (1) to use "at least eight coordinates of direction and distance to the edge, recorded from a central point within the gap" (Brokaw, 1982); (2) adding eight further distance/direction coordinates to Brokaw's method (Green, 1996); and (3) fitting gap length and width to the formula of an ellipse (Runkle, 1981). In the first two methods measures of distance/direction are used to produce a scale map from which gap area will be estimated; the last method estimates gap area directly by the formula for an ellipse area.

As for gap delimitation, the way of measuring gap area has yet to be established. Different methods of gap size measurement deserve the researcher's attention, mainly because they can produce different areas from the same gap delimitation. As an example, Green (1996) found that Brokaw (1982) method of measurement underestimated gap area by around 10 and up to 50% when compared to his 16 coordinate's method. Other aspects such as time consumed and workability should also be considered to choose a measuring method. In this context, the purpose of this study is to compare four different methods of estimating gap size in a tropical rain forest, based on a same gap delimitation method. The four methods chosen to carry out this comparison were Runkle (1981), Brokaw (1982), Green (1996) and a new field method proposed here. Between methods size deviation are analyzed, and precision, relative accuracy and workability of each method are evaluated. Finally, the implications of gap measuring on forest studies are discussed.

2. Methods

The study was carried out in the Carlos Botelho State Park (PECB), a 37.645 ha reserve of the Atlantic rain forest of South-eastern Brazil (24°20′ S, 47°44′W). Average annual rainfall is 1683 mm, evenly spread throughout the year, and the mean monthly temperature ranges from 14.5 to 22.4 °C. The study site is a plateau between 700 and 900 m height above sea level with well-drained, clayey and relatively deep yellow laterite soils above metamorphic parent material (Domingues et al., 1993). Local vegetation has been classified as Montane Tropical Rain Forest, with canopy height varying from 20 to 40 m. There is no recent evidence of human disturbance in the area.

Throughout the year of 2002, 42 canopy gaps of different sizes had their perimeter delimited. The delimitation method used followed Brokaw (1982), but it is noteworthy that virtually any gap definition could be chosen since gap definition does not affect