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Short Communication

Evaluating the stick-gap method in a Mexican tropical dryland: Effect of stick length and sample size

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ABSTRACT

The degradation of drylands by human activities is a serious problem in many developing countries. Monitoring in these countries therefore is basic to prevent or mitigate land degradation. The stick-gap method is one graphical approach that has been used to monitor rangelands in eastern Africa. This method collects data on vegetation cover and structure with a 1-m-long stick at 20 locations per site. These data are then used to calculate land health indicators. Because the stick-gap method is easy to implement and to understand, it is suitable for monitoring drylands in other developing countries. However, the effect of stick length and sample size on the estimation of indicators such as basal gaps should be first evaluated. In this study, we measured basal gaps with 1-m- and 0.5-m-long sticks at 20 and 100 locations per site in two mesquite shrublands with different vegetation structure within a Mexican tropical dryland area. We correlated the basal gaps estimated using different stick lengths and sample sizes with the basal gaps estimated using one standard tape method. The correlations between these estimates were not significant considering 20 locations per site, independent of whether 1-m- or 0.5-m-long sticks were used. However, the correlations between these estimates were significant considering 100 locations per site. Also, the correlations between these methods were slightly higher when 0.5-m-long sticks were used in comparison to 1-m-long sticks. These results were similar in mesquite shrublands with either open or closed canopies. We conclude that increasing sample size to 100 locations per site and decreasing stick length to 0.5 m would be sufficient for estimating the proportion of basal gaps in both open- and closed-canopy mesquite shrublands.

1. Introduction

Land degradation caused by agriculture and pastoralism negatively affects many dryland areas in developing African and Latin American countries (Reynolds et al., 2005; Huber-Sannwald et al., 2006). In these countries, dryland monitoring by people or by government agencies is necessary to preserve soil, water, and plant resources (Riginos and Herrick, 2010). However, monitoring must be easy to implement and to understand by people inhabiting these drylands because they usually lack financial resources and have low numeracy skills (Riginos and Herrick, 2010; Riginos et al., 2011).

Recently, one simple graphical approach was developed for monitoring rangelands in eastern Africa, which may be useful to monitor rangelands in other developing countries (Riginos and Herrick, 2010). Specifically, this graphical approach relies on using a 1-m-long stick to collect data on vegetation cover and structure with four monitoring methods: the stick-point method, the stick-gap method, the plant height method, and the plant density method. The collected data can then be used to calculate a variety of land health indicators (e.g., plant and bare ground cover, percentage of canopy and basal gaps, and plant density). Of the four methods, the stick-gap method measures the horizontal vegetation structure by recording the number of times that a 1-m-long stick falls within a gap between plant bases (i.e., basal gaps) or a gap between plant canopies (i.e., canopy gaps). Data are typically collected at 20 locations per site. However, the stick length and the sample size should be adjusted to particular ecosystems in order to properly capture their landscape characteristics. For instance, the stick length may be too long to adequately capture information for areas with small gaps, or the sample size may be too small to capture the average characteristics of certain sites (Riginos et al., 2011).

In this study, we evaluated the stick-gap method in the Zapotitlán Salinas Valley, a tropical dryland in south-central Mexico. This area has land degradation problems as a consequence of land use change and habitat fragmentation (López-Galindo et al., 2003). Local inhabitants of this region often lack financial resources and have low numeracy skills; therefore, the stick-gap method could be a simple means of enabling

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local inhabitants to monitor their lands. However, different stick lengths and sample sizes must be tested to ensure the reliability of this method. We measured basal gaps using two stick lengths and sample sizes and correlated them with basal gaps measured with one standard tape method. We described the results and discussed the limitations of the stick-gap method and its utility for government agencies responsible for preserving soil, water, and plant resources. As far as we know, this is the first evaluation of the stick-gap method in a developing country outside of Africa. We hope that this study encourages more evaluations of the stick-gap method in other developing countries.

2. Material and methods

The study was conducted in the Zapotitlán Salinas Valley (18° 20′ N, 97° 28′ W, 1550 m a. s. l.) located within the Tehuacán-Cuicatlán Valley in Puebla, south-central Mexico. The mean annual rainfall is 400 mm (80% of which falls between June and September), and the mean annual temperature is 21 °C (López-Galindo et al., 2003). Fieldwork was performed in the fluvial terraces of the Salado River, which have deep soils with sandy loam, clay loam, and silty clay loam textures. The main plant community is mesquite (*Prosopis laevigata*) shrubland mixed with columnar cacti (*Myrtillocactus geometrizans*, *Stenocereus stellatus*, and *Pachycereus hollianus*; López-Galindo et al., 2003). This plant community presents two alternative states: open-canopy mesquite shrubland and closed-canopy mesquite shrubland due to land use change and habitat fragmentation. The open-canopy mesquite shrubland has lower foliar cover and visual obstruction as well as higher bare ground cover than the closed-canopy mesquite shrubland, thus being a less structured plant community.

For each alternative state of mesquite shrubland, we selected three sites to measure basal gaps with the stick-gap method (Riginos and Herrick, 2010; Riginos et al., 2011) and with the standard tape method (Herrick et al., 2005; Fig. 1). For the standard tape measurements, we utilized the line-point intercept method because it is objective, precise, and efficient, and has been widely used for monitoring dryland plant communities (Herrick et al., 2005; Godínez-Alvarez et al., 2009; Herrick et al., 2010). We only measured basal gaps rather than measuring both basal and canopy gaps because water is the main agent of erosion in the region. For each site, we set up four 25-m-long measuring tapes on the ground surface, each separated by 10 m. For the standard tape method (Tape), we recorded the beginning and the ending in centimeters of all gaps > 0.5 m that occurred along the tape. The gaps ended when plant stems emerging from the soil surface intercepted the tape. Also, the gaps ended at the beginning and ending of the tape. For the stick-gap method, we used 1-m- and 0.5-m-long sticks to record gaps. We placed the sticks on the ground surface perpendicular to the tape every 5 m for a total of 20 locations per site (i.e., 5 measurements per tape x 4 measuring tapes; Stick-20). We recorded gaps > 1 m or > 0.5 m when the 1-m- or 0.5-m-long stick fell within a gap between plant bases, respectively. To increase the number of locations per site, we placed the stick parallel to the tape every meter for a total of 100 locations per site (i.e., 25 measurements per tape x 4 measuring tapes; Stick-100). We used both the 1-m- and 0.5-m-long sticks to record gaps, as previously described for the Stick-20 (Riginos and Herrick, 2011).

For the Tape, we calculated the size of each gap by subtracting the ending from the beginning. The gaps were classified as either > 1 m or > 0.5 m and then summed to calculate the total amount of tape covered by gaps. The proportion of gaps > 1 m and > 0.5 m was calculated by dividing the amount of tape covered by gaps by the total length of the tape (i.e., 25 m). For the Stick-20 and the Stick-100, we calculated the proportion of gaps > 1 m and > 0.5 m per transect by dividing the number of gaps by the total number of measurements per tape (i.e., 5 and 25 measurements, respectively). The proportions of gaps > 1.0 m and > 0.5 m estimated using the Stick-20 and the Stick-100 were correlated with the proportions estimated using the Tape with Spearman rank correlations. Also, the proportions of gaps > 1.0 m and > 0.5 m estimated by the Stick-20 were correlated with those estimated by the Stick-100 to test whether they were interchangeable (i.e., if they were estimating similar proportions of gaps). The correlations were performed separately for open-canopy and closed-canopy mesquite shrublands by considering the measuring tapes as the experimental units. All correlations were conducted with the JMP software version 10.

3. Results

In the open-canopy mesquite shrubland, the Stick-20 was marginally correlated with the Tape considering gaps > 1 m ($r_s = 0.6$, $p = 0.04$) yet was uncorrelated with the Tape considering gaps > 0.5 m ($r_s = 0.5$, $p = 0.09$). The Stick-100 was significantly correlated with

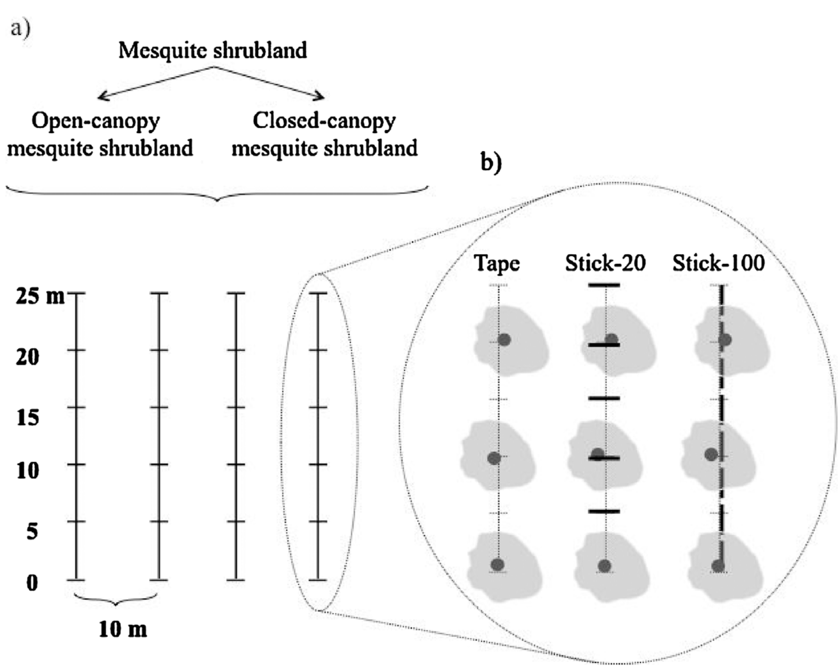

Fig. 1. The stick-gap method was evaluated in (a) the open- and closed-canopy mesquite shrubland. For each shrubland, we set up four 25-m-long transects, each separated by 10 m. For each transect, (b) we recorded basal gaps according to the Tape, the Stick-20, and the Stick-100 procedures described in the material and methods section. The light and dark gray areas represent the plant canopy and the plant base, respectively. The horizontal and the perpendicular black lines indicate the position of the stick in the transects.