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Interactive comment on "Structural effects of liana presence in secondary tropical dry forests using ground LiDAR" *by* A. Sánchez-Azofeifa et al.

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We thank Referee No. 2 for his/her comments and suggestions. They mirror the comments from Referee No. 1 in some aspects and we will refer to our previous responses when appropriate.

General comments:

The authors have undertaken an interesting study of the structural effects of lianas in tropical dry forests and the extent to which structural changes may be detected using ground based lidar at different stages of forest succession. Furthering our understanding of the role of lianas in forest successional processes is of great merit in terms of forest management in general and carbon accounting in particular. The use of ground based lidar (terrestrial laser scanning, TLS), as a structural measurement tool is reasonable in the context of the study. There are some aspects of the study which need to be improved to make the manuscript suitable for publication. These can be divided into two main categories:

Comment 1

1. Description of the lidar metric 'Radius of Gyration' (RG) as a means of describingforest structure. The authors have given a conceptual description, but I still have troubleunderstanding what it means, ecologically or structurally. For example, what would an'increase in RG' look like in the forest? On page 17165, line 5: ": : :Stands without lianasshowed a significant gradual increase in the RG. This is consistent with accumulation ofbasal area, vegetation material and biomass accumulation. . .". How does an increasein RG relate to an increase in basal area? Some further descriptive words or illustrative(even simulated) examples of PAVD profiles with different RG values would help greatly.

Response: We thank you for the comments and we agree on the need to provide additional clarification. As described above, RG provides a proxy to general forest volume. The greater the overall height, stratification and biomass of the forest (as a function of succession), the larger the RG value. The relation between RG and succession is evidenced in the the RG values obtained in Early, Intermediate and Late sampling plots with no lianas (Table 1). More basal area in a forest, means more hits and returns registered in the laser scan, and higher PAVD values per forest height.

In a successional trajectory, basal area and tree height are low in a early stage forest, so RG is low as well. A PAVD profile will show a large concentration of biomass at lower heights in this case. If the forest increases in overall height, stratification and biomass, laser returns are received from greater distances and the distances between PAVD values and the centroid increase, and so the RG increases its value. So, basal area and tree height increases as trees increase their DBH towards a late stage forest, but since stem density decreases in the understory and a greater amount of hits and returns now come from branches located in the sub-canopy and the canopy, changes include not only an increase in RG value but also a change in the PAVD vertical profile where larger plant volumes can be observed in the canopy and subcanopy strata.

The presence of lianas affect forest structure, and this is registered in the distances between PAVD values and the centroid of the vertical profiles of liana infested plots, therefore affecting RG values.

We fully agree with the reviewer that descriptive works and probably an illustration are necessary and we will include it in the next version of our paper.

Comment 2

2. Field plot selection and description. This is perhaps the biggest issue. A totalof fifteen plots were sampled across three different forest successional stages: early, intermediate and late. Of these, 9 sites had lianas and 6 did not. A detailed descriptionof these plots is critical as the basis for subsequent analyses. Specifically:

Response: We have tried to cover some of the points associated to this issue in the previous responses to the referee No. 1. We defined successional stages as classified in previous studies for the same study area (see Arroyo-Mora et al. 2005). Successional stages as classified based on forest structure using and age since land abandonment. Early successional stages comprise an area of sparse patches of woody vegetation and shrubs, and they only have a single stratum of tree crowns without lianas. The vegetation composition of this successional stage includes several species that lose most of their leaves during the dry season (Arroyo-Mora et al. 2005). The intermediate successional stage has 2 vegetation layers. The first one comprises fast growing deciduous tree species, shade-tolerant evergreen species and juveniles of tree species, which represent a second vegetation layer below the canopy. The late stage consists of 3 layers of vegetation. The upper layer consists of trees up to 30 m height, while the second layer consists of juveniles of all ages and heights, as well as a number of species that live entirely in the understory (Kalacska et al. 2004; Arroyo-Mora et al. 2005). We really appreciate the comments and we will include this section in the next version of the manuscript to improve the paper.

Comment 3

a. Describe the inherent between-plot variance within succession classes without-lianas. It is difficult to know whether statistically significant differences in PAI, PAVD orRG metrics could be observed between plots within the same succession class with-outlianas. This then makes it difficult to judge the significance of differences between plotswith- and without-lianas.

Response: We conducted a Kruskal-Wallis test to compare the PAI, PAVD, and RG in plots without lianas, and we found no difference across stages for PAI. The RG and PAVD were also similar between intermediate and late stages. But the RG and PAVD were significantly lower in the early stages compared to the late stages. We can add this result to the manuscript to improve clarity. We consider this result of significant differences in RG reinforce our hypothesis that successional trajectories increased positively in plots without lianas, as this test also showed significant greater values for RG in late stages.

Comment 4

b. What is relative location of the plots? It is interesting to note in Figure 2 that theintermediate-aged plots with lianas are approximately 4 meters taller that the intermediateplots without lianas. Is this caused by lianas or geographical differences relatedto climate, topography or soil. A map illustrating the plot locations would be useful.

Response: Many thanks for this comment. A map with the location of the plots will be included in the next version of the manuscript. Forest are more or less of the same age since abandonment and therefore regeneration started right after the Santa Rosa

National Park was created in 1971. The key element here is the pathway of succession: either controlled by vertebrates or by wind dispersal (Castillo et al. 2011, 2012). We will include a description of this on the paper and provide a map as requested.

Comment 5

c. In what way might the classification of age classes predetermine the observed differencesin PAI, PAVD or RG metrics? Page 17158, line 15 mentions that the numberof vertical strata" was one of the criteria used to differentiate age classes, a priori.

Response: Indeed, strata play a key role on the differentiation of succession as well as other elements such as LAI, PAI, canopy closure and species composition (all elements already described on several papers since 1998). We will include a better description of the plots based on our previous work.

Comment 6

d. How does liana density vary between plots? Is there any way to quantify this in termsof stems-per-hectare of lianas or liana-affected trees within the plots? On page 17165,the last paragraph discusses the general lower density of lianas in late, compared tointermediate, successional stages. This naturally raises the question "how does lianadensity vary within and between age classes in the sampled plots"?

Response: We conducted a Kruskal-Wallis test to compare the intermediate and late stages with lianas, and we did not find significant differences neither in the absolute number of lianas, neither in the number of lianas per hectare. We can add this information to the manuscript to illustrate the within-plot variation in sites where lianas are present.

Detailed comments:

âĂć p. 17154, line 18: ": : :distinction of vertical strata and the vertical height of accumulatedPAVD". Suggest changing this to "distinction of vertical strata and canopy height".

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Response: We will do it as requested.

âĂć p. 17155, line 11: change “old growth forests” to “old growth tropical forests”.

Response: We we will do it as requested.

âĂć p. 17156, last paragraph.: “Ground LiDAR has demonstrated the capability to measurecanopy properties such as height and cover (Ramírez et al., 2013) and tree architecture(Lefsky et al., 2008), using terrestrial laser scanning systems (TLS): : :”. Suggest removing “: : :using terrestrial laser scanning systems (TLS)” as this is synonymous with ground lidar in the context of this study. p. 17157, line 2: “: : :Laser 65 Scanners: : :”. Check.

Response: We will do it as requested.

âĂć p. 17157, line 3: “: : :pulses emitted in the visible or near-infrared comes into contactwith an object, part of that energy is reflected back toward the instrument: : :”. Technically,other wavelengths are reflected too. Lidar systems operating in the short-waveinfrared and even ultra-violet are common. Perhaps remove or qualify the wavelengthspecificity.

Response: We will specify the wavelength used.

âĂć p. 17157, line 23: “Significant increases in vertical structure with stand age (e.g., as aresult of increases in basal area, height and volume with stand age): : :”. Despite theexamples, I am a still confused by the terminology “increase in vertical structure”. Doyou mean “structural complexity”?

Response: Yes, we agree with this suggestion. We will change the phrase to "Structural complexity".

âĂć p. 17161, line 9: “we used the RG to relate the shape of the PAVD profile to forestbiomass at the footprint level (3600 m2 or 0.36 ha)”. At the fixed scan zenith angle of57.5 degrees the plot area is defined by the mean canopy height, as this dic-

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tates thehorizontal distance from the instrument when the laser exits the canopy. If the treeswere all exactly the same height (h), the laser would exit the canopy at a distance of (h * tan(57.5 degrees)), or approximately 1.6h from the plot center. At h = 33 m the laserhas reached its maximum effective range of 60 m as defined on page 17160, line 17.Based on the PAVD profiles in Figure 2, the minimum and maximum canopy heightsare approximately 10 m and 18 m, respectively. This translates to plot areas of 0.08hato 0.26ha.

Response: The footprint given was intended as a conservative overall approximation, but we will be more specific and include the footprints using real height measurements from the instrument as suggested.

âĂć p. 17162, line 9: "A change or no significant increase in PAI as a function of RG duringsuccession would suggest that lianas may be altering the successional trajectories: : :".This is somewhat confusing. A change in what way?

Response: The rationale for understanding this statement is explained in the response to the first question. We will, however, clarify and be more specific in stating the way the trajectories are altered.

âĂć p. 17162, line 14: ": : :the radius of gyration (RG) showed a significant increase alongin succession in plots with no lianas (Table 1): : :". First, consider removing the words"along in succession". Secondly, the RG metric increases in plots with no lianas in thelate successional stage plots only. In the intermediate age class the reverse seems tobe true. Please clarify.

Response: We will remove or rephrase the sentence. We disagree with the latter comment. Although an internal variation in RG values in successional stages exists, the increase in RG between successional stages is evident in Table 1.

âĂć P. 17163, lines 14 & 15: Should the text refer to Figure 2?

Response: We we will make these changes in the next version of the manuscript.

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Interactive Comment

âĂć p. 17166, line 12: The “vertical height of PAVD” is better described simply as “canopyheight”.

Response: We we will make these changes in the next version of the manuscript.

âĂć p. 17174: The Figure 2 caption refers to a “Time-series” of PAVD, yet there is notimescale or differentiation of scan dates in the figure. Suggest removing the “timeseries” terminology and simply state “Figure 2. Plant Area Volume Density (PAVD)values calculated by: : :”

Response: We we will make these changes in the next version of the manuscript.

Interactive comment on Biogeosciences Discuss., 12, 17153, 2015.