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Discussions

Interactive comment on "Landscape-scale changes in forest canopy structure across a partially logged tropical peat swamp" *by* B. M. M. Wedeux and D. A. Coomes

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General comments:

Overall, this is well written paper with a clean message regarding the effect of peat depth on forest structure, disturbances and selective logging of swamp tropical forests. It takes the advance of large collections of ground measurements and airborne lidar data to quantify changes in forest canopy structure related to environmental and anthropogenic processes.

Specific comments:

The effects of natural (tree fall-gaps) and anthropogenic (selective logging) disturbances in peat swamp forests are relevant for a broad audience of researchers. Wedeux and Coomes did an interesting analysis of the changes on forest structures across several peat swamp landscapes likely related to ecosystem processes of soil anoxia and fertility from different peat depth areas. Using airborne lidar data the authors were able to test the effects of natural and anthropogenic disturbances in a tropical peat swamp forests of Central Kalimantan, Indonesia. Based on previous studies, they hypothesized that peat depth is the main environmental factor that drives not only changes on forest structure, but also defines the intensity of logging in those areas. To test their hypothesis they quantified lidar canopy openings and forest structure across several peat depth gradients. The authors used a well-known statistical model of gap frequencies, forest height and an environmental variable (peat depth) to understand the effects of logging intensity on forest structure. They concluded that the exponents of gap frequency distributions increased dramatically from 1.76 to 3.78 likely because of the pervasive effects of peat depth. Tree height also decreases with the size of peat depth. There is a clear inverse relation between peat depth and tree heights.

Although the basic remote sensing analysis of this study seems to be technically sound, and the general ecological statistical analyses are almost certainly correct, I have two general questions/comments for the authors:

The key point of this study is the definition of forest gaps. Because lidar data allow us to quantify gaps in many ways, two parameters are critical to define forest gap disturbances using lidar data. The first critical parameter is the minimum gap size-area. The minimum gap size-area is the main parameter of a pareto distribution (see your equation 2, X_min). The second important parameter is lidar height threshold used to quantify forest gaps considering that the number of canopy openings increases aboveground.

1. The minimum lidar canopy opening used in this study (9 m2) is VERY small.

Although the choice of any minimum gap size-area is subjective, I do not believe that this minimum gap size-area is really related to forest gap disturbances. The most comprehensive study about the minimum gap size-area observed on ground was done at the 50 ha plot of the Barro Colorado Island (BCI). The minimum gap size-area reported there is around 25 m2 (see Hubbell et al., Science 1999). Because lidar technology allows us to quantify canopy openings beyond of this threshold, there is large ecological confusion between canopy openings related to forest gaps and tree crown spaces. If the authors consider the minimum gap size-area from BCI (which is also very small for a "classical" forest gap) the exponents of those distributions will drop dramatically, perhaps from 1.7 to 1.2. I feel that the authors incorporated in their power-law model much more information about tree crown spaces than forest gaps. The power-law exponents from their gap frequency analysis are not really reporting information about disturbance processes.

2. Lidar tree height used to quantify forest gaps in this study is also very subjective.

The author used height thresholds from 2 to 12 m, but somewhere in the manuscript they justified that the best choice for a lidar height threshold is around 8 m (Figure 4 and 5). What was the main criterion to quantify forest gaps around 8 m? I feel that the authors selected forest gaps around 8 m aboveground because at this height there is enough data (gaps) to fit a statistical model. At 2 m aboveground there are only few gaps because the sample area (100 ha or 1 km by 1 km) is also very small to quantify forest disturbances. In the Amazon the density of forest gaps (> 20 m2) per ha is around 0.3. If the authors increase the samples for 200 ha (1 km by 2 km) the gap frequency at 2 m height will be enough for a statistical test. Moreover, because gaps around 8 m aboveground includes a wider array of disturbance types (recent tree fall and gaps with regrowth or re-sprouting up 20 to crown-breaking or failure of large branches), gaps from heights close to the forest floor (2 m or 5 m aboveground) are "young" disturbances. More important, it excludes regrowth. Increasing the sample area for about 200 ha and focusing the analysis on recent gaps (2 m or 5 m above-

ground) the authors could really understand better the effects of forest disturbances on structure of peat swamp forests.

Technical corrections:

10986-L10: I agree that there area many canopy gaps in different height cross-sections of the lidar tree heights. The question is: are they millions of canopy gaps or millions of tree crown spaces? If you cut-off of the minimum gap size-area is based on ground observation ($\sim$ 25 m2), there area few gaps in a 100 ha forest plot. As I mentioned before, I feel that the authors have incorporated more information about crown spaces rather than forest gaps.

10986-L15: the exponent of the gap frequency distribution (1.76-3.76) is high because there is a huge number of small gaps incorporated in the statistical model. If you apply a minimum gap size-area threshold that matches ground observations (ex. BCI data or any other ecological study reporting a minimum gap size-area), the exponent of this power-law distribution will decrease; perhaps exponents will be around 1.2. I believe that this power law fit may be heavily weighted to small holes in the forest canopy that are not gaps in an ecological sense.

10987-from L1 to L23: This introduction is not well organized. The authors started with a discussion about forest structure, moved to light attenuations in the canopy, changed for biodiversity, mentioned land-use processes and finished with a description of Borneo. All those topics described at the begging of the introduction! Please, rephrase and focus only in few key points.

10988-L18: " It goes without saying…" Remove it? Rephrase? or Start from "Satellite studies have had …"

10989 – L23: "processed with ClasLite" . Ok, but the real analysis behind of this method is not ClasLite. It is an "un-mixing image spectrometry approach". I suggest you mention it. ClasLite is just an unmixing image algorithm. There are several others available. . .

10990 – from L3 to L5. I appreciated that the authors tried to quantify the intensity of logging using lidar data. However, I do not see why 500 m appeared to be more reasonable. Any buffer is subjective, but the support material (Figure S2) is not too much informative. The easiest way to see any spatial trend is to use "semivariograms" from geostatistics. Again, this is not critical – it is only a suggestion!

10990 – L23. This is critical. 100 ha is very small to quantify forest gaps. If the authors increase the sample area for 200 ha, you will find enough data at 2 m aboveground (tree-fall gaps without regrowth). It is also another additional suggestion. Overall, all statistic analyses of this paper were well done.

10991 – L23. Now, this is VERY critical! Gaps < 9 m2, are not gaps and I agree with the authors. However, I have not found a single publication about the minimum size-area of tree-fall gap in the ecological literature smaller than 20-25 m2. I think the majority of your data (Gaps < 9 m2) are not gaps in the ecological sense. Perhaps they are tree crown spaces related to sunflecks processes in forests. I think that the minimum gap size-area threshold should be increased for 20-25 m2. Using a large minimum gap size area threshold all lidar forest gaps (holes) are tree-fall disturbances (albeit Brokaw 1992).

10992 – L13. I appreciated the test of this "modified finite pareto function", but the model is more complex now. What is the ecological meaning of this transition parameter (θ) for forest gaps? It is not clear in the article. . .

10993 – L1-L7. The reason that the authors used a cross section starting at 5 m aboveground is because the sample area is very small (100 ha). The data does not show any trend of power-law because there is not enough data at 2 m aboveground. It does not mean that tree-fall gaps do not follow a power law distribution at 2 m height. If you increase your sample area for 200 ha and consider a reasonable minimum gap size-area (20-25 m2) the data will follow a power-law distribution even in 2 m aboveground.

10993 – from L11 to L14. I also appreciated the ground collections of peat depth. However, I just did not understand why the authors did not used the digital terrain model (DTM) directly to test the prediction of peat depth. Terrain information is more correlated with soil propriety than vegetation information. I am aware that the study site is very flat, but lidar remote sensing is very powerful to quantify small changes in the forest floor. DTM from my understanding are more meaningful to understand peat depth in the soils than a lidar canopy height model.

10996 – L25. "The GSFD scaling coefficient (exponent?) became larger with increasing peat depth, indicating a increasing proportion of small gaps". Is it really related to tree-fall gaps or increasing in crown spaces of the forest canopy? From my previous field experiences, flooded forests have more opened crowns than other areas. I guess the same thing happens for areas with large peat depth.

L10997 – from L1 to L2. I do not agree. I think the selection of 8 m cross section was based on lack of data (frequency of tree-fall gaps). Again, 100 ha is very small to detect recent gaps at 2 or 5 m aboveground. Only around 8 m aboveground the frequency of gaps are reasonable to test statistical power-law model.

L10997 – from L8 to L10. This was a fantastic result even using a lidar height threshold of 8 m! However, be aware that at 8 m your results are from disturbances and regrowth. Different processes!

L10998 – L19. The canopy of selective logged forests remained open 11 years after concessionary. It is from your observation or from some reference? I found difficult to believe, but I guess the intensity of logging was very high there. . .

L10999 – L1. Nice result! My only problem here is why the authors did not use the digital terrain model to estimate peat depth?

L10999 – L24. U-shaped pattern? Just because Kellner used this terminology, it does not mean that you should adopt. Because you did not illustrate a U-shape graph of the gap frequency distribution aboveground this terminology is not useful...

L10999 – L16. Small proportions of large gaps or high frequency of tree crown spaces (small gaps < 20 m2) on deep peats?

L10999 – L25. Pervasive? I do not see why. It was based on tree-fall gaps disturbances or tree crown spaces?

L1003 – from L12 to L14. The absence of tree fall gaps in those areas from 2 to 7 m aboveground is because of the size of the sample (100 ha) and not because of the absence of tree-fall gaps at the landscape scale.

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