Response to reviews on the manuscript "Landscape-scale changes in forest canopy structure across a partially logged tropical peat swamp" by B. M. M. Wedeux and D. A. Coomes.

We thank M. Disney, R. Hill, F. Espirito-Santo and M. Hayashi for their comments, which have helped improve the manuscript. We thank the handling associate editor A. Ito for considering the revised manuscript and hope he will now find it suitable for publication.

We respond to the comments in detail below. Additions to the manuscript are marked in blue, both in this response and the manuscript.

Response to M. Disney's comments

[Referee comment] **General comments**

This paper presents an interesting analysis of canopy height and structure (layering, gap size) from airborne laser scanner data, particularly in relation to peat depth and logging intensity. This is a rare opportunity to study the response of forest regrowth in relation to peat depth. The authors do a really good job of the analysis and there are some interesting findings, particularly the strength of correlation of height to peat depth, and the distinction between the regrowth patterns. One or two things arise which could perhaps be better explained/illustrated - particularly the empirical relationship with which peat depth is inferred (not measured). The rest of the analysis depends on this, and yet it isn't included in the main paper, in the supplement only. There is some validation of this in the Supplementary but I'd like to see this brought into the main paper and discussed in more detail, as pretty much everything else follows from this.

[Author response] This issue, also raised by R. Hill, has been addressed by adding more information from SI in the methods section of the main text, as follows:

10993 l.10: We disposed of an independent data set of more than 300 peat depth measurements across the study area and measured canopy top height (99^{th} quantile of height) within a 100 m neighbourhood. We first tested for the effect of logging on canopy top height in this independent dataset by fitting generalised linear models containing peat depth and additive or multiplicative effects of logging as a factor (yes, no). No significant logging effect was detected. We found that canopy top height was closely related to peat depth (R^2=0.79) except on shallow peat within 3000 m of the Kapuas river (Fig. S3a). On shallow peat, distance to river was linearly related to peat depth (R^2 = 0.59; Fig. S3b). Peat depth for our study plots was thus inferred as (Eq. 3):

$$Peat\ depth = \begin{cases} 26.0 - 0.7 \times top.height\ for\ dist.riv > 3000\ m, \\ 0.31 + 0.002 \times dist.riv\ for\ dist.riv \leq 3000m, \end{cases} \quad (3)$$

where *top.height* is canopy top height (99^{th} quantile) and *dist.riv* is distance to the large Kapuas river. The inference of peat depth from canopy top height was thus done from an independent data set to the plot data further used for analyses. This approach was validated, as it yielded a fit going through the origin and with an R^2 = 0.88 between predicted and measured peat values in 33 plots where peat data was available.

[Referee comment] *One question I had was whether there may be a confounding factor of logging on deeper peat being more tricky in terms of accessibility for vehicles etc so that logging intensity/rate is lower?*

[Author response] Commercial logging operations on peats use light railways to extract logs. The main determinant of logging effort is likely the distance to the river, and usually that means logging is predominantly on shallow peats that occur near rivers. The taller forests on these shallower peats are easier to navigate and have a higher density of large stems, so are more suitable for logging. However our research site is unusual in having a river cutting through deep peat (it formed after the peat swamp had developed) so logging did take place in areas that would normally be avoided. We find that these forests experience longer-lasting and more severe damage from selective logging, which we relate to their ecology. We added a couple of sentences in the discussion:

11002 l.17: PSF on deep peat were deemed unsuitable for commercial logging operations due to low density of poles and fragility of the system (Bruenig & Droste, 1995). Yet we detected concessionary logging railways on deep peat in our study area, and we are developing new techniques to better monitor illegal logging (unpublished data).

[Referee comment] *Otherwise, I think this paper is clear, sound and of broad interest to readers interested in tropical forests, peat and the use of lidar to estimate forest canopy structural characteristic. I only have a few very minor technical comments which should be addressed before final publication.*

Technical comments

<u>*Abstract*</u>

[Referee comment] *High-fidelity doesn't really mean anything to me.*
This word was removed in the abstract and replaced by 'detailed' in the main text (10988 l. 20):
[Author response] Airborne Laser Scanning (ALS) has opened new avenues for canopy research, as it provides detailed information on canopy height, layers and the location of canopy gaps over entire landscapes (Drake et al., 2002; Dubayah et al., 2010; Kellner and Asner, 2009; Lefsky et al., 2002).

[Referee comment] *l13: consistent*
Corrected.

[Referee comment] *l18: long sentence*
[Author response] Split into two sentences, now reads: Areas subjected to concessionary logging until 2000, and illegal logging since then, had the same canopy top height as old growth forest, indicating the persistence of some large trees, but mean canopy height was significantly reduced. With logging, the total area of canopy gaps increased and the GSFD scaling exponent was reduced.

[Referee comment] *l24: canopy structure recovery, as observed by lidar, modulated...*
[Author response] Corrected according to suggestion, the full sentence now reads as: This relationship breaks down after selective logging, with canopy structural recovery, as observed by ALS, modulated by environmental conditions.

<u>*Main*</u>

[Referee comment] *10987 l5: just light*
[Author response] [Author response] Deleted 'energy'.

[Referee comment] *10988 l1: obviously limited - how many?*
[Author response] Difficult to give a precise number but we site the major studies, sometimes spanning several peat domes but likely fewer than 10 in total: Yet this current understanding of forest structural changes is based on very few field studies (Anderson, 1961; Bruenig and Droste, 1995; Bunyavejchewin, 1995; Page et al., 1999; Whitmore, 1975).

[Referee comment] *10989 l21: new paragraph from "We mapped ..."?*
[Author response] Implemented.

[Referee comment] *10990: why 100 plots?*

[Author response] This was an arbitrary choice, but allowed a good coverage of the whole area while avoiding spatial clustering of plots and plots overlapping with land class boundaries.
We added this justification in the text 10990 l.22: A total of 100 virtual plots of 1×1 km were positioned throughout the research area to yield a good coverage of the landscape and avoid having plots crossing land cover boundaries (Fig. S4).

[Referee comment] *10991: why 10 000 points? Why height cutoff at 12m? How sensitive are results to these choices & are they arbitrary?*
[Author response] The number of points was chosen arbitrarily; it is sufficient to give a robust estimate of 99th quantile height while being computationally efficient:
Within each plot, canopy height was extracted from 10,000 random selected pixels (to optimise computing time and provide a representative sample) …
The 12 m cut-off was selected based on the fact that gaps from different origins (*e.g.* corresponding to separate gaps reaching down to the ground) start merging above 12 m (Fig. S5), creating huge gaps above the canopy of many trees. This causes these huge gaps to be truncated at plot edges, which we wanted to avoid. We clarified the main text:
The upper CHM cross-section considered was 12 m to avoid the coalescence of gaps from distinct origins and truncation of those huge gaps at plot edges, observed above this threshold (see Fig. S5 for a fuller explanation).
[Referee comment] *10992 l2: most? Or just various?*
[Author response] To our knowledge, all of them have fitted power laws. We removed 'most'. The sentence is now: Recent studies using ALS to detect canopy gaps have fitted a power law to describe the GSFD (Asner et al., 2013; Boyd et al., 2013; Espírito-Santo et al., 2014; Kellner and Asner, 2009; Kellner et al., 2011; Lobo and Dalling, 2013).

[Referee comment] *10996: visual inspection - any way of doing this quantitatively?*
[Author response] We reanalysed the data in order to address this question and noticed that we had made a small error in the calculation of the canopy shape coefficient. The new result is very similar to 'standardised mean canopy height', so the latter was removed. We have simplified the figure accordingly and have made amendments in the text and in Table S3. In the text we now have:
10996 l.9: The canopy shape, derived from the complete ALS point cloud, did not change along the peat depth gradient in old-growth forest (grey line, Fig. 3b) suggesting that the height of the main canopy volume decreased in parallel to canopy top height (Fig. 3a).
10997 l.14: However a marked decrease of canopy shape was observed (Fig. 3b), indicating the removal of canopy volume in logged plots. In the 8 m cross-section…
10998 l.6: Logging had a constant effect on canopy shape across the peat dome (Fig. 3b; model M2 selected), …
11002 l.3: Canopy top height remained unaltered after selective logging probably because some tall low-value timber trees remain unharvested, but the relative vertical distribution of canopy volume was reduced by tree removal under logging.

[Referee comment] *10996 l13: increasingly closer? Clumsy.*
[Author response] The sentence is now: The canopy shape, derived from the complete ALS point cloud, did not change along the peat depth gradient in old-growth forest (grey line, Fig. 3b) suggesting that the height of the main canopy volume decreased in parallel to canopy top height (Fig. 3a).

[Referee comment] *10996: do you mean significant in a statistical sense here?*
[Author response] We rephrased the sentence to include 'statistically significant' and refer to Table S3, clarifying that this analysis was based on generalized linear modelling. The sentence now reads: The GSFD transition parameter, θ, decreased significantly with peat depth for cross-sections up to 8-m height above ground (Fig. 4d, Table S3), but the trend was not statistically significant in the 8-m cross-section (Table S3).

[Referee comment] *10997 l3: define weak or just give values.*

[Author response] This was rephrased as: Negative correlations between α and θ in cross-sections ≥ 6 m height (Pearson correlation coefficient r = -0.25–-0.35) indicated that θ was greatest in sites containing large gaps.

[Referee comment] *10997 l7: define good or just give values. Avoid qualitative statements like this.*
[Author response] Since the R^2 values are given in the second part of the sentence, we rephrased the first part as: Canopy top height accounted for a large proportion of the variation in canopy gap metrics along the peat dome (recalling that peat depth is negatively related with canopy top height and mean gap area) and was linearly related to mean gap size (Fig. 5a, R^2=0.82, $p < 0.001$) and to α (Fig. 5b, $R^2 = 0.75$, $p < 0.001$) (Table S5).

[Referee comment] *10997 l27: indices*
[Author response] Corrected.

[Referee comment] *10998 l7: differing?*
[Author response] Corrected.

[Referee comment] *11000 l20: also, rather than additionally*
[Author response] Corrected.

[Referee comment] *11001 l17: "more ecologically meaningful scales" - meaning?*
[Author response] Rephrased as: Combining ALS-derived forest structure measurements with ground data of major environmental drivers opens new avenues for researchers to explore ecological processes, e.g. disturbance dynamics, at spatial scales at which such processes take place, rather than being confined to small-scale plot studies.

[Referee comment] *11003 l21: no "yet"*
[Author response] Corrected.

[Referee comment] *Fig 2 - maybe too much info in here to process properly in 1 fig. Would also be useful to have the pareto distribution plots (lower row) for the various cases above ie the different height layers.*
[Author response] We followed the reviewer's suggestion and replaced the first panel of the gap size distribution examples with a panel showing gap size distributions at different heights above ground. We have inserted more spaces between the different parts of the figure, but decided against split it into two. The figure caption is adjusted accordingly.

[Referee comment] *Fig 3 - the 'logged' symbols are red on the plots but not in the legend which is a bit confusing. This is also the case for figs 4 and 5.*
[Author response] This has been changed.

[Referee comment] *Fig 3 d is not very useful as it's too hard to tell the difference of the overlaid lines in terms of the colour. This needs to be displayed differently in some way. And why is old-growth grayscale and logged in colour?*
[Author response] To improve the readability of this figure, we selected a subset of representative plots at different peat depths for both old-growth and logged forest and only show the canopy profiles for those plots. The grey and red colour code in this figure is consistent with the colour code of other figures throughout the paper (old-growth = grey, logged = red).

Response to R. Hill's comments on the manuscript "Landscape-scale changes in forest canopy structure across a partially logged tropical peat swamp".

[Referee comment] *This manuscript investigates the dual effects of peat depth and logging disturbance on canopy structure in peat swamp forest in Central Kalimantan, Indonesia. The emphasis is on canopy height, shape and various gap size metrics. Data are drawn from 100 plots of*

1 sq. km size extracted from airborne lidar data. Overall, this manuscript is very well written, is thoroughly researched, well referenced and fully contextualised. The main article is well supported by supplementary material, although in places some of this information should to be included (or at least summarised in more detail) in the main article itself to provide a fuller justification of some of the methodological decisions. Also, perhaps the abstract would benefit from a final sentence highlighting specifically what the findings contribute to the understanding of tropical peat swamp forest ecology and management.

[Author response] A sentence was added as suggested: These findings improve our understanding of tropical peat swamp ecology and provide important insights for managers aiming to restore degraded forests.

Specific comments

[Referee comment] *10986 lines 6-7 (and 10988 line 20): what is meant by high fidelity ALS data?*

[Author response] This word was removed in the abstract and replaced by 'detailed' in the main text (10988 l. 20): Airborne Laser Scanning (ALS) has opened new avenues for canopy research, as it provides detailed information on canopy height, layers and the location of canopy gaps over entire landscapes (Drake et al., 2002; Dubayah et al., 2010; Kellner and Asner, 2009; Lefsky et al., 2002).

[Referee comment] *10986 line 13: this should probably be 'consistent with' rather than 'consistently with'.*

[Author response] Corrected.

[Referee comment] *10988 lines 17-19: this sentence relates specifically to satellite optical data. Perhaps an additional sentence should be added here to mention studies which have used satellite radar data for tropical forest structure assessment.*

[Author response] We clarify the difference between optical and radar satellite imagery and add a reference to a radar study analysing canopy openness in our study area:

It goes without saying that logging modifies canopy structure (Asner et al., 2004b), but optical satellite studies have had limited power in measuring logging effects as they lack information about the intricate three-dimensional structure of canopies, and only recently have researchers used satellite radar data to delineate degraded forests (e.g. Schlund et al., 2014).

[Referee comment] *10989 lines 25-26: perhaps edit to read 'high fractions of soil or dead vegetation'*

[Author response] Edited: ClasLite renders sub-pixel fractional cover information that enabled the identification of logging routes characterised by high fractions of soil or dead vegetation (Asner, 2009).

[Referee comment] *10990 lines 2-6: mean canopy height maps were used to determine that logging takes place within 500 m of a logging route, and therefore this was used as a generic buffer to determine selectively logged forest. However, a buffer of 5 km was applied to forest around the Kapuas River. Does the same decision rule of mean canopy height support this buffer size? If so, it is worth adding this to the manuscript, as the methods here do not seem to be quite consistent.*

[Author response] Local communities have traditional rights to use land within 5 km of settlements (this being accepted by local governments), and probably make use of forests far away from the rivers. So we could not classify these forests as 'old-growth'. We know that **54%** of the land used by communities overlapped with areas we had identified as logged by companies. The remainder of this land continues to be used. Therefore, the approach used to determine the buffer around the logging roads would not be suitable. We have improved the text:

Forest within 5 km of the Kapuas river, could not be classified as 'old-growth' because local villagers have traditional land rights in that area, and make use of the forests (KFCP, 2009). Since 54% of the area was interspersed with logging routes, it was classified as 'logged'.

[Referee comment] *10990 line 10: it is probably worth specifying how many returns were recorded per pulse in the main text, to help contextualise the figure of 2.8 points per sq. m.*

[Author response] This information was not provided with the data, and could not be provided by main contact person after request. So unfortunately we cannot provide readers with this information.

[Referee comment] *10990 line 18: perhaps it is worth stating why the lidar point data were voxelised at a 20 x 20 m horizontal spatial scale (i.e. how does this relate to crown and gap size).*
[Author response] The size of 20 x 20 m was chosen in order to have sufficient returns within each voxel (20 x 20 x 1m) to provide a robust estimate of the percentage of returns within each voxel relative to the column (1120 returns within column, split into 40 height layers, thus an average of 28 returns per voxel).

[Referee comment] *1091 line 4: why extract height metrics from 10,000 randomly selected pixels of the CHM. Why not simply use all pixels in the CHM? This decision should be justified.*
[Author response] This was chosen arbitrarily but allowed optimising computing time while providing a robust subsample of the plot, suitable to calculate the metric of interest. We added:
Within each plot, canopy height was extracted from 10,000 random selected pixels (to optimise computing time and provide a representative sample) …

[Referee comment] *10991 section 2.2.2. It is perhaps worth stating how gaps at the edge of the 1 sq. km plots were treated (e.g. gap size measurement was truncated at the plot edge, or gaps were only counted if the centre was in the plot, or gaps were measured if any part was within the plot, etc).*
[Author response] Gap size measurement was truncated at the edge of the plot, but the effect on gap size distributions is small because we used large plot sizes (1 km^2). We made a note in the text:
Gaps were truncated at the edge of the plot.

[Referee comment] *10993 section 2.3.1. The validity of the relationship between peat depth and both canopy top height and distance to river is fully demonstrated by the supplementary material. However, given that the effects of peat depth on canopy structure is a key aspect of this manuscript, then perhaps a little more information is required in the main article in this section – in particular to state how peat depth was inferred from the two relationships and with what accuracy level.*
[Author response] This issue was also raised by M. Disney, we have addressed it by adding more information from SI in the methods section of the main text, as follows:

10993 l.10: We disposed of an independent data set of more than 300 peat depth measurements across the study area and measured canopy top height (99th quantile of height) within a 100 m neighbourhood. We first tested for the effect of logging on canopy top height in this independent dataset by fitting generalised linear models containing peat depth and additive or multiplicative effects of logging as a factor (yes, no). No significant logging effect was detected. We found that canopy top height was closely related to peat depth (R^2=0.79) except on shallow peat within 3000 m of the Kapuas river (Fig. S3a). On shallow peat, distance to river was linearly related to peat depth (R^2 = 0.59; Fig. S3b). Peat depth for our study plots was thus inferred as (Eq. 3):

$$Peat\ depth = \begin{cases} 26.0 - 0.7 \times top.height\ for\ dist.riv > 3000\ m, \\ 0.31 + 0.002 \times dist.riv\ for\ dist.riv \leq 3000m, \end{cases} \quad (3)$$

where *top.height* is canopy top height (99th quantile) and *dist.riv* is distance to the large Kapuas river. The inference of peat depth from canopy top height was thus done from an independent data set to the plot data further used for analyses. This approach was validated, as it yielded a fit going through the origin and with an R^2 = 0.88 between predicted and measured peat values in 33 plots where peat data was available.

[Referee comment] *10995 line 9: was data normality tested or assumed in these cases?*
[Author response] Text modified to clarify: All other analyses assumed normal distributions, as supported by visual inspection of residuals.

[Referee comment] *10995 line 23 (and 10997 4): should p values also be stated here?*
[Author response] P-values added:

Note that LPIs did not significantly co-vary with peat depth ($r = 0.05–0.25$, $p > 0.05$).

Negative correlations were found between α and θ in cross-sections ≥ 6 m height (Pearson correlation coefficient r = -0.25–-0.35, p = 0.02 – 0.67);…

[Referee comment] *10996 lines 27-28: was the relationship between the GSFD transition parameter and peat depth tested statistically? (If so, it would be useful to give the r and p values in the text).*
[Author response] We rephrased the sentence to include 'statistically significant' and refer to Table S3, clarifying that this analysis was based on generalized linear modelling. The sentence now reads: The GSFD transition parameter, θ, decreased significantly with peat depth for cross-sections up to 8-m height above ground (Fig. 4d, Table S3), but the trend was not statistically significant in the 8-m cross-section (Table S3).

[Referee comment] *10997 line 23: should an R2 value also be quoted in this sentence for canopy top height?*
[Author response] Canopy top height is the explanatory variable here, and is related once to mean gap area and once to α. This is clarified by rewording the sentence to:

Because of unequal effects on canopy top height and gaps, we no longer observed the tight relationships (marked decrease in R^2) among canopy top height as an explanatory variable and mean gap area (Fig. 5a, $R^2 = 0.28$, $p < 0.001$) or α (Fig 5 b, $R^2 = 0.38$, $p < 0.001$) which we found in old-growth forest (Table S5).

[Referee comment] *10998 line 1: edit to 'in areas that we had identified as logged'*
[Author response] Added 'that'.

[Referee comment] *10998 lines 11-15: In the first half of this sentence it should be made more clear that this relates to gap structural characteristics rather than structure in general.*
[Author response] Inserted 'gap' to clarify: In all cases, canopy gaps showed … exhibited a more strongly altered canopy gap structure…

[Referee comment] *10998 line 20: 'landscape-scale coordination'. Perhaps this should be correlation, correspondence or relationship instead of coordination?*
[Author response] Indeed, 'coordination' is not the right word here. We have replaced it by 'relationship'. The sentence now reads: As such, the landscape-scale relationship between forest height and natural disturbance patterns was lost in selectively logged forests.

[Referee comment] *11000 line 23: should be forest communities (rather than forests communities).*
[Author response] Corrected.

[Referee comment] *11002 line 10: 'take long to recover' - reword this.*
[Author response] Reworded as: This effect did not vary with the age of logging routes which suggests that existing logging routes have slow structural recovery or continue to be used for informal timber harvesting.

[Referee comment] *11002 line 18: note that variation in logging pressure did not affect canopy structure, but logging pressure itself clearly did (i.e. this sentence could be interpreted to mean that logging does not affect canopy structure).*
[Author response] Addressed as: Since the logging pressure was relatively homogenous along the peat depth gradient and canopy structure did not respond to variation in logging pressure, we can interpret …

[Referee comment] *11003 line 9: perhaps specify which satellite images Franke et al. are referring to.*
[Author response] We specified the type of sensor and its spatial resolution: For instance, Franke et al. (2012) report that canopy disturbance of peat swamp forest from selective logging and small logging trails became invisible in RapidEye satellite images with 5 m spatial resolution only a year after they were active, likely due to leaf cover rather than biomass recovery (Asner et al., 2004a).

[Referee comment] *11007 line 18: delete 'replace by'*
[Author response] Corrected.

Response to M. Hayashi's comments

General comments:
The manuscript describes a detailed analysis for forest canopy structure of peat swamp forest using ALS. I highly evaluate the manuscript, because it can widen utilization possibilities of ALS for forest observation. However, I recommend some minor revisions listed below.

Specific comments:
Introduction
[Referee comment] - *I dose not know what is the 'peat dome', and the term is also unfamiliar for many people. Please describe a brief explanation of 'peat dome', including its origin, spatial scale, and so on.*
[Author response] A sentence was added in the introduction to give more details:
10987 l.24: Peat domes form by accumulation of organic matter over millennia; peat dome complexes can be up to 60 km in diameter, with peat depths reaching up to 20 m in the centre of the dome (Ashton, 2014).

[Referee comment] - *Please describe the previous studies which apply ALS to canopy structure analysis, and clear the novelty of this study.*
[Author response] We have clarified this as follows at 10988 l.20: Previous studies have used ALS to analyse the variation in gap sizes in different forest types within landscapes (Kellner & Asner, 2009; Kellner *et al.*, 2011; Asner *et al.*, 2013, 2014; Boyd *et al.*, 2013; Espírito-Santo *et al.*, 2014) and the impacts of logging on above-ground biomass (Andersen et al., 2013; d'Oliveira et al., 2012; Englhart et al., 2013; Kronseder et al., 2012; but see Weishampel et al., 2012). Changes in canopy structure along continuous environmental gradients within landscapes and the potentially long-term impact of logging on canopy structure remain to be studied.

Material and methods
[Referee comment] - *Was the ALS measurement conducted over the entire study area of 750 km2? If so,why did the authors analyze for only 100 plots of 1km 1km (= 100 km2)?*
[Author response] We chose to analyse only a subsample of the area because we needed discrete study entities in order to analyse gap metrics, notably the gap size frequency distribution, and relate them to peat depth. The study plots exceed the cover of many other studies. Finally, this was an arbitrary choice, but allowed a good coverage of the whole area while avoiding spatial clustering of plots and plots overlapping with land class boundaries. We added this justification in the text 10990 l.22: A total of 100 virtual plots of 1×1 km were positioned throughout the research area to yield a good coverage of the landscape and avoid having plots crossing land cover boundaries (Fig. S4).

[Referee comment] - *[section 2.3.1] Because the peat depth was estimated from canopy hieght, I felt a little strange about the analysis of relationship between peat depth and canopy structure. I think it is better to explain that the procedure was without problems.*

[Author response] We have attempted to clarify that the inference of peat depth by canopy top height was conducted from an independent data set. Thus it does not interfere with later analyses done on the plot data. We have added this section to the main text:
We disposed of an independent data set of more than 300 peat depth measurements across the study area and measured canopy top height (99th quantile of height) within a 100 m neighbourhood. We first tested for the effect of logging on canopy top height in this independent dataset by fitting generalised linear models containing peat depth and additive or multiplicative effects of logging as a factor (yes, no). No significant logging effect was detected. We found that canopy top height was a good predictor of peat depth (R^2=0.77) except on shallow peat within 3000 m of the Kapuas river (Fig. S3a). On shallow peat, distance to river was a good predictor of peat depth (R^2 = 0.59; Fig. S3b). Peat depth for our study plots was thus inferred as (Eq. 3):

$$Peat\ depth = \begin{cases} 28.0 - 0.8 \times top.height\ for\ dist.riv > 3000\ m, \\ 0.31 + 0.002 \times dist.riv\ for\ dist.riv \leq 3000m, \end{cases} \quad (3)$$

where *top.height* is canopy top height (99th quantile) and *dist.riv* is distance to the large Kapuas river. The inference of peat depth from canopy top height was thus done from an independent data set to the plot data further used for analyses. This approach was validated, as it yielded a fit going through the origin and with an R^2 = 0.88 between predicted and measured peat values in 33 plots where peat data was available.

Results

[Referee comment] - *[Figure 3] In Figure 3 (a), I wonder whether the canopy top height relates well to the peat depth, because the figure only looks that two data groups differed in characteristics (logged and old-growth vs. mixed) are plotted in a graph. I think it is better to explain the correctness about this.*
[Author response] This is valid because the relationship, and the absence of logging effect, was tested on a larger independent data set of peat depth and canopy top height. We modified the text and the figure legend and refer to section 2.3.1 and the Supplement.
10996 l.5: In an independent data set of more than 300 peat depth measurements and associated canopy top height measurements, canopy top height was not affected by logging (see section 2.3.1, Supplement), suggesting that some large trees (presumably of low commercial value) were left within the plots.
Figure 3 legend: For canopy top height only plots with direct peat measurements are shown and a single regression line is fitted as logging does not affect this metric in an independent data set (section 2.3.1, Supplement).

[Referee comment] *And, two color bars are shown in Figure 3 (d).What's different?*
[Author response] The colour bars refer each to either the old-growth (grey) and logged (red) canopy profiles.

[Referee comment] - *[Figure 4] There is a clear relationship between the peat depth and logged or oldgrowth, although there is no relationship for mixed. For reader's underastanding, it is better to explain the reason.*
We did not address this point specifically in the previous draft of the manuscript. We now relate this to Figure 5, showing that the relationship between canopy top height and gap metrics breaks down in logged forests and add one sentence at 10997 l.25:
This explains the absence of relationship between peat depth and gap metrics in the first half of the peat depth gradient (Figs 4a-d).