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Biogeosciences Discussions

Interactive comment on "Estimation of Coarse Woody Debris Stocks in Intact and Degraded Forests in the Brazilian Amazon Using Airborne Lidar" *by* Marcos A. S. Scaranello et al.

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Response to interactive comment, "Estimation of Coarse Woody Debris Stocks in Intact and Degraded Forests in the Brazilian Amazon Using Airborne Lidar"

We are especially grateful to Alice Gargano and Marc Grob and their professor Michael W. I. Schmidt for their attention and suggestions.

We respond to all concerns and suggestions below.

Interactive comment submitted by Michael W. I. Schmidt

Comment: Generally, the paper is very interesting to read and contains a detailed de-

scription, yet the abundance of numbers in % or meters per each dataset makes it hard for the reader to fully understand and keep track. It is very technical, mainly discusses the lidar predictor model and has only a limited part involving the dead wood's contribution to carbon storages, which makes us, as non-experts, reflect whether it really belongs to a biogeosciences journal or rather to a remote sensing one. However, we agree with the importance of the topic and think the paper can be published after some modifications.

Response: Our paper is technical and we strived to present a large amount of information in a concise manner. We prefer not to add background material that has been published many times elsewhere. One anonymous reviewer praised our presentation. Here is what reviewer 1 wrote, "The overall quality of the discussion paper is, to my impression, good. I appreciate the concise way of writing and the nicely structured style (well chosen paragraphs). All chapters are in good balance; language is mostly very good and as far as I can tell references are provided in an appropriate manner and number." Although this article sounds technical we strongly believe that this study is appropriate for the broad audience of Biogeoscience concerned with the importance of dead wood in forest ecosystems. Our study is novel because it is the most extensive dataset of CWD ever collected in the tropical forest using identical protocols for intact and degraded forests. Moreover, it is the first study that quantifies the relation between forest degradation and dead wood stocks using a unique methodology that combines airborne LiDAR and forest inventory.

Comment: At the beginning of the paper we would have appreciated a short section on the detailed contribution of dead wood to carbon storage and the related processes. It would be a good introduction to the topic and could better justify the importance of the study.

Response: The contribution of CDW on carbon storage and cycle are described in the following sentences of the introduction.

Forest degradation is accelerating the rate of tree mortality across the tropics (McDowell et al., 2018), leading to severe losses of live aboveground biomass (AGB) (Berenguer et al., 2014; Cochrane, 2003; Longo et al., 2016; Rappaport et al., 2018) and gain of coarse dead wood (CDW) in the forest floor. Aboveground live biomass decreased 35% after logging and 55% after burning + logging in Paragominas Municipality, in the eastern Brazilian Amazon, whereas in Santarem municipality (central Brazilian Amazon) the aboveground live biomass decreased 18%, 17%, 24% after logging, burning, and burning+logging, respectively (Berenguer et al., 2014).

We will highlight the importance of CDW by replacing the previous sentences with the section below.

Forest degradation is accelerating the rate of tree mortality across the tropics (McDowell et al., 2018), leading to severe losses of live aboveground biomass (AGB) (Berenguer et al., 2014; Cochrane, 2003; Longo et al., 2016; Rappaport et al., 2018). In several areas of the tropics, the AGB decreased dramatically after multiple events of forest degradation (logging, burning, burning and logging). In central and eastern Brazilian Amazon the AGB decreased between 18-24% and 35-55% in Santarém and Paragominas regions, respectively. On the other hand, forest degradation promotes the increase of CDW in the forest floor. The stocks of CDW increase substantially after forest disturbance by logging and fire. For example, fallen CDW stocks increased from 55 Mg ha-1 in intact forest to 75 Mg ha-1 with reduced impact logging, and to almost 110 Mg ha-1 in a conventionally logged forest in Paragominas Municipality (Keller et al., 2004). The importance of CDW is magnified in degraded tropical forests (Alamgir et al., 2016). In degraded forests, CDW stocks can exceed the live aboveground biomass pool (Gerwing, 2002; Palace et al., 2012). Quantifying the spatial and temporal variability of CDW production and decay is therefore critical to constrain the magnitude and timing of carbon emissions from forest degradation or climate anomalies such as droughts (Leitold et al., 2018).

Comment: Moreover, the paper does not describe clear hypotheses and expectations

regarding data collection and results. This part is particularly important due to the existing uncertainties and unexploredness regarding coarse dead wood.

Response: The reviewers are correct that we did not state an explicit hypothesis to be tested. However, our hypothesis is implicit to the goal statement at the end of the introduction. “Using airborne remote sensing data, we developed the first lidar-derived estimates of CWD for intact and degraded tropical forests including areas that have been logged, burned, and fragmented by deforestation for agricultural expansion.” The implicit hypothesis is that lidar metrics can be used to model the distribution of dead wood across tropical forest landscapes. We tested this hypothesis through the development of the regression models.

Comment: The Amazonian Forest is extremely large and your study focuses only on a small tract of the its area (according to the stated lidar-data used). How representative is this, given the not very high performance of the predictors?

Response: The study sites are distributed across a broad area of the Brazilian Amazon. They were not chosen based on a systematic or random design so we cannot be certain that they are representative. Testing the representativeness of our sample goes beyond the scope of this paper and presents a challenge for future studies.

Comment: In the results section, you could add a small table summarizing the results you compare, the best resulting predictors and comparison between lidar-only and historical models.

Response: Tables 4 and 5 summarize our tested models and we use the same table format to facilitate comparison of our results. We prefer not to add an extra table with no new information

Comment: Moreover, in the discussion you accentuate that the differences in site-specific characteristics are uncovered by the slight improvement achieved by the historical model. The RMSE decreased of only 1% making it questionable whether historical

scenarios are detailed enough.

Response: We agree with this comment and we acknowledged this comment in the discussion section. The historical data did not improve our models. We did not attempt to develop more detailed historical information because of the huge effort required to process all this information. This goes beyond the scope of this paper.

Comment: Page 2, line 11: What are the structural variables exactly? Maybe you could give a short definition.

Response: We agree that this statement may be confusing. We should have called these "variables quantifying forest structure," and we will change the text in the abstract.

Comment: Page 3, line 4: The exact value of 60 Pg-C is in our opinion not appropriate, due to uncertainty. You could either give a range or use "approximately" to reduce the anchoring effect of the absolute value.

Response: We will say "about 60 Pg-C."

Comment: Page 3, line 10f.: Too many percentages are reducing the readability.

Response: We believe that all these numbers are important and we prefer to leave these numbers in the article.

Comment: Page 3, line 25f.: Considering that the study was conducted during three years, the question arises whether any feedback or temporary changes during this period have been considered.

Response: The lidar and forest inventory collections were nearly simultaneous such that changes in forest structure during the study minimally influenced changes in stocks of CDW. We do not believe that these changes had influence in our models. Each combination of field sample and lidar sample represents a single unit of our sample design and thus useful for fitting our statistical models. We did not use or present any multitemporal comparisons (lidar flights collected at the same location with temporal

variation).

Comment: Page 4, line 10: Why did you choose this period? How can that be justified?

Response: Our airborne lidar campaigns happened between 2012 and 2015 constraining our analysis for this period. We wrote that "airborne lidar data used in this study was collected between 2012 and 2015." There is no justification except that we had funding during that period to collect a substantial amount of data.

Comment: Page 4, line 25f.: Were the assumptions for regression met? Normality, homoscedasticity, etc.

Response: The answer is yes. As we noted on page 7, line 25, "We log transformed (natural log) the response variables when necessary for improved model prediction and error distribution assumptions."

Comment: Page 7, line 14: Why was the subset selection approach chosen?

Response: As noted on page 7, line 14, "we used the subset selection approach to identify the simplest and most informative combination of variables (Andersen et al., 2014; Miller, 1984)."

Comment: Page 10, line 8: What is the single event (here mentioned) exactly?

Response: "A single event" refers to one episode of degradation such as logging or burning within one year. We will change the phrase to "single degradation event" for clarity.

Comment: Page 19, Figure 1: Figure 1 does not really help nor guide the reader, we believe it could be improved by adding an inset map to facilitate the orientation and readability of the location of the test sites and points for each site instead of the abbreviations of the test sites.

Response: We made improvements in figure 1 as requested by reviewer #2. We studied 14 sites as listed in Table 1. Providing inset maps for each site would require a

large amount of space (several pages) and we do not think that the additional information provided by multiple inset maps is necessary to support the conclusions in our paper. We note that detailed site design information including the locations of all lidar coverages and field plots to $\sim$1 m accuracy are provided in our on-line data and meta-data available at https://www.paisagenslidar.cnptia.embrapa.br/webgis/

Comment: Furthermore, the canopy height map colours are hard too identify regarding the visual differentiation on the small map as well as the tiny legend. We suggest to either enlarge the map and legend or change at least the colour way.

Response: We believe this comment refers to figure 5. If the journal allocates space, then the maps could be enlarged. We will consider alternative color bars although the one we use is quite common.

Comment: The small figure on the right top shows a rather unnatural pattern between fallen and standing wood, which we cannot explain.

Response: We do not understand this comment or know to which figure it refers. However, we note that the estimates for fall and standing dead wood components are more uncertain that the estimates for total dead wood.

Comment: The explanation of the used statistical approaches could contain a bit more details, like why the subset selection approach was used and whether all regression assumptions were met.

Response: These comments have been addressed previously.

Comment: Page 23, Figure 5: The colourway of the figure is cartographically questionable and the legends have different ranges, making comparison challenging.

Response: We do not understand what is questionable about the color bars and so we do not know how to respond to this comment. The color bar ranges are deliberately different because we felt that the within-site distribution of dead wood was more interesting to represent than the cross-site comparison that is already summarized by

means and standard deviations.

Comment: Furthermore, the predicted mean (red dotted line) and the field-based mean (black dotted line) are hard to detect and not explained in the legend. Moreover, the arrangement of the graphs makes it hard for the reader to compare the different graphs, maybe you use a consistent arrangement for all figures and graphs.

Response: We will add text to the figure legend to explain the field-based and lidar predicted means. The arrangement of the graphics is done to conserve space. It is possible to provide a uniform arrangement of the graphics but we do not think this is worth the effort or the space it will use. For example, all histograms could be placed to the right of the maps. This would use up far more space than our compact figure and provide no additional information. Many experts on research presentations shun so called “white space.”

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