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Interactive comment on "Life cycle of bamboo in southwestern Amazon and its relation to fire events" *by* Ricardo Dalagnol et al.

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General comments: This paper proposes methods to address a very challenging problem in remote sensing - distinguishing between two spectrally similar types of land cover (bamboo forest and bamboo-free forest) using moderate spatial and spectral resolution imagery (MODIS and Landsat). The aim is to map a little-studied, yet spatially expansive, ecosystem in the southwest Amazon - and to establish evidence (or lack thereof) for one hypothesis of bamboo forest establishment and expansion. The study focuses on a fascinating ecosystem, and remote sensing provides the most realistic means of collecting data over such a vast spatial extent in a very remote region. However, I have a number of concerns about the style, methods, and conclusions of the current manuscript, as follows:

1. The methods and results sections include overwhelming detail without clearly out lining goals - both in terms of holistically linking the steps in the methods, and in terms of how the methods relate to broader scientific questions. I am left wondering how the conclusions inform our understanding of the origin and/or biogeochemical processes that maintain/promote expansion of the bamboo forest.

Response: We thank the reviewer 2 for the comments that led to the improvement of the paper, mainly on increasing the clarity of methods section and discussing important aspects on the validation datasets. Specifically to this comment, we agree with the reviewer 2 that the methods section had too much details, and the goal of each analysis was in general not well described. Therefore, we corrected the methods text to address this problem, providing information on how each analysis is linked to the goals, and why the proposed method was chosen for each analyses. The reviewer 2 can check the changes in the updated manuscript, although some of them were shown in the subsequent comments.
About the conclusions, we tested and rejected the bamboo-fire hypothesis which argues that fire is the driver of bamboo domination in the forest. As pointed out by the reviewer 1 comments in a previous revision, and later acknowledged by us, the evidence we presented in the paper did not support the bamboo-fire hypothesis at all even with the underestimate of fire dataset. This was first stated in p.23 l.30: "We cannot support the 'bamboo-fire hypothesis' from Keeley and Bond (1999) because fire occurred only in a small fraction of bamboo-dominated areas during the 16 years of fire analysis (Fig. 6), equivalent to 2371 km^2 of burnt area or 0.0955% of the total bamboo area (155,159 km^2) burning each year, and the statistical tests comparing dead and live bamboo fire frequency showed that dead bamboo did not burn more than live bamboo (Fig. 11). Hence, we believe that there should be other explanations for bamboo maintenance in the forest, such as bamboo itself being responsible for its maintenance in the forest due to the damage it causes in the trees while increasing tree mortality (Griscom and Ashton, 2003).".

Then, aspects of the detection were further discussed in p.24 l.11: "The fire occurrence beyond 2 km inside the forest was probably underestimated because the forest canopy can obscure fires that occur only on the understorey, and, thus, are not detected by the MODIS/Aqua satellite (Roy et al., 2008). In addition, the MODIS active fire detections should be treated as a lower bound of fire occurrence, as it underestimates fire occurrences in the order of 5% for small fires with less than 0.09 km^2, or 10% of MODIS spatial resolution, due to the coarse spatial resolution, high cloud cover, and when having high viewing angles (> 15 °) (Morisette et al., 2005). Nevertheless, we do not believe this might have an impact on rejecting the 'bamboo-fire hypothesis' due to the minimal fraction of fire occurrences occurring over the large bamboo-dominated forests.".
Besides that, the bamboo die-off maps that were produced in the paper can help future studies addressing the bamboo dynamics processes.

2. The great amount of detail included in the methods swamps any discussion of why specific methods were chosen. As a result, there are many places in the manuscript where the reader may be left feeling that they must take things on faith, or, that the steps presented are the result of a circular logic.

Response: We agree. We have included a flowchart in the manuscript (Figure 1) to give a broad view of the analyses and how the sections interact before going into detail. Also, we have adjusted each paragraph in the methods section by first introducing why the analysis was done, stating the method to perform it and why this method was chosen.
Two examples: (1) In p.7 l.4: "The tree cover product was analyzed considering a pre-existent bamboo-dominated forests map from Carvalho et al. (2013) in order to explore the variability of tree cover in forests with and without bamboo which might help mapping the bamboo-dominated forests. We expect that bamboo-dominated forests present lower tree cover values than bamboo-free forest due to its fast dynamics and

higher mortality (Castro et al., 2013; Medeiros et al., 2013). This map was obtained by visual interpretation of live-adult bamboo using two Landsat mosaics 10 years apart from each other (1990 and 2000), supported by the known locations and dates of five bamboo dominated areas. Considering only the pixels inside the bamboo-dominated map, we calculated the 1st, 50th and 99th percentiles of the tree cover product and generated a map showing the areas below the 1st, between the 1st and 99th, and above the 99th percentiles of tree cover. The map was qualitatively analyzed exploring the areas which each percentile covered.";
(2) In p.7 l.28: "To automatically detect the bamboo die-off from 2001 to 2017 we compared each pixel of MODIS (MAIAC) NIR reflectance time series to a bilinear model using Pearson's correlation and an iterative shift approach. The model consisted in a linear increase in reflectance from 1 to 28% between 1 and 28 years of bamboo age followed by an abrupt decrease to 0% when the die-off occur. The model conception was based on Carvalho et al. (2013) findings which showed that forests with adult bamboo have higher NIR reflectance than forests with juvenile and dead bamboo, or without bamboo, and that bamboo present a life cycle approximate to 28 years. Thus, since not much is known about the spectral behavior of bamboo growth with age, we chose a bilinear model to characterize the bamboo signal change overtime because it was the simplest way to represent the change between life stages. We also assumed the signal coming from the trees as constant over time. Therefore, inter-annual reflectance variations were attributed to structural changes in the canopy related to bamboos. The Pearson's correlation coefficient (r) between the NIR reflectance time series and the bilinear model for a given pixel was iteratively tested by shifting the position of the NIR time series inside the bilinear model vector. The position showing the highest r corresponded to the estimated age of that pixel from which the die-off year was retrieved. Only pixels with very significant correlations ($p < 0.001$) were selected. The model was tested with both MODIS (MAIAC) NIR bands: NIR-1 band 2 (841-876 nm) and NIR-2 band 5 (1230-1250 nm). Both bands are sensitive to canopy structure scattering, but NIR-2 is also partially sensitive to leaf/canopy water scattering

(Gao, 1996), so that could lead to a different detection between bands."

3. Several of the steps in the methods depend on thresholds which are determined from sample means, completely ignoring the impact of spectral (and/or spatial) variability. This topic is briefly addressed in the discussion section, but should be treated more rigorously throughout the methods and analysis sections. In fact, I am left feeling that the authors have failed to demonstrate the practical significance of some of their conclusions because the within group variability seems to overwhelm the between group differences.

Response: We agree that the impact of spectral variability was not properly discussed in the paper. We have showed in the empirical bamboo-age spectral curves (Figure 7) that there is a lot of variability in the data. We believe the variability comes mainly from variations in forest structure and bamboo density. However, even though such variability exists, it did not affect the die-off detection, because our method was not based on absolute reflectance values, but on the correlation between the data and a reference, such as the simple bilinear model or the empirical curve. Besides that, even with such huge spectral variability, the method was able to detect the bamboo die-off with great performance (80% accuracy) and, although the predictions for 2017-2028 did not have high accuracy on estimating the exact die-off year, it had acceptable levels of error (around 3 years). We have added this sentence to the discussion in p.23 l.4 to complement the discussion on the large spectral variability: "Nevertheless, because our detection and prediction methods were not based on absolute reflectance values, but on the correlation between the time series and a reference, such as the bilinear model or the empirical curve, we do not believe that the large spectral variability should have a major impact on the detection/prediction."

4. In a similar vein, because many of the steps in the methods depend on sampling statistics, it is problematic that the sampling unit (point, pixel, polygon?) and

sampling protocol (sampling strategy, sample size) remain unspecified in most sections of the paper.

Response: We agree. The reviewer 1 has also pointed the terms (pixel, patch, geolocation, polygon) were confusing. Thus, we have improved the clarity on sampling protocols and terms on methods section. For the first validation dataset (MODIS) for die-off detection during 2001-2017, the new sentence in p.8 l.11 is: "For validation purposes, we compared the detected die-off events with recently dead bamboo areas visually detected in MODIS false color composites (bands 1, 2 and 6 in RGB). In this color composite (Fig. 2), adult bamboo patches show bright green color due to the comparatively higher NIR reflectance, while dead bamboo patches present dark blue/gray color. The visual inspection of bamboo die-off using MODIS and Landsat data was consistent with five bamboo mass flowering events observed in the field (Carvalho et al., 2013). In each of the dead bamboo patches visually detected, the geographic location and die-off year were registered for a sample of 5 random pixels. A total of 78 dead bamboo patches were identified in the 2001–2017 period, thus the validation dataset was composed of 390 pixels with corresponding year of bamboo death - the spatial and temporal distribution of the samples are shown in the supplementary material. For these pixels, the die-off year detected by our model was retrieved and compared to the validation dataset. To assess the detection, we calculated the accuracy (%) on detecting the exact die-off year, Pearson's correlation and p-value, and the root mean square error (RMSE) between the automatically detected and visually interpreted die-off year.".
For the second validation dataset (Landsat) for die-off prediction during 2018-2028, the new sentence in p.9 l.20 is: "Since the validation for 2018-2028 predictions could not be conducted using MODIS data because its time series do not span that time period, we used yearly TM/Landsat-5 color composites (bands 2, 4 and 1 in RGB) during the 1985-2000 period to visually detect the bamboo die-off events that occurred in the last bamboo life cycle and validate the predictions. We assumed that the die-off events

that happened in this period would happen again in the next life cycle of the bamboo, from 2018 to 2028. Therefore, we added 29 years to the visually detected die-off year in order to match the next life cycle. The sampling procedure for the validation dataset was similar to the detection, where 5 pixels were randomly collected for each recently dead bamboo patch visually identified in a given year. A total of 35 dead bamboo patches were identified and 175 pixels were collected with the corresponding years of death. The assessment was conducted by calculating the same metrics as in the die-off detection section. Additionally, in order to assess if the prediction error was randomly distributed, the residuals from predicted minus observed die-off year, where observed is the die-off from the Landsat validation dataset, was tested for normality using a two-sided Kolmogorov-Smirnov test at a 1% significance level."

5. Finally, I find it difficult to follow how each step and/or product is validated - in terms of methods, reference datasets, and sampling units and protocols.

Response: We agree that it was not easy to understand in the way it was presented. There were two validation datasets for two different analyses. One dataset used MODIS data from 2000-2017 and the other used Landsat data from 1985-2000. In both of them, color composites were used to visually inspect die-off events and collect pixels to create validation datasets. The validation dataset from 2000-2017 (MODIS) was used to assess the bamboo-die off detection by the bilinear model running on MODIS time series during 2001-2017. The validation dataset from 1985-2000 (Landsat) was used to assess the predictions of bamboo die-off during 2018-2028 by the model running on MODIS time series and the NIR empirical bamboo-age reflectance curve. This was possible because the die-off events that occurred in the previous life cycle of bamboo (1985-2000) were expected to occur again 28 years later (2018-2028). As we have shown in the last comment, we have improved the description on sampling pixels from bamboo die-off patches for validation datasets. We also believe that the flowchart that we have included (Figure 1) will help the reader

to better understand how each validation dataset was used.

Specific examples:
1. The level of detail presented in the methods often seems like a list of what was done, versus a careful retelling of the salient details. For example, the detailed comparisons of NIR1 to NIR2 get confusing and are perhaps unnecessary – an alternative would be to simply state that the two bands were each tested as input data and compared based on some criteria. The NIR 1 was determined to be more useful based on specified criteria. Then the discussion and figures that follow could focus on the results for NIR1 only. But, also see question below. Perhaps more importantly, additional discussion is needed to link specific results to broader scientific questions.

Response: We agree. We have showed the results for both NIR bands because they mapped slightly different areas of bamboo die-off probably because of the different sensitivities to vegetation composition. This is specially highlighted in the Figure 7 where the NIR-2 remains at its lowest during 0-2 years. Thus, we have included a sentence informing on these differences in mapped areas between NIR-1 and NIR-2 in p.12 l.5: "When comparing the areas detected solely by one of the two bands, NIR-1 detected more pixels towards the end of the time period, i.e. die-off areas from 2017 in the north-east between 8-9°S and 69-70°W, while NIR-2 detected additional pixels in the beginning of the time period, i.e. die-off areas from 2001 in the central region between 9-10°S and 70-71°W.", and adjusted the discussion on why they provided different maps in discussion in p.20 l.21: "When comparing the NIR-1 and NIR-2 bands, the leaf/canopy water sensitivity from NIR-2 might have contributed for a slightly better performance on bamboo die-off detection and the detection of different areas between the bands, which contributed for a larger coverage of the bamboo-dominated forests. This different sensitivity to vegetation structure is specially highlighted in the Figure 7 where the NIR-2 remains at its lowest during 0-2 years, explaining why NIR-2 band maps different areas than NIR-1.".

When we combined both maps, we were able to obtain a map covering a larger area of bamboo die-off with similar accuracy (80%), but lower omission errors (4.1%) than the NIR-1 (14.4%) and NIR-2 (7.2%) maps. We decided to include the combined die-off map to the supplementary material (attached Figure 1 - Bamboo die-off during 2001-2017 from the combined detections using MODIS (MAIAC) NIR-1 and NIR-2 and the bilinear model). Regarding the scientific questions, our evidences clearly do not support the bamboo-fire hypothesis, and, in relation to the die-off patches, we believe that knowing where and when the bamboo dies is an important information for future studies of the bamboo-dominated forests ecosystems. Thus, we added this sentence to discussion in p.23 l.25: "It could also be used to explore broader scientific questions on the ecology of bamboo-dominated forests such as studies on maintenance/expanse of bamboo patches, flowering waves, cross-pollination between patches, fauna habitat dynamics, impacts on short and long-term carbon dynamics.". However, the pursuit of such analyses was out of the scope of this paper.
In order to highlight the best prediction map (NIR-1) we have adjusted the Figure 9 to only include results from the NIR-1 prediction: the map, estimate vs. predicted, and residual error. Thus, the predictions from NIR-2 should be added to supplementary material as shown in attached Figure 4.

2. Steps described in the methods (and the results) often lack a presentation of the logic behind why specific methods were tested in the first place (and/or ultimately, selected). A few places where more justification is needed about proposed methods: 1- Why only test NIR bands (rather than combinations of other bands, standard vegetation indices, etc.)? 2- Why assume a linear model? 3- Why choose thresholds vs. probabilities? 4- How confident are you in Carvalho's estimates? 5- What percent of pixels are highly correlated?

Response: We agree that justifications were missing in the methods. As we stated in previous comments, we have improved the methods description to address

each of the presented problems. Now answering the specific points, which also provide examples of the changes:
(1) We focused the die-off detection on the NIR bands because of two reasons: (i) a previous work from Carvalho et al. (2013) showed that NIR band presented the best separability between bamboo life stages, where higher NIR was observed for adult bamboo than juvenile and dead bamboo; and (ii) we actually did some testing with other bands before the manuscript was written and they provided poor detections; the empirical curves (Fig. 7) corroborate that the other bands does not have a clear change with die-off. When adjusting the methods section, we added this sentence to clarify why we used the NIR band in p.7 l.31: "The model conception was based on (Carvalho et al., 2013) findings which showed that forests with adult bamboo have higher NIR reflectance than forests with juvenile and recently dead bamboo, or without bamboo, and that bamboo present a life cycle approximate to 28 years.". By retrieving the empirical bamboo-age spectral curves, we were able to demonstrate that the remaining spectral bands do not show an abrupt change in reflectance in the die-off year. We did not explore additional attributes such as combinations of bands and spectral indices because our simple model with only the NIR band already presented high accuracy (80%) and very low RMSE error (0.5 RMSE). Even though, we think that should be interesting to use different attributes to potentially improve detection. We added this sentence to conclusions in p.25 l.28: "The mapping approach can be applied with other remote sensing data, such as Landsat data with better spatial resolution and longer time series, and tested with different spectral bands and attributes to further improve the detection."
(2) We used the bilinear model because it was the simplest way to represent the spectral variation changes with bamboo growth overtime as there was no current knowledge on the spectral responses of these bamboos over time. Once we have detected the die-off with this method and reconstructed the empirical spectral variation, we further demonstrated that the relation is not really a linear increase with age, but, in general, more like an abrupt increase when bamboo reach the canopy after 12

years of age, and then an abrupt decrease with die-off (Fig. 7). To improve clarity, we have added this sentence to methods p.8 l.1: "Thus, since not much is known about the spectral behavior of bamboo growth with age, we chose a bilinear model to characterize the bamboo signal change overtime because it was the simplest way to represent the change between life stages."

(3) Regarding the thresholds, in some parts of the paper where we used thresholds, based on statistics that represent our data with high confidence, such as percentiles that capture 99% of the data or that have very low p-value. For example, in the die-off detection we filtered our map based on p-value statistics from the correlation, so only pixels with very high confidence ($p < 0.001$) would be mapped as a die-off. Also, when we extracted the bamboo-free median NIR signal, in order to get the signal from forests without bamboo, we applied the threshold of 99.88% tree cover that excluded at least 99% of the previously known bamboo-dominated areas.

(4) We are confident that the results from Carvalho et al. (2013) are accurate because their validation was made with field campaigns, aerial flights, and independent field data from previous field studies. Hence, it supports that the visual interpretation of bamboo die-off using color composites is indeed associated with the field processes, and, thus is adequate for our validation purposes.

(5) In the second paragraph of section 3.2.1 we have briefly stated that "The correlation coefficients found in the mapped pixels with significant relationship with our bilinear model ($p < 0.001$) were very strong ($r > 0.7$).". That meant that all pixels presented $r > 0.7$. Since more information could be added to it, we extracted additional statistics and adjusted the text in p.13 l.3 to: "The correlation coefficients found in all the mapped pixels with significant relationship with our bilinear model ($p < 0.001$) were strong ($r > 0.7$). More than 50% presented even stronger correlations ($r > 0.8$), and 15% of pixels presented very strong correlation ($r > 0.9$)."

3. The first two conclusions of this study - first, that bamboo-dominated forests have lower tree cover values than bamboo-free forests, and second, that the MODIS

NIR values have different distributions over the two forest types - are not supported by convincing evidence. In each case, the differences reported are so small (< 0.1% tree cover and <0.1% reflectance) that I would predict other sources of variability and/or error (e.g., radiometric calibration, sensor signal-to-noise ratio, atmospheric correction uncertainties) might overwhelm these differences.

Response: We don't agree with Reviewer 2. The tree cover is lower in bamboo-dominated forests than bamboo-free forests as shown for example in the attached Figure 5 (Tree cover over the whole study area and a tree cover percentiles of bamboo forests in a small subset). The differences in the NIR distribution, more thoroughly discussed below, also supports that these differences distinguish the forest types to a certain degree and were useful to help us detect the live bamboo. However, we did not intend that the tree cover would map the bamboo forests, but rather help us to do it with the NIR signal.

Most bamboo-free forests (north east of study area) presented near 100% tree cover, while the bamboo-dominated forests presented values between 96.95 and 99.88%, and only 1% of bamboo-dominated forests showed tree cover of 100%. Even with this small difference in tree cover percentage, it was possible to observe a coincidence between the tree cover percentile map and a previous mapped bamboo-dominated forests in a few areas of the attached Figure 5, which highlight the difference of tree cover in the borders of the bamboo forests. The percentiles were extracted as a way to select the most probable bamboo-free forests and separate from potential bamboo-dominated forests with high confidence. Hence, later on, we used the bamboo-free median signal as part of the live bamboo detection.

Since it was not easy to visualize the difference in the NIR distributions between the tree cover classes in the Figure 4, we have adjusted it in the updated manuscript by separating the three histograms. The mean difference between NIR reflectance in bamboo-dominated forests (mean = 28.7%) and bamboo-free forest (27.3%) is 1.4% and the distributions largely overlap each other. However, the important message is that the bamboo-dominated forests NIR signal is skewed to the right, because of the adult bamboo have higher NIR values than juvenile bamboo or forests without bamboo, as shown in Fig. 4. Hence, the first rule used to map the live bamboo was "(i) mean NIR reflectance equal to or greater than the median signal of bamboo-free forests". When we added the second rule "(ii) an increasing NIR reflectance over time", the light green pixels in the bamboo spatial distribution (Figure 6) were mapped, which mostly coincided with the remaining non-dead bamboo areas inside the map from Carvalho et al. (2013). This difference in NIR distributions between the three classes supports that differences in tree cover should occur.

4. In many cases, the methods lack a description of the sampling procedure employed to inform classification strategies. In all cases where data are sampled for "training" statistics, the authors should provide a concise description of the sampling unit, sampling protocol, and datasets sampled. For example, Section 2.3.1 mentions five pixels, 78 patches, and 380 geolocation points - but I am not sure how these numbers are related, nor what datasets are being compared. Section 2.3.4 mentions different numbers of pixels, patches, and geolocation points, and perhaps uses a different reference dataset? Additionally, no information is provided to place the samples within the larger context of the entire study area - i.e., what percent of pixels (or percent area) of the entire study area is sampled, and how might this impact confidence in the resulting predictions. That is, the predictive model is developed based on a very small sample of the entire study area, but little information is provided to assess what impact this has on the "predictive accuracy" for unknown pixels?

Response: Agreed. We have improved the description of the sampling as pointed out by reviewer 2, and also reviewer 1 comments. The two paragraphs were previously cited in the general comment 4. In order to show the spatial and temporal distribution of the validation datasets, we intend to add to the supplementary material two figures

which are attached in this document: (i) Figure 2 - Spatial distribution of validation samples obtained from MODIS (2001-2017) imagery in red and Landsat (1985-2000) imagery in blue. The image at background is a false-color composite from MODIS (MAIAC) images of bands 1 (Red), 2 (NIR) and 6 (shortwave infrared), in RGB, respectively, in August 2015; (i) Figure 3 - Temporal distribution of validation samples for bamboo die-off detection (2001-2017) from MODIS imagery and for bamboo die-off prediction (2018-2018) from Landsat imagery.
We agree that a discussion on the representativeness of the validation datasets was missing. We sampled a total of 390 pixels in 78 bamboo patches to validate detections between 2001-2017, and 175 pixels in 35 patches to validate predictions between 2018-2028. We believe that the sampling was at acceptable levels given that the we found a total of 802 patches between 2001-2017 and 778 patches during 2018-2028, which equals to around 10% and 4.5% of the total patches, respectively. It is noted, however, that our visual analysis sampled mostly big patches that died-off, because those were the ones that we could be sure that were attributable as bamboo die-off. This information was added to the discussion in p.21 l.3: "Our validation dataset was composed of 390 pixels visually detected in 78 bamboo patches during 2001-2017. Therefore, we can be confident that the sampling was representative to our study area given that we found 802 patches in the same time period, that is, the sample consisted in around 10% patches. It is noted, however, that our visual analysis mostly sampled big patches that died-off, because those were the ones that we could be sure that were bamboo die-off.", and p.23 l.17: "The validation dataset for the predictions (2017-2028) corresponded to 175 pixels in 35 bamboo patches and represented 4.5% of the 778 bamboo patches predicted for the 2018-2028 time period.".
Our models did not require any training pixels, because they were based on the correlation of the MODIS NIR time series and a reference – such as the bilinear model and the empirical bamboo-age reflectance curves. Therefore, the validation datasets were used as independent sources of validation, providing robust accuracy metrics for the whole map.

5. Building on the previous point, each validation dataset should be clearly (and concisely) described (perhaps summarized in a table) - and discussions of predictive uncertainty should be included in the results section (not just the discussion section).

Response: We agree. We have adjusted the description of each validation dataset (cited in the general comment 4) and added a brief discussion on its representativeness as pointed out in the previous comment (specific comment 4). Nevertheless, we believe that the report of results is appropriate in the results sections, and its interpretations in the discussion section. We have included two figures in supplementary materials (attached Fig 2 and 3) where one can see the spatial and temporal distribution of samples instead of a table, because we believe that would be more useful for the reader.

Technical corrections/suggestions:

1- Consider refining methods to state the goal of each step first, as well as to identify how each of the steps in the methods sections are related. Currently, the steps are presented in isolation from each other, and in some cases, the almost overwhelming detail makes it difficult to follow how the individual steps are related. Start in the abstract by clearly stating research questions and goals.

Response: We agree. We have added a flowchart (Fig 1) to help the reader get a quick grasp of the whole paper before going into detail. Regarding the abstract, we have added a sentence specifying the main goals of the paper, and then described more specifically what was done. The sentences in p.1 l.5: "In this study, our aim is to map the bamboo-dominated forests and test the 'bamboo-fire hypothesis' using satellite imagery. Specifically, we developed and validated a method to map the bamboo die-off and its spatial distribution using satellite-derived reflectance time series from MODIS (MAIAC) and explored the 'bamboo-fire hypothesis' by evaluating

the relationship between bamboo die-off and fires detected by the MODIS thermal anomalies product in the southwest Amazon.".

2- Clearly cite previous work and clearly identify which steps were followed in the current study.

Response: We have improved the description of steps performed in the paper as commented in the previous responses. We believe we have cited all the previous works published in peer-reviewed journals that mapped the bamboo forests in the southwest Amazon, the most important being Nelson et al. (2004) and Carvalho et al. (2013).

3- Consider including a table to present the imagery used in the analysis, including Landsat WRS-2 and MODIS tile coordinates and image dates.

Response: We have prepared a table containing the Landsat images used for validation of bamboo die-off predictions to be included as supplementary material (attached Table 1).

4- Check the use of the term "cross-validation."

Response: Ok, it was incorrectly used in the paper. We have changed the terms "cross-validation" to only "validation".

5- Limitations of the MODIS active fire detection product are mentioned at the very end of the discussion section - what implications does this have for ecological process? Could it be that the bamboo fire hypothesis is still an open question because we are not measuring understorey fires?

Table 1. Dates of TM/Landsat-5 images used for validation of bamboo die-off predictions. The date of each image (YYYY-MM-DD) is presented for each path-row (World Reference System 2) in the columns.

006-065	003-066	002-067	003-067	005-067	003-068
1985-06-28	1985-07-09	1985-09-04	1985-08-26	1985-07-23	1985-07-09
1986-08-02	1986-07-28	1986-08-06	1986-09-30	1986-07-26	1986-10-16
1987-08-05	1987-08-16	1987-08-25	1987-08-16	1987-08-14	1987-08-16
1988-08-07	1988-07-17	1988-08-11	1988-08-18	1988-07-15	1988-06-15
1989-08-26	1989-07-20	1989-08-14	1989-09-22	1989-09-04	1989-08-21
1990-04-23	1990-07-07	1990-09-18	1990-07-23	1990-06-19	1990-08-24
1991-06-13	1991-07-26	1991-07-27	1991-07-26	1991-07-08	1991-07-10
1992-10-05	1992-08-13	1992-07-21	1992-07-28	1992-08-27	1992-07-28
1993-08-05	1993-09-01	1993-08-25	1993-06-13	1993-08-14	1993-06-13
1994-07-23	1994-07-18	1994-07-27	1994-07-18	1994-06-30	1994-07-18
1995-08-27	1995-08-22	1995-07-30	1995-08-22	1995-06-17	1995-07-05
1996-07-12	1996-07-23	1996-08-01	1996-07-23	1996-07-05	1996-07-23
1997-09-01	1997-07-10	1997-07-19	1997-07-10	1997-07-24	1997-08-27
1998-07-18	1998-07-13	1998-09-24	1998-08-30	1998-09-13	1998-07-13
1999-08-06	1999-08-01	1999-08-10	1999-08-17	1999-07-30	1999-08-17
2000-10-11	2000-07-18	2000-07-27	2000-07-18	2000-09-02	2000-09-04

Response: We adjusted the fire discussion as a response to Reviewer 1 comments which reinforced that we should fully reject the ‘bamboo-fire hypothesis’. The adjusted sentences in p.23 l.30: “We cannot support the ‘bamboo-fire hypothesis’ from Keeley and Bond (1999) because fire occurred only in a small fraction of bamboo-dominated areas during the 16 years of fire analysis (Fig. 6), equivalent to 2371 km^2 of burnt area or 0.0955% of the total bamboo area (155,159 km^2) burning each year, and the statistical tests comparing dead and live bamboo fire frequency showed that dead bamboo did not burn more than live bamboo (Fig. 11). Hence, we believe that there should be other explanations for bamboo maintenance in the forest, such as bamboo itself being responsible for its maintenance in the forest due to the damage it causes in the trees while increasing tree mortality (Griscom and Ashton, 2003)”. In the updated manuscript, we acknowledged that the fire datasets underestimate the total fire occurrence but it should not affect the conclusions in p.24 l.11: “The fire occurrence beyond 2 km inside the forest was probably underestimated because the forest canopy can obscure fires that occur only on the understorey, and, thus, are not detected by the MODIS/Aqua satellite (Roy et al., 2008). In addition, the MODIS active fire detections should be treated as a lower bound of fire occurrence, as it underestimates fire occurrences in the order of 5% for small fires with less than 0.09 km^2, or 10% of MODIS spatial resolution, due to the coarse spatial resolution, high cloud cover, and when having high viewing angles ($> 15\,^{\circ}$) (Morisette et al., 2005). Nevertheless, we do not believe this might have an impact on rejecting the ’bamboo-fire hypothesis’ due to the minimal fraction of fire occurrences osccurring over the large bamboo-dominated forests.”.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-207/bg-2018-207-AC2-supplement.pdf

Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-207, 2018.

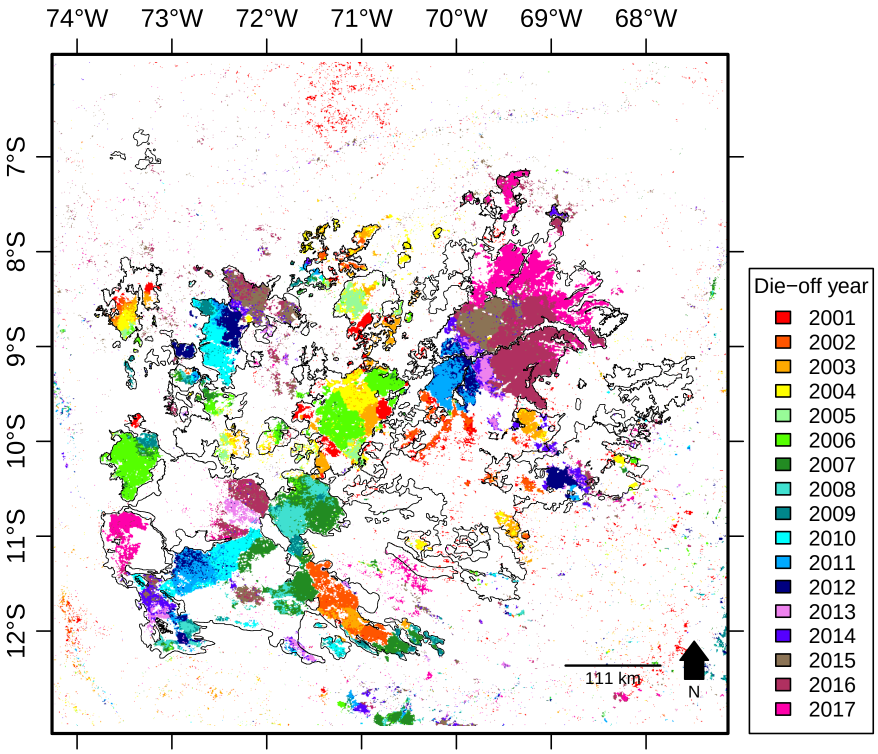

Fig. 1. Bamboo die-off during 2001-2017 from the combined detections using MODIS (MAIAC) NIR-1 and NIR-2 and the bilinear model.

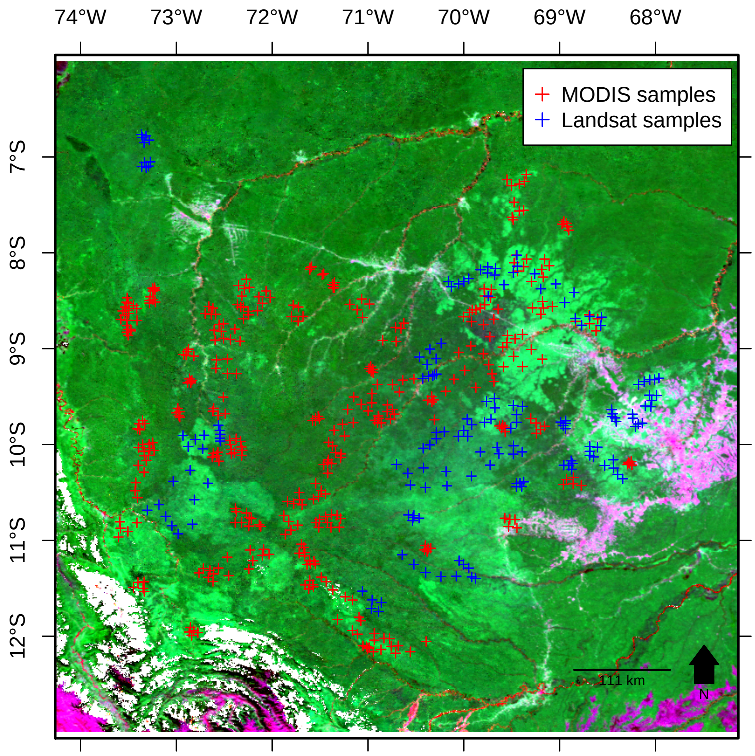

Fig. 2. Spatial distribution of validation samples obtained from MODIS (2001-2017) imagery in red and Landsat (1985-2000) imagery in blue. The image at background is a false-color composite from MODIS [...]

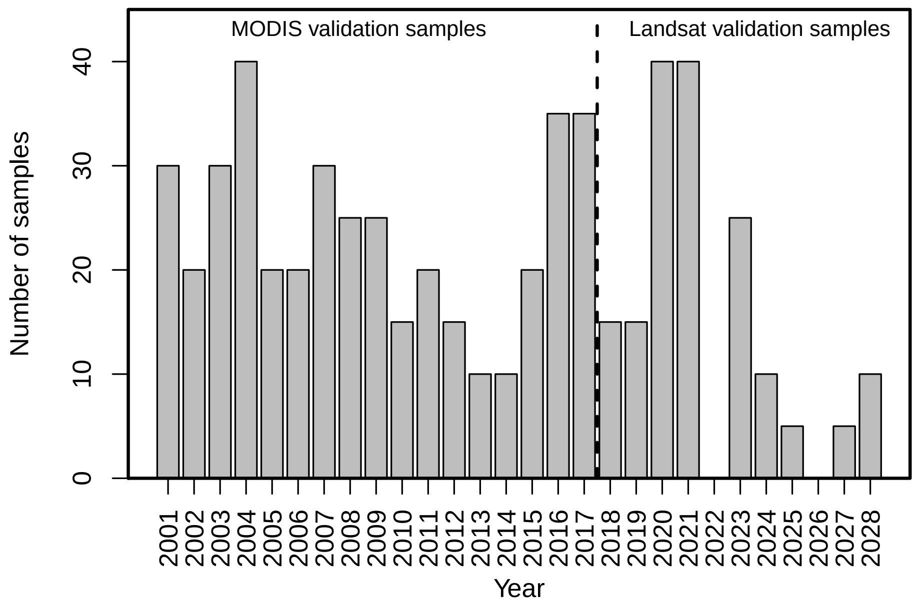

Fig. 3. Temporal distribution of validation samples for bamboo die-off detection (2001-2017) from MODIS imagery and for bamboo die-off prediction (2018-2018) from Landsat imagery.

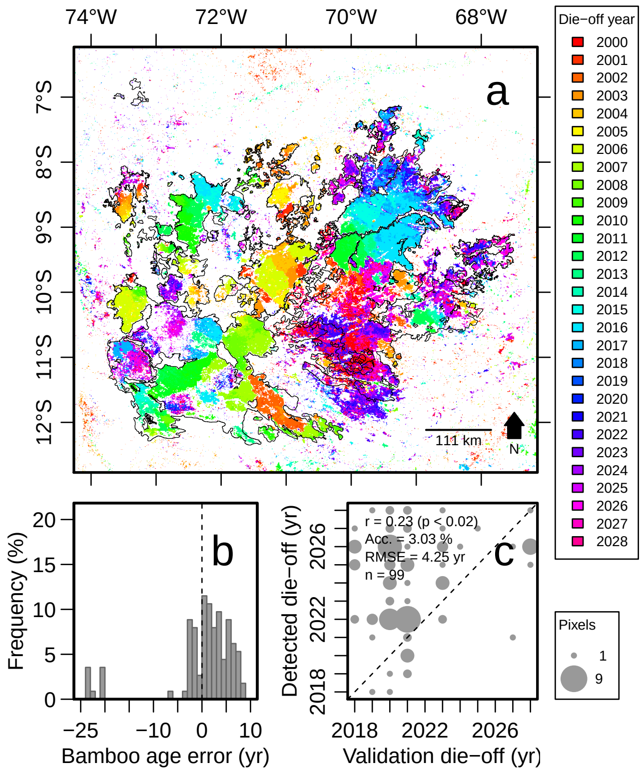

Fig. 4. MODIS bamboo die-off prediction map from 2000 to 2028 using the empirical curves of the near infrared 1 (NIR-2) reflectance as a function of bamboo cohort age (a). Validation between predicted [...]

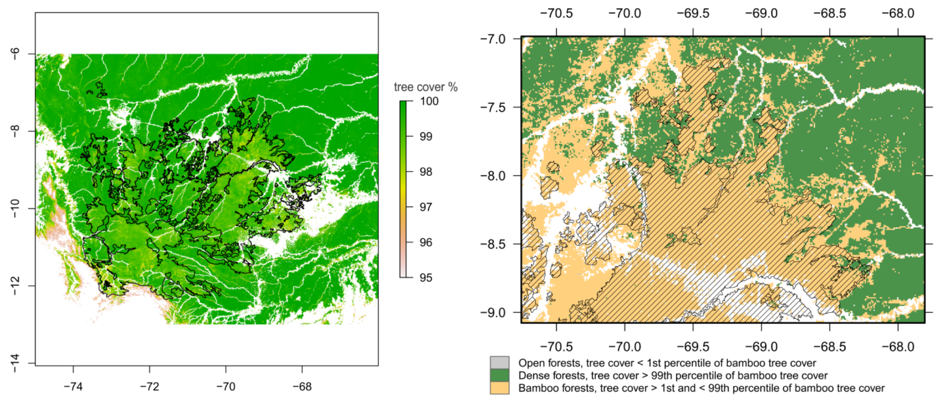

Fig. 5. Tree cover over the whole study area and a tree cover percentiles of bamboo forests in a small subset.