We thank reviewer 1 for their detailed comments and suggestions. Our replies (standard font) to the primary comments (italics) are below. We have addressed the handwritten comments directly in the manuscript.

1. In context of the terminology, I have two primary comments. First, I find the use of the term "control" to describe the RCP 2.6 scenario somewhat confusing. In the climate and Earth system modelling literature the term "control" is typically used for the preindustrial simulation. I suggest calling the standard RCP 2.6 simulation what it is - the RCP 2.6 scenario. Second, I am confused by the term "restoration". I am familiar with the terms reforestation, deforestation, and afforestation but I have no idea what does the term "restoration" actually refers to. I understand the intent here but perhaps it would be helpful to clarify the intent more clearly and upfront in the manuscript.

We have renamed the "control" RCP 2.6 scenario simulation to "esmrcp26", highlighting its similarity to the emission-driven CMIP5 "esmrcp85" experiment (https://view.es-doc.org/?renderMethod=id&project=CMIP5&id=b933ca20-d3a5-11df-837f-00163e9152a5) to avoid confusion with the standard concentration-driven "rcp26" experiment. We also changed the name of the restoration simulation to "esmrcp26restor".
The term "forest restoration" is used in forest ecology to describe actions that lead to the recovery of forests, their biomass, biodiversity, or other ecosystem services (e.g. Lamb et al., 2005). In its simplest form this can be achieved by abandoning land use and letting vegetation regrow. This is exactly how our restoration experiment works, all land use activity in the tropics is ceased and natural vegetation is allowed to regrow.

We have now added a definition of forest restoration in line 26.

2. Why the emissions driven RCP 2.6 scenario in this manuscript is driven with diagnosed emissions from the concentration driven RCP 2.6 scenario simulation of the HadGEM2-ES. Wouldn't it had been much easier to explain and to drive the emissions driven simulations of the RCP 2.6 scenario with the standard emissions provided by the integrated assessment models for the RCP 2.6 scenario.

Jones et al. (2013) have shown that HadGEM2-ES achieves the decline in atmospheric CO_2 concentrations as specified in RCP 2.6 without the need of negative emissions. This means that when driven by RCP 2.6 emissions HadGEM2-ES would simulate lower atmospheric CO_2 concentrations than specified in RCP 2.6. We have therefore decided to use the fossil fuel emissions that match the RCP 2.6 atmospheric CO_2 concentrations.

We have now added a brief explanation in line 96.

3. I am unclear of the protocol followed in the "restore" simulation. The reason for this is that the manuscript doesn't show time series of crop [and pasture] area in the "control" and "restore" simulation so I can't visualize how anthropogenic LUC is avoided in the "restore" simulation. This, I think, is the first aspect. The second aspect is related to the fact that the TRIFFID component of the MOSES land surface scheme is able to simulate the fractional cover of its plant functional types (PFTs) dynamically (note that I am not calling it "dynamic vegetation"). I am unclear how this second aspect works. Is the model allowed to dynamically simulate fractional cover of PFTs in areas already deforested and is this the reason for expansion of trees into an area of 1529 Mha?

The grey line in Figure 1A denotes anthropogenic disturbance (i.e. crops and pasture). We have now changed the label to “Crops + Pasture”.
The reviewer’s assumption is correct, the model dynamically simulates the fractional share of each PFT based on a plant competition (Lotka-Volterra) approach where trees outcompete shrubs and woody vegetation outcompetes grasses under suitable climatic conditions. Land use is simulated by applying a mask where no trees are allowed to grow, and existing trees are being replaced with bare soil (which in turn will be replaced by C3 and C4 grasses, representing crops and pastures over time).

We have now changed Figure 1a’s legend from “disturbance” to “Crops + Pasture” to highlight the type of anthropogenic land use and adjusted the figure caption to emphasize that the anthropogenic land use mask converts to crops and pasture. We have changed anthropogenic disturbance to anthropogenic land use where suitable in the text.
We clarified that TRIFFID simulates the fractional cover of each PFT dynamically in line 70ff.

4. I have no clue what is the purpose of section 1.3. I was not able to understand the context for this section and it appears to come of the blue.

Section 1.3 describes the biomass scaling we discussed in section 4.1 (now section 5.1) and was accidentally left in this place from an earlier version of the manuscript. It has now been placed in section 5.1 “Restoration timescales and carbon uptake”, line 316 where more context is provided . We apologize for this mistake.

5. At a number of places in the manuscript, it is mentioned that the carbon not released by avoided deforestation and carbon sequestered by the expansion of tree cover does not yield the expected reduction in atmospheric CO2 burden because this carbon benefit is overwhelmed by negative feedbacks. These negative feedbacks include reduction in CO2 uptake by the ocean and extra-tropical vegetation due to the reduction in atmospheric CO2 concentration.

In the context of the earth system, positive and negative feedbacks amplify and reduce the initial perturbation, respectively. For example, the carbon uptake by land and ocean in response to increasing atmospheric CO2 is a negative feedback since it reduces the amount of CO2 in the atmosphere caused by fossil fuel emissions. If we use this standard definition/sign/interpretation of feedbacks then it becomes a little difficult to interpret that the negative feedbacks as you call them in your study reduce the climate benefit of “restoration” since in the normal context of climate warming negative feedbacks are the good feedbacks that reduce the rate of climate warming.

Perhaps it would be more clear if the phrase “negative feedbacks” is not used in this context but rather it is explicitly mentioned that “the carbon benefits of avoided deforestation and the increase in forest cover, in the restore simulation, are not fully realized because the resulting reduction in atmospheric CO2 also reduces carbon uptake by the ocean and extra-tropical forests”.

We agree with the reviewer and changed all instances where we use the term “negative feedback” accordingly.
Line 228 – changed to “reduced uptake by the ocean”

Line 341 – changed to “reductions in carbon uptake by the ocean and extra-tropical forests”
Line 412 – changed to “carbon benefits of avoided deforestation and the increase in forest cover are not fully realized because the resulting reduction in atmospheric CO2 also reduces carbon uptake by the ocean and extra-tropical forests”

6. Equation (1) on page 4 is not 100% correct. The reason for this is the ambiguity in the term E DEF OR which represents the deforested biomass according to lines 72 – 73 on page 3. Note that the deforested biomass is allocated to wood product pools with different turnover timescales. As a result, the land-use change related emissions seen by the atmosphere (and thus in equation 1) are not equal to deforested biomass but rather the sum of the fluxes from the wood product pools. Please note and correct this subtlety when revising your manuscript.

We have now adjusted the description of E_{DEFOR} in line 78 to highlight that it represents the emissions into the atmosphere from sum of the wood product fluxes at a given point in time. We use E_{DEFOR} instead of E_{LU} to emphasize that emissions from land use calculated in HadGEM2-ES only include deforestation emissions.

7. There are two aspects to vegetation acting as a dynamic component in an Earth system modelling framework. The first is related to changes in the structure of the vegetation including vegetation height, its leaf area index, rooting depth, prognostic leaf onset and offset times and its biomass. These dynamic changes in vegetation structure, in response to changes in climate and atmospheric CO2 concentration, occur regardless of changes in the spatial extent of vegetation. The second aspect of vegetation dynamics is related to the changes in the fractional coverage of different PFTs. In the manuscript, the term “dynamic vegetation” is used to describe the second aspect. I would suggest to be explicit here (as I have done in point 3 above) and clearly mention “the changes in the spatial extent of PFTs” if that’s what you’re referring to.

We thank the reviewer for pointing this out. TRIFFID is a dynamic vegetation model that simulates changes in the fractional coverage of the PFTs dynamically. We have now clarified this in lines 71ff.

8. Lines 356 – 357. You cannot call HadGEM2-ES the most sophisticated ESM. The diversity of ESMs in the climate community is considered a healthy aspect of the community. Several studies have shown that the model mean response to any perturbation is more robust than any individual model.

Absolutely, by no means were we attempting a rating of individual models. We were referring to the model and scenario choice so far used for such an experiment since previous models are all pre-CMIP5 generation models forced with high CO_2 concentrations and/or fully afforested/deforested scenarios. We have now changed the wording to “more recent ESM and scenario choice”.

9. Finally, I think the manuscript can benefit from some reorganization to improve the flow of the manuscript. Perhaps starting with the big picture of changes in atmospheric CO2

burden and temperature, followed by land C changes, and then finally by ocean C changes will be helpful.

We thank the reviewer for the suggestion. We think that showing the i) impact of the cessation of tropical land use and the subsequent land cover change, ii) its impact on terrestrial carbon and then iii) the global response to that makes it easier for the reader to follow.

Regarding co-authorship, we closely worked with the relevant Earth System Modelling team at the Met Office and are grateful for their support as stated in the acknowledgement.

Minor comments from handwritten notes

line 96 reformat equation and introduce terms
We thank the reviewer for this suggestion. We have reformatted equation 1 and are now introducing the terms.

Figure 1A legend labels; y-axis in %
We have changed the figure labels to be more informative. The aim of Figure 1A is to illustrates the trajectory of the PFTs over time. Table A1 contains the information of the absolute area change by 2100.

line 121 is this global change in the area of BDL trees over 2008-2100?
This is the global difference between emsrcp26restor and esmrcp26, although most of this is due to increases in BDL in the tropics (see Table A1). We have highlighted that this difference is between emsrcp26restor and esmrcp26.

line 125 how about plots to confirm this
We have now added Figure A2 and reference it here.

Use million km2 or km2 instead of Mha
Several studies and initiatives addressing forest restoration work in million ha (Mha). We therefore keep these units but provide a conversion in the caption of table A1.

In RESTORE is future LUC stopped in addition to making additional deforested area available for tree growth?
That is correct, we have now clarified this in line 48 and again in line 117.

Line 148 show decline in NPP in Figure
The time series of NPP can be found in Figure A3A. We have now added a reference.

Put thick moving average line in Figure 3
Adding a moving average would blur the abrupt changes we see in e.g. Figure 3C. We don't think any additional information would be conveyed by adding a moving average here.

Does delta SC also contain changes in the litter pool?
HadGEM2-ES does not have a litter pool, carbon from litter fall is directly moved to a fast, medium and slow soil carbon pool. We thank the reviewer for highlighting this and have added this information in line 89ff.

Issues with figure labels line 230ff

We have now corrected the figure references and apologize for the confusion.

Is FA a flux or is it the atmospheric C burden?
FA is net carbon flux into the atmosphere (line 242).

Figure 4 change y axis and increase size of legend
Done.

Line 243 Do you mean planetary albedo due to reducing snow and sea ice.
Yes, although we prefer the term surface albedo here to emphasize the surface changes. We do not make any assumptions about snow or sea ice cover as this is beyond the scope of the manuscript.

Line 245 Only someone who is familiar with literature may understand what a 5%, 2.62 W/m2 decrease in albedo means.
The follow-on sentence describes that the lower surface albedo has a warming effect. We believe this sufficiently explains what a 5% decline in albedo implies.

Line 319 How were these numbers calculated with restoration simulation alone?
The carbon benefit on a per area basis from stopping deforestation is calculated using the difference between esmrcp26restor and esmrcp26 for E_{DEFOR} and RCP 2.6 land use change over 2008-2100 (9.6 Pg C / 286 Mha). Similarly for the forest restoration we use the difference between esmrcp26restor and esmrcp26 for F_{LA} and the abandoned 2008 land use area (41.8 / 1529 Mha). We have added this to the per area numbers.

Line 394 You haven't paid any specific attention to negative emissions as such. Just that your restoration is based on a scenario which happens to have negative emissions.
We highlight the response of the Earth System to negative emissions, i) the reduction in land and ocean carbon uptake after the reduction of atmospheric CO2 through negative emissions and ii) that the Earth System response to these negative emissions reduces their carbon benefit by more than 50%.

Sources:
Lamb, D., Erskine, P. D., and Parrotta, J. A.: Restoration of Degraded Tropical Forest Landscapes, Science (80)., 310, 1628–1632, 2005.

Jones, C. D., Hughes, J. K., Bellouin, N., Hardiman, S. C., Jones, G. S., Knight, J., Liddicoat, S., O'Connor, F. M., Andres, R. J., Bell, C., Boo, K.-O., Bozzo, a., Butchart, N., Cadule, P., Corbin, K. D., Doutriaux-Boucher, M., Friedlingstein, P., Gornall, J., Gray, L., Halloran, P. R., Hurtt, G., Ingram, W., Lamarque, J.-F., Law, R. M., Meinshausen, M., Osprey, S., Palin, E. J., Parsons Chini, L., Raddatz, T., Sanderson, M., Sellar, a. a., Schurer, a., Valdes, P., Wood, N., Woodward, S., Yoshioka, M., and Zerroukat, M.: The HadGEM2-ES implementation of CMIP5 centennial simulations, Geosci. Model Dev. Discuss., 4, 689–763, https://doi.org/10.5194/gmdd-4-689-2011, 2011.

Liddicoat, S., Jones, C., and Robertson, E.: CO2 emissions determined by HadGEM2-ES to be compatible with the representative concentration pathway scenarios and their extensions, J. Clim., 26, 4381–4397, https://doi.org/10.1175/JCLI-D-12-00569.1, 2013.

We thank reviewer 2 for their comments and kind suggestions. Our replies (standard font) to the comments (italics) are below.

1. For the title of the paper, I would actually prefer something like "Effects of Earth System feedbacks on the potential mitigation of large-scale tropical forest restoration", but this is just a suggestion. I think it highlights better the advantage of this work over the previous studies.

We thank the reviewer for this suggestion. Title changed.

2. The abstract points in the end three key points. I think the first one, "carbon benefit of restoration is CO 2 -scenario dependent", is really not surprising. Differences on the CO2 atmospheric concentration should affect the carbon benefit of restoring part of deforested tropical land. Also, the paper does not address different CO 2 scenarios to claim this result. I think one key message that should be highlighted in the end of the abstract is the estimate that the expected benefit of restoring a large part of the tropics would actually be largely limited (maybe in half or even more?) by negative feedbacks in the Earth System.

We have removed the point about scenario dependence and adjusted the abstract to include the point about the limiting carbon cycle responses. The sentence in line 13ff now reads:
“We identify two model-independent key points: (i) in a world that follows Paris Agreement emission cuts restoration is best deployed immediately, and (ii) the global carbon cycle feedbacks potentially cut the efficacy of negative emissions technologies by more than half.”

The abstract length is now 287 words.

3. Methods: Why did you skip a section 2. Methods ? I think the structure should simply follow 1.Introduction, 2.Methods, 2.1 HadGEM-ES, ... 3.Results, 4.Discussion, etc. But, apart from this, I think you need to explain better what is the restore simulation. What does it mean to ’stop anthropogenic land use’ in the Discussion model? Does that mean that all of the existing crop areas in the model are abandoned or only all NEW crop areas (which would be informed, maybe yearly, by RCP 2.6 transitions from vegetated area to cropland...)? Please clarify.

We apologize for the omission of a clear Methods section header and have now added section 2 Methods.
The “restor” (now called “esmrcp26restor”) involves that all currently existing land use area is abandoned and no future land use takes places. We have now clarified this in line 49 “all current and future anthropogenic land use in the tropics […] is stopped…” and in line 111 “abandoning all present-day and future land use areas led to an increase” as well as line 115 “current anthropogenic land use of 1529 Mha”.

4. It would be nice also to describe in more detail how the inter-PFT competition happens in the model. What factors will provide advantage to one or other PFT in the dynamics of succession?

The following has been added to line 71ff: The share of each PFT of a grid cell depends firstly on a grass-shrub-tree hierarchy where shrub PFTs dominate grasses and tree PFTs dominate grasses and shrub, and secondly on a species competition approach (Lotka-Volterra) that determines the share between two PFTs of the same type (e.g. broadleaf and needleleaf) depending on height (Cox, 2001).

5. Section 1.3 (which I think could actually be section 2.3, given a new section 2.Methods is added): I think this section is difficult to understand as it is. Is this included in the text to present the approach used to convert the information obtained by the model (land surface sink) to infer the impact on atmospheric CO2 concentration? Please improve this section to clarify.

Section 1.3 describes the biomass scaling we discussed in section 4.1 (now section 5.1) and was accidentally left in this place from an earlier version of the manuscript. It has now been placed in section 5.1 “Restoration timescales and carbon uptake”, line 316 where more context is provided. We apologize for this mistake.

Minor comments

1. line 112: "In the control simulation (control), broadleaf forest declined globally by 107 Mha from 2006–2100 CE and by 213 Mha in the tropics." So, the first number is 107 Mha outside the tropics, and the global area of broadleaf forest decline was actually 320 Mha ?

Broadleaf forest declined globally by 107 Mha from 2006--2100 CE, driven by a decline of 213 Mha in the tropics that is somewhat offset by an 106 Mha increase in the extratropics. We added this clarification to line 112.

2. line 122: "The spatial pattern of land cover change shows that the largest change, 786 Mha, is new broadleaf trees, mostly located on ... ", I suggest "The spatial pattern of land cover change shows that the largest change that the restoration scenario indicates, 786 Mha, is the growth of new broadleaf trees, mostly located on …

Changed to reviewers suggestion.

3. line 140 "... resulting in an emission reduction of 9.6 Pg C from halting deforestation alone." I think you could rewrite to "... resulting in the prevention of 9.6 PgC of emissions from halting deforestation alone. "

Changed to reviewers suggestion.

4. legend of Figure 2. Modelled global carbon emissions …

The figure shows global, tropical, and extra-tropical emissions, we have therefore chosen the figure title to simply state “Modelled carbon emissions..”.

5. Figure 3 and Figure 2A are the same? Or fig 2A is for the tropics only?

Figure 2 shows all fluxes into the atmosphere including land use emissions in Figure 2A. We clarified this by adding “Modelled global carbon emissions and fluxes 2006–2100 CE into the atmosphere” to the Figure 2 caption. We assume the reviewer is referring to Figure 3C. There F_{WP} represents the carbon flux from the cut down woody biomass into the wood product pools while E_{DEFOR} is the flux from the wood product pools to the atmosphere (i.e. land use emssions). We have clarified this relationship in line 78.