THE UNIVERSITY *of* EDINBURGH
School of GeoSciences

Expert statement on the basis for Arla´s sustainability report, on which "net zero" claims are made in relation to their dairy products - especially regarding permanence issues

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Edward Mitchard BA PhD SMIEEE
Professor of Global Change Mapping
School of GeoSciences
University of Edinburgh
Crew Building
Edinburgh
EH9 3FF

edward.mitchard@ed.ac.uk
+44 (0)7850 861130

Executive Summary

Arla sells dairy products in the Swedish market with claims of a net-zero carbon footprint for a certain segment of products. Arla's claim is based on the fact that Arla reduces its own emissions as much as possible, and offsets the remaining emissions through the purchase of carbon offsets from e.g. three projects in the tropics. These are Plan Vivo projects involving planting or protecting trees, and the permanence of these offsets (given trees can be cleared), and thus their suitability for use in a claim of net zero, is questioned in a memo produced for the Swedish Consumer Agency by two researchers, Rasmus Einarsson and Elin Röös. These researchers also question the use of the specific metric and time horizon Arla have used to calculate the quantity of offsets they needed to purchase in order to claim their product segment has a net-zero carbon footprint.

I am Professor of Global Change Mapping at the University of Edinburgh, and in that role I have developed significant expertise in forest-based carbon offsets, including with the Plan Vivo carbon standard. I have visited and assessed several Plan Vivo projects and been a member of Plan Vivo's Technical Advisory Committee for over a decade. Arla therefore asked me to investigate the analysis made by Einarsson and Röös, who I assume are capable scientists, but I believe do not have specific expertise in these type of projects.

While I find that the analysis of Einarsson and Röös is thorough, and makes no mathematical errors, it does make a number of assumptions which I think are incorrect or highly unlikely. If corrected, these would have the impact of removing the questions over the net-zero carbon footprint claim made by Arla. These include:

- The metric chosen, Global Warming Potential over 100 years (GWP100), is absolutely the standard used in all such net-zero claims, including by all EU governments including Sweden. It is also as recommended by the IPCC Good Practice Guidelines. While it is scientifically interesting to look at the relative warming over different time periods of different combinations of gases, it would have been extraordinary, and very poor practice, for Arla to use anything other than GWP100 in their calculations. Anything else would have risked misleading or confusing consumers, by making their figure incompatible with other claims/targets of companies and governments, all of whom will use GWP100.

- The researchers create two scenarios for non-permanence of the Plan Vivo projects, and analysis to show that in both cases Arla's emissions at year 0 are not fully compensated by year 100 (under GWP100). These scenarios assume that the Plan Vivo projects perform successfully during their project durations (20-40 years), but that after that either 50% (S2) or 100% (S3) of the trees are cut down and the carbon immediately returned to the atmosphere. My knowledge of Plan Vivo projects and tropical landscapes strongly suggests that even the less extreme of these scenarios (S2) is extremely unlikely to happen. This is because:

    - They confuse the loss of an individual tree that was planted/protected, with the permanent loss of forest or a tree-filled landscape. Individual trees are indeed harvested or die, returning their carbon to the atmosphere. But new trees grow in their place, or are replanted. Both scenarios assume that once lost, no trees are planted or regrow: in wet tropical countries, in land that has just held trees, that's incredibly unlikely.

- Plan Vivo projects are designed to create permanent changes in how local communities live. These changes in livelihoods embed trees as essential parts of their livelihoods, meaning clearing trees without replanting will simply not occur.

- Plan Vivo projects that perform tree planting calculate carbon stocks based on a long-term average, assuming a cycle of harvesting and regrowth/replanting occurs. Thus the tree planting project considered here will not have sold carbon credits equivalent to the peak carbon the trees grow to, but to the long-term average of a cycle of tree growth and harvest (less than half that total). This is ignored in Einarsson and Röös's calculations, but means, combined with the point above, that even in the case 100% of trees were cut down immediately at the end of the project (I think incredibly unlikely), as long as replanting occurred this would actually not represent any non-permanence at all, as the long-term average would still match or exceed the offsets purchased

- Clearing trees is, or is likely to be, illegal in these countries when the projects finish. This is likely to make it very difficult for landowners to cut down trees to match scenarios S2 or S3, even if they wanted to.

- Clearing 100% of a forested area in a single year seems unlikely in these cases. If as the researchers suggests, a fire comes through, canopy trees are unlikely to burn: forest fires as seen during droughts in northern countries do not occur in the wet tropics, where trees retain much water even during the dry season. Burns do damage trees, but release far less than 100% of carbon – and clearly forests recover afterwards. Similarly, logging in tropical forest typically only involves clearing a few percent of the trees (the species that are commercially valuable), leaving much of the carbon behind. And again, forests recover after such disturbance.

- Both countries covered by the Plan Vivo projects, Uganda and Indonesia, are going through a stage of their development where deforestation has been very rapid. Under forest transition theory, as remaining forest becomes scarce, and a country becomes more developed, forest area should stabilise and then recover. Under these models, by the time the projects have finished, there should be little pressure for deforestation.

- Even were the scenarios to occur, the researchers are too pessimistic about the resulting consequences for the amount of carbon released to the atmosphere:

    - In reality much of the trees cut down will end up in long-lived wood products (such as furniture or buildings), with the carbon locked up rather than returning to the atmosphere.

- Plan Vivo projects tend to over-deliver carbon credits, as conservative assumptions are made at every step of their Technical Specifications. This extra carbon captured by the project is ignored.
- Trees do not stop growing at the end of the crediting period: but this potential future carbon capture is ignored by the researchers
- Trees influence climate through their structure, changing wind patterns and rainfall. In the tropics, these physical impacts likely cool the planet, and certainly cool the local environment, assisting some of the places most suffer the worst effects of climate change.
- Trees stabilise soils, preventing their loss in extreme events.

Overall, I conclude that the memo focuses on the analysis of scenarios that are very unlikely to occur in practice, and in analysing them makes assumptions that minimise potentials for keeping carbon out of the atmosphere. I therefore believe that, against the analysis of these researchers, the net zero carbon footprint claim made by Arla is valid.

1. Background

Arla sells dairy products in the Swedish market with claims of a net-zero carbon footprint for a certain segment of products. The Swedish Consumer Agency commissioned two researchers, Rasmus Einarsson and Elin Röös, to answer specific questions related to validity of this net-zero carbon footprint claim. This assignment asked various specific questions of these researchers, which they attempted to address in their report.

This report has, in turn, been commissioned by Arla to offer an expert perspective based on the author's expertise in the topic of carbon offsetting through nature-based solutions, and the Plan Vivo Standard in particular. This relates to a subset of the questions covered by Einarsson and Röös, specifically:

- whether the chosen metric (GWP100), that is the Global Warming Potential totalled over the subsequent 100 years, is an appropriate metric to use to determine this 'Net Zero' claim, or whether a different metric would better meet scientific best practice or consumers' expectations?
- to what extent Plan Vivo projects, and specifically the trees protected/grown in the two projects funded by Arla to offset their emissions, are likely to result in 'permanent' removals of carbon from the atmosphere: or whether these will likely be returned to the atmosphere once the projects finish?
- If Plan Vivo projects cannot guarantee perfect permanence, whether the impact of the emissions of various GHGs in advance/around the time of sale of the dairy products can truly be said to be 'net zero' if compensated for in part by the purchase of Plan Vivo credits?

The memo addressing these by Einarsson and Röös suggests that Arla's claims are unjustified, and that due to non-permanence Arla may miss their Net Zero target by 20-50%. It also states that expressing their target in terms of GWP100 is potentially not appropriate.

In discussing the issues, it became clear that this memo does not represent the view of scientists with experience of tropical Nature Based Solutions projects and Net Zero claims. I have thus been asked by Arla to produce this Expert Statement on these issues. I am a Professor of Global Change Mapping at the University of Edinburgh, specialising in the mapping of forest carbon stock changes using field and satellite data (CV included as Appendix 1). I have worked on avoided deforestation and reforestation/agroforestry projects in the tropics for over 15 years in a number of capacities: as a scientist quantifying their carbon storage and assessing their success; as a formal Validator for the Plan Vivo Standard, assessing whether they meet all aspects of the Standard; as an advisor on how to maximise success and monitor such projects, under the Plan Vivo and other carbon standards (e.g. Verra, Gold Standard); and as an author and reviewer of carbon standards (including Plan Vivo's 2013 version of the Standard), carbon quantification methodologies, and Good Practice Guidelines. Since 2010 I have been a member of Plan Vivo's Technical Advisory Committee, and from 2015-2020 I was the Chair of that Committee, and as such I have reviewed the Technical Specifications of many Plan Vivo projects, as well as discussed at length many of the issues related to Permanence in this report. I have, however, never been employed by the Plan Vivo Foundation in any capacity: my role on the Technical Advisory Committee is a volunteer role, as is common for academics. I do not stand to gain financially from the success of the Plan Vivo Standard or projects that follow it.

In the interests of full disclosure, I am also the Director of a UK company that provides carbon mapping services (Space Intelligence Ltd). I do not believe this results in any conflict of interest, and this company has never worked for Arla nor solicited work from them.

The various issues raised by the Einarsson and Röös memo will be addressed in turn in the report below.

2. Use of GWP100

It is absolutely true that 1 kg of different Greenhouse Gases (GHGs) create different degrees of global warming, and remain in the atmosphere for different lengths of time. 1 kg of methane has a much greater warming impact at the moment of release than 1 kg of carbon dioxide, but this impact lasts for far less time. Therefore, if warming was considered over only a single year, 1 kg methane would have a far greater warming impact than 1 kg of carbon dioxide, but 1000 years after emissions no methane will remain in the atmosphere to warm it, whereas a significant proportion of the carbon dioxide molecules will remain.

It is therefore necessary to consider the time frame under consideration when comparing emissions from different gases. This is relevant to Arla's case, as much of the remaining emissions from their supply chain (after they have made efforts to reduce these emissions, following best practice) are methane and nitrous oxide, whereas almost all credits available as offsets involve the removal of carbon dioxide from the atmosphere.

Arla have chosen to use a metric called Global Warming Potential 100 (GWP100), which measures the cumulative heating effect of the emitted GHGs over a 100 year time period. Einarsson and Röös question the use of GWP100 by Arla in making their 'Net Zero' claims, and suggest other metrics that could be used, considering for example a shorter time frame (GWP20, i.e. only looking over 20 years), or using Global Temperature change Potential (GTP) metrics, which is the temperature change effect of the gas release after a given time.

I am not an expert in the use of these metrics, so I will not go into this subject in detail. However I will state clearly that **it would have been most unusual, indeed very poor practice, for Arla to base their claims on any other value than GWP100**. It is absolutely the standard measure: for example it is as set out as the standard to be used in various IPCC Good Practice Guidelines, including the IPCC Guidelines for National Greenhouse Gas Inventories (2006) [1] used by the EU's Nationally Determined Contributions (NDC) submitted to the UNFCCC in December 2020, which states that greenhouse gas emissions related to its targets and converting between gases will be on a "Global Warming Potential on a 100 timescale"[2]. While country level net zero commitments are not normally as specific on methodology as an NDC, the scientific consensus is that they will use GWP100 in calculating 'net zero', using some Nature Based Solutions to achieve the 'net zero' using identical calculations to those performed by Arla. Indeed, on my reading of the Katawice climate package from COP24, countries are obliged to use GWP100 for any NDC and net zero claims submitted to the UNFCCC[3].

As a scientist, therefore, I fully expect any "Net Zero" claim involving different GHGs to use GWP100 to convert between them: i.e. 1 kg of biogenic methane should be offset by the GWP100 equivalent kgs of carbon dioxide (34).

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[1] https://www.ipcc-nggip.iges.or.jp/public/2006gl/

[2] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Spain%20First/EU_NDC_Submission_December%202020.pdf

[3] UNFCCC. 2019. *Report of the Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement on the Third Part of its First Session, Held in Katowice from 2 to 15 December 2018 Addendum Part two*: *Action Taken by the Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement*, https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf

3. Permanence of Plan Vivo credits

Einarsson and Röös produce three scenarios for the Cumulative Radiative Forcing of the net effect of the release of a mixture of GHGs due to Arla's dairy products, and the mixture of offsets they funded, over 200 years. These scenarios all assume that the projects are successful during their project periods, and capture that carbon as planned without any reversals during these 20-40 year periods. However, they differ in how much of that carbon captured is returned to the atmosphere due to non-permanence subsequently.

Overall they assess these scenarios by looking at the Cumulative Radiative Forcing at year 100. This is effectively equal to GWP100, as discussed above, and should be 0 or negative if "Net Zero" should be claimed.

Einarsson and Röös's simple model suggests that, if there is perfect permanence in the Plan Vivo project components of the offsets purchased, i.e. after the projects end there is no net release of the additional carbon stored in the forests due to the project activities into the atmosphere (their Scenario S1), then the cumulative radiative forcing will be negative from ~70 years onwards. In other words, the Net Zero claim is correct, and in fact the overall impact of the sale of the dairy products is, by the year 100, clearly positive. This overdelivery is mostly caused by Arla having chosen to purchase 10% more credits than their calculations suggested were needed to balance out their residual emissions. Note that this scenario does not mean that no harvesting or death of trees occurs in the decades following the forest end – just that there is no net loss of carbon below the level equivalent to the carbon offsets generated.

Einarsson and Röös only find a problem with the validity of the net-zero carbon footprint claim for scenarios where this permanence is not achieved. They test this through the use of two scenarios:

- S2. Partial permanence after the project period: 50% of avoided emissions from Plan Vivo projects are released in the 50 years after the crediting period of the projects finishes
- S3. No permanence after the project period: 100% of avoided emissions are released the year the crediting period finishes.

Using their model and assumptions, in neither of these cases is GWP100 under zero, with climate compensation taking 135 years for S2, and over 1000 years in S3. If all their assumptions are correct, even under their more lenient scenario, Arla's emissions would not be fully compensated by the year 100, and they would not have achieved "net zero" under the normally used definition (a 100 year timeframe, see Section 2).

These scenarios, and the assumptions that come with them, will have seen reasonable to Einarsson and Röös, and I am sure their analysis is done in good faith. The use of the simple carbon model seems entirely appropriate, and their scenarios seem to be reasonable representations of conceivable outcomes. However, neither are experts in forest carbon projects, and they therefore have produced scenarios, and accompany assumptions, that are very unlikely to happen, or simply incorrect.

I will divide my response to their analysis into two sections; firstly I will consider why I believe their estimates of GWP100 are overly pessimistic even if their fundamental non-permanence assumptions (their S2 and S3 scenarios) are correct, and then secondly I will explain why I believe Plan Vivo credits are likely to be permanent, so something near perfect permanence (S1) is far more likely to be what will occur.

3.1 Global Warming consequences of non-permanence of Plan Vivo projects

In this section I explore the results of the analysis performed by Einarsson and Röös, based on the assumption that their non-permanence scenarios (S2 and S3, described above) actually occur. I believe it is highly unlikely that even the more optimistic of their scenarios, S2, would actually happen, as discussed in the following section, but for the purposes of this section I will assume that they go ahead.

There are two Plan Vivo projects that are used by Arla and considered in the analysis:

- Trees for Global Benefits (TGB), a tree planting project in Uganda with credits issued *ex ante*, i.e. before tree planting occurs after credits are purchased
- Bujang Raba (BR), a forest protection (REDD) project in Indonesia, with credits issued *ex post*, i.e. after the protection of the forest has occurred (though with an assumption that the trees will remain protected).

A third project was also used for offsetting, the African Biogas Partnership Programme under the Gold Standard, which due to the nature of its avoided emissions has no non-permanence risk considered by Einarsson and Röös, so it will not be discussed further here.

There are a number of ways in which the analysis presented by Einarsson and Röös in their analysis of the GWP100 resulting from their scenarios S2 and S2 is an unrealistic representation of outcomes, and biases their calculations unfairly against Arla's net zero claims:

1. **100% release of carbon to the atmosphere.** They assume that once 'cut down' or 'burned' (their words, for TGB and BR respectively) all carbon is immediately released to the atmosphere, and that there is no recovery of biomass in the area. This is very unlikely to be the case.

   An 100% release of carbon is highly unlikely in the case of burning (their scenario for BR). Fires in tropical forests do not normally transform forest into non-forest, instead many trees survive. Indeed I'm aware of no stand-replacement fires in Indonesian tropical forest, and could find no evidence of them in the literature. Though of course such fires may be more possible following climate change, I do not think they will occur frequently in the coming decades. As an example of real emissions following fires, a set of forest plots were burned in Acre state in Brazil in 2005 and 2010: in general this reduced Aboveground Biomass stocks from 237 Mg/ha to a minimum of 155 Mg/ha after the fires[4]; a study in Borneo found biomass losses of 40% following the passage of single fires through forest plots[5]. Certainly such fires would represent large emissions, but not 100%.

   In the case of tree harvesting, again it is rare for there to be a complete clearance of an area of land, unless for conversion to agriculture (unlikely in either of the projects here, as both are on land that is marginal for agriculture), as many trees are not suitable for timber use. But

[4] Numata et al. 2017. Fire and edge effects in a fragmented tropical forest landscape in southwestern Amazon. https://doi.org/10.1016/j.foreco.2017.07.010

[5] Slik et al. 2008. Tree diversity, composition, forest structure and aboveground biomass dynamics after single and repeated fire in a Bornean rain forest. https://link.springer.com/article/10.1007/s00442-008-1163-2

assuming full clearance does occur, In TGB in Uganda trees might be cut down for charcoal or fuelwood, which would indeed release carbon to the atmosphere almost immediately. But equally it is highly likely that instead some or most of the resulting timber would be used in construction or to make furniture. Such long-lived wood products might last for decades or even centuries, keeping the carbon locked up[6]. Life-cycle analysis shows that timber harvested and allocated to long-lived wood products can result in negative GWP100 values[4,7]. I am not sure what percentage of the harvested timber in TGB or BR would end up used in furniture or construction of buildings, but given the scenario where non-permanence occurs is likely one where population densities are very high in the region the trees are planted, and poverty also high (otherwise the trees would likely be protected), it is very reasonable to assume that timber would be required for these purposes to at least some degree. Einarsson and Röös's assumption of 0% conversion to long-lived wood products appears very unlikely.

2. **No regrowth.** Einarsson and Röös's models assume no regrowth of trees in the land that once held the project: once harvested/burned, the land is assumed to remain holding a carbon stock at zero. This is unlikely to be the case, as if land has been forested for generations (BR) or 40 years (TGB), there will be a strong ecological (seed bank) and social tendency for at least some natural regeneration or replanting.

   Einarsson and Röös assume a fire destroys the forest permanently. In fact, forests recover after fires in the tropics. For example, in a classic study Vargas *et al.* used a set of tropical forest plots to show that ecosystem carbon recovers fully 50 years after fire[8]. Even if this was wrong by an order of magnitude, and the forest took 500 years to fully recover, Einarsson and Röös's assumption is unfair by assuming no recovery at all.

   Similarly, in the case of TGB, it is highly likely that farmers, having had trees on their land for 40 years, would have enjoyed the fruit, shade or timber they provided. They would likely therefore, at least in some cases, replant the trees or allow some natural regeneration after harvest. Indeed, there is evidence that, once embedded, agroforestry systems tend to persist[9]. And the TGB PDD explicitly assumes that trees will go through a cycle of growth, harvest and replanting – indeed the carbon credit calculations in the PDD rely on this cycle, only giving carbon credits for the long-term average carbon stored in a plot of land as trees grow and are removed, not the peak achieved at the end of the crediting period. Why would the replanting suddenly stop at the end of the crediting period?

   The idea that, in no case at all, would any regrowth or replanting occur on the land over the decades following clearance, seems highly unlikely. Yet this is, unfortunately, what Einarsson and Röös assume.

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[6] Pingoud et al. 2011. Global warming potential factors and warming payback time as climate indicators of forest biomass use. https://link.springer.com/article/10.1007/s11027-011-9331-9

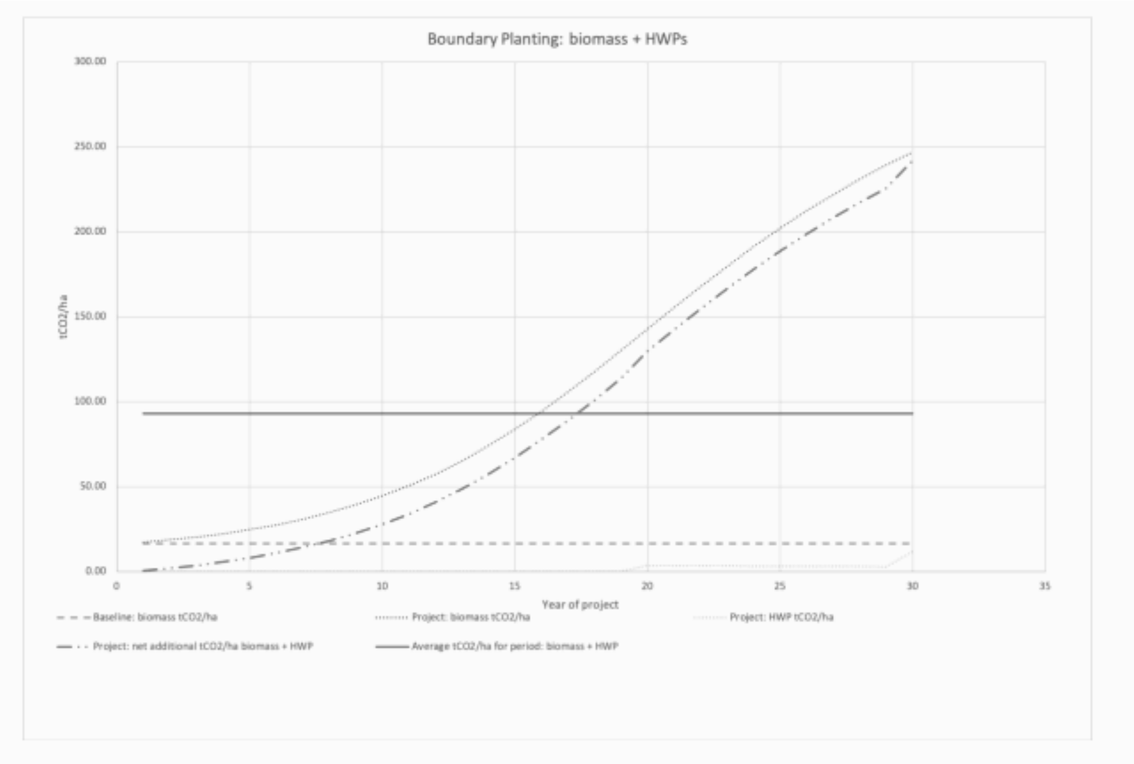
[7] Liu et al. 2017. Analysis of the Global Warming Potential of Biogenic CO2 Emission in Life Cycle Assessments. *Scientific Reports*, 7, 39857. https://www.nature.com/articles/srep39857?origin=ppub

[8] Vargas et al. 2007. Biomass and carbon accumulation in a fire consequence of a seasonally dry tropical forest. https://doi.org/10.1111/j.1365-2486.2007.01462.x

[9] Meijer et al. 2014. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. https://www.tandfonline.com/doi/full/10.1080/14735903.2014.912493

3. **Long-term average calculations.** Relevant only to the TGB project, afforestation/ reforestation/agroforestry projects under the Plan Vivo standard use a long-term averaging approach to calculate carbon credits. This means that rather than claiming for the maximum carbon achieved (tree growth by the end of the project), projects can only claim for the average carbon over the project period. This is because there is an assumption that trees will be harvested or die, and then replanted: the purchaser is buying the transformation of an area from a non-forest to a forested landscape, and receives a conservative number of carbon credits for this assuming this forested landscape will remain dynamic and with humans using it well into the future.

   For example, see this figure for one type of intervention in the TGB project (boundary planting), from their Technical Specification[10]



   I think Einarsson and Röös assume that TGB sells carbon offsets based on the peak carbon stored in year 30 – but in fact it claims the red horizontal line, less than half this peak value. Thus large reductions in the carbon captured from the atmosphere due to harvesting at some point followed by natural regrowth or replanting are already included in the carbon offsets purchased by Arla.

4. **Over-delivery.** Einarsson and Röös assume that only the carbon benefits purchased are captured by the project, and that they stop entirely once the project period ends. This is a very unrealistic set of assumptions for a Plan Vivo style project, for a number of reasons.

[10] EcoTrust, Trees for Global Benefit Programme: Technical Specification: Agroforestry farming system: mixed native and naturalized tree species. Version 1.2, updated 10 February 2020. https://www.planvivo.org/Handlers/Download.ashx?IDMF=ed5c7520-3341-461b-862b-18a38517fb3f

a) Plan Vivo projects purposefully make conservative assumptions at every step, in order to ensure that *at least* as much carbon as sold is captured, but that in all likelihood considerably more is captured. Plan Vivo is set up like this because there are many uncertainties, both in terms of the carbon calculations (for example the exact amount of carbon stored in a forest), and in the uncertainties of the future (how fast trees will grow). I am not aware of any scientific studies that specifically looked at this in Plan Vivo projects after they have finished: fundamentally very few projects have yet reached the end of their crediting period, as the forest carbon market is relatively new. But this principle of conservativeness can be seen in the Plan Vivo Standard and associated guidance documents, and it is thus very likely it will feed through to project outcomes.

For example, the Plan Vivo Guidance on Climate Benefit Estimation states “All projects that generate Plan Vivo certificates must include a credible and **conservative** estimate of the climate benefits that are expected to result from the project intervention”[11]. This principle of conservativeness is embedded in the process of the review of the Technical Specifications of projects, with reviewers ensuring that conservative assumptions are made throughout. In my view, this is likely to mean that each project effectively undersells carbon credits over the project period by a factor of 50-100%: and this is exactly as it should be, to ensure that even in a case where assumptions are very wrong, the amount of carbon that should be removed from the atmosphere due to the sold credits genuinely is removed. Note that this conservativeness is entirely separate from the risk buffer, which is discussed in the section on permanence – the risk buffer is additional to the conservative assumptions.

b) Trees will continue to grow after the end of the crediting period. For example, the forests of BR and the trees planted in TGB (or the replanted trees after the first cohort are harvested and used in construction or furniture) will carry on capturing carbon every year of the 100 years considered, not just the 5 or 40 years of project considered in the BR and TGB crediting periods respectively. This is only relevant to the S2 scenarios, but in that case assuming tree growth entirely stops at that point in time, in either project case, is unlikely to be true. Even mature tropical forests are known to be increasing in carbon stocks at significant rates, likely due to climate change and recovery from past disturbance[12]. In the S2 (partial non-permanence) scenario, I have done a quick estimate to suggest this factor alone, in Bujang Raba alone, would be sufficient to enable net zero to occur before the required 100 years. This could be worked into a more formal calculation if required.

c) Plan Vivo projects have widespread and long-term multiplicative effects, that increase the carbon storage of the surrounding landscape. For example, by creating a local industry of tree nurseries, creating industries such as selling fruit (real examples from the TGB project) whole communities can be transformed to having many more trees permanently. In BR, by a community obtaining *hutan desa* status and thus the ability to manage their own forests, they may encourage other communities to do the same without obtaining carbon funding. This is obviously uncertain, and hard to quantify, but is commonly believed to occur, and indeed is

[11] https://www.planvivo.org/Handlers/Download.ashx?IDMF=35194e64-addc-45f0-80f3-52871d0ff91d

[12] Pan, Y., et al. 2011. A large and persistent carbon sink in the World’s forests. *Science.* https://www.science.org/doi/abs/10.1126/science.1201609

often argued as likely within Plan Vivo Project Documents, which are accepted by the formal audit process. It is hard to imagine that Arla's investments in forest protection (BR) and reforestation/agroforestry (TGB) will have no long-term positive impact on tree cover, but that is the pessimistic assumption of Einarsson and Röös's model.

5. **Non-carbon climate benefits.** Einarsson and Röös have used a very simple carbon model to produce their estimates. As they discuss in the Technical Details note A, as this is a non-dynamic model, it does not including carbon-cycle feedbacks that would likely result in slightly less favourable results for Arla's claims, due to the different mixes of gases in the emissions and offsets. However, this model also does not include the climate effects of trees that are unrelated to carbon, which is that they cool the local area due to shade and evaporation from their leaves, change surface roughness, and change albedo, and thus change wider climate and rainfall patterns[13]. These are not fully captured in any climate models, but the modelling that has been done shows that tree removal in the tropics is associated with greater temperatures in the tropics, exacerbating climate change in this most vulnerable region[14]. Unlike the bias described in Technical Details note A, this difference disadvantages Arla compared to a more complex model: more trees in the tropics will definitely impact global climate, likely in a way that causes at least local, and quite possibly global, cooling[13,14].

   This can be taken further, well beyond what climate models cover. Trees in the tropics have other well known positive benefits for local people: they stabilise soils, reduce local temperatures, provide non-timber forest products such as fruits, can increase crop yields, and can result in the earning of carbon credit revenues[15] (as is clearly the case in this Arla example, with Plan Vivo projects all committed to spending at least 60% of sales to communities as payments for ecosystem services[16]). Such benefits are likely to increase local incomes and quality of living, both of which are known to reduce birth rates[17], and lower population growth and higher incomes are likely to reduce conflict and migration. In turn, lower migration and conflict are ultimately likely to reduce deforestation and carbon emissions. Such feedbacks are a key reason why forest protection and reforestation credits are so popular, and are likely (to some extent) genuinely occurring or likely to occur in the future. They should form part of Arla's Net Zero argument, but the difficulty of quantifying them means they are unlikely to be, even though in the S2 scenario (for example) considerably more trees will be on the landscape throughout the next 100 years, despite the lack of permanence.

6. **Soil stabilisation.** Extreme events will increase over the coming decade. They will be especially strong in the tropics, with an increase in droughts and large storms/floods expected. Trees

[13] Betts, R. 2001. Biogeophysical impacts of land use on present-day climate: near-surface temperature change and radiative forcing. *Atmospheric Science Letters* https://www.sciencedirect.com/science/article/abs/pii/S1530261X01900234

[14] Devaraju & Noblet-Ducoudré, 2018, Quantifying the relative importance of direct and indirect biophysical effects of deforestation on surface temperature and teleconnections. *Journal of Climate* *https://journals.ametsoc.org/view/journals/clim/31/10/jcli-d-17-0563.1.xml?tab_body=pdf*

[15] https://www.sciencedirect.com/science/article/pii/S1389934117300345

[16] Plan Vivo Standard, 2013, clause 8.12. https://www.planvivo.org/Handlers/Download.ashx?IDMF=a677d7d1-ce55-4925-aeea-71b8c95caf1c

[17] Colleran H & Snopkowski, K. Variation in wealth and educational drivers of fertility decline across 45 countries. *Population Ecology* https://link.springer.com/article/10.1007/s10144-018-0626-5

stabilise soils, providing some resilience against extreme events, preventing landslides[18] and damaging floods[19]. This is generally considered a very good thing simply for preventing or reducing human suffering, but it is also important in preventing soils being disturbed or washed away, ultimately releasing the carbon stored in them, which may match or exceed the carbon stored in the trees that were removed. Like the non-carbon climate benefits described above, this is not really included in any climate models and thus Arla will obtain no credit for it: but it is a key reason for forest protection and reforestation. In the case of Scenario S3 this protection is only there for the first 20/40 years (BR and TGB respectively), but in S2 it is there throughout as some trees remain. Assuming the carbon impact of this is zero is again likely results in an understatement of Arla's claims.

Taking all these together, I believe that under the Partial non-Permanence scenario (S2), it is highly likely that the impact of Arla's emissions would remain countered by the offsets that they purchased under the GWP100 measure (remembering that under the analysis of Einarsson and Röös this was already close, with net zero reached by year 135 and the net impact being negative when considered beyond that date). Under the full non-permanence scenario (S3) it is also possible that there would be a full offset of emissions under GWP100, but I am less certain. However, as discussed in the next section, I believe S3 or anything close to it is incredibly unlikely to happen in practice.

3.2 Why Plan Vivo certificates are likely to represent long-term removals

Section 3.1 discussed the carbon impact of the partial (S2) and full (S3) non-permanence of the Plan Vivo certificates purchased by Arla. It suggested that, even if these scenarios occurred, the likely global warming impact of that non-permanence would be lower than that estimated by Einarsson and Röös. However, it did assume that their scenarios did occur as they set out.

In this section, I discuss the reasons why I believe scenario S2 (involving a gradual loss of 50% of the trees) is unlikely to occur in practice in either project considered, and why S3 is incredibly unlikely to occur in any Plan Vivo project.

I conclude this section by explaining why I believe a different scenario I have developed, called Scenario S1.5, is a more likely 'worst case scenario' for non permanence in these landscapes.

1. **Project design.** Plan Vivo projects all follow the Plan Vivo Standard[20], and are audited against this. They also submit annual reports and other reporting to the Plan Vivo Secretariat throughout the project duration. During the 'crediting period' (20 years for BR, 40 years for TGB, according to Einarsson and Röös's analysis), monitoring, reporting, and the presence of a pooled risk buffer, has convinced Einarsson and Röös that there is no non-permanence risk, so

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[18] Grima, M. et al. 2020. Landslides in the Andes: Forests can provide cost-effective landslide regulation services. *Science of the Total Environment* *https://doi.org/10.1016/j.scitotenv.2020.141128*

[19] Bhattacharjee, K & Behera, B. 2018. Does forest cover help prevent flood damage? Empircal evidence from India. *Global Environmental Change https://doi.org/10.1016/j.gloenvcha.2018.09.004*

[20] https://www.planvivo.org/Handlers/Download.ashx?IDMF=c72b7fa8-4818-4bae-884e-fba717a49cab

I do not discuss it further here. However, the premise of the non-permanence risk they discuss is that there could be a rapid loss of trees immediately that crediting period ends.

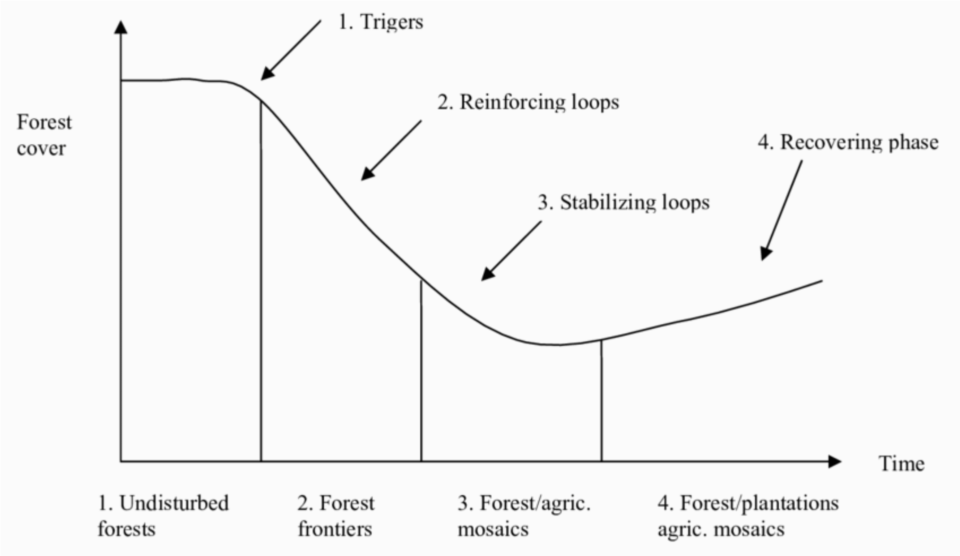
Einarsson and Röös seem to be under the mistaken view that tree planting and forest protection under the Plan Vivo Standard occurs only because payments are made to communities each year, and that once these stop, the communities will simply cut the trees down again. But this is not how the Standard works: every project must prove that it has a plan to transform livelihoods and attitudes in its area such that trees will form part of the landscape in the long term. Before being registered every project must provide and prove this plan in its Project Design Document (PDD), and this is revisited as the project evolves. These are described in detail in Part H of Plan Vivo PDD, which covers short and long-term risks, including after the project ends.

The Plan Vivo Foundation have provided a document detailing how a plan for permanence is embedded in the design of the two projects in question, so I will not repeat this in detail here[21]. But to summarise, in BR the local community has through this project won the rights to protect their 5,000 hectare community forest from palm oil development. Given the extent of cleared forest around this community, it is very unlikely that after the project finishes the community would want to give up this forest (even if it was legal for them to clear it, which is unlikely, see below), as they obtain valuable products and cultural value from it. And in TGB, the trees grown on farmers' land are chosen to increase farmer's incomes, through the provision of fuel wood (woodlots), fruits, or timber (in a long-term harvesting/replanting cycle). While individual trees may be cleared after the project (as they were during the crediting period, with the carbon benefits reduced accordingly in the original calculations to account for this), overall the expectation is that the trees will remain either because livelihoods still depend on them, and people would be poorer if they were permanently removed, or because their owners have become richer and value the tree cover in its own right, with the marginal agricultural land on which trees have been planted no longer farmed. I believe these arguments, and find it unlikely that even S2, and certainly S3, would actually occur over the coming decades.

2. **Legal framework.** It is highly likely that it will be illegal to clear these trees once the projects end. The world's countries have signed up to Sustainable Development Goals that include a target of "*15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally*"[22]. Further commitments to halt deforestation, and restore substantial amounts of forest, have been made by Indonesia and Uganda in their NDC submissions to the UNFCCC[23], and these will likely be strengthened over the coming decades. Of course, I do not believe these laws will prevent all deforestation: sadly, it is likely to continue to some degree. But it is hard to believe that in the subsequent decades the complete clearance of the BD forest, or all trees planted in the TGB project, would be likely to be cleared without significant negative consequences for the people doing the clearance. This would likely act as a strong deterrent.

[21] PV Response on Permanence.
[22] https://sdgs.un.org/goals/goal15
[23] https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx

3. **Local/regional transformation.** Beyond the specific plans of the project, and the law, local and international cultural views of trees shift with time. We know that there is a forest transition as countries develop, whereby deforestation rates peak as countries develop rapidly, and then slows or reverse as they become richer[24]. See the figure below taken from Angelsen (2007)



Indonesia and Uganda have both experienced rapid deforestation over the recent decades, and are likely past the steepest part of this curve as in both cases much forest on land most suitable for agriculture has already been cleared[25]. In the 20+ years before the non-permanence risk is relevant, they may be past the reduction phase and into the 'recovering' phase – and as such the trees that needed protected at this point in time, will have little need of protection at that point in the future. In effect Arla's investment protected the BR forest from deforestation during its most vulnerable period, but it may be largely safe on its own in 20+ years time; similarly the new trees planted in Uganda under TGB may be much safer in 2050+ than they would be now.

The global view of trees is also changing, with IPCC reports[26], UNFCCC agreements and other pacts such as the Bonn Challenge[27] all calling for the prevention of deforestation and massive investments in tree planting to restore past deforestation and draw down carbon. If this becomes a reality over the coming decades, then the whole global culture will be tilted much more towards maintaining trees in landscapes.

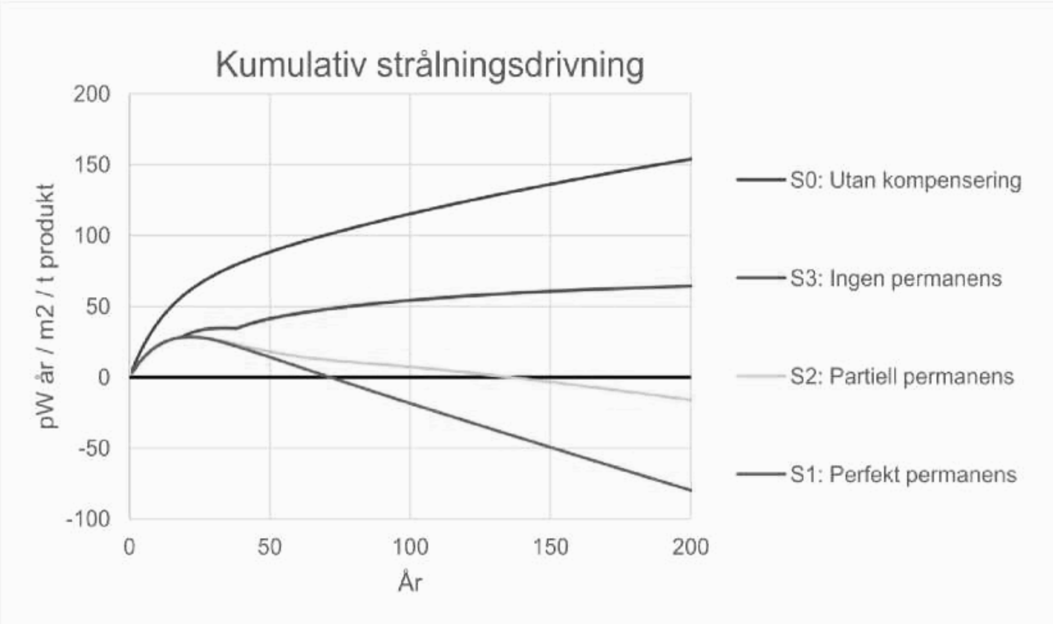
I expect that the above means the trees planted/protected by Arla will thus remain standing, or if harvested, replaced, for decades or centuries following the crediting period. However, if some trees were destroyed, I believe the S2 and S3 scenarios are unlikely. S3 just seems unfeasible: that many

[24] Angelsen, A. 2007. Forest Cover Change in Space and Time : Combining the von Thünen and Forest Transition Theories. Policy Research Working Paper; No. 4117. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/7147
[25] Hansen, M.C. et al. 2013. High-resolution global maps of 21st-century forest cover change. https://www.science.org/doi/10.1126/science.1244693
[26] https://www.ipcc.ch/sr15/
[27] https://www.bonnchallenge.org/

trees would not be harvested in a single go the moment the project ended, and there would not be no regrowth and no storage of wood in long-lived products. But S2 also seems unlikely, with 50% of trees removed with no regrowth. I suggest instead a scenario S1.5 represents a reasonable non-permanent scenario, as a reasonable worst case option. This would feature:

- Loss of 30% of trees spread out over 20 years following the termination of the project
- A gradual regrowth of the trees once cut at the rates in the PDD
- 30% of removed biomass not returning to the atmosphere, but remaining in long-lived wood products.

I do not have access to the model to be able to run this scenario, but by looking at the lines for Scenarios 1 and 2, assuming this model would be approximately in between, it would seem likely that under this scenario Net Zero under GWP100 would be achieved. This is of course using the model provided, which has some flaws as explained in 3.1.



4. Conclusions

Overall, I conclude that, firstly, GWP100 is the only reasonable metric to use when calculating net zero claims involving different greenhouse gases, so Arla were correct to use it when calculating what number of offsets they needed to purchase to offset their emissions. And secondly, that the non-permanence scenarios drawn up by Einarson and Röös are not realistic, ignoring many features of the design of Plan Vivo projects, and simply the nature of peopled tropical forest landscapes. The non-realistic (overly-pessimistic) scenarios used in their analysis might nonetheless be compatible with a successful net zero claim had other assumptions not been made by the researchers that biased the calculations away from the net zero claim.

I believe, based on the evidence of the literature and my own experience of such projects, that the Plan Vivo credits purchased by Arla represent high quality products, that have and will continue to transform landscapes from a low-tree to a high-tree state, while simultaneously achieving great livelihood and biodiversity benefits. It is highly likely that their investment in these projects mean that there are many more trees now than there would have been without the project (this was not disputed by Einarsoon and Röös), but also that this transformation will remain for many generations. The trees that Arla has directly funded the protection or planting of will be harvested or die: but they will regrow or be replanted, the land will not be converted to a non-forest state because none of the surrounding people will either want to do so, or be allowed to do so.

I therefore do not believe that the memo produced by Einarsoon and Röös contains valid information that could be used to challenge Arla's claim to produce net zero carbon footprint products.

E. Mitchard

13/10/21

Professor Edward Mitchard, BA PhD SMIEEE

Professor Edward Mitchard B.A. Ph.D SMIEEE

School of GeoSciences, Crew Building, The King's Buildings,
University of Edinburgh, Edinburgh, EH9 3FF, UK
edward.mitchard@ed.ac.uk https://mitchardgroup.wordpress.com @edmitchard

Personal Chair of Global Change Mapping, University of Edinburgh (2020-);
Senior Lecturer (2018-20); Chancellor's Fellow (2013-18)

Director, SENSE (Satellite Data for Environmental Science) Centre for Doctoral Training (2019-)

- Permanent, senior position within the School of GeoSciences, the top-rated institute in its category at the last UK-wide Research Excellence Framework ranking (2015)
- Director of a Centre for Doctoral Training joint between the Universities of Leeds, Edinburgh, British Antarctic Survey and the National Oceanographic Centre, funded by the UK Space Agency. This will train 50 new PhD students in applying machine learning and artificial intelligence methods to satellite remote sensing data to solve environmental problems, with a budget of £5.5 million
- Manages group of nine: four postdoctoral researchers and primary supervisor for five PhD students. Co-supervisor for further 4 PhD students.
- Received £3 million in funding as PI since 2011 to map changing forest and savanna characteristics and peat swamps around the tropics, using networks of forest inventory plots and satellite data, including an ERC Starting Grant (£1.8 million, 2018-2023)
- Expert in the analysis of optical, radar and LiDAR satellite datasets for tree/forest and drought characterisation, and collects LiDAR and optical data from drones owned by his group.
- Formal advisor to the UK government on land use mapping methods, to the UK Department for International Development on monitoring forest change in its UK-AID projects round the world, and advisor to the Gabonese government on setting up forest inventory networks and mapping
- Contracted as a Senior Expert by the World Bank to advise sub-Saharan African countries on forest inventory, carbon stock assessment, deforestation and forest degradation baseline mapping
- In 2013, became the youngest ever recipient of a Chancellor's Fellowship, a prestigious research position at the University of Edinburgh. Used this period to build up research group and international research reputation through winning research grants, advising NGOs and governments, conducting fieldwork throughout the tropics, and writing high impact publications.

NERC Research Fellow, University of Edinburgh (2011-2014)

- Independently funded to develop new methodologies and assess uncertainties in the monitoring of tropical deforestation and degradation, and forest carbon stocks, concentrating on Africa
- Field campaigns in Cameroon, Gabon and the Republic of Congo

Education

Ph.D (GeoSciences), University of Edinburgh, 2011, funded by Gatsby Plants

- Developed new algorithm to allow the use of satellite radar data to map tropical biomass change, now widely used and accepted by scientific community
- Published six first-author peer-reviewed papers during PhD
- Led extensive fieldwork campaigns in Cameroon, Gabon, South Africa and Uganda
- Spent seven months based in NASA Jet Propulsion Laboratory in Pasadena, CA, working with PhD co-supervisor Dr Sassan Saatchi

B.A. (Biological Sciences), 1st Class, University of Oxford, 2007

- Led and raised £14,000 funding for a 6-week expedition to Trinidad in 2005 to set up forest inventory plots and climb trees using advanced techniques to collect epiphytic plants

Positions of Responsibility & Knowledge Exchange

- Member of the Technical Advisory Panel for the Plan Vivo carbon standard (2010 to present).
- Organised workshops on forest mapping for government and officials in Cameroon (2012, 2014), Ghana (2013), Gabon (2015), Peru (2017), & Indonesia (2021)

Major Research Grants as Principal Investigator

- European Research Council (2018-2023), **£1.8M,** Starting Grant “FODEX: Tropical Forest Degradation Experiment”
- UK Space Agency (2016-17), **£131K**, International Partnership Space Programme
- NERC (2015-17), **£242K**, Commercialising radar-based detection of deforestation & degradation
- US Forest Service (2015-18), **£42K**, PhD studentship and research grant on fire and aboveground biomass in the savannas of the Bateke Plateau
- Technology Strategy Board (2014-15, now Innovate UK), **£125K**, SAREDD - An operational service providing reliable forest degradation information using satellite radar data.
- NERC (2011-2014), **£318K**, Research Fellowship: Using satellite data to monitor REDD+ projects: developing methodologies and error estimation for Africa
- **As Co-I:** many including UK Space Agency (2017-20), **£15M** (UoE share **1.1M**), FORESTS 2020 – improving forest monitoring capacity in Brazil, Colombia, Ghana, Kenya, Mexico & Indonesia

Publications

74 peer reviewed publications, cited over 5970 times (Scopus, Sep 2021). Full list at https://scholar.google.co.uk/citations?user=DSmGQwEAAAAJ Recent highlights:

Morley, J., Buchana, G., **Mitchard, E.T.A.** & Keane, A. 2021. Implications of the World Bank’s environmental and social framework for biodiversity. *Conservation Letters* doi:10.1111/conl.12759

Nwobi, C., Williams, M. & **Mitchard, E.T.A.** 2020. Rapid Mangrove Forest Loss and Nipa Palm (*Nypa fruticans*) Expansion in the Niger Delta, 2007-2017. *Remote Sensing* doi:10.3390/rs12142344

Poulsen, J.R., et al. including **Mitchard, E.T.A**. 2020. Old growth Afrotropical forests critical for maintaining forest carbon. *Global Ecology & Biogeography* doi:10.1111/geb.13150

Hansen, J.N., **Mitchard, E.T.A.,** & King, S. 2020. Assessing forest/non-forest separability using Sentinel-1 C-band synthetic aperture radar. *Remote Sensing,* doi:10.3390/rs12111899

Sullivan, M.J.P., Lewis, S.L., et al. including **Mitchard, E.T.A.** 2020. Long-term thermal sensitivity of Earth’s tropical forests. *Science* doi:10.1126/science.aaw7578

Hubau, W. Lewis, S.L., et al. including **Mitchard, E.T.A**. 2020. Asynchronous carbon sink saturation in African and Amazonian tropical forests. *Nature* doi:10.1038/s41586-020-2035-0

Bush, E., **Mitchard, E.T.A.,** *et al.* 2020. Monitoring mega-crown leaf turnover from space. *Remote Sensing,* doi:10.3390/rs12030429

Lewis, S.L., Wheeler, C.E., **Mitchard, E.T.A.,** & Koch, A. 2019. Restoring natural forests is the best way to remove atmospheric carbon. *Nature*, doi:10.1038/d41586-019-01026-8

Nomura, K., **Mitchard, E.T.A.,** *et al.* 2019 Oil palm concessions in southern Myanmar consist mostly of unconverted forest. *Scientific Reports* 9, 11931.

McNicol, I.M., Ryan, C.M., & **Mitchard, E.T.A.** 2018. Carbon losses from deforestation and widespread degradation offset by extensive growth in African woodlands. *Nature Communications*, doi:10.1038/s41467-018-05386-z

Mitchard, E.T.A. 2018. The tropical forest carbon cycle and climate change. *Nature*, 559, 527-534

Kalamandeen, M., Gloor, E., **Mitchard, E.T.A.,** *et al.* 2018. Pervasive Rise of Small-scale Deforestation in Amazonia. *Scientific Reports*, doi:10.1038/s41598-018-19358-2

Milodowski, D.T., **Mitchard, E.T.A.** et al. 2017. Forest loss maps from regional satellite monitoring systematically underestimate deforestation *Environmental Research Letters* doi:10.1088/1748/9326

Joshi, N, **Mitchard ETA** *et al.* 2017. Understanding ‘saturation’ of radar signals over forests. *Scientific Reports*, doi:10.1038/s41598-017-03469-3

Dargie GC, Lewis SL, Lawson IT, **Mitchard ETA**, Page SE, Bocko YE & Ifo, SA. 2017. Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature*, doi:10.1038/nature21048

Collins, M.B. & **Mitchard, E.T.A.** 2017. A small subset of protected areas are a highly significant source of carbon emissions. *Scientific Reports,* doi:10.1038/srep41902