Reviewer 1:

We thank the reviewer for their comments on our draft paper, which have helped to improve our study.

1. *The uniqueness of the study lies in the use of multi-ESMs, confirming the robustness of earlier results, but the selection of these models should be justified. For instance, do they well simulate the present-day observed states and variability?*

   The models used within the study were all available models which ran the experiment G6sulfur, of which there were only five from distinct modelling centres. A sixth model, MPI-ESM1-2-HR, also ran the experiment but as it is only a high-resolution version of the model already used within the study (MPI-ESM1-2-LR) we chose to omit it from our analysis to avoid double-counting that centre's model.

2. *SRM terms are often used interchangeably with SAI, which is incorrect*

   Thank you for spotting this, we have now changed SRM to SAI where applicable.

3. *The discussions, with respect to uncertainties could be improved.*

   We have increased the discussion of model biases and related uncertainties (see our responses to point 9., below).

4. *The title suggests that the Amazon rainforest would be endangered if SRM is not applied. But nowhere in the paper it is shown that the models simulate a detrimental effect of climate change should SAI is not applied. Do any of the models capable of simulating Amazon forest dieback under the SSP245 or SSP585? It is not clear if dynamical vegetation is implemented in these models and what are the implications of not including it.*

   We will include two figures in the supplementary material which show an area of notable relative decrease in vegetation carbon in the Amazon for UKESM1-0-LL in SSP585 compared to G6sulfur. We also include timeseries of the evolution of vegetation carbon averaged over the identified region, which demonstrates the efficacy of SAI in improving resilience in the Amazon. We have added to the discussion to address this point starting on line 193 of the paper:

   "We have previously seen evidence of localised Amazon forest dieback, in multiple CMIP6 models, in idealised runs of CO_2 increased by 1% per year (Parry et al., 2022). ***However, of the models studied here, only UKESM1-0-LL exhibits a notable reduction in vegetation carbon under the SSP585 scenario. Under SSP585 UKESM1-0-LL projects a notable decrease in vegetation carbon over the northeast of the Amazon, amounting to up to a 40% decrease in some small areas (Figure S5). Looking at the projected evolution of vegetation carbon averaged over this region,***

we see that by 2100 SSP585 projects a decrease of about 4 kgC m^{-2} (Figure S6). This is a decrease that is largely avoided after the application of SAI, with the same region experiencing a decrease of less than 1 kgC m^{-2}. All other models show an increase in resilience over this region after SAI is applied, compared with SSP585. **As forest dieback arises when the rate of forest carbon loss exceeds the rate of carbon gain, changes in simulated NPP imply changes in the risk of forest dieback. However, while the results presented here indicate that SRM would protect against carbon losses in the Amazon forest, in the future it would be beneficial to run SRM experiments over longer periods that yield clearer examples of forest dieback in the absence of SRM."**

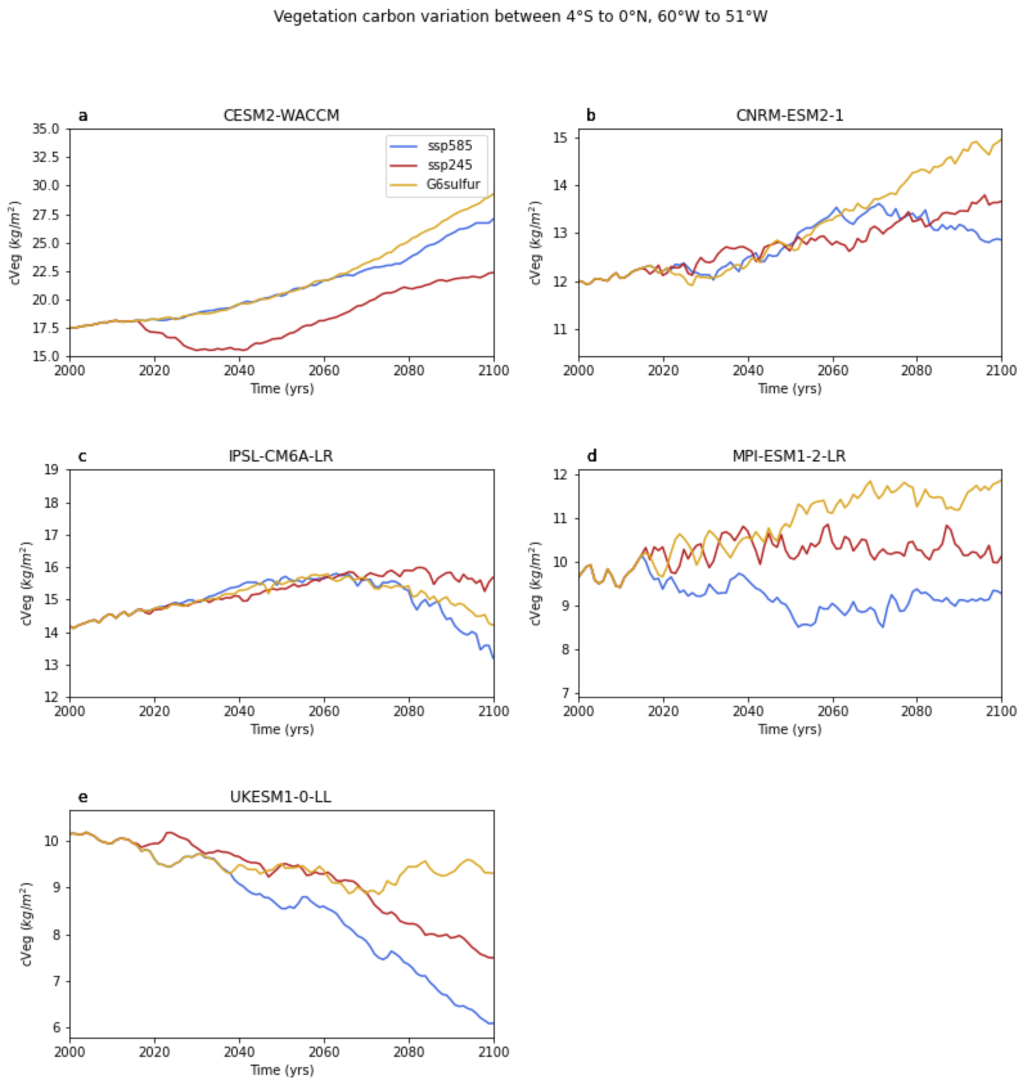


Figure S6: Evolution of vegetation carbon averaged over the region 4°S to 0°N and 60°W to 51°W.

For other examples of models from CMIP6 which show dieback in the Amazon, see Figure 1 from Parry et al., 2022.

5. *Sect.2.2 Validation. It is difficult to validate the patterns shown in Fig. 1 when observational-based estimates are not included. Please include estimates e.g., from Piao et al. (2020). The authors indicate that the spatial pattern is comparable, but how about the spatial magnitudes? Actually, I am not convinced that the comparison with volcanic eruption is useful. As stated, the impact of eruption differs based on climate states (here you can also cite Frolicher et al. 2013; https://doi.org/10.1002/gbc.20028), and given the large ESMs spread, it looks like the solid black line is insignificant (Fig. 2).*

   While the behaviour we observe after a volcanic eruption is not identical to SAI, it does show how the climate system in these models responds to an analogous aerosol forcing. This allows us to judge the efficacy of these models in responding to aerosol forcings of this type and check they are reasonable. We use the same methodology as in Piao at al. (2020) to produce Figure 1 and allow reasonable comparison, though the two are not directly comparison as we use four separate volcanic eruptions as opposed to the two used in Piao et al,. 2020.

   We also add the following text discussing spatial magnitudes to our analysis, starting on line 97:

   "The magnitude of the land carbon flux anomalies in the models we analyse are comparable to those from Piao et al., 2020, with both experiencing land carbon anomalies between that lie predominantly in the range +/- 70 gC m^{-2} yr^{-1}. The land carbon anomalies in high latitudes are relatively small in both examples, with more notable changes occuring around the equator and low latitudes.

   We also expand on our discussion of the importance of climate states on the impact of a volcanic eruption (line 101):

   "Observed responses to individual volcanic eruptions differ due to changes in the ENSO phase (Jones et al., 2001; Frolicher et al., 2013), which are often different to the ENSO phase being experienced in the models for the same year. In fact, one study finds that the response of atmospheric CO_2 to volcanic eruptions can be as much as 60% larger during El Nino and winter (Frolicher et al., 2013), highlighting the difficulty of directly comparing the response to volcanic eruptions between models and observations."

6. *Throughout the paper (inc. Fig. captions), the 'SAI' experiments are often referred to as 'SRM'. Use SAI throughout the text, as SRM refers to a broader radiative-based climate engineering.*

   "SRM" changed to "SAI" throughout the text.

7. *The definition on L29 is also incomplete, e.g. SRM also includes cirrus cloud thinning, which is not primarily aimed at reflecting sunlight. Differences in SRM methods could lead to considerably different impacts (e.g. for the Amazon precipitation patterns: Park*

et al., 2019; https://doi.org/10.1029/2019GL084210). Instead, I recommend using the IPCC definition of SRM:
"Refers to a range of radiation modification measures not related to greenhouse gas (GHG) mitigation that seek to limit global warming. Most methods involve reducing the amount of incoming solar radiation reaching the surface, but others also act on the longwave radiation budget by reducing optical thickness and cloud lifetime."

Changed as suggested to use the IPCC (Assessment of SRM in the IPCC AR6 WG1 report) definition. The definition starting on line 28 now reads:
"IPCC states that SRM refers to a range of radiation modification measures not related to greenhouse gas (GHG) mitigation that seek to limit global warming. Most methods involve reducing the amount of incoming solar radiation reaching the surface, but others also act on the longwave radiation budget by reducing optical thickness and cloud lifetime."

8. *Information on 'Fire' representation is included in Table 2, but its impact is not discussed in the paper. Please clarify.*

   Fires are an important mediator of forest dieback and form part of a positive feedback loop that can lead to abrupt, large-scale losses of vegetation. Thus, when analysing the simulation of dieback dynamics, it is important to identify which models explicitly represent fire processes. We therefore include information on fire representation in the models analysed in this study to provide context for some of behaviour we observe in land carbon storage and net primary productivity.

   We have added the following text to line 83 to highlight this point:
   "Fires are an important mediator of forest dieback and form part of a positive feedback loop that can lead to abrupt losses of vegetation. Thus, when analysing the simulation of dieback dynamics, it is important to identify which models explicitly represent fire processes."

9. *CO2 fertilization is often credited as the 'primary' reasons for the enhanced NPP and land carbon storage. For NPP, this is only true if precipitation remains at a sufficient level, right (i.e., if precipitation decline considerably, higher CO2 will not enhance NPP, as happens in IPSL model)? For land carbon storage, this is true if the vegetation biomass mostly contributes to the land carbon increase. But earlier studies have indicated that the higher land C storage is due to cooling-induced less soil respiration.*

   Given the emphasis on the Amazon region, the authors should provide a more detailed pretext on how well these ESMs simulate the NPP (e.g., seasonal cycle as compared to flux tower estimates), vegetation or soil carbon storage, mean precipitation, temperature, etc. in the contemporary Amazon region. It is my understanding thats ESM underestimate precipitation in this region (Hagos et al., 2021; https://doi.org/10.1175/JCLI-D-20-0211.1), and would be necessary to elaborate what are the implications of this and other biases on your conclusions

In these models, vegetation in Amazonia is not strongly limited by water, which means that a small reduction in rainfall does not cause a significant reduction in NPP. Additionally, the response in land carbon storage and NPP, despite changes in precipitation, is counteracted by increased water use efficiency under the higher CO_2 concentrations in SSP585 (Dekker et al., 2016).

Regarding how well ESMs simulate NPP etc. in the Amazon, we have added the following text to the discussion starting on line 292:

"Model ensemble averages show that CMIP6 models tend to underestimate NPP in central and northeastern areas of the Amazon but overestimate in northwest and south easterly regions, when compared with MODIS data. Looking at individual models, CESM2-WACCM and IPSL-CM6A-LR underestimate NPP in Amazonia, while MPI-ESM1-2-LR generally overestimates NPP (Hu et al., 2022). These individual model variations are important to take into account when interpreting CMIP6 outputs for the Amazon."

"Although improved on the CMIP5 model generation, the CMIP6 models still tend to overestimate temperatures in the Amazon basin (Firpo et al., 2022), and underestimate rainfall (Hagos et al., 2020; Parsons 2020; Monteverde et al., 2022). This tends to bias models towards less favourable conditions for the Amazon rainforest. However, CMIP6 models show greater agreement in rainfall projections for the Amazonian basin, than previous model generations (Parsons et al., 2020)".

From the paper, the readers get the message that SAI can be used as an emergency protection against loss of Amazon rainforest. While this is implied by their findings of NPP changes, SAI has also been also shown to induce negative impacts on NPP and land carbon storage in many other regions (high latitude NH as shown in this study). This result should be conveyed accordingly. In addition, the first sentence of conclusion can be expanded to highlight the regional disparity in the benefit of SRM with some examples. Given the controversial topic of SRM, it is the authors' responsibility to not be partial in delivering their messages.

We have included new text addressing the regions which experience decreases in NPP or land carbon storage in some model in the abstract:

"Our results therefore suggest that SAI could provide some protection against the risk of climate change induced carbon losses from the Amazon rainforest, though this is not universally observed in all tropical forests. Additionally, we observe decreases in NPP and land carbon storage in some regions, such as eastern Africa, the northern high latitudes, and Indonesia."

And the conclusion on line 300:

"We note, however, that these observed increases in NPP and land carbon storage are not universal, with regions such as eastern Africa, the northern high latitudes, and Indonesia showing decreases for some models."

10. *Finally, it should be mentioned that SRM is a temporary mitigation measure, and it doesn't address the primary drivers of climate change (growing level of atmospheric CO2), despite the higher land C storage. Hence, when terminated, the issue would likely reappear at a considerably faster rate (Jones et al., 2013, https://doi.org/10.1002/jgrd.50762; Muri et al., 2018, https://doi.org/10.1175/JCLI-D-17-0620.s1), with potential of triggering other tipping element of the Earth system*

    We now include a mention of the temporary nature of the mitigation provided by SRM starting on line 192.

    "Additionally, we note that SAI is a temporary mitigation measure which, while reducing global temperatures, does not address the primary drivers of climate change, (increased concentrations of greenhouse gases). As a result, if SAI is terminated, global temperatures would rise rapidly due to the elevated greenhouse gas concentrations (this is known as the 'termination effect', Jones et al., 2013; Muri et al., 2018). Therefore, global efforts to reduce carbon emissions would still be required even if SAI were to be deployed temporarily to reduce the risk of Amazon dieback."

11. *Title: Stratospheric Aerosol Injection instead of SRM, and perhaps "SAI has the potential to increase ...."*

    We have changed the title to read: "Stratospheric aerosol injection geoengineering has the potential to increase land carbon storage and to protect the Amazon rainforest"

12. *L1-2: Change SRM definition.*

    Changed as discussed above.

13. *L9: define G6suplhur or remove "under G6suplhur"*

    "Under G6sulfur" removed.

14. *L51: reduce the radiative forcing*

    "reduce the forcing" changed to "reduce the radiative forcing".

15. *L53: remove instead*

    "instead" removed.

16. *L56: G6Sulpur => G6sulfur*

    Done as suggested.

17. *L56: from a higher*

Done as suggested.

18. *L60: cite Lee et al. (2021); https://doi.org/10.5194/esd-12-313-2021*

    Done as suggested.

19. *L102: cite Frolicher et al. (2013); https://doi.org/10.1002/gbc.20028*

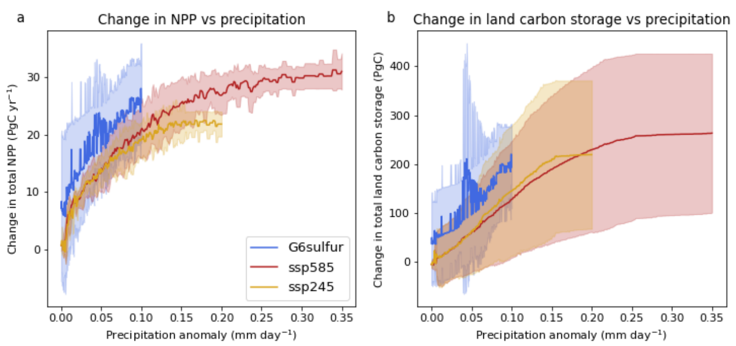
    Done as suggested.

20. *L112: 1850-1899, but in Figs. 3&18 captions: 1850-1900*

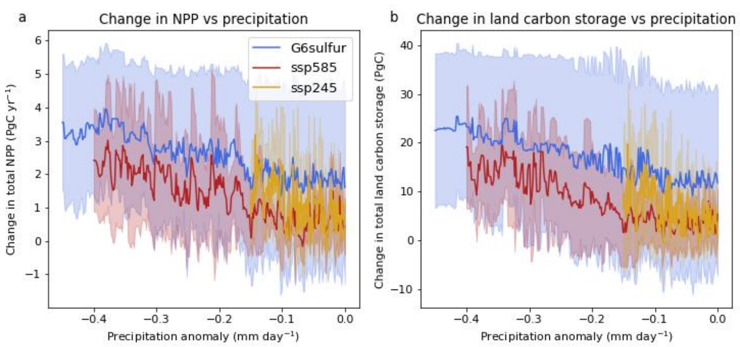
    1850-1899 corrected to 1850-1900

21. *L230: This statement appears not well supported, i.e., precipitation could be more important at regional scale. I suggest producing figures similar to Fig. 18, but for the different regions mentioned prior to this sentence. Include precipitation, in addition to T and CO2, for each individual model.*

    We have created a new figure showing precipitation vs NPP and land carbon storage.



Global



Amazonia

Global mean NPP and land carbon storage is higher in G6sulfur than either SSP585 or SSP245, even for the same precipitation anomaly. As the figure above shows, there is a weak relationship between global precipitation and global NPP or global land carbon storage, which are instead determined primarily by changes in atmospheric CO_2 and temperature.

For the Amazon region, the simple correlation between changes in precipitation and changes in NPP is negative (<-0.85), but this is not a causal link. In these runs, area-mean NPP goes up with increasing CO_2 in both SSP585 and G6sulfur and increases in CO_2 and SAI also lead to small reductions in rainfall.

The overall increase in land carbon storage in Amazonia under G6sulfur, despite reductions in precipitation, is largely due to increased water use efficiency at higher concentrations of CO_2 compared to SSP245, and reduced soil and plant respiration under the reduced warming compared to SSP585.

22. *L237: add "(Fig. 8c)" after SSP585.*

    Done as suggested.

23. *L244: percentage changes are mentioned in several places. Suggest including them in Table S1.*

    Done as suggested. The new version of the table is found below.

Model	Experiment	Region	NPP change (PgC yr^{-1})	NPP % change	Land carbon change (PgC)	Land carbon % change
CESM2-WACCM	SSP585	World	0.01	0.01%	52.1	1.9%
		Amazon	1.4	11.8%	18.2	5.4%
	SSP245	World	10.8	20.3%	149.5	5.5%
		Amazon	3.1	31.2%	55.8	18.6%
CNRM-ESM2-1	SSP585	World	4.9	7.6%	95.8	3.5%
		Amazon	1.7	27.2%	21.7	8.8%
	SSP245	World	12.4	21.7%	178.1	6.6%
		Amazon	0.7	9.6%	13.6	5.3%
IPSL-CM6A-LR	SSP585	World	-0.6	-1.0%	-0.5	-0.04%
		Amazon	1.0	11.9%	5.7	3.0%
	SSP245	World	1.2	1.9%	24.1	2.4%
		Amazon	-0.4	-3.8%	-2.4	-1.2%
MPI-ESM2-1	SSP585	World	-0.6	-0.8%	15.7	1.3%
		Amazon	0.2	1.4%	7.8	3.2%
	SSP245	World	9.3	15.1%	73.6	6.4%
		Amazon	1.8	11.3%	14.6	6.2%
UKESM1-0-LL	SSP585	World	2.5	3.0%	122.4	5.5%
		Amazon	2.0	13.4%	41.0	13.2%
	SSP245	World	13.9	19.2%	148.1	6.8%

		Amazon	2.6	18.7%	30.7	9.5%

24. *L245: 'primarily due to the CO2 fertilization effect', but not the case for IPSL (Figs. 14&15) despite having similar high CO2.*

    We added more detail to the discussion of the IPSL model from line 251:
    "The increase in NPP and land carbon storage is observed in all models except IPSL-CM6A-LR (Figure 17 and Figure 14). For IPSL-CM6A-LR there are small reductions in both, likely resulting from the stronger drying trend in northern Amazonia in this model (Figure 13) (Flores et al., 2024). Previously, IPSL-CM6A-LR has also been noted to have relatively low land carbon uptake compared to other models (Arora et al., 2020)."

25. *L256: CESM2-WACCM also show relative weak decline in precipitation here, so it seems that CO2 fertilization alone is insufficient (Fig. 13).*

    In these models, vegetation in Amazonia is not strongly limited by water, which means that a small reduction in rainfall does not cause a significant reduction in NPP. Additionally, the response in land carbon storage and NPP, despite changes in precipitation, is counteracted by increased water use efficiency under the higher CO_2 concentrations in SSP585 (Dekker et al., 2016).

    We also include an acknowledgment that CESM2-WACCM experiences a weaker decline in precipitation in Amazonia than other models following on from line 256:

    "This further suggests that CESM2-WACCM has a particularly strong CO_2 fertilisation effect compared to other models. Additionally, CESM2-WACCM experiences a weaker decline in precipitation over the Amazon compared with other models."

26. *L268: reference studies that show regionally-varying NPP sensitivity to warming (e.g., Cramer et al., 2001, https://doi.org/10.1046/j.1365-2486.2001.00383.x; Tjiputra et al., 2010, https://doi.org/10.5194/gmd-3-123-2010).*

    Cited as suggested.

27. *L282-4: please elaborate or give examples.*

    "However, it is important to note that a reduction in precipitation has other impacts which, though not observable in NPP or land carbon storage, remain important to consider. Examples include threats to freshwater availability for human consumption and agriculture (Pauloo et al., 2020; Van Loon et al., 2024), increased susceptibility of soils to wind and water erosion (Dollar et al., 2013) and increased wildfire risk (Brando et al., 2014; Albertson et al., 2009) to name a few."

28. *L291: describe G6solar*

    Description of the G6solar experiments now included on line 291 – "*However, we see similar increases in projected NPP and land carbon storage in the G6solar experiments, which reduce the radiative forcing from the high emissions scenario (SSP585) to the medium forcing scenario (SSP245) by reducing solar irradiance (Kravitz et al., 2015) (Supplementary Figures S3&S4).*"

29. *Table 1: why do CNRM and MPI models starts from 2015 instead of 2020?*

    The protocol for the G6sulfur experiments specifies that the experiment should begin in 2020 (Kravitz et al., 2015). However, MPI and CNRM initiated these simulations earlier. Because the baseline experiment for G6sulfur is SSP585, the years preceding the onset of SAI in 2020 correspond to SSP585 simulations.

    When processing the data, we concatenate the historical simulations with the G6sulfur runs, using SSP585 to bridge the gap between the end of the historical period and the start of G6sulfur. For the MPI and CNRM models, this is not required and the historical simulations are concatenated directly with G6sulfur. As a result, the final time series for all models spans 1850–2100 (or 2300 where available), with SAI starting in 2020.

    We have included the following text on line 85:
    "MPI and CNRM initiate the G6sulfur simulations slightly earlier than the other modelling groups (2015 rather than 2020). As the baseline experiment for G6sulfur is SSP585, the years preceding the onset of SAI in 2020 correspond to SSP585 simulations. Therefore, after concatenation, all models can be treated the same. "

30. *Fig 1 caption and elsewhere: remove Gunung from (Gunung Agung).*

    Done as suggested.

31. Fig 3: Looks very smooth. Specify if you applied running average.

    The data used in these plots are means found over a sliding 10-year window. This is now stated explicitly in the text of the figure caption: "Timeseries showing the evolution of the decadal means, calculated over a 10-year sliding window, of…". This is done similarly for an equivalent series of plots, Figure 18.

32. *Figs 7,17 caption: S3 => S2.*

    Fixed.

33. *Fig 18: improve resolution. Also clarify that this is a multi-models mean(?). If yes, how are these calculated since each model simulates different warming and CO2 evolutions? Did you apply smoothing?*

    We have improved the resolution of Figure 18. This figure depicts multi-model means, where we interpolate the temperatures onto the same range of

temperatures and finish plotting at 3 degrees of warming. Some models go beyond 3 degrees of warming, but we stop there to ensure that no models are lost when we take our averages. SSP585 has a specified CO2 concentration evolution so is the same for all models.

We have clarified in the caption that these are multi-model means: "Multi-model means showing the evolution of the global mean changes in…"

34. Fig 18 caption: remove comma: 'and CO2'.

    Done as suggested.