Review for

Disturbance legacies have a stronger effect on future carbon exchange than climate in a temperate forest landscape

This study depicts the past and future of a forest landscape in Austria. It aims at evaluating the respective weights of past natural disturbances, past human management, and future climate change on the forest capacity to sequester carbon. For this, the authors reconstructed the landscape history of the federal forest under study using historical data sources. This history is marked by a windstorm in 1905 followed by a bark beetle outbreak, technological evolution of management practices until 1997 when management is ceased, and a second wind and bark beetle event in 2007. The historical reconstruction results show that there is no correlation between the locations impacted by the first and the second natural disturbance events. In a second time, the authors designed a factorial simulations experiment in which the forest landscape under study undergoes all combinations of conditions : 1917 windstorm and bark beetle event or no, evolution of management practices between 1924 and 1997 or no management after 1924, 1997 windstorm and bark beetle event or no, four climate scenarios from 2013 to 2099. The simulations show that the net ecosystem exchange is dominated by past management found to explain 97.7%. The recovery from past management causes an increase in the future carbon storage. The authors find that by 2100 the effect of human and natural disturbances overcome the effect of climate change.

The object of this study is interesting and timely as the issue of the response of forests to climate change becomes more pressing. The case study is interesting due to its particular history including two large natural disturbance events and a ceasing of human management that allow the analysis of the legacy of management practices on a forest landscape. The simulation experiment is well designed and the model used (iLand) is appropriate to address the questions raised and introduced in a satisfactory way. However, the results and discussion section are somewhat superficial and do miss some important points. Also, the way the study is presented is often confusing or misleading and impairs the comprehension and interpretation of the results. The display items as well as the presentation of the results should be reconsidered to enhance the impact of the work presented.

Detailed comments

Terminology : « disturbance »

My main concern is about the use of the word disturbance all along the article, from the title on. The use of this term disturbance is misleading. Usually disturbance refers to natural disturbance (Overpeck et al., 1990; Seidl et al., 2014, 2011). In the present manuscript, it is sometimes used to refer to natural disturbances only (p4 L73 or L395) and sometimes to refer to natural + anthropogenic. It seems that the authors are aware of the confusion this creates, because most times they explicit that disturbances is natural+anthropogenic (ex : p5L86).

Aggregating two very different processes such as management and natural disturbances, on top of being very confusing for the reader, impedes the discussion of one very important result which is the extreme dominance of the effects of management compared to natural disturbances on carbon sequestration of forests. To this regard even the title of the article is misleading or even incorrect since it is not the legacy of the natural disturbance events (explaining only 2,8%) but of past management that has a stronger legacy effect than climate change.

The manuscript should be revised to account explicitly for this distinction in the processes analyzed which is obvious in the results.

Methods

In the description of the simulation experiment it is noted that each scenario is replicated 20 times (p15 L 347) ? The rationale for this should be explained. What changes between the replicates ? Is there a stochastic component in the model ?

L212 : the sentence describing the 1905 age distribution seems a bit far-reaching from fig S8 as the bimodal distribution is not obvious, and the statement is very qualitative.

Results and discussion

The manuscript seems very unbalanced with 13,5 pages of intro and methods (both well written and with relevant content) and only 5,5 pages of results and discussion (2,5 and 3 respectively). As reflected by these numbers, the results and discussion sections are sometimes shallow compared to the information presented and the very large number of display items included both in the main text and the supplementary materials (8 and 12 respectively).

Some missing information :

- 3.1 Performance of the reconstruction of past events :L377 « a good match » with reference to three supplementary figures, L379 « well able » with reference to one supplementary figure, L381 « small overestimation », L382 « corresponded well » with reference to one supplementary figure etc. all results from section 3.1 are qualitative and based on supplementary figures. An effort should be made to quantify the quality of the reconstruction and to present it in a concise manner in one

display item, that, if judged crucial for the validity of the results should be presented in the main text.

- 3.2 Temporal interaction of disturbance events : the autocorrelation between natural disturbance events is described and found very low. No link is analyzed between disturbance events and management : is there a correlation between stands affected by natural disturbance and species ? And age ? And density ?

- 4.1 The discussion of the lack of autocorrelation between both natural disturbance events and the link to previously published literature is not always clear. For example, the authors state that their hypothesis was that older stands are more prone to wind and bark beetle damages (L442) and link this statement to the low probability of a same area to be affected twice. The fact that a stand is affected by a disturbance does not make it older hence more susceptible to a second disturbance. Several hypotheses are formulated to explain the lack of autocorrelation between both episodes as found in other studies, but none is backed by data so that the discussion is not convincing. One hypothesis is that the longer and larger temporal and spatial scales analyzed here weaken the link found in smaller scale studies. I do not see why stands being more prone would not show up at the landscape scale. Similarly, the hypothesis of a dampening effect of a previous disturbance due to the resulting heterogeneity should be backed by minimal tests on the age and species structures of the affected and non affected stands. As well, the suggestion as to the difference in wind directions of both events needs to be investigated.
In summary, an analysis of the characteristics of the stands affected by both natural disturbance events would enlighten this part.

-4.2 disturbance legacies on future C uptake
The authors argue that other studies of effect of climate change on carbon sink do not explicitly consider the legacy of past events. It is a bit surprising as past events' legacy in embedded in the initial conditions. The legacy spinup method derived here is interesting and relevant but should be placed in the context of alternative methods to describe forest initial conditions, see for example (Crookston et al., 2010; Garcia-Gonzalo et al., 2007; Hurtt et al., 2002; Karjalainen et al., 2002; Peng et al., 2009). The novelty of this study does not seem to be the inclusion of the disturbances' legacy but their quantification so this section should be rephrased. Several sentences are not backed by any reference and should be justified and developed. For example on L484, the sentence stating that these results may not hold for longer time frames, on L499 the sentence interepreting the simulation results as a change in forest types.

- effect of climate change
It is not explained in many details what response of forest growth to climate change is simulated by iLand (with respect to species or altitude for example). The results shown here on the comparison of climate change and management are highly related to the processes included in the modeling exercise as correctly stated in L501-507 and would deserve a

more in-depth explanation. A discussion section on the simulated response of forest growth to climate change only would help put the results in perspective.

Display items

Some display items do not help the understanding of the text, are redundant, or at the contrary lack information, and so should be rethought as material that supports the claim made in the text.

Fig2 aims at summarizing the events included in the historical reconstruction of the forest landscape. Its design is more appropriate for a slideshow than a written article.

Fig3 illustrates how the events shown in fig2 are included in the simulation experiments. Its design is confusing, especially with the 'n' that is cumulated from left to right (it takes some time to understand this) and that attempts at expliciting the factorial combination of the events simulated.

These 2 figures could be condensed into a single display item where only the information relevant to the study would be presented. For example a table structured as below :

period	**Scenarios' options**	**details**
1905-1924	disturbed	storm+bark beetle+...
	undisturbed	
1924-1997	managed	Technological improvements
	unmanaged	Forest left to grow
1997-2013	disturbed	
	undisturbed	
2013-2099	Climate scenario 1	
	Climate scenario 2	
	Climate scenario 3	
	Climate scenario 3	

Other problematic display items are Fig5, Fig6 and FigS14. These three figures are redundant and should be combined into a single figure that shows the time evolution of NEE attributed to climate, event1, event2, and management. Please explain 'cumulative NEE'. From fig5, since the climate driven cumulative NEE decreases it means that the forest becomes a source of carbon between 2035 and 2050 ? This pattern should be discussed (see comment on 'effect of climate change').

Supplementary materials

The supplementary figures are excessive.

Some could be merged into a single figure such as Fig. S11 and S12 that show the same variable (growing stock per species)

Some are not even cited in the text such as Fig S13.

Fig. S5 is not clear, why showing two sites in the fictitious landscape map with only on stand development below. Letters A to D are shown but not used in the explanation but the outcome of the spinup (letter D I guess?) is not highlighted.

Technical details

P3 L49 ‘Keenan and others’ instead of ‘et al’

the numeration of the supplementary materials is confusing with only one line of numbering for text sections and figures. There should be section S1, section S2, section S3, figure S1, figure S2, figure S3, figure S4…

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Hurtt, G.C., Pacala, S.W., Moorcroft, P.R., Caspersen, J., Shevliakova, E., Houghton, R.A., Moore, B., 2002. Projecting the future of the US carbon sink. Proc. Natl. Acad. Sci. 99, 1389–1394.

Karjalainen, T., Pussinen, A., Liski, J., Nabuurs, G.-J., Erhard, M., Eggers, T., Sonntag, M., Mohren, G.M.J., 2002. An approach towards an estimate of the impact of forest management and climate change on the European forest sector carbon budget: Germany as a case study. For. Ecol. Manag. 162, 87–103.

Overpeck, J.T., Rind, D., Goldberg, R., 1990. Climate-induced changes in forest disturbance and vegetation. Nature 343, 51.

Peng, C., Zhou, X., Zhao, S., Wang, X., Zhu, B., Piao, S., Fang, J., 2009. Quantifying the response of forest carbon balance to future climate change in Northeastern China: model validation and prediction. Glob. Planet. Change 66, 179–194.

Seidl, R., Schelhaas, M.-J., Lexer, M.J., 2011. Unraveling the drivers of intensifying forest disturbance regimes in Europe. Glob. Change Biol. 17, 2842–2852.

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