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# Reply on RC3

Chen Yang et al.

Author comment on "Updated estimation of forest biomass carbon pools in China, 1977–2018" by Chen Yang et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-18-AC3, 2022

## RC3

This an important contribution to the series of studies about biomass C of China's forests. Using standard methodology developed in previous published works, the authors have compiled a credible time series of estimated net C uptake for natural and planted forests that can help inform China's GHG policies as well as help the world understand how massive reforestation as well as deforestation of older forests in China are influencing the global C budget. Although not particularly innovative in methodology, the study is comprehensive and informative, and I recommend publishing after some relatively minor revisions. Most recommended revisions are for clarity of language, though two comments about the analysis are more substantive. First, there have been several papers written that challenge the success of large-scale plantings especially in areas of China subject to drought. Do the results here conclude that most plantings have been successful as measured by the forest inventory over time? Second, the large reduction in area and C density of natural forests in the 1994-1998 time period is quite significant, and I would like to hear more about this in the discussion. The authors provide a few insights in lines 196-202, particularly related to aging forests and slower growth, but the references tend to be from other regions and so I would like to see some exploration of literature that nis more relevant to China. In addition, the idea that harvesting old forests and converting them to younger managed forests will result in higher growth rates is very misleading as a "natural climate solution" in that the loss of accumulated carbon in the harvested forest will not be replaced by accumulated growth of young forests for decades or centuries.

**Response:** Thanks for the important and helpful comments.

Firstly, we agreed that several papers pose a huge challenge to large-scale planting of plantations in arid regions of China, because several studies have found that plantations are more sensitive to drought than natural forests (Zhong et al., 2021). The main methods of afforestation in China are artificial afforestation (regeneration), aerial seeding afforestation, and mountain closure for afforestation (Wang, 2019). In China, subtly selected afforestation methods are applied according to the local environmental conditions to improve the success of afforestation. In the inventory, only those successfully established trees are taken as afforestation stands. The inventory is not a direct measure of whether a specific afforestation practice is successful or not. Changes in inventory over time reflect the overall changes of forest where areal increases are attributed to afforestation.

The forests of China, as a whole, were C sources (-2.9 Tg C/a) in 1994–1998. This is the result of forest area loss and most importantly damages of the natural forests at that period (Guo et al., 2013). The area of natural forest decreased from 1994 to 1998 (Table 2), which led to a slight decrease in the total biomass C pool. We have added discussion on this issue (Lines 222–226).

We added discussion of related studies (Guo et al., 2013; Zhao et al., 2019, 2021; Yue et al., 2018; Luyssaert et al., 2008; Zhou et al., 2006) on old-age forest biomass C pools in China, and discussion of soil C accumulation of old-age forest (Lines 233–234, 237–250). Conversion of old forests by young forests means on-site loss of forest carbon, though growing of young forest can compensate the "loss" of old forest after years. But the replaced old forest is not inevitably converted into carbon emission by full percent. Usually, the harvested timbers are turn into deposited carbon by many means such like furniture, house building and instruments etc. and only debris of harvested trees turn into dead litters. To avoid confusion, we have revised the sentence (Lines 248–250).

**Reference:**

Guo, Z., Hu, H., Li, P., Li, N. and Fang, J.: Spatio-temporal changes in biomass carbon sinks in China's forests during 1977-2008, Sci. China-Life Sci., 43, 421–431, 2013.

Luyssaert, S., Schulze, E. D., Borner, A., Knohl, A., Hessenmoller, D., Law, B. E., Ciais, P., and Grace, J.: Old-growth forests as global carbon sinks, Nature, 455, 213–215, 10.1038/nature07276, 2008.

Wang, Y.: Review on China's plantation development since the reform and opening up, Forest Resources Management, 1, 6–11, 2019.

Yue, J., Guan, J., Yan, M., Zhang, J., Deng, L., Li, G., and Du, S.: Biomass carbon density in natural oak forests with different climate conditions and stand ages in northwest China, J. For. Res., 23, 354–362, 10.1080/13416979.2018.1536313, 2018.

Zhao, M, Yang, J., Zhao, N., Liu, Y., Wang, Y., Wilson, J. and Yue, T.: Estimation of China's forest stand biomass carbon sequestration based on the continuous biomass expansion factor model and seven forest inventories from 1977 to 2013, For. Ecol. Manage., 448, 528–534, 2019.

Zhao, M., Yang, J., Zhao, N., Liu, Y., Wang, Y., Wilson, J. P. and Yue, T.: Estimation of the relative contributions of forest areal expansion and growth to China's forest stand biomass carbon sequestration from 1977 to 2018, J. Environ. Manage., 300, 113757, 2021.

Zhou, G., Liu, S., Li, Z., Zhang, D., Tang, X., Zhou, C., Yan, J. and Mo, J.: Old-growth forest can accumulate carbon in soils, Science, 314, 1417–1417, 2006.

Zhong, Z., He, B., Chen, Y., Yuan, W., Huang, L., Guo, L., Zhang, Y. and Xie, X.: Higher Sensitivity of Planted Forests' Productivity Than Natural Forests to Droughts in China, J. Geophys. Res.-Biogeosci., 126, 2021, https://doi.org/10.1029/2021JG006306.

Here are some specific comments for consideration:

Lines 46-48: is there a difference between “forest census data” and “survey data”?

**Response:** There is no difference between “forest census data” and “survey data”. To avoid ambiguity, we have replaced the word of “census” with “survey” (Line 46).

Line 51: replace “sequestrating” with “sequestering”.

**Response:** Thanks for your suggestion. We have modified accordingly (Line 50).

Line 52: replace “have” with “has”.

**Response:** Yes, we did (Line 51).

Line 54: add “net” between the words “reducing greenhouse”.

**Response:** Yes, we did (Line 53).

Line 102: replace “increase” with “increasing”.

**Response:** Yes, we did (Line 120).

Line 106: replace “may lead” with “has led”.

**Response:** Yes, we did (Line 124).

Line 112: replace “average” with “average increase”.

**Response:** Yes, we did (Line 131).

Line 127: delete “during”

**Response:** Yes, we did (Line 151).

Lines 148-149: please provide a clear definition of the 5 terms that describe age of forest. Explain how these terms are associated with stages of forest succession and that the associated forest ages are different among different forest types.

**Response:** Good suggestion, we have added explanation and Table A6for classification of forest ages for different forest types in China (Lines 497-518).

Figure 2 uses 3 age classes that are different than the 5 classes described in lines 148-149. Are the 3 classes aggregated from the 5 classes, or defined differently?

**Response:** The 3 classes are aggregated from the 5 classes. In China's forest inventory of early years, the age groups were divided into three groups, namely young forest, middle-age forest and mature forest. After 1984, the forest inventory data were divided into five age groups, namely young forest, middle-age forest, pre-mature forest, mature forest and over-mature forest. In order to implement the temporal comparison of the inventories, we aggregated the pre-mature forest, mature forest and over-mature forest into one age group—old forest. The young and middle-age forests remained unchanged. We have modified the description accordingly. Please see Lines 172, 174-176.

Line 163: Forest inventories based on sample plots are not really "spatial" in that they are based on sample points spaced some distance apart. It is more a "statistical" approach to data rather than "spatial".

**Response:** Thanks for your suggestion. We have modified accordingly (Line 189).

Line 188: this would be a good place to add some further explanation for the reduction of area and stock in 1994-1998.

**Response:** Yes, we did (Lines 202–207).

Line 211: replace "promoting" with "the increase of".

**Response:** Yes, we did (Line 260).

Lines 228-231: The errors seem rather small – what is included in the estimation of error? Are both sampling and modeling errors estimated? How the errors were calculated should be referenced in the methods, perhaps in the "statistical analysis" section.

**Response:** Phillips et al. (2000) analyzed the growing stock and its estimation error in the five southeastern of the United States, and divided the estimation error into three parts: sampling error, measurement error and regression error. The results showed that the estimation errors of regional forest accumulation and its changes were mainly caused by sampling errors (accounting for 90%–99% of the total variation) (Phillips et al., 2000). In the discussion of Lines 286–289, the error we mentioned is only sampling error. According to the forest inventory report, survey accuracy of the forest area and timber volume was over 90% (National Forestry and Grasslands Administration, 2019). Refer to the methods of Phillips et al. (2000) and Piao et al. (2009), we calculate national sampling error for growing stock change between preceding and current inventory periods, using China's forest inventory statistics which provide area, growing stock per unit area (density of growing stock), and number of sampling plots for each forest type for each province. The

measurement error was assumed to be 0 in this study because we cannot re-run the forest inventory. In the discussion of Lines 291–293, the error we mentioned was regression error. This error generated by the continuous BEF method calculated earlier by Fang and Chen (2001) of this research team when converting the growing stock to biomass at the national scale, that is, the regression error (modeling error).

According to your suggestion, we have added the calculation of sampling error in the "statistical analysis" section (Lines 104–113). Thanks again for your suggestion!

**Reference:**

Fang, J. and Chen, A.: Dynamic forest biomass carbon pools in China and their significance, Acta Bot. Sin., 43, 967–973, 2001.

Phillips, D. L., Brown, S., Schroeder, P. E. and Birdsey, R. A.: Towards error analysis of large-scale forest carbon budgets, Glob. Ecol. Biogeogr., 9, 305-313, 2000.

Piao, S., Fang, J., Ciais, P., Peylin, P., Huang, Y., Sitch, S. and Wang, T.: The carbon balance of terrestrial ecosystems in China, Nature, 458, 1009–U82, 2009.