MS NO.: essd-2023-309

MS Type: Data description paper

Title: National forest carbon harvesting and allocation dataset for the period 2003 to 2018

Dear editor and referee,

We appreciate the valuable opportunity to further revise our manuscript “National forest carbon harvesting and allocation dataset for the period 2003 to 2018” (MS No.: essd-2023-309) for possible publication in ESSD.

The remaining issues pointed out by referee #3 have been carefully addressed. Specifically, we further clarified the allocation of harvested carbon to wood pools. The corresponding text in the Methods have been carefully revised.

Please find attached the point-by-point responses to the comments of the referee. Please note that the comments from the referee are in **bold** followed by our responses in regular text. The changes in our manuscript are underlined with red.

Thank you for your consideration.

Sincerely,

Daju Wang, Wenping Yuan, on behalf of all co-authors

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Response to Referee #3

I notice that the authors redo the wood product pools (Fig.2).

1. First, Fig.2 is still extremely confusing to me. The relationship is unclear between the statistical harvesting data (in section 2.3.2, commercial and noncommercial) and the allocation of the product pools (in section 2.2). Fig.2 mixes the raw wood materials with the products.

Sorry for the confusion. We revised Fig. 2, and it now clearly shows how the statistical harvesting data been allocated to six wood pools.

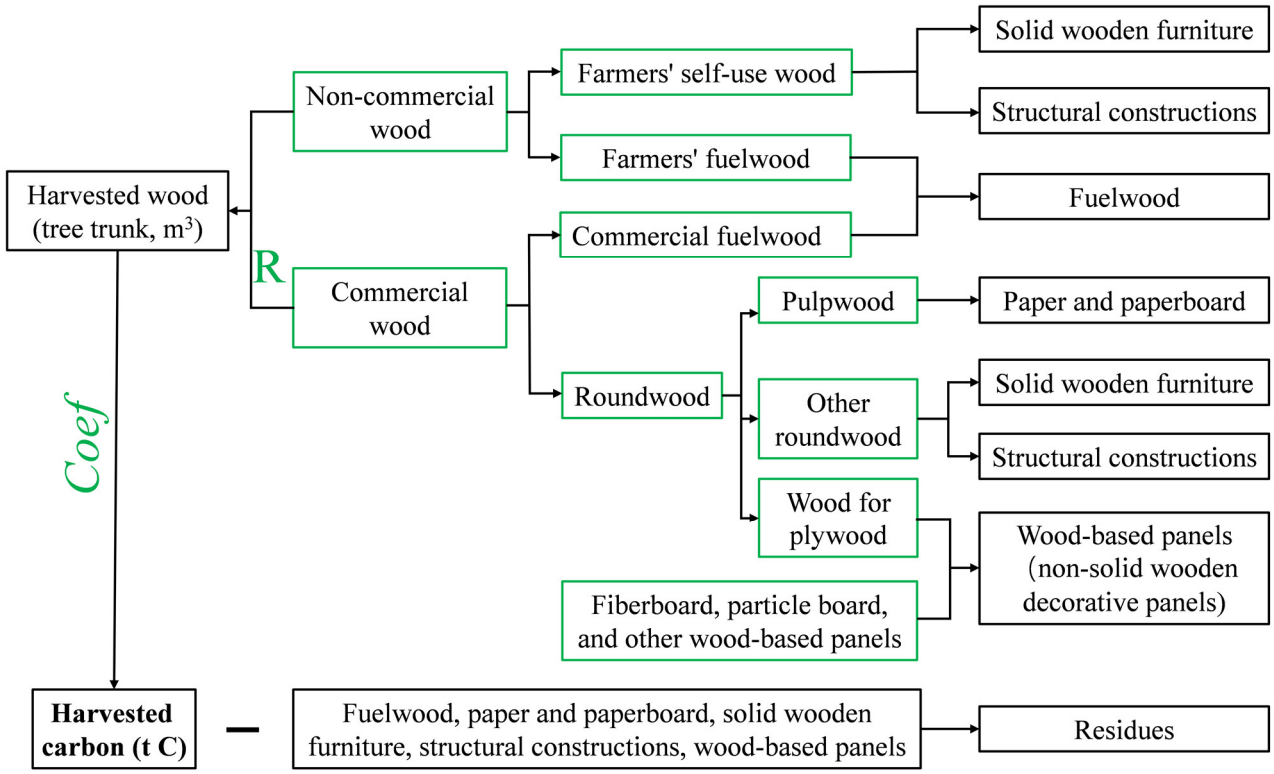

Figure 2: The allocation of post-harvest wood to six wood pools. The green boxes indicate the variables are available from the China Forestry and Grassland Statistics Yearbook. R is wood output rate of commercial wood, and *Coef* (t C m^{-3}) is the coefficient that converts harvested wood (m^3) to harvested carbon (t C) (i.e., biomass carbon of trunks, branches, leaves and understory vegetation).

We revised the corresponding description in section 2.2 and section 2.3.2.

Section 2.2:

"The harvested wood was allocated into six wood pools (Fig. 2). (1) Fuelwood pool, the sum of commercial fuelwood and non-commercial fuelwood (i.e., farmers' fuelwood), where the wood is burned as fuel, resulting in immediate carbon emissions through combustion; (2) paper and paperboard pool, including household paper, printing paper, packaging paper, etc.; (3) wood-based panels pool,

including plywood, fiberboard, particle board, and other wood-based panels, made from roundwood, wood residues (such as barks, branches, sawdust) or small stems bonded with adhesives, are commonly used as decorative panels for various applications like wall cladding and ceiling finishes; (4) solid wooden furniture pool, referring to solid wooden household items such as tables, chairs, wood beds, etc.; (5) structural constructions pool, referring to the structural components used to support buildings, such as beams, columns, and trusses; and (6) residues pool, including leaves, killed understory vegetation, and unutilized wood residues, which are typically left on the logging site or treated as fuel (Lippke et al., 2011; Stockmann et al., 2012), and were assumed as fuel in this study."

Section 2.3.2:

"The annual provincial wood output (m^3), extracted from the China Forestry and Grassland Statistical Yearbook, was categorized into two main types: commercial wood and non-commercial wood (Fig. 2). Commercial wood included fuelwood and roundwood, and roundwood was further categorized into pulpwood, wood for plywood, and other roundwood (e.g., roundwood for directly use, internally processed roundwood, etc.). Non-commercial wood included farmers' fuelwood (i.e., the volume of wood logged by farmers for burning) and farmers' self-use wood (i.e., the volume of wood logged by farmers for their personal consumption). Non-commercial wood refers to the actual logged volume, which can be totally used by farmers. Commercial wood refers to the wood output volume of peeled wood that meets the national wood standards, not the total volume of wood logged from the forest (National Forestry Administration, 2000). After wood logged, preliminary processing (such as peeling, sawing, etc.) is carried out and some unusable or poor-quality wood is eliminated. Therefore, the commercial wood output is generally less than the actual logged wood (National Forestry Administration, 2000). Based on the provincial wood output rate (R, i.e., the ratio of commercial wood output to wood logged) provided by China's timber production plan from the National Bureau of Statistics (Table S2), we calculated the actual annual wood logged for each province as:

$$W_{log} = \frac{W_{output}}{R} \quad (20)$$

where W_{log} is the actual annual wood logged for producing commercial wood, W_{output} is the volume of commercial wood output. Then, the total harvested carbon (i.e., the SHC in Sec. 2.1) for a given province was calculated as:

$$SHC = \left(W_{log} + F_{log}\right) \times Coef \quad (21)$$

where F_{log} is the volume of non-commercial wood, and *Coef* (t C m^{-3}) is the coefficient that converts harvested wood (m^3) to harvested carbon (t C) (i.e., biomass carbon of trunks, branches, leaves and understory vegetation) (Table S2)."

2. (a) Wood-based panels refer to different "board" products made from wood chips, veneers, sawdust, strands, or fibers. Most of the source materials are from manufacturing sawn wood and it is rare to include barks and branches as wood-based panels. Therefore, one can consider wood-based panels as part of roundwood.

Thanks for such detailed comment. Plywood is indeed derived from roundwood, other wood-based panels such as fiberboard and particleboard are predominantly manufactured using logging and processing residues, as well as low-quality wood like small stems (Sun et al., 2000). To meet the increasing demand for wood products and optimize the utilization of forest resources, it is common to use branches and barks in the production of wood-based panels. Branches possess physical and mechanical properties similar to those of the trunks and are often used as wood chips and fibers for particleboard and fiberboard production (Olarescu et al., 2022; Olarescu et al., 2023). Barks exhibit excellent acoustic and thermal insulation properties, making it suitable for manufacturing acoustic and insulation panels (Kain et al., 2020; Tudor et al., 2020).

(b) In fact, table S2 "lumber" rate reflects such wood residues while making furniture/construction.

The "lumber" rate ("wood output rate" in the revised manuscript) refers to the ratio of commercial wood output volume to wood logging volume. The commercial wood output volume refers to the volume of peeled wood that meets the national wood standards. In the wood processing (e.g., peeling and sawing) and transportation, there are several wood losses due to harvesting, processing, poor wood quality, and gathering transport (Local standard: DB35/T 1876-2019). Therefore, as we stated in section 2.3.2, what the wood output rate reflects is wood losses from wood logging volume to wood output volume, including poor quality wood, wood residues such as tree tops, barks, and sawdust, etc.

3. (a) Wood-based panels, furniture, and construction typically are not mutually exclusive, which means some of the wood-based panels are used for furniture/construction. Can you check the definitions and make sure there is no double counting?

In this study, the wood-based panels were not double counted with furniture and constructions. As we stated in section 2.2, the furniture pool only includes solid wooden furniture, and the constructions pool only refers to the structural components used to support buildings (e.g., beams and columns). However, the wood-based panels are usually used for building decoration (e.g., wall cladding and ceiling finishes) and panel furniture (non-solid wooden) manufacturing. The turnover time of wood-based panels is different from both solid wooden furniture and structural constructions (Table S3, Table S5). Therefore, there is no double counting. To clarify this point, we revised "furniture" as "solid wooded furniture" and "constructions" as "structural constructions" throughout the revised manuscript.

Due to the absence of statistical data on the quantity of roundwood utilized for plywood production post-2012, plywood was not individually quantified in our previous version. To clearly distinguish between wood-based panels and solid wooden furniture and structural constructions, we extracted the roundwood used for plywood production, which was allocated to the wood-based panels pool. From 2003 to 2012, roundwood used for plywood production comprised 6% to 12% of the total roundwood consumption. The proportion of roundwood used for plywood production post-2012 was replaced by the 2012 data. The results of carbon emissions and stocks of harvested carbon were revised accordingly.

(b) I am also surprised that the wood-based panels are larger than the sum of furniture/construction.

Wood-based panels holds a considerable share in the Chinese timber market. According to China Timber and Wood Products Distribution Industry Yearbook, fiberboard and particleboard comprised over 50% of domestically produced wood products in 2015 (China Timber and Wood Products Distribution Association, 2016). The production of solid wooden furniture relies on high-quality wood, which is primarily imported (China Timber and Wood Products Distribution Association, 2016). Consequently, the volume of solid wooden furniture produced from domestic wood is relatively low.

4. What component in Fig.2/7 corresponds to the farmer's fuelwood?

Farmer's fuelwood is included in the component of "fuelwood" in Fig.2/7. We revised Fig. 2 and clarified the fuelwood pool (refer to response #1).

5. the data analysis and calculation steps are missing. The 2.2 data has fuelwood, pulpwood, wood-based panels, and sum of furniture/construction. The 2.3.2 data has roundwood, fuelwood, pulpwood, and noncommercial fuelwood.

(a) It is not clear whether roundwood in 2.3.2 includes fuelwood and pulpwood or not (as Fig.2).

Sorry for the confusion. Roundwood includes pulpwood, not includes fuelwood (refer to revised Fig.2 in response #1).

(b) Additionally, do fuelwood and pulpwood have the same values in these two data sources?

Yes, the pulpwood has the same values in the section 2.2 and section 2.3.2, while the fuelwood in section 2.2 is the sum of commercial fuelwood and non-commercial fuelwood (i.e., farmers' fuelwood) (refer to response #1).

(c) Based on "The carbon entering the residues pool can be calculated by subtracting the carbon in pools (1) to (5) from the total harvested carbon", there are several possibilities. For example:

If roundwood includes fuelwood and pulpwood, then

residues pool =roundwood/R + noncommercial fuelwood – (fuelwood + pulpwood + wood-based panels + sum of furniture/construction).

If roundwood does not include fuelwood and pulpwood, and the two data sources have similar values for fuelwood/pulpwood, then

residues pool = (roundwood + fuelwood + pulpwood)/R + noncommercial fuelwood – (fuelwood + pulpwood + wood-based panels + sum of furniture/construction) = roundwood/R – wood-based panels – sum of furniture/construction + (fuelwood + pulpwood) * (1-R)/R + noncommercial fuelwood.

In the above formulas, R is a key parameter from a third source (NBS), and wood-based panels are the largest category (Fig.7). Please clarify the above calculation steps using explicit equations.

Thank you for such thoughtful comment. We added an equation to clarify the allocation of harvested carbon to residues pool and revised the corresponding sentences in section 2.2.

"The wood in pools (1) to (5) was converted into carbon, with conversion factor of 0.229 for fuelwood and roundwood, and 0.269 for wood-based panels (IPCC, 2019b). Then, the carbon entering the residues ($Residue_C$) pool can be calculated by subtracting the carbon in pools (1) to (5) from the total harvested carbon (SHC in Sec. 2.3.2) as Eq. (7):"

$$Residue_C = SHC - \left(W_{output} + F_{log}\right) \times 0.229 - wood\_based\ panels \times 0.269 \quad (7)$$

where *SHC* (Eq. (21)) is the total harvested carbon for a given province, W_{output} represents the volume of commercial wood output, and F_{log} represents the volume of non-commercial wood. Unlike commercial wood, the actual logging volume of non-commercial wood can be totally used effectively by farmers (Sec. 2.3.2). The sum of W_{output} and F_{log} is the total volume of pools (1) to (4), and wood-based panels here do not include plywood (Fig. 2)." (Lines 187-197 in the revised manuscript) (See more details in response #1)

(d) discuss data uncertainties surrounding R.

Thanks for your valuable comment. We have added a short discussion for the uncertainty of R.

"Wood output rate (R) is a key parameter for calculating the total wood harvest at provincial level. Its value varies depending on factors such as tree species, wood quality, and processing ways (Jiang et al., 2022). Even within the same province, R can vary significantly. However, due to the lack of R data at the sub-provincial level, this study utilized the provincial R values for 2009 obtained from the official website of National Bureau of Statistics (Table S2). Using provincial-level R for a single year overlooked the intra-provincial and inter-annual variations in R, potentially leading to bias in estimating the total wood harvest." Lines (528-534 in the revised manuscript)

(e) I will be surprised if the residues pool will always be positive since R comes from an external independent source. In fact, the residues after 2014 are pretty small, which is quite suspicious, as we know fuelwood/residues are more than 60% globally (Fig.7).

As we stated in sec. 2.2 and responded to comment #2(b), after harvesting, the killed understory vegetation and leaves are usually left on site to enhance soil fertility or treated as fuel, allocated to the residues pool. Meanwhile, not all branches and processing residues can be utilized, a portion of them also goes into the residue pool. Therefore, the residues pool must be positive. And the wood residues decreased from 2003 to 2018 demonstrates the increase in wood processing and utilization.

Minor questions

6. The authors estimate that 80% of the harvested biomass is from selective logging. Assuming selective logging one pixel provides 50% of the biomass from clear-cutting a pixel, then the area

of selective logging will be 8x of the area of clear-cutting. Please provide the provincial level forest areas for clear-cutting and selective logging, respectively, in order to verify this result.

Yes, it is a good idea to provide the provincial level forest areas for clear-cutting and selective logging. We added a figure that shows the number of pixels where clear-cutting and selective logging occurred and the proportion of harvested carbon from selective logging to the total harvested carbon at the provincial level averaged from 2003 to 2018. Besides, we added a short discussion in section 4.2.

"Nevertheless, selective logging has remained the principal way of forest harvesting in China. For entire China, the pixels occurred selective logging is about 50 folds of that occurred clear-cutting (Fig. S5), and the mean harvested biomass in a pixel from selective logging is 8% of that from clear-cutting (Fig. 6, Fig. S5). The occurrence of such a small percentage of biomass removal at pixel level suggests the ability of the LEAF dataset to capture minor disturbances." (Lines 469-473 in the revised manuscript)

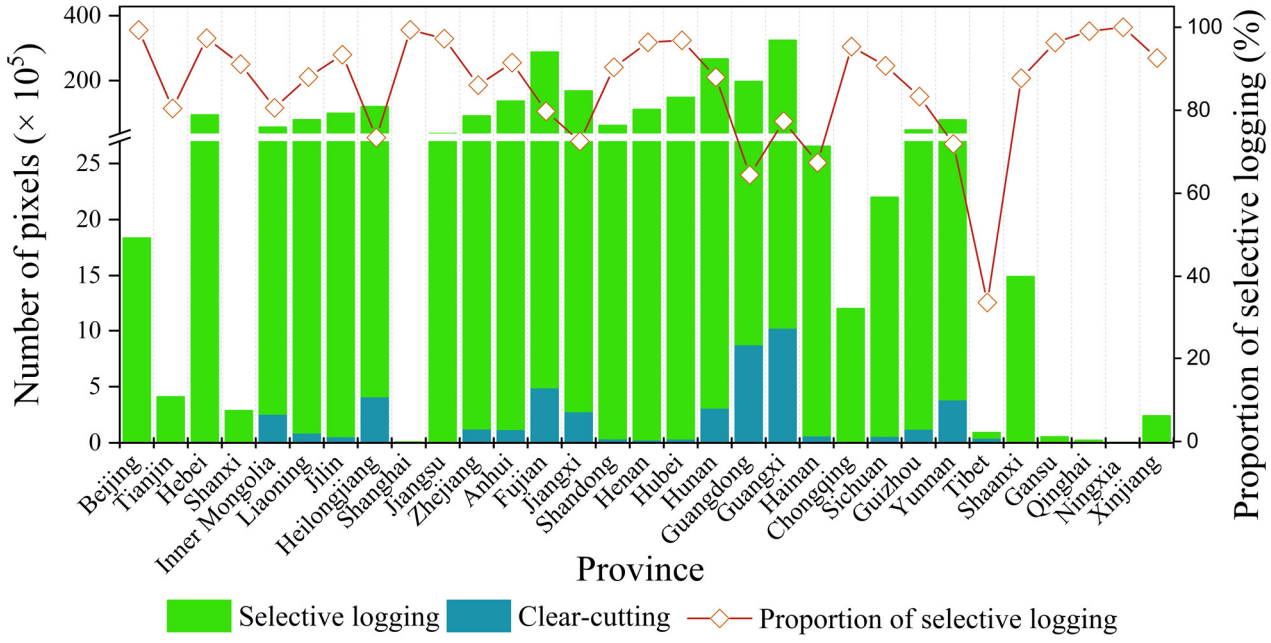

Figure S5: The number of pixels where clear-cutting and selective logging occurred and the proportion of harvested carbon from selective logging to the total harvested carbon for each province averaged from 2003 to 2018.

7. Figure 4: I still don't understand the response of comment #48 and I do not see any changes been made.

"48. Figure 4. It is hard to compare a and b as the scales in the legends are so different. It also

suggests that 30m resolution is less capable in capturing harvesting compared to the 0.1 degree."

Sorry for the confusion. In several provinces (e.g., Xinjiang, Inner Mongolia, etc.), forest harvesting frequency is relatively low, resulting a poor visualization of forest harvesting in these regions at 30 m resolution (Fig. 4a). To enhance the visualization of spatial patterns of forest harvesting, we provided an additional map at 0.1° resolution (i.e., Fig. 4b). The unit of pixel value in Fig. 4a and 4b is '$g\ C\ m^{-2}\ yr^{-1}$', refers to the ratio of the annual total harvested carbon in a pixel to the corresponding pixel area. Not all of the 30 m pixels within the 0.1° × 0.1° range occurred harvesting, for those pixels without harvesting, the pixel value is 0. Therefore, the proportion of harvesting within the 0.1° pixel is much smaller than that within the 30 m pixel, despite the larger area of the 0.1° pixel compared to the 30 m pixel. As a result, the pixel value within 0.1° resolution is much smaller than that within 30 m resolution, resulting the scales in the legends of Fig. 4a and 4b are so different. As you stated, 0.1° resolution is more capable in capturing harvesting compared to the 30 m. The 0.1° graph we provided here is only to better demonstrate the spatial pattern of forest harvesting. Therefore, we did not make any change on Fig.4.

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