

**Interactive comment on “High-resolution forest carbon flux mapping and monitoring in the Pacific Northwest with time since disturbance and disturbance legacies inferred from remote sensing and inventory data” by Huan Gu et al.**

**Anonymous Referee #2**

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*We would like to thank the reviewer for giving us very helpful suggestions that help us greatly improve the quality of this manuscript. We provided our responses to all the comments point by point below (italicized typeface).*

This is a pretty good and potentially useful paper that could be published after some modifications. The main problems I can identify are (1) the introduction is poorly written in places, (2) an important and highly relevant citation is missing, and (3) the discussion needs more work.

**Response:** *(1) We rewrote most of the “Introduction”, making the content proportional to the objectives. (2) The suggested citation was included in our introduction. (3) We expanded more in discussion.*

Detailed comments below address some problems with the introduction. The missing citation is more troubling since it presents an alternative approach to using the CASA model for estimating growth (or NEP) which is a center piece of this study. The citation is: Raymond, C. L., Healey, S., Peduzzi, A., Patterson, P. 2015. Representative regional models of post-disturbance forest carbon accumulation: Integrating inventory data and a growth and yield model. *Forest Ecology and Management* 336: 21-34. This should be referenced in a couple of places (p. 2 line 20 and p. 4 line 1).

**Response:** *Thanks for suggested citation, we have included it in our introduction.*

The discussion should compare using the CASA model and using the Raymond et al. approach which relies on an FIA driven empirical model, the Forest Vegetation Simulator (FVS). What are the advantages and disadvantages of each approach, and do they yield similar results (the regions are different but still may be able to compare results for one or two forest types). I also suggest that the discussion should explore in more depth the many assumptions and inferences that have to be made to estimate time since disturbance for “undisturbed” pixels (section 2.2.2). For example, the Kellndorfer biomass map used to estimate biomass of “undisturbed” pixels has fairly high uncertainty at the pixel level; some pixels were assigned forest types based on a nearby neighbor pixel, etc. By the way, the title of section 2.2.2 is an oxymoron – if the pixel is “undisturbed” there should not be a time since disturbance. So instead of “undisturbed” the authors should use a different term to identify pixels that had no detected disturbance since 1986, perhaps something like “recently undisturbed”.

**Response:** *We didn’t compare CASA and FVS models in discussion for two reasons: (1) the process of carbon cycle model is not the main focus in this paper, which has been described and discussed in our prior work (Williams et al., 2012, Ghimire et al., 2012, Ghimire et al., 2015). Our objective related to CASA is to use CASA-derived carbon stock and flux trajectories to do mapping; (2) it’s not appropriate to compare carbon trajectories developed for different study area. Both CASA and FVS models heavily depend on FIA data, without same/similar FIA input, the comparison won’t make a solid point. But when we moved to Rocky Mountain region in our future work, it sounds good to make such comparison.*

*We added a new discussion paragraph on Kellndorfer NBCD biomass products. It reads as “Second, we assume remote sensing-derived NBCD biomass products were well calibrated by field-derived biomass. However, the correlation coefficients between observed and predicted biomass were estimated to be 0.62-*

0.75 in the PNW region (Kellndorfer et al., 2012). And at 30 m pixel level, NBCD biomass values were biased with a large number of zero biomass values that had predictions in local biomass products (Huang et al., 2015). Discrepancies in biomass values between remote sensing- and field-derived data lead to biased stand age, as well as associated carbon stocks and fluxes. These were addressed in this study by imposing 20% error to pixel level biomass estimates and replacing zero biomass by the mean biomass of forest pixels with the same forest type and site productivity within this region.”

We also added more discussion on forest type group, “It was reported that accuracy of forest type group map in the PNW region ranges from 61% to 69% (Ruefenacht et al., 2008); besides, forest type groups for some pixels undefined from original data were assigned as the forest types of the nearest pixels. For the same biomass value, inferred stand age and estimated carbon fluxes can vary greatly given difference in forest type group (Fig. 4 & Fig. 6).”

The title of section 2.2.2 was edited as “Time since disturbance for recently undisturbed forest pixels”.

#### Specific comments

The title is too long and redundant. Suggest “High-resolution forest carbon flux mapping in the Pacific Northwest with disturbance legacies inferred from remote sensing and inventory data”. Could also leave out “in the Pacific Northwest”.

**Response:** We apologize that our title didn’t fully convey main objectives and focuses of this manuscript, we edited the title as “High-resolution mapping of time since disturbance and forest carbon flux from remote sensing and inventory data-inferred disturbance legacies in the Pacific Northwest”.

p. 1 line 22: delete the second “probabilistic,”

**Response:** Second “probabilistic” was deleted as suggested.

p. 1 line 26: re-word so that it does not appear that tracts of land can somehow “see”.

**Response:** “seen” was deleted from the sentence.

p. 2 line 13: replace “is itself a sort of record of” with “reflects”

**Response:** Replaced as suggested.

p. 2 line 14: replace “general” with “predictable rate of”

**Response:** Replaced as suggested.

p. 2 line 22-23: needs some rewording. The idea is that it is important to include smallscale disturbances down to some minimum threshold, not that disturbances typically are at this small scale.

**Response:** The sentence was edited as “characterization of time since disturbance across landscapes at a scale of being able to detect small-scale disturbance events, typically around 100 m or less.”

p. 2 lines 27-28: add “at smaller scales” to the end since national forests inventories can provide useful guidance only at larger scales. But importantly note, it is possible to conduct field inventories at very small scales, so the statement is not very correct at all, only partially correct with respect to national forest inventories.

**Response:** “at smaller scales” was added at the end of this sentence.

p. 3 lines 11-12: One objective is clearly stated. What are the others? The last sentence of this paragraph seems to be another objective, but then, I'm confused as to whether the purpose is to develop a method for large-scale monitoring and management, or small-scale, or both?

**Response:** *We rewrote the last paragraph in Introduction, all the objectives were listed. Now it reads as "This study estimates and maps time since disturbance at a fine scale of 30 m from RS-derived products and FIA-derived biomass growth curves, and then maps net ecosystem productivity (NEP) based on disturbance history, time since disturbance and carbon flux legacy. The specific objectives in this study are to: (1) introduce a method for inferring a pixel's representative time since disturbance from RS-derived biomass and disturbance products at the 30 m resolution; (2) map NEP based on model-derived carbon stock and flux trajectories that describe how NEP changes with time following harvest, fire, or bark beetle disturbances of varying severity; (3) propagate uncertainties from RS-derived biomass products and FIA into uncertainty quantification of stand age and NEP. Our research represents an approach to map carbon stocks and fluxes at a high resolution across the conterminous US in support of national carbon monitoring, reporting, and management."*

*The last sentence of this paragraph is misleading, we have edited it as shown above. Our method will be used to map carbon stock and fluxes at a fine scale in the conterminous US.*

p. 3 lines 27-28. Terminology again – “undisturbed” pixels by definition should not have a time since disturbance.

**Response:** *“undisturbed forest pixels” has been edited as “recently undisturbed forest pixels”.*

p. 3 line 32: Biomass curves were developed by forest type group and productivity class. How were these 2 classes allocated to the 5 NEP classes described on p. 4 lines 2-4?

**Response:** *Biomass curves by forest type group and productivity class were used to infer stand age for forest pixels undisturbed during remote sensing observation period.*

*NEP curves were derived from CASA carbon cycle process model with inclusion of disturbance processes. Biomass curves were used to adjust model's rates of NPP and wood turnover for each forest type group and productivity class. At the final stage of the modeling, the disturbance processes imposed stand-replacing harvest, fire or insect-induced partial disturbance to generate carbon stock and flux curves as a function of time since disturbance, and are specific to forest type group, site productivity class, disturbance type and disturbance severity.*

p. 3 line 35: add citation after “. . . varying severity”.

**Response:** *Citations “Williams et al. 2012, Ghimire et al., 2012, Ghimire et al., 2015” were added after “. . . varying severity”.*

p. 6 line 26: replace “stand” with “standard”

**Response:** *Replaced as suggested.*

p. 8 line 21: sentence that begins with “Again” needs editing.

**Response:** *This sentence was edited as “Again in contrast, bark beetle outbreak areas for low and high productivity classes are similar in Douglas-fir forests, but beetle outbreak occurrence was about three times more likely in low productivity sites.”*

p. 9 lines 24-25: the imprint is not so clear to me. Maybe need to highlight somehow on the graphic.

**Response:** We included the position description of Biscuit fire in the bracket, “bottom left of Fig. 8a, also refer to bottom left of Fig. 5a & 5b”.

p. 10 lines 12-14: One could argue that inventory data does not provide such a reliable estimate of biomass/age. Both of these variables can be rather difficult to measure/estimate especially with respect to the selection of biomass equations, but also the difficulty of assigning a stand age to stands that are uneven-aged.

**Response:** We added more discussion on the first assumption as suggested. “However, both stand age and biomass are difficult to measure and estimate, especially considering the difficulty of assigning a stand age to uneven-aged forest stands, as well as selecting appropriate species-specific biomass equations (Parresol, 1999). If FIA ages are older than actual stand ages, the associated forest biomass will be underestimated, and stand age inferred from biomass products will be overestimated. And younger FIA ages than actual ages will result in an overestimation in biomass accumulation, but an underestimation in biomass-inferred stand ages. Though a possible bias in stand ages, our estimates of carbon stocks and fluxes are not likely to be largely adjusted by a stand age bias within 5 years (Williams et al., 2012).”

p. 12 lines 1-7: not stated—FIA does not do a good job of detecting recent disturbances because the remeasurement cycle in the PNW is about 10 years, so the average time lag of the data at any point in time is at least 5 years.

**Response:** We added the suggested point in this paragraph, now it reads as “FIA data miss some recent disturbances, partly because FIA remeasurement cycle in the PNW region is about 10 years, with the average time lag of the data being around 5 years.”

## References

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