Anonymous Referee #1
Received and published: 15 March 2015

General comments*: In this manuscript, Adame and colleagues measured carbon pools in vegetation, downed wood, and soils of seven mangrove sites, one peat swamp forest, and one herbaceous marsh within Mexico's La Encrucijada Biosphere Reserve (LEBR). They also measured soil N pools at all sites and rates of soil C sequestra- tion at the mangrove sites. The peat swamp and marsh sites appear to have been included only for the sake of making casual (rather than statistical) comparisons, since there was just one of each of those site types. The primary hypothesis was that soil C and N stocks and soil C sequestration rates would be higher in upland vs. lowland mangroves.*

This is a very descriptive place-based study. Although the authors made some suggestions about why some sites store more carbon than others (e.g., perhaps it is related to geomorphology or the dominant tree species), this manuscript didn't leave me with any new ideas or insights about how wetlands "work." I didn't feel that it told me any- thing more than some specific information about one specific location, and I think that will limit its appeal to the diverse readership of Biogeosciences.

The manuscript has been rewritten as to highlight the differences we found among vegetation types (mangroves vs. peat swamp vs. marsh) and among geomorphical settings (upper estuary vs intermediate vs lower estuary). The revised manuscript has moved from a "site description" study to a comparison among C stocks among different kinds of wetlands on the basis of vegetation structure and geomorphology, a study that should have a high international appeal. In this revised manuscript we have also included the analyses and discussion of extrapolating field C stock measurements to large areas on the basis of vegetation type, species composition and geomorphological setting.

For example:

L26-(Abstract) "Riverine wetlands are created and transformed by geomorphological processes that determine their vegetation composition, their primary production and soil accretion, all of which are likely to influence C stocks. Here, we compared ecosystem C stocks (trees, soil and downed wood) and soil N stocks of different types of riverine wetlands (marsh, peat swamp and mangroves) whose distribution spans from an environment dominated by riverine forces to an estuarine environment dominated by coastal processes.."

L76 (Introduction): "Many forces contribute to the formation of riverine wetlands in deltaic-estuarine landscapes, including: river run-off, wave action, tidal inundation and the incidence of cyclones (Thom 1967, Woodroffe 1992). In the Southern Mexican Pacific (Fig. 1), wetlands where freshwater input is constant, tidal inundation is negligible and wave and storm damage is relatively low, are formed by a mosaic of marshes and peat swamps. Lowland, mangroves dominate the vegetation from the upper to the lower estuary. Upper estuarine mangroves have periodic input of freshwater and lower tidal and wave influence compared to mangroves in the lower estuarine region (Thom 1975). In this study, we compared C stocks (trees, soil and downed wood) of riverine wetlands of La Encrucijada Biosphere Reserve (LEBR) in the Pacific south coast of Mexico. We compared C stocks of different vegetation types (mangroves, peat swamps and marsh) and throughout a geomorphological gradient (upper to lower estuary)."

L477 (Discussion): "In general, mangroves within the upper estuary had higher C stocks compared to mangroves in the lower estuary. However, the most striking difference was not related to C content, but to site variability. Mangroves from the upper estuary were quite similar in structure and C stocks within sites. On the contrary, mangroves from the intermediate and lower estuary were much more variable. We also found differences in soil C with depth: soil C increased or was similar with depth at mangroves in the upper estuary, while soil C decreased with depth in mangroves from the lower estuary (similar to Donato et al. 2011). We suggest that differences in geomorphological forces explain the variation in C stocks and soil C distribution within the sediment column. Mangroves in the upper estuary have grown in a relatively stable environment that allowed C to be buried and forests to develop into a mature state. Comparatively, mangroves in the lower estuary are exposed to frequent changes in hydrology, sedimentology and are directly struck by tropical storms (Woodroffe, 1992). As a result, mangroves in the lower estuary are a mosaic of old and young forests, some of them with productivities and soil C similar to those in the upper estuary, but others with low productivity, statures and soil C, and thus, C stocks."

As detailed below, I also have concerns about the number of sites (are they sufficient for scaling up to the landscape level?) plus some questions about the collection of data and presentation of results.

We have conducted new spatial analyses in order to estimate C stocks within mangroves of the Reserve (Detailed explanation in Methods, L 276-297). We have also included uncertainty analyses of the estimations (Fig. 4 and Supplementary Table 1, Figure 1 and 2). Additionally, the estimation of C stocks of marsh sites was strengthened by the inclusion of new 9 sampling points across the Reserve (see Fig. 1). Finally, the accuracy of the spatial estimations and constrains are detailed explained (Results L422-455) and discussed. Improvements for future studies that aim to extrapolate C stocks through large areas of wetlands have also been suggested (Discussion L533-551).

Specific comments:

1) A question about the wood density values that you used: in the Zanne et al. wood density database, there are multiple wood densities for each of the mangrove species at your site. How did you decide which values to use? For example, there are seven different R. mangle wood density values in the database (range: 0.810–0.105; average = 0.898; median = 0.890); why did you decide to use the value of 0.84?

We selected the value that was obtained from a climatic location similar to that of LEBRE (Costa Rica –warm subhumid), as wood density is associated with climate (specially rainfall). We have clarified our selection criteria in the Methods section:

L199- "Belowground root biomass was calculated using the formula by Komiyama et al. (2005) and wood density values of Chave et al. (2009) using density values of comparable climatic regions as the LEBR (Table 2)"

2) p. 1030, lines 9-14: This calculation of C loss due to fire assumes that all vegetation and all soil C is converted to CO_2 when the site burns. Is that a reasonable assumption? If the marsh and peat swamp forests burn "frequently" (p. 1023, line 5) and all of the soil C is lost, it seems highly unlikely that you would end up with soils that have up to □30% organic C (and this 30% average value is at 30-50% depth, Table 5). Unless you have evidence that says otherwise, it seems unreasonable to suggest that 100% of the ecosystem carbon in the marsh and peat swamp is oxidized to CO_2 whenever there is a fire.

We have modified our discussion following the Reviewers' suggestion. In the revised discussion, we only accounted for the loss of C during fires from the top layer of soil (0-15 cm) as has been reported in the literature (Schmalzer and Hinkle 1992). We have also actualized the offset of C according to the recently published emissions by the International Energy Agency (2014):

L564- " With the C stocks calculated in this study, we estimated that if a fire consumes all the vegetation and the top 15 cm of soil (Schmalzer and Hinkle 1992), every hectare of burned marsh or peat swamp could emit 287 ton CO_2 and 567.4 ton CO_2, respectively. Every year between 500 and 4,500 ha of marshes are burned within the reserve (L. Castro pers. comm), which results in an annual mean emission of ~0.6 millions tons of C or **4.6%** of the emissions of the state of Chiapas (based on emissions reported by IEA, 2014)."

3) p. 1016, lines 9-10, "We hypothesized that riverine wetlands have large C stocks. . ." and p. 1018, lines 112-13, "We predict that the riverine wetlands within the LEBR have large ecosystem C stocks and high C sequestration rates." Large C stocks and high C sequestration rates compared to what? Compared to non-riverine wetlands? Compared to a terrestrial forest? Compared to something else?

We have clarified our hypotheses:

L31- "We predicted that C stocks in mangroves and peat swamps would be larger than marshes, and that C, N stocks and C sequestration rates would be larger in the upper compared to the lower estuary."

L119: "We expect that C stocks within the riverine wetlands of the South Mexican Pacific coast will have high C stocks compared to other terrestrial ecosystems. We also predict that mangroves and peat swamps have higher C stocks compared to marshes. Finally, we expect that geomorphological setting will affect C, N stocks and C sequestration rates with higher values for mangroves in the upper estuary compared to those in the lower estuary."

4) I had some trouble with the different ways that you described the sites. a. For the mangroves, you had three classes based on plant vigor, with Class I corresponding to upland mangroves and Class III corresponding to lowland mangroves. According to your text, Class II mangroves have intermediate vigor, although you don't provide enough information to let the reader know if Class II mangroves are a) intermediate in location between upland and lowland mangroves; b) upland mangroves that are less productive than the typical (Class I) upland mangrove; or c) lowland mangroves that are more productive than the typical (Class III) lowland mangrove. [Edit: some text in the Results section (p. 1026, lines 15-16) indicates that lowland mangroves include Classes II and III but I don't think the reader should have to scour the Results section to learn such basic details about your study sites, especially when one of your pre- dictions/hypothesis is about the differences between upland and lowland wetlands.] b. How are upland and lowland mangroves defined? Is it based on elevation? Do you have elevation data for your sites? c. Then, I wasn't sure how your sites fell into riverine vs. non-riverine categories. Your prediction on p. 1018 (lines 13-16) suggests that some of your sites are riverine (perhaps some of all of the upland mangroves) whereas others (the lowland sites?) are non-riverine. However, in the Abstract (p. 1016, lines 11-13) suggests that all of your sites were riverine wetlands; in that sentence the values given are the same as those from Table 6, which shows all of your study sites (* the standard error for the peat swamp differs between the Abstract and Table.) d. In Tables 4 and 5, you have sites named Zapotón and Tular. I assume that one is the peat swamp and one is the marsh, but you don't specify which is which.*

We have simplified and clarified our wetland categories throughout the manuscript. "Riverine wetlands" refer to all the wetlands within the Reserve as they are all more or less affected by river discharges. The wetlands were classified according to vegetation types (peatswamp , marsh and mangroves) and the mangroves were further classified according to geomorphic location (upper, intermediate and lower estuary). This has been clarified throughout the manuscript.

L78: "In the Southern Mexican Pacific (Fig. 1), wetlands where freshwater input is constant, tidal inundation is negligible and wave and storm damage is relatively low, are formed by a mosaic of marshes and peat swamps. Lowland, mangroves dominate the vegetation from the upper to the lower estuary. Upper estuarine mangroves have periodic input of freshwater and lower tidal and wave influence compared to mangroves in the lower estuarine region (Thom 1975). In this study, we compared C stocks (trees, soil and downed wood) of riverine wetlands of La Encrucijada Biosphere Reserve (LEBR) in the Pacific south coast of Mexico. We compared C stocks of different vegetation types (mangroves, peat swamps and marsh) and throughout a geomorphological gradient (upper to lower estuary."

L156: "The mangrove Classes along with the distance to the mouth of the estuary were used to classify our sites into three categories: upper estuary mangroves with the most vigorous vegetation, lower estuary mangroves with the least vigorous vegetation and intermediate mangroves in terms of vigour and distance to the mouth of the estuary (Fig. 1). Hereinafter, we will refer to our mangrove locations as "upper estuary", "intermediate" and "lower estuary".".

The SE from the C stocks of peat swamps has been corrected in the Abstract.

The names "Zapoton" and "Tular" have been changed for "Peat swamp" and "Marsh" in the mentioned Tables.

*5) Some of the numbers in the text do not agree with those in the tables. a. One example, compare p. 1025, lines 8-9 with Table 3. The text says that Las Palmas and Esterillo each had vegetation C stocks > 620 Mg C ha-1 yet, according to Table 3 *none* of the sites had vegetation C stocks that were that high. The rest of the sentence then says that Santa Chila and Zacapulco had vegetation C stocks < 340 Mg C ha-1. Since these sites actually had vegetation C stocks of 132 and 196 Mg C ha-1, the authors' sentence is technically true but I wonder why they said "< 340 Mg C ha-1" when "< 200 Mg C ha-1" would be a better descriptor of the data. b. Another example: Table 7 reports a total of 27,477 ha of mangrove in the LEBR. Multiplying this by the average soil C sequestration rate of 1.3 Mg C ha-1 yr-1 produces a LEBR-wide C sequestration rate of 35,720 Mg C yr-1; you report 27,762 Mg C yr-1 (p. 1029, line 23). Using class-specific areas and sequestra- tion rates, I come up with 34,013 Mg C yr-1 which is still quite different from the number you reported.*

The manuscript has been thoroughly revised to check for any inconsistencies between the Tables, Figs and text. We have rewritten the text that the Reviewer found confusing regarding vegetation C stocks.

L355-" Tree biomass and vegetation C stocks were not significantly different among upper, intermediate and lower estuary mangroves ($F_{7,40}$= 1.826; p = 0.109). However, there were significantly differences among sites with lowest C stocks measured in the vegetation of Santa Chila (132.1 Mg ha-1) (t= 2.54; p = 0.015) and highest at Las Palmas (440.0 Mg ha-1) (t= 2.03; p = 0.049), the only site dominated by *A. germinans* and not *R. mangle*."

The C sequestration rate was corrected as 39,842 Mg C yr^{-1}, which is the correct estimation using the different mangrove forest types (L464). We have also actualized the offset of C (10,348 people instead of 9, 143) according to the recently published C emissions by the International Energy Agency (2014):

6) I question whether you have enough sampling sites to come up with a good estimate of C stocks across the entire LEBR. There are three issues: a. There is a lot of variability from site to site. For vegetation (Classes II and III), downed wood (all classes), and soils (Classes II and III), the C stocks vary by a factor of two or more between sites of the same class. For Classes I and III, this variability fortunately cancels itself out such that total ecosystem C pools are reasonably similar within a single class. However, for Class II, there is a 2-fold difference in ecosystem C *between the two sites. If Esterillo is the more typical Class II site, then you have underestimated (by 25%) the amount of C in the 7000 ha of Class II mangroves. Conversely, if Esterillo is an outlier and Santa Chila is a more-typical Class II site, you have overestimated C in this class by 50%. Of course, with just two sites, you can't say which site is more typical of Class II mangroves. b. All of your sampling sites appear to be located along rivers. However, there are large areas of the LEBR that appear to be 1-2 km (or more) from a river. You have not justified that C data from riverine wetlands are comparable to mangrove areas that are far from rivers. c. You had one marsh site, which you then scaled up to the landscape scale. Is one marsh site representative of 32,000+ ha of marsh, which represents 70% of all wetlands in the LEBR? If your measured C stocks at the single marsh site are not representative of all marshes in the LEBR, your estimate of total C stocks in the LEBR wetlands could be wildly inaccurate due to the large area of marsh.*

We have addressed the Reviewer's concern as explained above by:

-Conducting additional spatial analyses to determine the aboveground C of the Reserve, which was then associated to the C stock based on our field data.
-Compare different ways of extrapolating the data (Aerial C stocks vs. NDVI classes) and discuss the differences between them
- Provide analyses of uncertainty and the potential errors of our estimations
- Include new information of marsh C stocks for 9 sampling locations across the Reserve
-Explain that we are only providing a rough estimation of the C stocks of the wetlands of the Reserve

7) The reporting of statistical results was poor; I counted only 5 p values in the entire text but quite a few instances of saying that something was "higher" or "lower" in a particular site/class. Should I assume that such comparisons don't have any sta- tistical support behind them? The authors present a hypothesis about differences in soil C and N stocks between upland and lowland mangroves. Statistical results were reported for the C stocks (p. 1026, line 5) but only after one site was removed from the analysis – why was the site removed? Is it a statistical outlier? There were no statistics comparing soil N stocks between mangrove types. I don't think that the authors tested to see if there were differences in total (ecosystem) C stocks between sites.

We have included p values for every comparison made (See Results with 14 *p* values reported). We included analyses to compare soil N stocks and C stocks. To improve the accuracy of our results, we eliminated the comparison among classes that removed one of the sites.

8) Did your study design lead to a double counting of root biomass? You estimated belowground biomass using allometric equations and you also measured soil C. There was no indication that roots were removed from the soil samples before the soil C content was measured.

The soil in mangrove forests is mostly composed of dead roots, wood and leaves accumulated over time. This organic material that hasn't completely decomposed can sometimes account for most of the soil (see Adame et al. 2014). While the allometric equations account for coarse roots (about > 1 cm thick), most of the fine roots are unaccounted for. Additionally, allometric equation does not account for the dead roots accumulated in the soil. This is the reason why root biomass and soil (including dead roots) are measured separately (See Kauffman and Donato, 2014).

Adame, M.F., C Teutli, N. S. Santini, J.P. Caamal, A. Zaldivar, R. Hernandez, J.A. Herrera-Silveira (2014). Root biomass and production in mangroves surrounding a karstic oligotrophic coastal lagoon. Wetlands. 34: 479-488.

Kauffman, J. B., D.C Donato. Protocols for the measurement, monitoring, and reporting structure, biomass and carbon stocks of mangroves (2013) Working paper 117, Bogor, Indonesia, CIFOR.

Technical comments:

1) p. 1016, line 17: I think the units should be Mg C, not Mg C ha-1.

We have deleted this line from the Abstract, so the revision is no longer relevant.

2) p. 1019, line 1: Should this be LEBR, not LEBRE?

Yes, the typo has been corrected

3) p. 1021, lines 2- 4: Change start of sentence to read "Belowground root biomass for mangroves was calculated..."

Done

4) p. 1021 and Table 2: As requested on the Dryad site for the wood density database, you should cite the Chave et al. (2009) article and the database itself (Zanne AE, Lopez-Gonzalez G, Coomes DA, Ilic J, Jansen S, Lewis SL, Miller RB, Swenson NG, Wiemann MC, Chave J (2009) Data from: Towards a worldwide wood economics spectrum. Dryad Digital Repository. http://dx.doi.org/10.5061/dryad.234).

Done

5) Table 2: For belowground biomass of L racemosa, why is DBH first raised to the power of 2.22 and then to the power of 1.11? Is this a typo?

Yes, we have deleted this typo.

6) p. 1022, line 16: hydrochloric does not need to be capitalized.

7) p. 1023, line 3, replace "of" with "and"

Done

8) p. 1026, line 6: Is "downland" a synonym for "lowland"?

To simplify, we have changed our nomenclature as described above (upper, intermediate and lower estuary)

9) p. 1026, line 23: Change "de N" to "N"

We have deleted this line so the revision is no longer relevant.

10) Table 7: In the table itself, "emissions" is misspelled.

The typo has been corrected

11) p. 1029, line 8: According to the wood density database I cited earlier, the maximum wood density for A. germinans is 0.90, not 0.99 g cm-3.

The typo has been corrected

12) Figure 1: On the part of the figure that shows NDVI classes, there are 8 mangrove sampling sites (indicated by black squares) but you only had 7 actual sites. It looks like the "Esterillo" site on the NDVI figure is not shown on the larger map of the entire LEBR.

The site Esterillo has been included in the map (see Fig. 1).

END OF REVIEW

Anonymous Referee #2
Received and published: 23 March 2015
General comments As stated by Referee #1, Adame and coauthors provide mostly a "very descriptive place-based study" of mangrove forests, one peat swamp site, and one marsh site in the La Encrucijada Biosphere Reserve (LEBR). However, the study does provide a useful and needed inventory of carbon stocks and soil C sequestration rates for LEBR.

As explained above, the manuscript has been rewritten as to highlight the differences we found among vegetation types (mangroves vs peat swamp vs marsh) and among geomorphical settings (upper estuary vs intermediate vs lower estuary). The revised manuscript has moved from a "site description" study to a comparison among C stocks among different kinds of wetlands, a study that should have a high international appeal.

In agreement with Referee #1, additional analyses need to be performed to better address the uncertainty in C stocks and C sequestration rates across the LEBR. For instance, the two class 2 mangrove forest sites exhibit very different C stocks. This uncertainty needs to be addressed in computing the carbon budget for Class 2 mangrove forests across the LEBR. Also, Class 3 mangrove forests cover a large range of NDVI (0.1 to 0.632), and this likely contributes to additional uncertainty in the total carbon budget of LEBR. What are the NDVI values of the two Class 3 sites? If, for instance, the NDVI values are near the upper bound (0.632) for Class 3, then biomass estimates using only these two sites may represent an overestimate. Again, some justification and additional uncertainty analysis is warranted here.

As explained above we have now provide new spatial analyses, which include uncertainty analyses of our spatial estimations.

Specific comments

p.1016 l.17 – The units should be in Mg C and the uncertainty should be much higher (more than 10% of the mean value of 27762 Mg C).

The units have been corrected and the uncertainty has been largely explained in the discussion section

p.1027 l.8-9 – The text should read something like, "C stock of mangrove forests of LEBR to be 20.9 x 10ˆ6 Mg of C. "

The formatting of the stock has been modified to scientific notation as suggested by the Reviewer

p.1030 l.19 – should read, "forests of Chiapas. . ."

p.1030 l.24 – should read, ". . .designed the project, led the field campaign,. . ."

The grammatical errors have been corrected.