Hydrol. Earth Syst. Sci. Discuss., 8, C1016–C1025, 2011
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Hydrology and Earth System Sciences Discussions

Interactive comment on "Heterogeneity of soil carbon pools and fluxes in a channelized and a restored floodplain section (Thur River, Switzerland)" *by* E. Samaritani et al.

E. Samaritani et al.

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Anonymous Referee 1

Comment: I would have liked to see some hypotheses underpinning the paper – although there is not a great deal of research in the area, the development of broad hypotheses to be tested using the empirical data collected would have helped to direct the discussion. However, the paper works well without these so this is not an essential modification.

Reply: Since this is also a request by Referee 2, we agree on adding the following

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broad hypotheses in the last paragraph of the introduction: (i) In dynamic FPZs, frequent disturbance by flood pulses affects C pools and fluxes temporary and locally. (ii) Such effects are an essential precondition to achieve a broad spectrum of conditions and processes supporting a large variety of organisms and, thus, biodiversity. In the conclusions this can be taken up as follows: Irrespective of the FPZ, the input of non-structured allochthonous soil material and possibly the destruction of local aggregates during flood pulses appears to be the driver for a temporary and - in dynamic FPZs – local increase of microbial activity. The related variability in available carbon or soil respiration cannot be explained by the spatial heterogeneity of bulk soil properties or the variability of environmental conditions. Our results thus confirm the first hypothesis put forward in the introduction. However they also show, that the temporal effects are not restricted to dynamic FPZs. The strong increase in plant biodiversity brought about by the recurrent rejuvenation of the habitats seems to support our second hypothesis, that frequent disturbance – defined as temporary and strong changes in environmental conditions and substrate availability – creates a large functional diversity.

Comment: The discussion is good and covers all the major topics – however, given that the aim of the paper as stated (p. 1064) is within the context of ecosystem services, I would have expected some discussion of the significance of the findings for key services in the discussion.

Reply: we agree that this is an important aspect and will add at the end of the conclusions chapter some implications regarding the ecosystem services habitat provision and carbon storage as follows: In particular, this (creation of near-natural floodplains comprising both dynamic gravel bars and stable alluvial systems) ensures the provision of a large diversity of habitats. On the other hand, the complex interplay of organic matter input and hot spots of both mineralisation and incomplete degradation very likely strongly affects the potential of floodplains to store carbon, an ecosystem service of great current interest (Cierjacks et al., J. Plant Nutr. Soil Sci. 173:644-653).
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Comment: It would have been interesting to see the PCA demonstrating 'completely different characteristics' of plant species composition in the 'dynamic' FPZs compared to the 'stable' ones. Was this left out only to save space? I think it would be a useful addition, with some brief discussion.

Reply: We did not include such a figure because vegetation is not a major focus of this paper as well as to save space. Including this aspect in a sound way would indeed require not only to include a figure but also to explain how the characteristics were selected, measured etc.

Comment: For Table 2, is it possible to statistically test whether the coefficients of variation differ significantly between the FPZs?

Reply: It would be possible to calculate ANOVA for the CVs of soil environmental conditions, carbon pools and soil respiration. However, the CVs are for different samplings and doing simple one way ANOVA of these temporal replicates to look at significant spatial differences between FPZs might provide misleading results. Furthermore, the CVs are not normally distributed.

Comment: Page 1062, lines 6-10: This opening paragraph needs some references. They are general statements but still require some acknowledgement of the literature.

Reply: We can add the following references to this paragraph: (i) Ward et al. 1999, as already in the reference list. (ii) Pinay, G., Clement, J. C., and Naiman, R. J.: Basic principles and ecological consequences of changing water regimes on nitrogen cycling in fluvial systems, Environmental Management, 30, 481-491, 10.1007/s00267-002-2736-1, 2002.

Comment: Page 1063 line 1: insert 'consequent' in front of 'rehabilitation'.

Reply: will be done

Comment: Page 1063 line 6: remove 'the' before 'embankments' and before 'flood levees'

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Reply: will be done

Comment: Page 1063 line 10: 'tightly linked to organic C dynamics in riparian soils' – this statement needs a reference.

Reply: We will add here the following references: (i) Hill and Cardaci, 2004 as already in the reference list (ii) Wilson et al. 2010, as already in the reference list

Comment Page 1066 line 15: 'the growing season 2008' should be 'the 2008 growing season'

Reply: will be done

Comment: Page 1066 line 18: 'topsoil samplings were' should be 'topsoil sampling was'

Reply: will be done

Comment: Page 1071 line 5: insert 'and' before 'those'

Reply: will be done

Comment: Page 1073: insert 'us' after 'allow'

Reply: will be done

Comment: Page 1074 line 29: competitive species tend not to dominate in high degrees of disturbance, rather ruderals do, so this line should be clarified.

Reply: This sentence was indeed unclear. It will be modified as follows: This hypothesis predicts highest species richness in habitats characterised by intermediate inundation frequency (i.e. WILLOW BUSH), and lower diversity under high or low degrees of disturbance (i.e., GRASS and the two forested FPZs, respectively) where ruderal or competitive species dominate, repectively (in particular Phalaris arundinacea as flood tolerant species in GRASS, Foster and Wetzel, 2005).

Comment: Page 1076 (actually 1075) line 24: change 'samplings' to 'samples'

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Reply: we do not agree; here we relate to the overall differences between the four samplings in October, January, April, and August.

Comment: Page 1076 line 9: 'content of fine soil' would be better as 'fine soil content'

Reply: will be done

Comment Page 1076 line 22: change 'evidences' to 'observations'

Reply: will be done

Comment Table 1: can you check the superscript letters, they don't quite seem right to my viewing.

Reply: The respective calculations were checked, and indeed some of the superscripts for "Sand", "Organic C" and "Total N" need to be changed; see the corrected table (Table 1 in Supplement)

Comment: Table 3 caption: 'samplings were' should be 'sampling was' – 'all samplings' should also be 'all sampling'

Reply: We will replace "Samplings were" by "Sampling was" and "all samplings" by "all sampling periods".

Comment: Fig 3 caption: 'each are represented' should be 'each represented'

Reply: will be done

Anonymous Referee 2

Comment It might be of advantage for the discussion to make clear how vegetation pattern and hydrological characteristics are interlinked and how important the vegetation pattern might be for the soil carbon pools in each specific functional process zone.

Reply: For the restored part, a link between vegetation pattern and hydrological characteristics can be made indeed. GRASS: the community of pioneer plants with Phalaris arundinacea as dominating plant providing an efficient sediment trap and tolerating

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both wet and dry conditions is characteristic of pulse-flooded river systems (Foster and Wetzel 2005, as already in the reference list); the two forest FPZs are characteristic forest communities for floodplains with an intermediate groundwater level that is deep and shallow, respectively (Schmider et al. 2003; Wälder im Kanton Thurgau; Mitt. Thurg. Naturf. Ges. 58:, Frauenfeld, 268pp.). We will include these informations and references in the description of the FPZs. However, our data do not allow to evaluate the influence of vegetation patterns on soil carbon pools or fluxes; we tried to establish a correlation with root density, however the data were inconclusive; thus, except for the lack of temperature buffering by the missing vegetation cover in GRAVEL (which is discussed in the second paragraph of chapter 5.1.), there are no features in the data that could be attributed to plant effects rather than soil properties or flooding.

Comment I would appreciate to get some more details of the FPZ in the introduction. The definition is based on the manuscript by Thorp et al, but used here in a bit different spatial context. Thus, a bit more explanation already in the intro might be beneficial.

Reply: Indeed, in the cited reference (Thorp et al., 2006), FPZs refer to hydrogeomorphic patches "intermediate in scale between valleys and reaches" (as specified by Thorp et al., 2008. The Riverine Ecosystem Synthesis. The Academic Press), and function relates to the "physical functioning of geomorphic and hydrologic forces". We suggest to add the following text at the appropriate location in the introduction: In the context of the present study we apply the FPZ concept at a smaller scale to hydrogeomorphic patches within a single reach. Furthermore, we extend "functional" to ecological processes rather than to restrict to "physical functioning of geomorphic and hydrologic forces" (Thorp et al. 2008).

Comment In the method section it would be of advantage to give clear descriptions for the variables (topography, flooding frequency while vegetation is defined) used and the classes for each FPZs. For the willow bush FPZ it might be good to point out, if the selected sites are mainly sites with planted willows or recently established willow vegetation.

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Reply: In the methods section, we can add a table showing minimum and maximum elevation in each FPZ and the respective minimum discharges for flooding these points (see Table 2 in supplement). However, it should be noted that the minimum and maximum elevations are based on measurements in spring 2010, and particularly in the GRAVEL, GRASS, and WILLOW BUSH, these values change from year to year due to the high geomorphodynamics. Therefore, flooding frequencies for the dynamic FPZs are rough estimates only and are based on the last 3 years only. Flooding durations are in addition highly variable, in particular for the frequently flooded FPZs. Therefore we prefer to give a range rather than an average value. WILLOW Bush: it is clearly stated in the "Test site" paragraph that this FPZ is dominated by planted willows; since this is the case also for all selected plots within this FPZ, we do not think it is necessary to repeat this information when we describe the plot selection.

Comment: Although there is a detailed description on the objectives, the reader would appreciate to see hypotheses to be tested in the research. This is missing.

Reply: see respective comment to referee 1

Comment: Some more details and hydrological characteristics to the FPZ sampled would be good. In fig.2 the thresholds for connectivity were presented, still a short table summarizing mean frequency and mean duration of connectivity events for each site would provide a good overview. These values should be based on a longer time series, which seem to be available.

Reply: see table 2 in supplement and reply to comment above

Comment: I also suggest adding in the method section a short paragraph which hydrological variables have been measured and estimated for the sites and used in the following data analyses.

Reply: The following informations will be added in the Method section. Exact elevations of all plots were measured in May 2010 by triangulation. The minimum river discharge

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required for flooding a specific plot was estimated from inundation maps for different river discharge levels as produced by a 2-D hydrodynamic model (details see Pasquale et al. 2011, Hydrol. Earth Syst. Sci. 15, 1197-1212). The estimates of days after last inundation (LI) at a given sampling were based on these minimum discharge values and the time course of river discharge.

Comment: In the first paragraph of the discussion the effects of flood disturbance are highlighted – there are two aspects to be discussed. Firstly, vegetation is not mentioned, which seem to have a quite strong effect as well, is this right? If so, I would suggest to include the role of vegetation clearly in the discussion, if not in the analyses as well. Secondly, I would not describe flooding here as disturbance, it is more a driving force controlling the structural development.

Reply: As stated in our reply to your introductory remark above, our data do not allow to relate C pools or fluxes to vegetation patterns. In order to make a link to biodiversity we would like to keep the term "disturbance“, in particular in this system of irregularly occurring pulse-floods. Of course the recurring reset of conditions can also be considered a driving force to maintain a geomorphically dynamic ecosystem. In order to acknowledge this, we can modify the introductory paragraph of the discussion as follows: . . . and to effects of flood disturbance as driving force of a geomorphically dynamic system . . ..

Comment: The discussion is well structured and addresses almost all main points, still I am wondering what is about the ecosystem services mentioned in the introduction and the link to restoration measures. I would welcome to add some text on what are important aspects for a restoration design addressing the heterogeneity of soil carbon pools, thinking in the line of controlled versus uncontrolled flooding for example.

Reply: With respect to ecosystem services see reply to the respective comment by referee 1. With respect to important aspects of restoration design see reply to your next comment.

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Comment: The last statement of your conclusions sound convincing, but what are the needed measures or better - design criteria to achieve this? Furthermore, what is the minimum of space needed to develop a necessary gradient for heterogeneity?

Reply: Without getting overly speculative, we probably can add the following statements regarding restoration design: River widening combined with reconnecting former floodplains from the time before channelization as in the example presented here, is likely to be a successful recipe to achieve this goal, at least for a river characterized by pulse flooding. The Thur example also shows that doing so on a rather small scale is sufficient to achieve a high heterogeneity of carbon pools and habitats. In cases where, in contrast to the Thur, the river is dammed upstream, this may have to be combined with controlled outflow mimicking the natural discharge regime including a few larger floods.

Comment Page 2, line 33: the link between the 2 sentences is not completely clear and not easy to follow. Please add a sentence to make the logic link from environmental policy to organic carbon dynamics.

Reply: We suggest to directly combine the two sentences as follows: Restoration of floodplain habitats and the rehabilitation of key ecosystem functions, many of them linked to organic carbon (C) dynamics in riparian soils, has therefore become a major goal of environmental policy.

Comment: Page 5, line 117 – 118: please specify the ecosystem services related, not clear here.

Reply: We agree on adding to this sentence as follows: . . ., may affect related ecosystem services such as carbon storage and habitat provision.

Comment: Page 8, line 198 – 199: please use the chemical formula (H_2O_2) or the name of the compound.

Reply: we will change the paragraph by using names of compounds consistently

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Comment: Page 18 line 505: the conclusion that short term inundation is an important driver for microbial habitat structure might need some more explanation – based on what parameters and patterns you derive to this statement?

Reply: this statement is not based on our own results but is the conclusion of the cited paper by Wilson et al.. We merely say that our results, when interpreted in terms of functional diversity, “support” that conclusion.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/8/C1016/2011/hessd-8-C1016-2011-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 1059, 2011.