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Hydrology and Earth System Sciences Discussions

Interactive comment on "Hydrological heterogeneity in Mediterranean reclaimed slopes: runoff and sediment yield at the patch and slope scales along a gradient of overland flow" *by* L. Merino-Martín et al.

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Some lack of clarity in the paper arises on two fronts:

(i) with respect to hydrological diversity, what is cause and what is effect? That is, is hydrological diversity a result of vegetation heterogeneity, or vice versa, or are the two so intertwined that it is impossible to separate because of the undoubted strong feedback loops between the two. Is vegetation heterogeneity due to in the first place?

Soil factors, especially ones that influence soil water, which are known to be hugely spatially variable?

Ecohydrological interrelationships between hydrology and vegetation are very intense in these restored slopes (Merino-Martín et al. 2011). Thus, we consider that these two processes present strong feedbacks that make problematic to separate them and define what is before and what is after.

The initial situation was similar for the three slopes: (1) we did not find significant differences in soil traits between slopes (see Table 1) and (2) they were restored using the same general procedures. We have shown that the differences in the size of the up-slope water contributing area and its associated erosion processes have promoted large differences in vegetation development. Our results showed two types of "mosaic pattern" generation processes (Puigdefábregas et al., 1999): (1) In Slopes 1 and 2, overland flow generated different areas of channelization and deposition, spatially distributing concentrations of nutrients, water and seed resources. As a consequence, there were areas with better conditions for vegetation development, where vegetation was established. (2) In Slope 3, runoff volumes have not eroded the surface differentially and did not generate different micro-structures. In these conditions the main driver of change is the vegetation.

(ii) I believe that the authors have poorly addressed the topic of infiltration. After all, runoff only occurs if infiltration capacity is exceeded. Not much information is presented on how the reclaimed slopes differ compared to close by natural slopes, and hence how 'unique' the reclaimed slopes are. It is not clear whether the authors intend for 'runoff sinks' and 'runoff splays' to be the same phenomenon.

We agree with your suggestion. Infiltration is (partially) not well addressed in this paper because the experimental layout was not equipped to accurately measure infiltration processes. However, as runoff occurs when infiltration is exceeded, we consider that we have implicitly included the infiltration processes in our results. Moreover, the interest of placing the TDR sensors at 25cm was to measure infiltration driven by interrelationships between vegetation and hydrology (and caused mainly by macropore flow).

The two sinks defined ("deep" and "surface" sinks) are the same phenomenon but with different intensity of infiltration processes (see Fig. 3 for soil moisture results at 25cm). The infiltration at that depth only would have happen in case of soils under a type of patch that would allow macropore flow. The last sentence of the abstract is a powerful one. Is this a result that the authors expected, and do they recognize the feedback loop between hydrologic diversity and volume of runoff? Might the authors be better off using 'hydrologic heterogentity'as opposed to hydrologic diversity' as in the title? If not then diversity needs to be defined.

We used "hydrological heterogeneity" and "hydrological diversity" as synonyms. In fact, the hydrological diversity is a quantitative descriptor of the heterogeneity of hydrological behaviours (Page 12, line 20).

One of our hypotheses was that the heterogeneity of hydrological behaviours (i.e. the hydrological diversity) was modulated by the amount of overland flow. We expected the results obtained although we didn't know if our gradient and number of samples was enough to obtain a clear answer. We do recognize a feedback between the diversity of hydrological groups and the overland flow running through the slopes.

Early ecosystem development is a hot topic internationally now. The authors could make an even greater contribution to the literature if they could discuss how they envisioned their reclaimed slopes 'developing', that is developing hydrological heterogeneity. Did that start with how the material were placed done to begin with, and the inherent variability in soil parameters that lead to varying infiltration that leads to varying germination that le3ads to varying vegetation establishment that leads to varying runoff volumes?

Please, see the above reply in section (i). See also paragraphs on discussion (line 23,

page 20; line 22, page 23).

Specific comments:

(a) Page 9935, line 23: how is event defined? It would be good to note that the precipitation was 18.1% above normal (next line).

Event was defined in the description of the hydrological measurements (Page 10, lines 22): "...after each runoff event (runoff producing rainfalls occurring within a 24 h period were considered the same event)". We have included the suggested comment (Revision, page 14, line 5).

(b) Page 9936, lines 7-11; this could be counterintuitive: higher runoff should mean lower soil moisture (less infiltration, which occurred first), and higher soil moisture through its influence eon infiltration is often related to higher runoff. How do the authors rationalize this discrepancy?

We did not find that relationship. Lower runoff was always related to higher soil moisture. Please note that our soil moisture data were recorded at 25 cm depth and within 5 days after each precipitation event. We do not have information on the antecedent soil moisture at very shallow soil depths (i.e. 0-10 cm), which has a critical importance on runoff generation. In fact, we did not aim to analyze the soil moisture dependence of the runoff generation phenomenon although the writing could have been unclear about this issue. Therefore, we have modified the text to make it more comprehensible (Revision, section 3.2).

(c) Page 9937 line 11: capitalize Gerlach.

We have included the proposed modification (Revision, page 16, line 6).

Line 19: is preferential sheet-flow not an oxymoron?

We used the term "preferential sheet flow" indicating the areas of slopes where there are small watercourses with more water flow than in places without any geomorphological microstructure (i.e. flat forms). However, these watercourses could not be considered rills because their depth was very small in comparison with the width.

We have extended the information about this topic in the results (Revision, section 3.5).

(d) Page 9939 top 3 lines: why should it be delved into?

We have changed the writing to clarify why it should be delved (Revision, page 18, lines 14-24).

Lines 22-23. Statements here justify my comment (ii) above. 'Good at obstructing runoff and sediments' means that the water has failed to infiltrate and is flowing; the meaning and explanation for the phenomenon in the next part 'it is not so efficient infiltrating water in depth' is unclear. Why not? Infiltration first, then runoff, or not.

We wanted to mean with the statement "Good at obstructing runoff and sediments" that the water has been stopped, infiltrated and is not flowing. We suggest that Brachypodium patch retains water and sediments, but it is not as good as the other sink patch (Genista) on enhancing deep (i.e. macropore) infiltration of water. Regarding this result, we have included a reference explaining this result. Arnau Rosalén et al. (2008) found that the B. retusum clumps have a high infiltration capacity but reach runoff stability (i.e. steady runoff) very quickly (mainly due to the lack of large soil macropores). Thus, we suggest that there are two types of sinks (depending on the infiltration capacity): one group with lower infiltration capacity ("surface sinks") and other group with higher infiltration capacity ("deep sinks").

(e) Page 9940 line 5: I think the authors should say: Higher soil moisture after rainfall is a good indicator of a runoff sink role.

We have included the suggestion (Revision, page 20, line 6).

Then lien 7: what is the physical explanation for why this vegetation would incorporate water at depth? Physically that is not possible: vegetation can enhance soil properties that in turn enhance infiltration that in turn increases soil moister, so the effect is

extremely indirect.

We have included a brief explanation (Revision, page 20, lines 7-10): "...it also enhances deep (macropore) infiltration that in turn increases soil moisture. In fact, we found that the soil characteristics of G. scorpius understorey are significantly different, with lower bulk density and surface strength than the other patches."

Line 8; lower than what?

They reach lower values than in the other patches (Revision, page 20, line 12): "...lower bulk density and surface strength than the other patches".

Lines 17-18: dependent variable always mentioned first: vegetation patches depend on micro-topographic structures not the other way round.

We have included the suggestion (Revision, page 20, line 22).

(f) Page 9941 lines 17-19: powerful statement and very important, but what proof do the authors present for this?

The explanation of this affirmation is presented in the paragraph above. We have changed the writing to make it more comprehensible (Revision, page 21, line 24).

Lines 20-26: does alliopathy paly any role in heterogeneous vegetation patches?

We have not explored allopathy issues in the identified patches of vegetation. However, we believe that this is not an important issue, since we have found no relevant information in the bibliography regarding allopathy for the plant species of our study sites.

(g) Page 9942 line 10: significantly.

We have included the proposed modification (Revision, page 23, line 10).

Line 18; causes

We have included the proposed modification (Revision, page 23, line 19).

line 19: referred to as

We have included the proposed modification (Revision, page 23, line 20).

(h) Page 9943, first 2 lines: how could higher soil moisture not be a pulse for vegetation growth?

We have changed the writing to clarify what we wanted to mean (Revision, section .4.3). We think that it is interesting to investigate whether the water retained on these patches could induce a patch expansion pulse, so it can facilitate the expansion of vegetation in the slopes. This could have important applications for restoration activities: including this type of sinks in revegetation practices could be a cheap and useful way to quickly get restored slopes with extensive (optimal) levels of vegetation cover.

Line 14: what proof do the authors have that this unequivocal statement is true. And what exactly is 'hydrologic diversity' and how is it related to heterogeneity, the sword used in the title?

We have included a brief explanation (Revision, page 24, line 20). We used "hydrological heterogeneity" and "hydrological diversity" as synonyms (please, note that the hydrological diversity is a quantitative descriptor of the heterogeneity of hydrological behaviors). We have better defined the term "hydrological diversity" in abstract and methods (Revision, page 2, line 22; page 12, line 20).

(i) Table 1: 10 cm depth of sampling seems to be rather shallow. Soil profile characteristics in at least the top 60 cm likely influences infiltration and vegetation growth. Two decimal places for most parameters are unwarranted, e.g., % S, Si and C. Corerct SI untis for bulk density are Mg m-3. A value of 0.05 for field studies seems rather stringent.

Previous research in this site (Moreno de las Heras, 2009; Geoderma) showed that the most important changes caused by the development of vegetation in the soil properties of these slopes are concentrated within the top 10 cm of the soil profile. Please, note

that no topsoil replacement was carried out for the reclamation of these slopes. Parent soil material consisted of 80-100 cm of overburden spoil (a clay-loam substratum free of major physicochemical constraints). This is the reason why we concentrated the physicochemical characterization of the soils in the top 10 cm.

We have included the proposed modifications for Table 1.

(j) Table 2: Correct SI units for bulk density are Mg m-3. The authors are using AWC incorrectly. The difference between field capacity and wilting point is available water holding capacity (AWHC) or in some journals simply water holding capacity (WHC).

We have included the proposed modifications (Table 2).

(k) Table 3: great data. 30 minutes is a fairly long time. The data might be more instructive if they were arranged in descending order of storm depth. It is not clear form the table that Depth is indeed storm depth.

We have re-arranged the data and changed Depth to Storm depth (Table 3).

(l) Figure 3; the one line is so different fo0mr the others; do the authors speculate why? Better to use L for litres to avoid confusion (in b). And always a space between a number and its units.

In order to clarify the differences in Figure 3 we have included the following text (Revision, page 22, line 14): "Medicago patches showed also a scarce controlling effect on hydrological processes in comparison with other patches, which could be due to their high proportion of bare soil (vegetation cover is <less than 3% in Medicago patches)."

We have changed lm-2 to mm in Figure 4b to avoid confusion.

(m) Figure 6; vegetation types are explained but they are not referred to in the figure.

The description of the different vegetation types has been deleted from the caption, since this information is not relevant for the figure (Revision, page 56, line 23).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 9927, 2011.