Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-214-AC1, 2016

Hydrology and Earth System Sciences
Discussions

Interactive comment on "The distribution pattern of desert riparian forests and its relationship with soil moisture and soil properties in the low reaches of Heihe River Basin, China" *by* J. Ding et al.

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Received and published: 1 August 2016

We thank reviewer for the detailed comments. We have gone through all the comments and will amend the original manuscript based on the suggestions and comments. In the following pages we provide brief answers to the review comments and we will make corresponding changes after we receive the editorial decision.

Major issues

Reviewer: This work presents soil water content and biogeochemical data to explain how riparian vegetation changes as distance from the river increases. Vegetation is

characterized by species composition and diversity, and occurrence and coverage of different plant functional types. The topic is overall relevant for readers of HESS. The manuscript is relatively clear, but might benefit from proofreading by a native English speaker. Despite the interest of the topic, I have some concerns regarding the analyses conducted and the mismatch between the ecological processes causing the observed vegetation patterns, and the one-time soil sampling adopted for this study.

Authors: We thank the reviewer for the suggestions to improve the quality of this manuscript. We will carefully amend the manuscript based on the comments that you provided.

Reviewer: 1) Ecological processes vs. one-time sampling. The plant communities examined in this work are the result of decade- if not century-long successional dynamics, but they are treated as if they are the result of short term processes. I refer specifically to soil water content, used as a predictor of vegetation community despite being measured only once. How representative are these water content measurements of the long-term water availability? Other soil properties vary at slower rates and could be more meaningful predictors (texture, SOM).

Authors: We thank the reviewer for pointing out the mismatch between the ecological processes and the one-time soil sampling which is central to our study. The distribution of community is a result of long-term mutual effect between vegetation and soil. While the analysis of the temporal variance of vegetation communities may better illustrate the ecological process in a study area, it is also considered as a difficult and onerous work. We therefore propose an analysis on the temporal variation of vegetation and its relationship with environment factors using remote sensing data that can be obtain from the West Data Centre (http://westdc.westgis.ac.cn/). Although desert riparian forest community especially trees are established for decades or even longer, in our case, the growth vitality of the community and vegetation characteristics mainly formed under the influence of the ecological water conveyance which was implemented in 2000 (Zhang et al., Environmental Geology, 2009 and Zhang et al., Hydrological Processes,

2011). This program revived the whole ecosystem from severe drought and vegetation degradation after the implement of ecological water conveyance. In order to add the analysis of temporal variation, we will add the hydrological data (e.g. the amount of water conveyance, annual groundwater table) and remote sensing data (e.g. soil moisture inversion product, NDVI, LAI) to better illustrate the ecological process of community formation in the study region between 2000 and 2013. We also agree that soil moisture is much variable comparing to the soil physical and chemical properties due to the diurnal variation and annual variance. However, the dynamic monitoring data of soil moisture in the desert riparian forest showed that the diurnal variation of soil moisture was mainly restricted to the top soil layer (0-20cm), while the deeper layer was almost constant during the same day. Monitoring data also showed that soil moisture formed similar annual variation pattern due to the regulated ecological water conveyance. The soil moisture formed a unimodal pattern and peaked in July, which indicated that the soil moisture in July could reflect water condition of the community for the whole year. Thus, our sampling data of 0-200cm soil moisture is relative stable in the terms of diurnal variation and sampling time in July can represent a relatively good water condition of the site that support most vegetation communities during the year. To support this account, we will add the annual soil moisture dynamics in the supplementary material based on the dynamic monitoring data of soil moisture in desert riparian forests site.

Reviewer: How old are the trees and shrubs in this community? Are these communities shaped by the time they spent growing on a given soil (no information is provided to this regard), or by the edaphic properties of a given site (focus of the current study)?

Authors: We obtained the community age by referring to the studies on the growth characteristics of shrub and trees in the study area and consulting the local forestry government (Xiao et al., Acta Botanica Boreali-Occidentalia Sinica, 2005). The trees established on the sites are beyond 50-60 years old, while the shrubs are quite young with 80% of them developed within the last 15 years. The remaining 20% are between 15 and 30 years of age. Although trees and few shrubs initially grew on the stand in

1950s-1980s, they were in poor growing condition due to the scarce water supply from the dry stream channel (Guo et al., Environment Geology, 2008). The present growth vitality of the community and vegetation characteristics mainly formed after 2000, when the ecological water conveyance was implemented to restore the ecosystem that suffered from the severe drought at the downstream of Heihe. In addition, during the last 15 years, the large-scale factors (i.e., climate) did not change significantly (Zhang et al., Arid Land Geography, 2011). The communities in our study site are thus mainly affected by the edaphic properties rather than by time. The water condition and soil properties (soil texture, soil chemical) in our sampling are heterogeneous (Fig 5 in the manuscript), changing from shruby meadow soil to grey–brown desert soils, and finally to aeolian soil along the distance from river channel. Under a given site, the mutual effect between edaphic properties and vegetation result in the formation of certain community, and eventually result in the distribution pattern of the region. Following the question raised by reviewer, we will further add explanation regarding the formation of communities in both Methods and Discussion sections to better illustrate our points.

Reviewer: No data are reported on the variability in river discharge – how dynamic is the riparian environment? How frequent are flooding events that can re-shape the community (and soil properties)? Without this information, it is difficult to disentangle time effects from site effects.

Authors: We thank the reviewer for the question. In the downstream of Heihe, the river discharge comes from the ecological water conveyance from the middle reaches. The ecological water conveyance is an ecological restoration project conducted by the national government with the aim of restoring the ecosystems of Heihe River basin since 2000. It is implemented according to the water dispatching scheme and conducted in the April, July, August, September and November with scheduled discharge (Feng et al., Science Press Ltd, 2015). Due to the regulated water discharge, the ecological water conveyance hardly caused any flooding event. Even when a flood event happens, it only affects the sites that near the river bank (within 100m radius) (Liu et al., Beijing

Forestry University, 2011). It is unlikely to re-shape the community and soil properties of our sampling plots that mainly located beyond 100 m from the river channel. Following the reviewer's suggestion, we will add this information and data of the ecological water conveyance in the Method section to illustrate the variability of river discharge.

Reviewer: Many of the measurements used as predictors are partly correlated, making it difficult to interpret the regression results. For example, soil water content is related to texture (as noted in P4, L18). Fine textured soils can hold more water, and this effect would appear in the gravimetric water content measurements. Total nutrient (TN and TP, which I assume include organic N and P) are also correlated to SOM, since large SOM stocks are associated with large N and P stocks (as noted in P20, L30). Due to these correlations, it seems difficult to apply regression approaches that assume independence, as in this case (if I interpreted the approach correctly).

Authors: We agree with the reviewer that the factors we chose were partly correlated, such as soil water content and soil texture, TN/ TP and soil organic matter. We selected these factors that covered the aspects of soil moisture and soil properties to better illustrate the relationship between vegetation and soil in the desert riparian forest. The regression approach as mentioned by reviewer is actually a forward selection (Table 2) in the RDA (Redundancy Analysis). The RDA is an ordination rather than a regression analysis. Its main aim is sorting the principal components and finding variables that best explain the vegetation distribution. Although these factors are partly correlated, the aim of the forward selection is to identify the significant factors and their contribution rate from each principal component rather than to form the regression equation for predicting the vegetation characteristics. According to the main purpose and function of the RDA, we believe that it is reasonable to involve factors that not totally independent from each other (Lepx et al., Cambridge University Press, 2003). We will add the explanation of the RDA method in the section of Methods to clearly illustrate the analysis we used in the manuscript.

Reviewer: The conclusions are based on too short-term a study to be really useful for

planning. Either a long-term monitoring or a different study to identify possible historical reasons for the observed patterns would provide (or not!) support to a possibly large and expensive conservation project.

Authors: As suggested by the reviewer, we will add temporal analysis on the vegetation and its influencing factors during 2000-2013 to better illustrate vegetation variance after the implementation of ecological water conveyance in 2000. We will re-evaluate our conclusions after the remote sensing analysis of long-term data. By combining the temporal and spatial analysis of vegetation variance in the desert riparian forest, we would provide better suggestions to the conservation project in the study area.

Minor issues Reviewer: I am listing here only some of the small editorial issues in this MS – better to ask a native English speaker to give a thorough proofreading.

Authors: We will carefully amend the manuscript based on the editorial issues that you provided and give a thorough proofreading accordingly.

Reviewer: P2, L3: "focused" rather than "stressed"

Authors: We will replace the "stressed" with the "focused" at the P2, L3.

Reviewer: P2, L11: optimum in which sense? Is biomass higher around 1000 m, or what criteria was used to establish what the 'best' conditions are?

Authors: The "optimum" is a comprehensive demonstration of the community and environment condition based on the Shannon-Wiener diversity index, Pielou evenness index, Patrick richness index that peaked at the distance of 1000 m from the river channel. We also used other indicators. For instance, community I and II that mainly distributed within 1000 m from river formed multiple layers of vertical structure. The average community coverage also reached the highest point (88%) at this distance. Soil properties such as low bulk density and high proportion of clay contribute to the aggregation of nutrient and the transportation of soil moisture. Overall, sufficient water source, relatively good soil properties and high value of community characteristic are

the reasons we define the 1000 m away from river as the optimum range. We will add the explanation of the “best condition” in the discussion section.

Reviewer: P2, L19-20: it would be better to write if the mentioned influences are positive or negative.

Authors: We will add the positive/negative influence of soil physical and soil nutrition on the community characteristics.

Reviewer: P3, L3: vague – what ecosystem services are important in this specific context?

Authors: We will specify the ecosystem service such as sand fixation and carbon sequestration service in this study.

Reviewer: P3, L14: the term “ecological water conveyance” is not entirely clear? Is there a more commonly used term?

Authors: The “ecological water conveyance” is a restoration project with delivering the water from the middle reaches of Heihe to the low reaches of Heihe to restore the ecosystem in the low reaches which suffered from the drought stress and vegetation degradation severely. This term appeared in some relevant papers. We will explain the term in the Introduction section to make it clearer.

Reviewer: P4, L18: the fact that fine textured soils can hold more water than coarse textured soils was well known before Rosenthal (2005)

Authors: We will replace this citation with a more suitable one.

Reviewer: P5, L14: “that are differently. . .”

Authors: We will revise this sentence carefully according to the reviewer’s suggestion

Reviewer: P5, L21: the long-term perspective is not covered in this work, so the suggested measures may be consistent with the findings, but do not take into account

climate or land use change.

Authors: Combining reviewer’s suggestion on the long-term study, we will add temporal analysis on the vegetation and its influencing factors from 2000 to 2013, during which the area has experienced land use change due to the vegetation restoration and farmland expansion after implement of ecological water conveyance. This new analysis can illustrate the vegetation variance accompanied with land use change in a relative long term. The sampling data mainly illustrate the distribution pattern of desert riparian forest along the decrease gradient of water availability (i.e. the distance from the river), which may provide reference to the vegetation pattern in the drought scenario under the impact of the climate change. Based on the temporal and spatial analysis of vegetation variation, we will develop more complete suggestions on management. We will add some relevant studies in this area to support our suggestion on the management and we will rewrite this part of discussion to avoid the mismatch between our result and the discussion.

Reviewer: P6, L10: “As the distance. . .increases, water. . .”

Authors: We will revise the grammatical error of this sentence according to the reviewer’s suggestion.

Reviewer: P7, L14: if I understand the sampling design correctly, there are five replicate gradients (transects perpendicular to the river), each with 6 sampling points – perhaps re-phrase?

Authors: Following the reviewer’s suggestion, we will rephrase this sentence to make it clearer and easier to understand.

Reviewer: P8, L10: is the importance value calculated for each plant functional type as written, or for each species?

Authors: The importance value is calculated for each species (19 species in total). We will rephrase this sentence to make it clearer and easier to understand.

Reviewer: P8, L14: RF is not present in the equations.

Authors: We will revise this mistake and carefully check throughout the manuscript.

Reviewer: P8, L23: the thickness of the canopy layer might not tell much about the actual biomass. Perhaps leaf area would be more representative.

Authors: We agree that leaf area is better than the thickness of canopy in depicting vegetation biomass. Due to the harsh environment, however, it is more difficult to get a precise measurement of the leaf area of all species in the community because some kind of leaf turn into the assimilating branches (i.e. T. ramosissima). By contrast, the thickness of each layer is much easier to be measured and the equation of community diversity is well-reported in the literature (P27, L13: Zhu, et al, 2013).

Reviewer: P8, L25: what does "them" refer to?

Authors: It refers to the different growth type (tree layer, shrub layer, herb layer). We will rephrase this sentence to make it much clear and easier to understand.

Reviewer: P9, L2: suggested rephrase: "...and herb layer, which can be calculated..."

Authors: Following the reviewer's suggestion, we will rephrase this sentence to make it clearer and easier to understand.

Reviewer: Equations 5-8: to calculate D the only equation needed is Eq. 6, but in that equation, what is P? Is P related to IV defined in the previous page? Presented in this way, the equations do not seem to be related to D, which is the variable that needs to be calculated (if I understood the rationale).

Authors: The P refers to the important value of species (P9, L13). We apologize for using "D" in equation 4 and 6, which caused a misinterpretation of the latter. We will replace the D in P8 with a different letter to eliminate this error.

Reviewer: P9, L17: the layers used for gravimetric water content are not consistent with the layers used for other analyses

Authors: We thank the reviewer for pointing this out. Indeed, the layers used for soil moisture measurement are different from the layer used for measuring other soil properties. We divided the soil moisture into three layers in accordance with the fine root distribution of herb, shrub and tree since different layer of soil moisture showed different influence on the herb, shrub and tree in this area (The result of correlation in Table 1 showed that SWC1 mainly correlated with herb, while SWC2 and SWC3 mainly correlated with community coverage and density). The other soil properties, however, were analyzed using the mean values of each property from 0-100cm layer because the vertical variation of soil chemical properties was not significant in the data preprocessing. Thus we use different layers in analyzing soil moisture and other soil properties. We will explain this reason in the Methods section.

Reviewer: P16, L22: it is not entirely clear which parameters are being predicted here – presence/absence for a given species, or the diversity indices?

Authors: The parameters being predicted here are the community characteristics, namely the vegetation indices in Table 1. We will explain it clearly in this section to make the manuscript easier to understand.

Reviewer: P18, L9: suggested rephrase: "... formed a bimodal pattern and reached local maxima at the distance..."

Authors: Following the reviewer's suggestion, we will rephrase this sentence.

Reviewer: P20, L14: "and possibly inducing..."

Authors: Following the reviewer's suggestion, we will carefully revise this sentence.

Reviewer: P20, L15: as explained in the major issues above, it is not easy to infer water availability effects on the plant community from a one-time water content measurement.

Authors: Following the reviewer's suggestion, the long-term variance of water availability will be illustrated by adding the temporal analysis of soil moisture and groundwater based on the hydrological data and remote sensing data. We believe that it will clarify

the long-term water availability effects on plant community and we will add relevant discussion in the manuscript.

Reviewer: P20, L18: suggested rephrase: "...also partly explained the variance of the plant community, with TP representing 8.1% of the explained variance and SOM being negatively..."

Authors: Following the reviewer's suggestion, we will rephrase this sentence to make it clearer and easier to understand.

Reviewer: P20, L22: when the groundwater table is "low", shouldn't it be "below" the degradation threshold?

Authors: We intended to use the "low" to express the meaning of "shallow", we will replace it with "shallow" to avoid further confusion.

Reviewer: P20, L24: what is the relation between TP and groundwater level?

Authors: We did not show the relationship between TP and groundwater level directly in this study. We referred to a study reporting that the effect of TP on the vegetation was more obvious with the rapid decrease of groundwater table (P20, L25: Zhang et al., 2015b). In other words, TP exerted more influence on vegetation under the drought stress condition, which was different from our study. To avoid further confusion, we will explain it in details (e.g., from the physiological-ecological process of vegetation) in the manuscript.

Reviewer: P21, L4: "thus halting..."

Authors: Following the reviewer's suggestion, we will carefully revise this sentence.

Reviewer: P21, L7: it is also possible that the points now at 1000 m from the river have been less disturbed, and thus harbor a community with larger biomass, diversity, or coverage.

Authors: Thank the reviewer for pointing the possibility. In fact, the area that distance

1000m from the river is vicinity to the main road which was developed parallel to the river channel. Although the vegetation community growing nearby the road is unlikely to be disturbed by severe human as the road is separated from the surrounding by iron wire, the points at 1000 m from the river are unlikely to be less disturbed compared to other points. We will add the main road in the Figure 1 and explain the information in the Discussion section.

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