Hydrology and
Earth System
Sciences
Discussions

Interactive comment on "Can the Pinus sylvestris var. mongolica sand-fixing forest develop sustainably in a semi-arid region?" *by* Yiben Cheng et al.

Yiben Cheng et al.

chengyiben07@gmail.com

We thank the reviewer for the constructive and detailed comments. The manuscript has been significantly improved by addressing the comments. The following are our point-to-point responses to the comments.

Sustainable soil remediation is an important and urgent topic, as it is presently still unclear how effective some remediation strategies are. The authors address the use of Pinus sylvestris var. mongolica as a way to fixate sand in the Mu Us Sandy land in Northwestern China, specifically, if rain-fed forestry can sustainable develop in the region. Their study describes the use of a newly developed deep soil recharge lysimeter

to monitor a 30-year old pine artificial forest. The current presentation of the methodology lacks sufficient detail (see specific comments below), and the results present only parts of the water balance on which the conclusions are then based. This results in a paper that is currently difficult to evaluate. Also, there is no discussion section present.

Reply: Implemented. The focus of the study is to measure the deep soil moisture infiltration in the Pinus sylvestris var. mongolica forest land, using a newly designed lysimeter. The detailed description of the design and application of the instrument has been documented in a previous publication on HESS (Cheng et al., 2017), so it is only briefly described in this study, see page 5-6, line 138-160. The Pinus sylvestris var. mongolica has been in existence in the study area for more than 30 years, so the purpose of this study is to find out whether there are sufficient water resource available in the region to support vegetation ecosystem, through the measurement of deep soil water recharge (or DSR). As suggested, the title of the paper has been changed to "On the soil moisture dynamics of sand-fixing Pinus sylvestris var. mongolica forest in a semi-arid region", which is a better representation of the body of this study. We have rewritten the discussion part as suggested. See page 13-14

Specific comments: Line 16: in this semi-arid region Line 18: "as an example" In the introduction I read in line 90-99 that many of the reforestation efforts are unsuccessful and Pinus sylvestris var. mongolica (Psvm) is the most common specie used in 3NSP. There is no statement on whether this species is more resilient, or why the abstract mention this as being an example. Can these several statements be more connected to clarify the actual success of using Psvm?

Reply: Implemented. Most of the afforestation practices mentioned in the introduction of the paper were terminated prematurely due to various reasons. In contrast, the Pinus sylvestris var. mongolica was found to be a suitable species in the most of practice of afforestation in the Three North Region of China and have been planted here for 30 years, but reforestation in some places with unclear reasons. Specifically, trees grow into dwarf trees, which are ineffective in battling land degradation, or even die, see

page 3, line 76-79. Therefore, the lessons leant from this afforestation practice are important for future adaptation of this species in other regions as well. We have revised the statements and provided further references to address the issue of resilience of this species. See page 2-3, line 64-79.

Line 29-30: Reported results are for period2016-2018, and it is concluded deep soil recharge happened and thus Psvm can sustainably develop. I think this conclusion is not merited on a 3-year observation period. There is nothing reported on the state of the 30-year-old Psvm forest, are these trees normally developed or not? Were they irrigated during that time? What is the minimum amount of water needed for these trees to survive? Also I have my doubts at the significance of the reported digits of the water balance. See later comments.

Reply: Implemented. The point raised here is similar to the comment No. 2 from the other reviewer. Please see our detailed response to that comment. "One should be cautious that the three years (2016-2018) soil moisture measurements presented in this study may not always be reliable for performing long term (such as decades long) prediction of whether the studied species can develop sustainably over decades as some artificial trees may have life cycles over decades long. Therefore, continuous (preferably decades long) measurements are necessary in the future. Another notable point is that the adaptability of long-lived woody species may not be based solely on water, temperature, light, and soil texture. Despite of such limitations, we think this three-year investigation offers an important step for understanding the soil moisture dynamics of sand-fixing Pinus sylvestris var. mongolica forest in a semi-arid region. Furthermore, these three years happen to encompass rather dramatically different weather patterns in the region (wet versus dry years), thus offer additional insights on the function of the Pinus sylvestris var. mongolica forest under highly variable external forces."

Line 37: In the abstract the term desertification was used in the context of an arid environment. Here it is used in a broader sense. The World Atlas of Desertification

(2018) has revised the definition due to confusion outside the context of (semi-)arid areas and now promotes the use of the term land degradation instead of desertification. Whether the authors use desertification or land degradation I suggest to refer to a formal definition in this particular general context. Line 101:"sustainable" This question is not veryspecific. Sustainable in term of what exactly?

Reply: Implemented. We have revised the language and the choice of words. For instance, we will use the term "land degradation", and we will re-define the term "sustainable" as meeting the growth needs of Pinus sylvestris var. mongolica and also having excess water to replenish deep soil layer as a sustainable standard. See page 3 line 87-89, page 13, line 306-308.

Line 128-129: Unclear if this refers to general observations from literature or from the inspected field site. Please explain. Line 135-137: "measurements were made without interference of canopy in the middle between forest lines" So, no root water uptake was measured, no intercepted precipitation or interecepted evaporation? The assumption being that the amount of deep recharge will be the amount available to the trees to take up water? But in that case you are missing the interception term, and the amount of water infiltration in the forest will be less than what is measurement in the DSR setup, which then invalidates your conclusions. Please explain more clearly so the reader can follow.

Reply: Implemented. "Root analysis of Pinus sylvestris var. mongolica shows that it has a shallow root distribution and underdeveloped main root, which belongs to a typical lateral root type" This is the result of in situ observation after on-site excavation. Similar findings can also be found in the literature. In semi-arid areas, vegetation depends on precipitation, and roots are concentrated in shallow soil. Measuring the water absorption of roots, precipitation or interception of the canopy are complicated processes and often involves a great degree of uncertainty. This research, however, regards the canopy and topsoil as an integrated entity. And by measuring the amount of water entering the entity (precipitation) and the amount of water leaving the entity

(deep soil recharge), one may conduct a water balance computation to calculate the amount of overall evapotranspiration.

Line 139-143: What was the soil composition/classification? Which soil moisture sensors were used? The miniTrase refers to the cable tester, not to the particular type of moisture sensor. Was a factory calibration used with the soil moisture sensors, and which one? Line 146: "sur-face runoff does not exist" Was this not observed, even in snowmelt conditions? What was the slope in the area? Please specify.

Reply: Implemented. The soil type in this area is sandy soil, the particle size distribution of 0-200 cm depth is as follows: extra coarse sand of 0.00%, coarse sand of 3.23%, middle sand of 50.53%, find sand of 36.06%, very fine sand of 7.19%, and silt sand of 2.99%. The EC-5 soil moisture probe was used and the correction equation is (wu, 2014ïïjŽField-Specific Calibration and Evaluation of ECH 2 O EC-5 Sensor for Sandy Soils): . where xsand and ysand are Analog value and Standard value. The topographic variation of area is almost negligible and long-term observations show that there is no surface runoff.

Line 152-154: "point A and B" not indicated in Fig. 2 Fig 2: Does not include an arrow for evaporation? Is it not measured?

Reply: Implemented. The figure is revised as below

Fig 3: The caption states the figure shows annual precipitation as well, but only the soil moisture readings are reported. As soil moisture changes in the lysimeter are a result of precipitation and soil evaporation (assuming no trees were growing in the lysimeter), so please include precipiatation over 2016-2018 in the results section. Also in the frozen season the soil moisture sensors readings drop. As freezing impacts the dielectric permittivity the sensor readings can be impacted. See for example: Hallikainen, M. T., Ulaby, F. T., Dobson, M. C., El-Rayes, M. A., & Wu, L. K. (1985). Microwave dielectric behavior of wet soil-part 1: Empirical models and experimental observations. IEEE Transactions on Geoscience and Remote Sensing, (1), 25-34. Nothing is mentioned in

the text, regarding these readings.

Reply: Implemented. We have revised the manuscript to include more detailed information on the soil moisture data and precipitation data of the past three years (2016-2018) to analyze the DSR. Under low temperature conditions in the winter, the accuracy of EC-5 may drop by 5% (according to the original manufacturer's instructions). To avoid the possibly unreliable data in the winter, we focus on analyzing the data from April to November (unfrozen ground period).

Line 186: Please explain how I can assess this from Fig 3? I see more than four increases in soil moisture at the 200 cm depth. Do the authors mean there are four time when water was collected in the measurement section of the DSR?

Reply: Implemented. According to Figure 3, the soil moisture content of the upper 200 cm soil layer fluctuates multiple times during the three-year experimental period. After November, the soil moisture content of the upper 200 cm soil layer fluctuations but DSR is not detected. This is probably due to the error of the EC-5 probe under frozen winter condition. Therefore, the active research period has been revised to from April to November each year. Between April to November, the DSR signals generated by the precipitations on August 11 and August 22 cannot be distinguished from each other, so we combine them together as one event. We will revisit this matter in this revised version to get a better description by inspecting the data more carefully. Fig 4: Changes are reported in increments of <0.01%. What was the accuracy of the soil moisture sensors, and are the data in Fig 4 not impacted by this? Or is the scale perhaps not what I think I am seeing, fraction instead of percentage?

Reply: Implemented. Figure 4 is revised to avoid the confusion. The data on the abscissa will be multiplied by 100%, with a range of 0-0.12, or 0-12% for better inspection.

Line 201: "annual soil moisture infiltration" Please explain how these reported numbers were obtained in the methodology, I suspect the infiltration is either weighed or measured otherwise, but it is not described at present. Table 2: If the accuracy of the

precipitation measurement is 0.2 mm, the calculated ET cannot have more reported significant digits. Please adjust. Also if as stated the measurements were made in the middle between the forest line, what then caused the transpiration term in the ET? Or was the DSR placed underneath the canopy, while precipitation and soil moisture were measured outside of the canopy. For me as a reader it became a bit vague at this point. In this water balance the canopy interception is not considered as well, making the concluding statements doubtful.

Reply: Implemented. "The annual soil moisture infiltration is only 0.2 mm, which is 1.2 mm lower than that of 2016." Should be revised as "The annual DSR measured at the 200cm soil depth is only 0.2 mm, which is 1.2 mm lower than that of 2016."

Line 213: And this would not depend on posterior soil moisture conditions as well? Line 318&324: Please adjust the reported significant digits.

Reply: Implemented. The line 210-213 describes the general state of soil moisture fluctuations in the experimental area after precipitation. The soil moisture rises with precipitation and decreases after vegetation consumption or infiltration. It is notable that the precipitation event in arid and semi-arid areas is not always strong enough to induce DSR. The line 318-314 refers to the change in soil moisture in 2016 and this part will be revised accordingly.see line 255-260

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-110/hess-2019-110-AC4-supplement.pdf

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