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# *Interactive comment on* "Application of geophysical tools for tree root studies in forest ecosystems in complex soils" *by* Ulises Rodríguez-Robles et al.

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Dr. V. Resco de Dios Referee (RC1)

We have now reviewed the comments by RC1. We appreciate the suggestions and comments posed by the referee. Below we include the answers to all his questions in this version of the manuscript.

Comment 1. Rodríguez-Robles et al present the results of jointly using GPR and ERT for study soil water and root dynamics. I cannot evaluate this as an expert in these geoscientific tools, but as a scientist with a general interest in water uptake and a potential end user in the long term. Considering this perspective, I found the manuscript



provides a set of novel tools to the vexed problem of assessing root water uptake, particularly in semi-arid, rocky environments. The authors show how this is the first study using this technique shallow and rocky soils, rendering the manuscript as novel. The graphics and overall data presentation is outstanding (although axes labels could be made bigger for ease of reading).

Authors: We thank the referee for his comments. In this new version we improved the font size of figures to facilitate readability.

Comment 2. I only have a couple of minor comments, in case they help to improve even more this study: 2.2 – PST 55 (notice the typo) are notorious for lack of temperature compensation. How did you account for that?

Authors: We corrected the typographical error (page 5, line 2). Regarding the lack of temperature compensation by the psychrometers, soil psychrometers (model PST-55) are designed with materials of high thermal conductivity to minimize temperature gradients. It includes a stainless-steel screen to allow only the water vapor to enter the sensor improving water vapor exchange with the soil thereby reducing internal condensation and maintaining temperature equilibrium. For this, the sensor must be buried at least to 12 cm under the soil surface. Also, to minimize thermal gradients, we installed the psychrometers with the axis of the sensor parallel to the soil surface. In our case, depending on the depth of soil pockets we installed the psychrometers between 12 - 15 cm deep. The soil psychrometer were monitored with a HR-33T microvoltimeter (Wescor) in the dewpoint mode.

Comment 3. Table 5 – please pay attention to wording of legend.

Authors: Legend of Table 5 was revised and corrected with the following text, "Nested two-way analysis of variance for examine differences in root diameter for four soil depths (10, 20, 30 and >30 cm) comparing forest stands (Pinus cembroides, Quercus potosina and Mixed) in a semiarid forest ecosystem in Central-North México." (page 19, table 5).

Comment 4. Please clarify x-axis and legend in fig. 2b.

Authors: We improved and increased font size of x-axis and clarified legend in Figure 2b as follows; (a) Relationship between root diameter from different stands and time interval with zero crossing of detected roots, which were later used for calibration with both GPR systems: 500 MHz frequency antenna (n = 48), $P < 0.0001$, and 800 MHz frequency antenna (n = 28), $P < 0.0001$. (b) Average diameter of roots recorded with GPR for each of the three forest stand types at four depths. Different letters next to the bars indicate statistical differences among treatment combinations at a probability value of $P < 0.05$.

Comment 5. Note also that roots are thicker at the top...Does the results of thicker roots in pine at 30 cm indicates that 1 single big root at the top divides into more thick roots afterwards?

Authors: What the figure shows is the different adaptations to rocky soils by the two forest species. Quercus in the one side, distributes a large proportion of its thicker roots on the top soil (0-10 cm depth, Fig. 2b) whereas its thin roots are located into the deepest rock fractures at the site (from 20 to more than 30 cm). For Pine, the opposite pattern of root distribution is observed. The sampling intensity used with the GPR survey did not allow us to examine root architecture as to be able to distinguish how roots divide into subsequent root orders. An additional study (Rodriguez-Robles et al., in preparation) examining the natural isotopes signature of plant tissue, soil and rock water as well as the hydrological status of plants showed that Quercus gets its water from the fractured rock whereas pine gets it from the top soil, coinciding with the distribution of fine roots.

Comment 6. How do you explain having more thick roots at deeper surfaces for pines? That's particularly surprising because, as your diagram in Fig. 3 shows, pines have a shallow root system.

Authors: As explained previously, root distribution in pine is an adaptation to a prepon-



derance of small precipitation pulses (60% of rain events < 5mm) in shallow (< 25cm depth) and rocky soils. Thus, fine roots located at the top soil allows pine to profit from those precipitation pulses as well as soil water remobilized from the rock fractures to the top soil by oak. Thick roots have more a function of anchoring the tree.

Comment 7. Fig. 5 – there are some fairly low soil water potentials. Why?

Authors: The values of soil water potentials for this system ranged between -1 to -6 MPa and were also reported in a previous study at the site (Rodriguez-Robles et al., 2015). Values under -7 MPa, represent water potential observed in weathered volcanic rocks whereas values up to -24 MPa represent those observed in fresh bedrock. For this study, we observed that soil resistivity values ($\Omega$ Âů m-1) correlated negatively with soil water potentials ($\Psi$s, Fig. S6). The soil water potentials reported in this manuscript coincide with soil water potentials reported in other ecophysiological studies in semiarid forest in North America (McDowell et al. 2008; Hagan et al 2009).

Hagan DL, Jose S, Thetford M, Bohn K. 2009. Production physiology of three native shrubs intercropped in a young longleaf pine plantation. Agroforestry Systems 76(2): 283-294.

McDowell N, Pockman WT, Allen CD, Breshears DD, Cobb N, Kolb T, Plaut J, Sperry J, West A, Williams DG, et al. 2008. Mechanisms of plant survival and mortality during drought: why do some plants survive while others succumb to drought? New Phytologist 178(4): 719-739.

Rodriguez-Robles U, Arredondo JT, Huber-Sannwald E, Vargas R. 2015. Geoeco-hydrological mechanisms couple soil and leaf water dynamics and facilitate species coexistence in shallow soils of a tropical semiarid mixed forest. New Phytol 207(1): 59-69.

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