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Water infiltration and hydraulic conductivity in a natural Mediterranean oak forest: impacts of hydrology-oriented silviculture on soil hydraulic properties

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In the last years researchers reported an increasing need to have more awareness on the intimate link between land use and soil hydrological properties (soil organic matter storage, water infiltration, hydraulic conductivity) and their possible effects on water retention (e.g., Bens et al., 2006; del Campo et al., 2014; González-Sanchis et al., 2015; Molina and del Campo, 2012). In the Mediterranean ecosystems, special attention needs to be paid to the forest–water relationships due to the natural scarcity of water. Adaptive forest management (AFM) aims to adapt the forest to water availability by means of an artificial regulation of the forest structure and density in order to promote tree and stand resilience through enhancing soil water availability (del Campo et al., 2014).

The opening of the canopy, due to the removal of a certain number of trees, is an important practice for the management of forests. It results in important modifications to the microclimatic conditions that influence the ecophysiological functioning of trees (Aussenac and Granier, 1988).

However, the effect of thinning may vary depending on the specific conditions of the forest (Andréassian, 2004; Brooks et al., 2003; Cosandey et al., 2005; Lewis et al., 2000; Molina and del Campo, 2012). Different authors reported that a reduction in forest cover increases water yield due to the subsequent reduction in evapotranspiration (Brooks et al., 2003; González-Sanchis et al., 2015; Hibbert, 1983; Zhang et al., 2001). On the other hand, the water increase may be easily evaporated from the soil surface (Andréassian, 2004).

In this context, determining soil hydraulic properties in forests is essential for understanding and simulating the hydrological processes (Alagna et al., 2015; Assouline and Mualem, 2002), in order to adapt a water-saving management to a specific case, or to study the effects of a particular management practice.

However, it must be borne in mind that changes brought about by the practice of forest management persist for almost one century. It is therefore important to monitor managed sites over longer periods, since short-term investigations are insufficient to detect changes that may influence e.g. larger parts of watersheds (Bens et al., 2006). In addition, soil hydraulic properties exhibit strong spatial and temporal variations and a large number of determinations are required to assess the magnitude of the variation within the selected area (Logsdon and Jaynes, 1996). The use of simple and rapid field techniques is therefore important to obtain reliable data with a sustainable effort (Bagarello et al., 2014; Di Prima et al., 2016).

The Beerkan Estimation of Soil Transfer (BEST) parameters procedure by Lassabatere et al. (2006) is very attractive for practical use since it allows an estimation of both the soil water retention and the hydraulic conductivity functions from cumulative infiltration collected during a ponded field experiment and a few routinely laboratory determinations. Lassabatere et al. (2006) suggested to measure the infiltration time of small volumes of water repeatedly poured on the soil surface confined by a ring inserted to a depth of about 1 cm into the soil. BEST considers a zero ponded infiltration model which was assumed to be appropriate for an infiltration run performed with small, but positive, pressure heads. This assumption was supported by numerical tests carried out by Touma et al. (2007).

Recently, Di Prima (2015) developed a method to automate data collection with a compact infiltrometer under constant head conditions. The device, maintaining a small quasi-constant head of water (i.e., 2-3 mm) on the infiltration surface, is equipped with a differential pressure transducer to measure the stepwise drop of water level in the reservoir, and, in turn, to quantify cumulative infiltration into the soil. The data acquisition system has been designed with low cost components and it is based on the open source microcontroller platform, Arduino. The very limited cost of the system could represent a step towards a cheaper and more widespread application of accurate and automated infiltration rate measurement.

However, automatic data collection increases measurement speed, permits measurement at short time intervals, improves measurement precision, allows for more efficient data handling and analysis, and reduces the amount of effort involved and the potential for errors that may occur when manual procedures are applied (Di Prima et al., 2016).

The main objective of this study was to determine soil hydraulic properties by using the combination of the automated infiltrometer and the BEST algorithm in a natural Mediterranean oak forest. The forest is located in a typical Mediterranean area, within the public forest La Hunde, Valencia (NE Spain). Two contiguous plots established in previous studies conducted by González-Sanchis et al. (2015) were selected, one of them was thinned reducing the forest density from 861 to 414 tree per ha. Control plot was not thinned. These authors studied the water cycle during the period 2012-2013. In particular, they characterized and compared the plots in term of throughfall, stemflow, soil moisture and transpiration, concluding that the AFM results in an increasing water availability, and at the same time in a substantial maintenance of overland and surface flow, precluding therefore enhancement of erosion rate.

In this paper, the focus was put on the impacts of thinning on soil hydraulic properties, such as infiltration capacity, hydraulic conductivity and soil water retention, determined by simplified and low-cost methods in connection with a hydrology-oriented silviculture.

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References

Alagna, V., Bagarello, V., Di Prima, S., Iovino, M., 2015. Determining hydraulic properties of a loam soil by alternative infiltrometer techniques. Hydrol. Process. doi:10.1002/hyp.10607

Andréassian, V., 2004. Waters and forests: from historical controversy to scientific debate. Journal of Hydrology 291, 1–27. doi:10.1016/j.jhydrol.2003.12.015

Assouline, S., Mualem, Y., 2002. Infiltration during soil sealing: The effect of areal heterogeneity of soil hydraulic properties. Water Resour. Res. 38, 1286. doi:10.1029/2001WR001168

Aussenac, G., Granier, A., 1988. Effects of thinning on water stress and growth in Douglas-fir. Canadian Journal of Forest Research 18, 100–105. doi:10.1139/x88-015

Bagarello, V., Di Prima, S., Iovino, M., Provenzano, G., 2014. Estimating field-saturated soil hydraulic conductivity by a simplified Beerkan infiltration experiment. Hydrological Processes 28, 1095–1103. doi:10.1002/hyp.9649

Bens, O., Wahl, N.A., Fischer, H., Hüttl, R.F., 2006. Water infiltration and hydraulic conductivity in sandy cambisols: impacts of forest transformation on soil hydrological properties. Eur J Forest Res 126, 101–109. doi:10.1007/s10342-006-0133-7

Brooks, K.N., Folliott, P.F., Gregersen, H.M., DeBano, L.F., 2003. Hydrology and the Management of Watersheds. Hydrology and the Management of Watersheds 575.

Cosandey, C., Andréassian, V., Martin, C., Didon-Lescot, J.F., Lavabre, J., Folton, N., Mathys, N., Richard, D., 2005. The hydrological impact of the mediterranean forest: a review of French research. Journal of Hydrology 301, 235–249. doi:10.1016/j.jhydrol.2004.06.040

del Campo, A.D., Fernandes, T.J.G., Molina, A.J., 2014. Hydrology-oriented (adaptive) silviculture in a semiarid pine plantation: How much can be modified the water cycle through forest management? European Journal of Forest Research 133, 879–894. doi:10.1007/s10342-014-0805-7

Di Prima, S., 2015. Automated single ring infiltrometer with a low-cost microcontroller circuit. Computers and Electronics in Agriculture 118, 390–395. doi:10.1016/j.compag.2015.09.022

Di Prima, S., Lassabatere, L., Bagarello, V., Iovino, M., Angulo-Jaramillo, R., 2016. Testing a new automated single ring infiltrometer for Beerkan infiltration experiments. Geoderma 262, 20–34. doi:10.1016/j.geoderma.2015.08.006

González-Sanchis, M., del Campo, A., Lidón, A., Lull, C., Bautista, I., García-Prats, A., Francés, F., others, 2015.

Incorporación de criterios eco-hidrológicos en la gestión forestal: adaptación a la escasez de agua de una masa marginal de encina. Cuadernos de la Sociedad Española de Ciencias Forestales.

Hibbert, A.R., 1983. Water Yield Improvement Potential by Vegetation Management on Western Rangelands1. JAWRA Journal of the American Water Resources Association 19, 375–381. doi:10.1111/j.1752-1688.1983.tb04594.x

Lassabatère, L., Angulo-Jaramillo, R., Soria Ugalde, J.M., Cuenca, R., Braud, I., Haverkamp, R., 2006. Beerkan Estimation of Soil Transfer Parameters through Infiltration Experiments—BEST. Soil Science Society of America Journal 70, 521. doi:10.2136/sssaj2005.0026

Lewis, D., Singer, M.J., Dahlgren, R.A., Tate, K.W., 2000. Hydrology in a California oak woodland watershed: a 17-year study. Journal of Hydrology 240, 106–117. doi:10.1016/S0022-1694(00)00337-1

Logsdon, S.D., Jaynes, D.B., 1996. Spatial Variability of Hydraulic Conductivity in a Cultivated Field at Different Times. Soil Science Society of America Journal 60, 703. doi:10.2136/sssaj1996.03615995006000030003x

Molina, A.J., del Campo, A.D., 2012. The effects of experimental thinning on throughfall and stemflow: A contribution towards hydrology-oriented silviculture in Aleppo pine plantations. Forest Ecology and Management 269, 206–213. doi:10.1016/j.foreco.2011.12.037

Touma, J., Voltz, M., Albergel, J., 2007. Determining soil saturated hydraulic conductivity and sorptivity from single ring infiltration tests. European Journal of Soil Science 58, 229–238. doi:10.1111/j.1365-2389.2006.00830.x

Zhang, L., Dawes, W.R., Walker, G.R., 2001. Response of mean annual evapotranspiration to vegetation changes at catchment scale. Water Resour. Res. 37, 701–708. doi:10.1029/2000WR900325