

Supplementary material

Launiainen S., Kieloaho A.-J., Lindroos A.-J., Salmivaara A., Ilvesniemi H. & Heiskanen J. Water retention characteristics of mineral forest soils in Finland: impacts for modeling soil moisture. *Forests*, 2022; 13(11):1797. <https://doi.org/10.3390/f13111797>

1. Open geospatial and NFI data

The site coordinates in the observed soil water retention characteristics dataset were transformed using python pycrs library from EPSG:2393 (KKJ / Finland) into EPSG:3067 (ETRS89/TM35FIN(E,N)) coordinate reference system. A 15m buffer for examined site were used and statistics (mean, std, count, minimum, maximum, median and majority) were extracted for buffered points with Python utilizing geopandas, shapely, rasterio and osgeo libraries for the open geospatial data examined (Table S1).

Table S1. Examined open geospatial data, their resolution, and source.

Data item	Resolution	Source
Superficial deposits (topsoil type, 0.4 – 0.9 m depth)	1:20 000/ 1:50 000 / 1:200 000	GTK, Geologian Tutkimuskeskus (Geological Survey of Finland) (2021). Superficial deposits 1:20 000 / 1:50 000 / 1:200 000, http://hakku.gtk.fi
TWI, Topographic Wetness Index	16 m	Salmivaara, A., Launiainen, S., Tuominen, S., Ala-Ilomäki, J. and Finér, L. (2017). Topographic wetness index for Finland. Natural Resources Institute Finland, Etsin research data finder, CSC (distributor). http://urn.fi/urn:nbn:fi:csc-kata20170511113233803176 (accessed on April, 2022).
DTW, depth-to-water index with 4 ha threshold	2m	Salmivaara, A. 2020b. DTW-kosteusindeksikartta, 2m, CSC – Tieteen tietotekniikan keskus Oy, http://urn.fi/urn:nbn:fi:att:3403a010-b9d0-4948-8f9f-2bc4ca763897 .
TRI, terrain ruggedness index	2m	Calculated based on 2m Digital Elevation Model (DEM) by National Land Survey of Finland (NLS), Elevation model 2008-2020, 2 m x 2 m. CSC - IT Center for Science Ltd. http://urn.fi/urn:nbn:fi:csc-kata000010000000000000187
TPI, topographic position index	2m	Calculated based on 2m Digital Elevation Model (DEM) by National Land Survey of Finland (NLS), Elevation model 2008-2020, 2 m x 2 m. CSC - IT Center for Science Ltd. http://urn.fi/urn:nbn:fi:csc-kata000010000000000000187
Slope	2m	Calculated based on 2m Digital Elevation Model (DEM) by National Land Survey of Finland (NLS), Elevation model 2008-2020, 2 m x 2 m. CSC - IT Center for Science Ltd. http://urn.fi/urn:nbn:fi:csc-kata000010000000000000187
Aspect	2m	Calculated based on 2m Digital Elevation Model (DEM) by National Land Survey of Finland (NLS), Elevation model 2008-2020, 2 m x 2 m. CSC - IT Center for Science Ltd. http://urn.fi/urn:nbn:fi:csc-kata000010000000000000187
Mineral soil site fertility class (forest site type)	2m	Multi-source national forest inventory (mNFI) data layer, Mäkisara, K., Katila, M., Peräsaari, J., & Tomppo, E. (2016). The multi-source national forest inventory of Finland—methods and results 2013. Natural resources and bioeconomy studies 10/2016, 215p. http://urn.fi/URN:ISBN:978-952-326-186-0

Geospatial data used as input in the SpaFHy hydrological model follows Launiainen et al. (2019), including data on TWI, peatland and mineral soil masks, and vegetation information from mNFI on canopy height,

foliage biomasses and basal area. Vegetation information from NFI or mNFI was not used for soil WRC prediction, as stand characteristics are strongly affected by forest growth and management. The NFI grain-size (soil texture) is based on visual observation from top 30 cm layer in the mineral soil, and provides four categories: organic soil or rock without mineral soil, fine (clay, silt, finer fine sand, silty till), medium (finesand, sand, finesandy till) and coarse (coarse sand, gravel, sandy and gravelly tills).

2. Average water retention curves for the five hydraulic property classes (C1-C5, 0-19cm layer in the mineral soil)

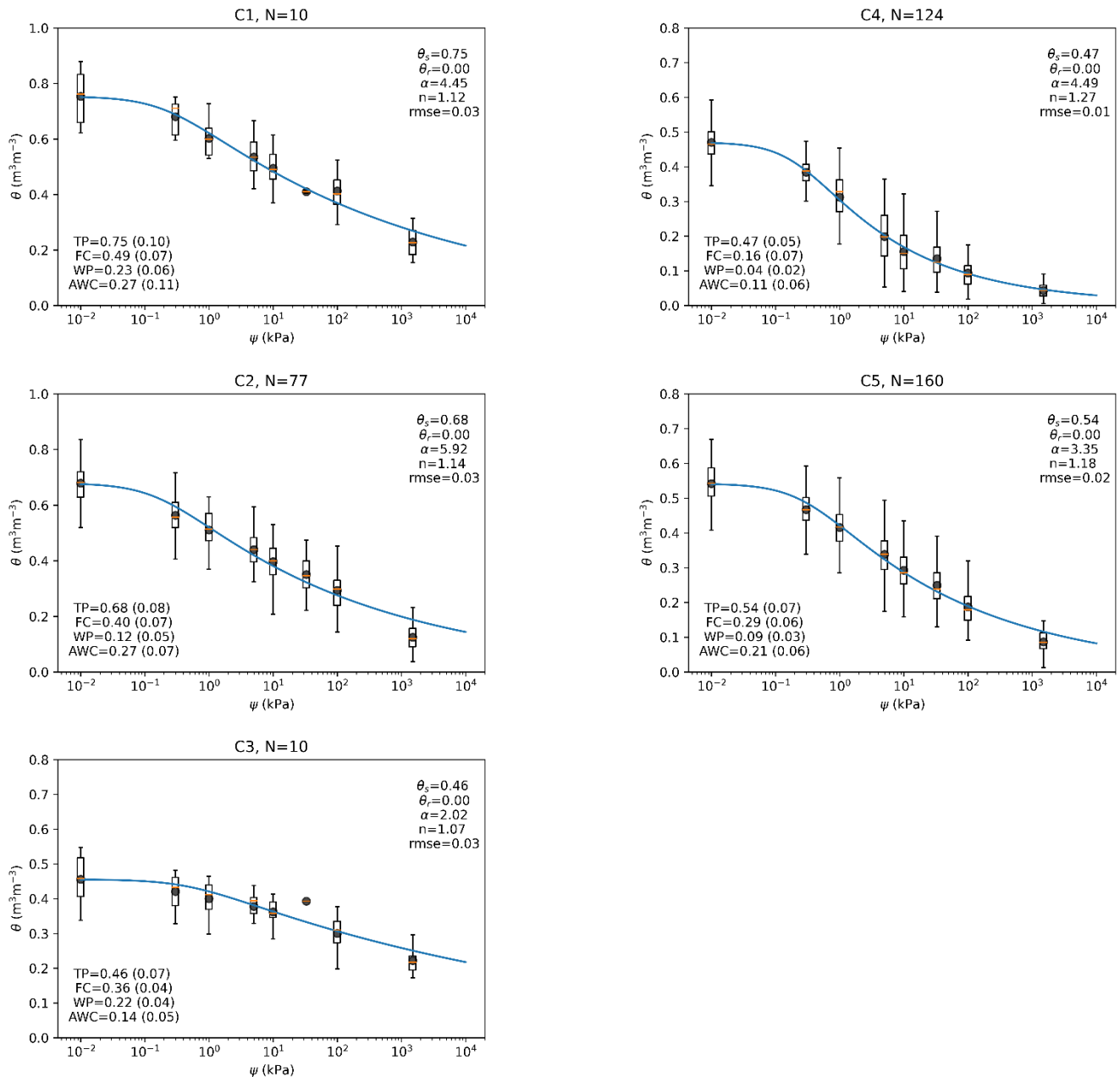


Figure S1: Mualem-vanGenuchten water-retention curve and physical properties in 0-19 cm depth for the five clusters (C1 – C5). N is the number of samples in each group. See Table 1 for summary of the physical properties.

3. Hydraulic properties for forest site-types

Figure S2 shows the ensemble averaged hydraulic properties and MvG -curves for each of the four site types. Figure 3 shows variability of soil physical and hydraulic properties across the site types, and between NFI grain-size within a site type.

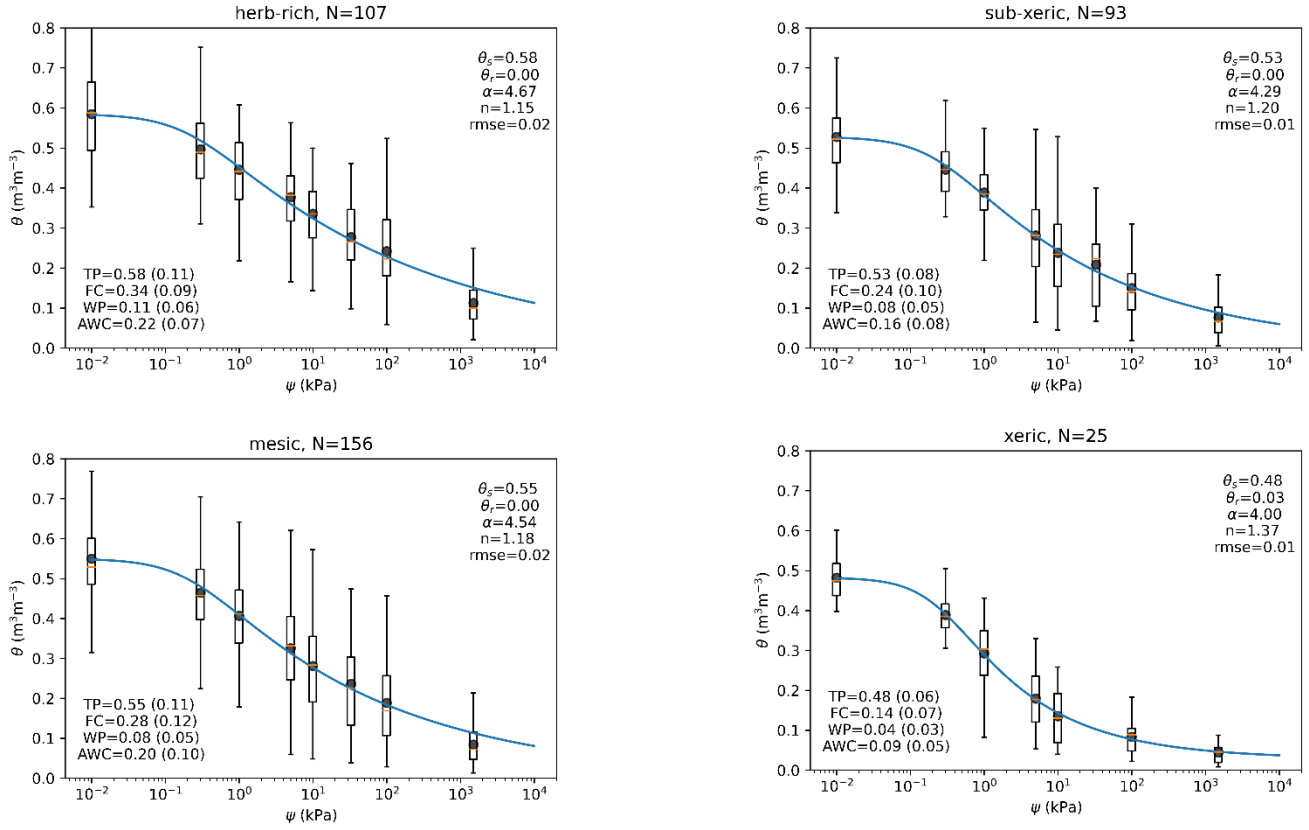


Figure S2: Mualem-van Genuchten water-retention curve (Eq. 1) and physical properties in 0-19cm depth in mineral soil grouped by site-type. The site-type productivity decreases from herb-rich to and xeric sites. N is the number of samples in each group. See Table 2 for summary of the physical properties.

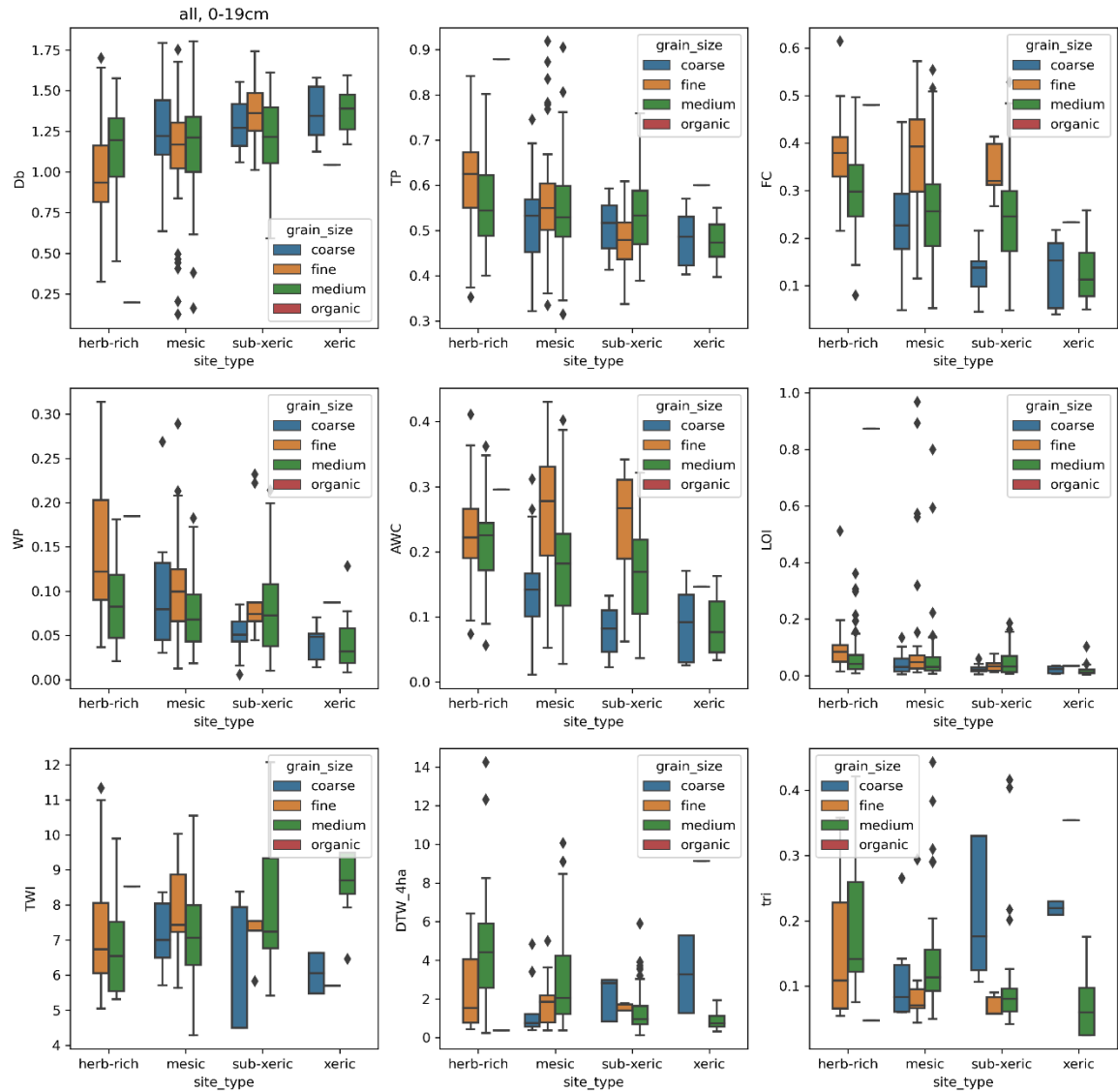


Figure S3: The variability of soil physical and hydrological properties among forest site-types, and across NFI grain-size observation within a site-type. D_b (g cm^{-3}) is bulk density, LOI organic matter content (mass %) TP, FC, WP and AWC total porosity, field capacity, wilting point and plant available water (m^3m^{-3}), respectively. The lowest row shows topographic wetness (TWI) and depth-to-water index (DTW) and terrain ruggedness index (tri), respectively. The site fertility decreases from herb-rich to xeric.

4. Soil map categories do not predict WRC properties

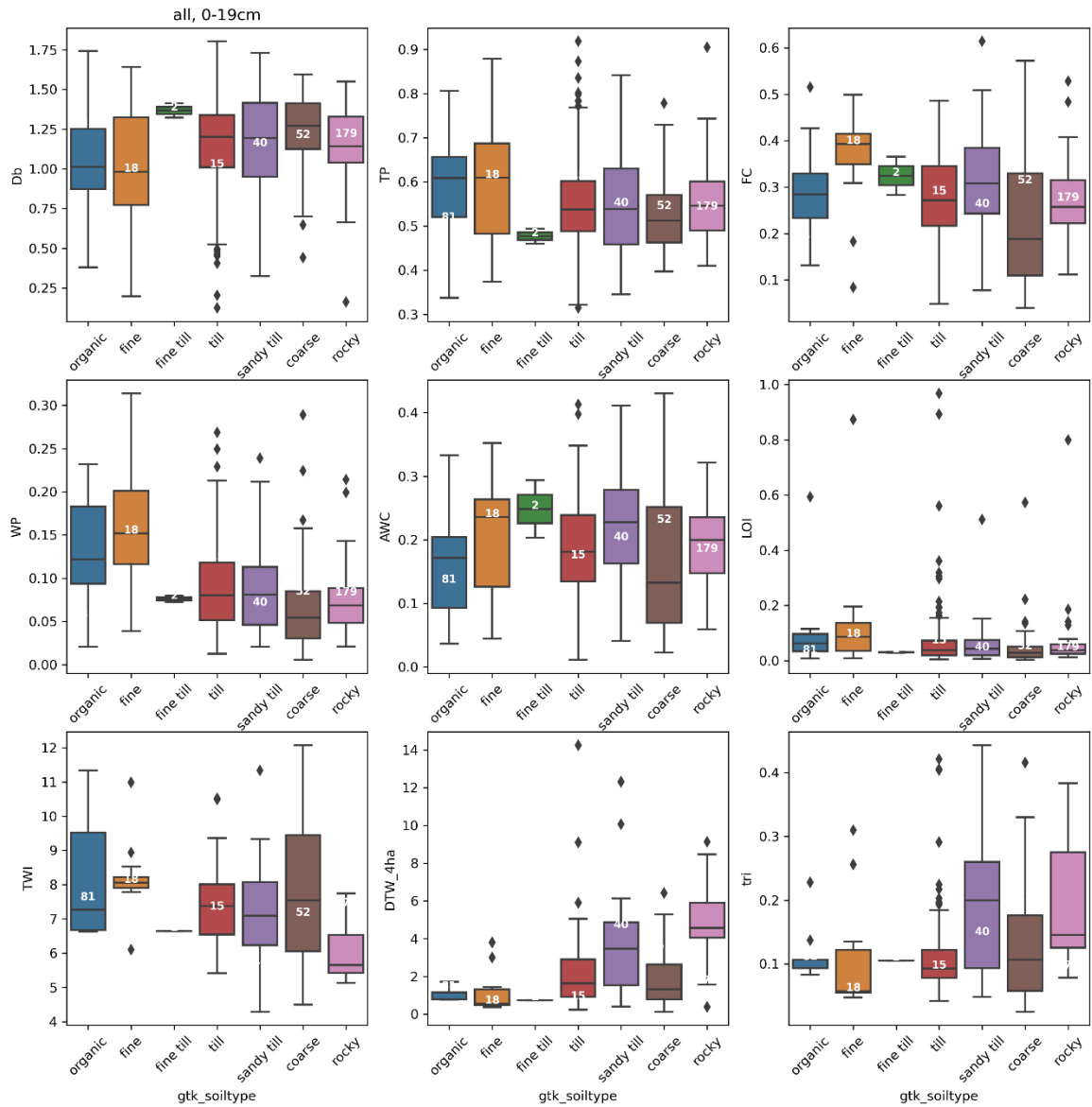


Figure S4: The variability of soil physical and hydrological properties among categories from the most accurate soil maps in Finland. D_b (g cm⁻³) is bulk density, LOI organic matter content (mass %) TP, FC, WP and AWC total porosity, field capacity, wilting point and plant available water (m³m⁻³), respectively. The lowest row shows topographic wetness (TWI) and depth-to-water index (DTW) and terrain ruggedness index (tri), respectively.

5. Inter-annual soil moisture variability at 'dry' gridcells within each site type

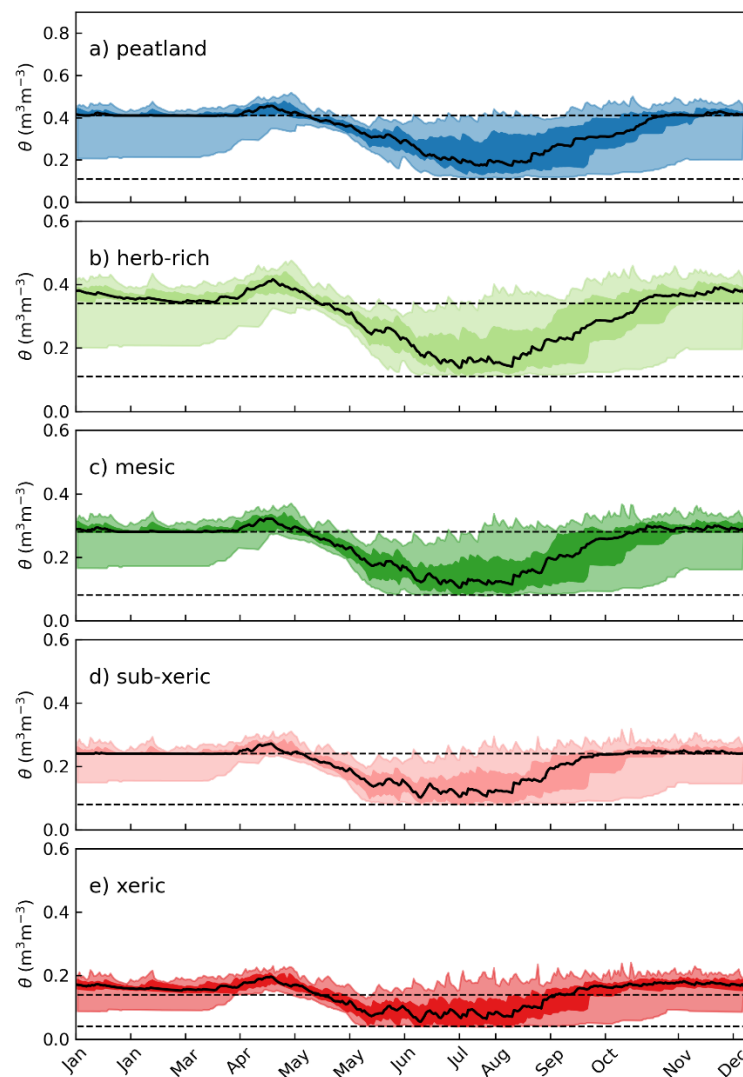


Figure S5: Inter-annual variability of soil moisture (θ) at the driest 5% of grid cells within each site type at Paunulanpuro catchment in Southern Finland. The black lines show 2000 – 2015 median for given day of year, the dark shade the IQR (25th/75th) and light shade 2.5th/97.5th percentiles. The site-type color is as in Fig. 8c and 9. The dashed horizontal lines indicate field capacity and wilting point and their difference plant available water (AWC, Table 2). Note y-axis scale in (a) is different to other panels.