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Land use effects on soil pore-size distribution and soil water retention

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INTRODUCTION

Concerns about increasing land degradation and the associated loss of long term productivity substantiate the need to improve ecosystem management to maintain underlying soil quality. Conversion of native forest to meadow and cropland is known to have wide-ranging impacts on individual soil properties, but little is known about how this impacts soil physical quality indicators in the low-laying continental ecosystems. More importantly, most of the previous research was carried out on a short-term basis, using a time scale of 1–15 y following deforestation. Knowledge of long-term trends in soil properties is important in identifying indicators of agronomic productivity and sustainability. New information on soil quality responses to land use will improve the delivery and communication of appropriate land management and stewardship practices among policymakers, scientists, and land owners.

The objectives of this study were: (i) to assess the long-term (100 y +) effects of native deciduous forest conversion to meadow and arable lands on pore size distribution and soil water retention characteristics and (ii) to determine the effect of long-term tillage on total SOM content and bulk density of noncarbonate, silty clay Fluvisol in the lowland ecosystems of W Serbia.

MATERIALS AND METHODS

Three study locations were selected in the Kolubara Valley. At each location, adjacent land, were natural deciduous forest, natural meadow, and long-term conventionally tilled land for 100 (yr), were selected. Within each land use area, three sampling sites with similar soil profiles and landscape positions were selected at each location. For each land-use type and at all three sampling areas core samples (volume of 100 cm^3 volume, n = 5 core samples) and disturbed samples were taken from a hand-dug cross-sectional test pit. Particle-size distribution, organic-C content, bulk density, pore size distribution (PSD) and water retention were determined. Retention curve data were determined by calculating the mean volumetric water content at tensions of approximately 0, 10, 30, 100, 680, and 1500 kPa. Soil water characteristics were analyzed using the van Genuchten model. The capillary rise equation was used to estimate effective pore sizes from water retention measurements.

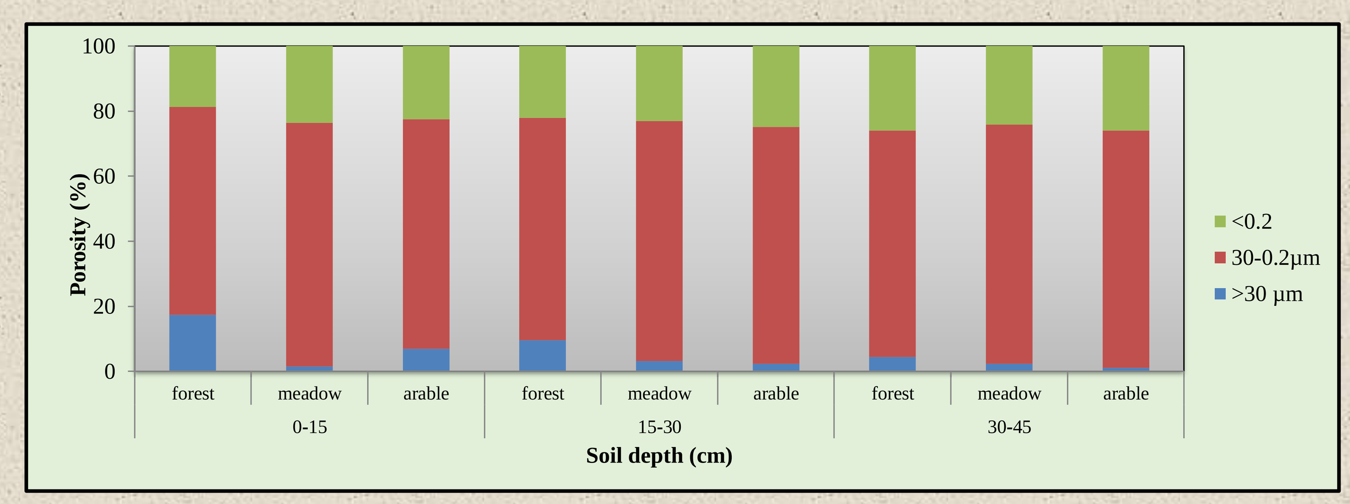

Fig. 3. Porosity distributions depending on land use at several depth increments [(A) 0-15 cm, (B) 15-30 cm, and (C) 30-45 cm]. Each values is the average of fifteen replications.

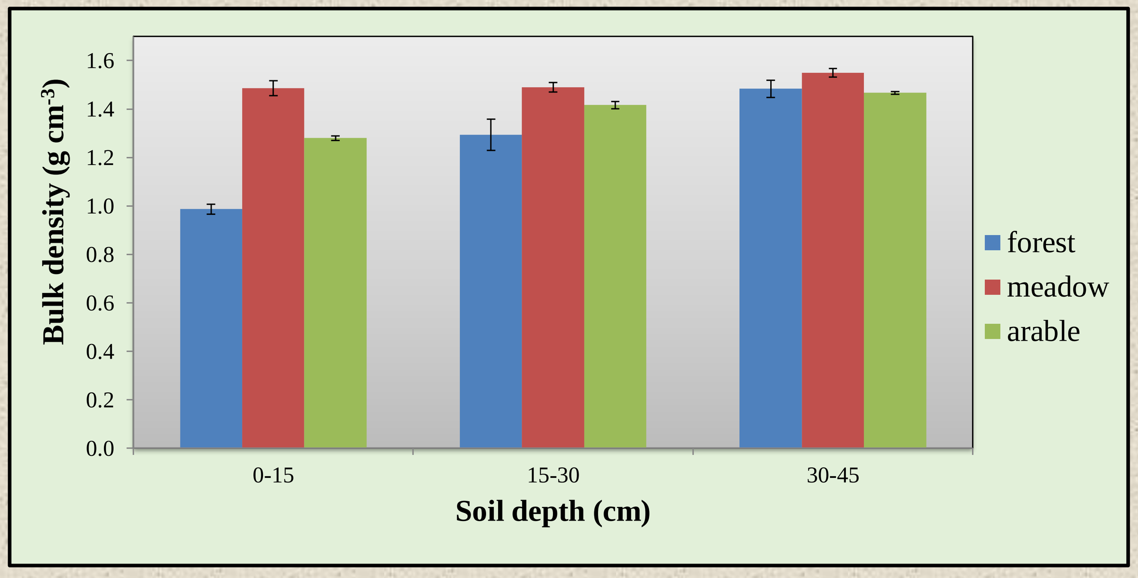

Fig. 1. Bulk densities depending on land use at several depth increments [(A) 0-15 cm, (B) 15-30 cm, and (C) 30-45 cm]. Each values is the average of fifteen replications; lines: standard deviation.

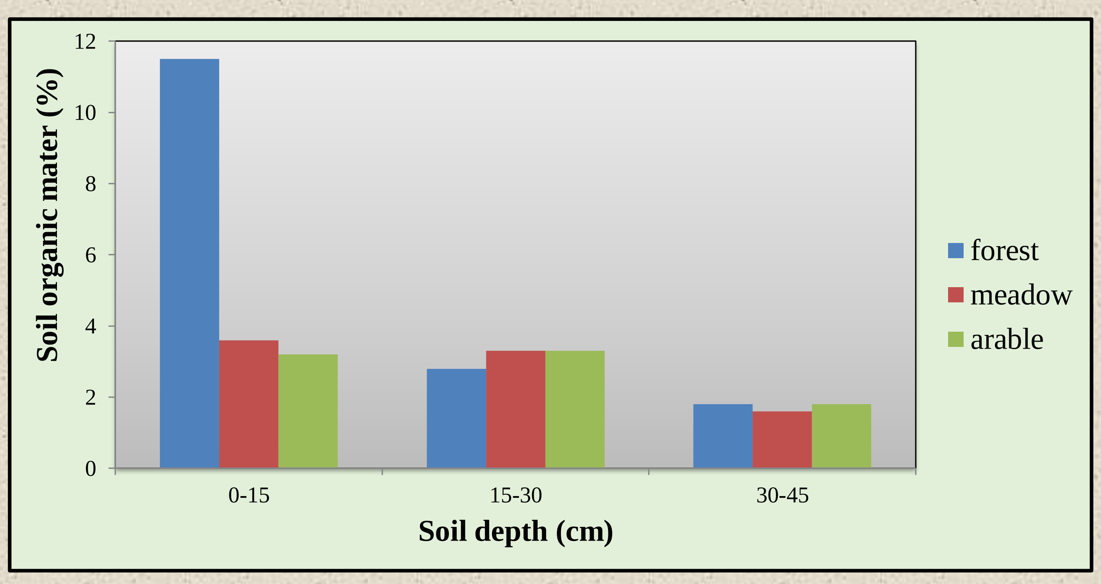

Fig. 2. Soil organic matter concentrations depending on land use at several depth increments [(A) 0-15 cm, (B) 15-30 cm, and (C) 30-45 cm]. Each values is the average of three replications.

RESULTS

The bulk density (BD) was significantly ($P < 0.05$) larger for meadow (1.48–1.49 g cm^{-3}) and arable land (1.28–1.42 g cm^{-3}) than forest (0.99–1.29 g cm^{-3}) at the top 30 cm of soil. There was no significant difference in BD between meadow and arable land in the subsurface soil layer (15–30 cm). Depending upon the increases in BD and disruption of pores by mowing and tillage management, total porosity decreased accordingly in meadow and arable land. Land use had significant effect on PSD. Volume of macropores (> 30 μm) were significantly higher for forest (10.93–16.19%) than meadow (4.77–5.74%) and arable (4.83–7.81%) land for 0–30 cm soil layer. Among the diferent land use types, forest and arable land had significantly higher mesopores (30–3 μm) volume compared with meadow. Mowing and tillage management significantly decreased volume of micropores < 3 μm diameter size at the 0–30 cm soil depth. The plant available water (PAW) was the lowest in meadow at depth of 0–15 cm. Soil under natural forest and arable land did not show significant difference in PAW at depth of 0–30 cm. After fitting the van Genuchten model to the water retention data, we observed significant effects of the land use on the empirical model parameters (*a* and *n*), (only for the 0–0.15 m soil depth.

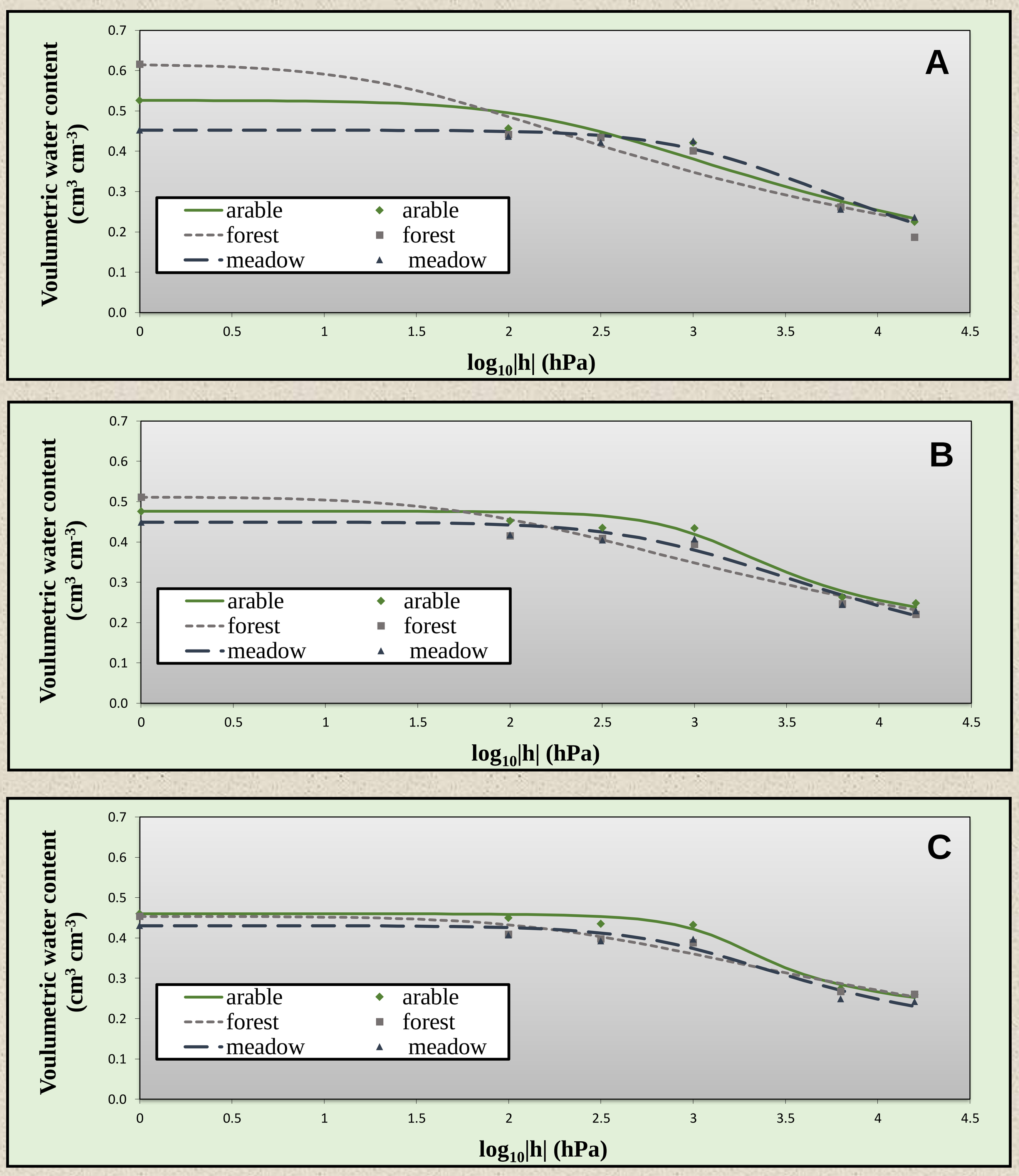

Fig. 4. Soil moisture retention curves for native forest , native meadow and arable soils, at several depth increments [(A) 0-15 cm, (B) 15-30 cm, and (C) 30-45 cm]. Van-Genuchten models were fitted to each land use dataset. Lines reflect the modelled data, and symbols show the measured mean values for volumetric water content versus water tension. There were 15 measured values (n) available to develop averages for every land use type (3) and the depicted water tensions (6).

CONCLUSIONS

Our results showed that total porosity, PSD, and moisture retention significantly changed because of the different management systems in the top 30 cm of soil, which can potentially influence crop yields and ecosystem function. This information can be used to identify and foster land use systems that contribute to sustainable ecosystems and land stewardship.

Acknowledgements

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