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Effect of land use on soil chemical properties after 190 years of forest to agricultural land conversion

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Abstract: Land use changes have a significant impact on soil properties and in some cases they are considered to be among the main threats to soil quality. The present study focuses on the relationship between soil chemistry and land use in a karstic region in Romania, where forests were converted to agricultural land 190 years ago by Czech settlers in the Banat Region. Out of several villages founded by the Czech settlers the study was done around the village of Sfinta Elena. The uniqueness of this study is that traditional agricultural practices using low intensity farming (fallow period, organic fertilizers) have been used continuously since the village was founded. Nowadays the landscape is a mosaic of different land uses. Sixty soil samples from 6 land uses, analysed for pH (active and exchangeable), total cation exchange capacity (CEC), base saturation, amount of Ca^{2+}, Mg^{2+}, K^{+}, accessible P, total N, and soil organic carbon, showed very low concentrations of analysed elements and very low values of CEC and base saturation in soils. Current arable land use exhibited the lowest values especially of soil organic C. Surprisingly, forest soils differed significantly from agricultural soils only in C/N ratio and soil organic C concentration.

Keywords: Banat; fallowing; low intensity farming; soil chemistry; Romania

Land use and management practices influence both chemical and physical properties of soils. Forest to agricultural land conversion is of considerable concern worldwide as it leads to soil degradation and alteration of soil nutrient cycles (Matson *et al*. 1997). Agriculture has enormous consequences for soils, thus the agriculture legacy could be detectable even long after cessation (Falkengren-Grerup *et al*. 2006; Holliday & Gartner 2007). For example on arable land the amount of soil organic matter (SOM) is commonly lower, compared with forests or natural grasslands, because harvests decrease its inputs to soil (Paz-González *et al*. 2000; Malo *et al*. 2005; Schulp & Veldkamp 2008; Zhu *et al*. 2012). The absence of vegetation cover and the disturbance of the surface promote higher rates of wind and water soil erosion (McLauchlan 2006), causing a loss of nutrients and SOM leading to decline in soil productivity as well as reduced soil biodiversity, buffering capacity, cation exchange capacity (CEC), and infiltration due to the degradation of soil aggregates (Caravaca *et al*. 1999; Paz-González *et al*. 2000; Papini *et al*. 2011; Zhu *et al*. 2012). The rate of agricultural soil erosion could be surprisingly fast even in SOM rich soils with stable soil structure, as was well documented on thick colluvial soils on the footslopes in Chernozem regions (Sagova-Mareckova *et al*. 2016; Zádorová *et al*. 2013, 2015).

The soil depletion of or enrichment with essential nutrients and SOM also depends on the agricultural practices, with industrial agriculture adding large amounts of pesticides and mineral fertilizers com-

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pared to low intensity farming with low external inputs. Low intensity farming is low yielding, often using fallowing: the fallow land is then grazed for several years to maintain soil fertility and restore the SOM content. The positive effect of low intensity farming has been proved in several studies in which land under low intensity farming shows significantly better soil nutritional and microbiological conditions with increased level of total nitrogen (Reganold 1988; Marinari *et al.* 2006), available P (Marinari *et al.* 2006), higher pH, soil organic carbon (SOC), CEC (Reganold 1988) and an increased microbial biomass content and enzymatic activity (Reganold 1988; Marinari *et al.* 2006). However the long-term data on properties of soils under low intensity farming are missing.

Therefore, this study presents data on selected soil chemical properties under different agricultural land uses after 190 years of traditional low intensity farming in a karstic region in the Romanian Banat where traditional agricultural practices, due to the rugged hilly terrain unsuitable for modern industrialized agriculture, have remained continuously up to the present. The specific aim of this study is to evaluate the differences in selected soil chemical properties between low intensity agriculture land uses and compare them with continuously forested soils.

Due to traditional low intensity farming with its rotation of agricultural land uses, the hypothesis is that these different uses will not create any differences in soil properties and that the major difference will be between continuously forested land and other land uses. Rotation of land uses is supposed to diminish differences in soil properties. In addition, the forest soil is expected to have originally lower soil fertility (lower concentration of nutrients) following the assumption that formerly cultivated fields had been established on the best soils (Wulf *et al.* 2010).

MATERIAL AND METHODS

Study area. The study area of 33.5 km^2 is located in the Banat region of Romania, in the Locvei Mountains around the village of Sfinta Elena (Figure 1), one of several villages inhabited by a Czech enclave in Romania (Šantrůčková *et al.* 2014). It was founded in the 19^{th} century by Czech settlers. They settled a forested area on a karst plateau above the Danube river valley and converted forest land to agricultural land.

Most soils develop predominantly on limestone or are polygenetic which is common in karstic areas (Yassoglou *et al.* 1997; Kučera *et al.* 2014). The occurrence of other types of parent material is limited, with some igneous rocks in the southeastern and northwestern part of the area and fluvial sediments in the Danube river floodplain. Soils in these parts were not sampled. Soils show silt loam texture in the upper parts of the profile, grading to silty clay

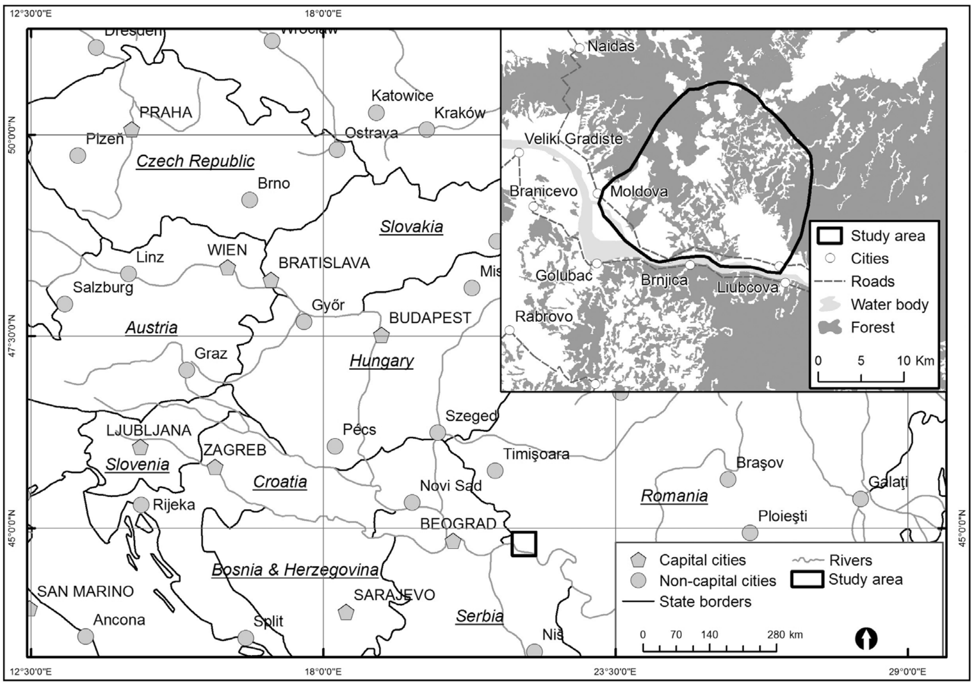

Figure 1. Location of the study area

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or clay at depth (Kučera *et al.* 2014). The dominant soil types are Chromic Luvisols, Albeluvisols and Rendzic Leptosols (Figure 2, classified according to WRB 2006).

The former forested landscape is now a diverse mosaic of various land uses (tilled fields, meadows, fallow land, pastures, orchards, woods and coppices) composed of rather small parcels, taking less than 1 ha on average. The most common cropping system is the crop rotation of maize – wheat – oat/clover/alfalfa (Šantrůčková & Klavč 2014). Farther away from the agrarian landscape surrounding the village there are beech forests and various shrubs.

Data collection and analysis. To collect soil samples under different land uses in a heterogeneous relief and analyse selected chemical properties, stratified random sampling based on land use and relief typology was applied. The land use stratification was based on a land use/cover map produced by Machala *et al.* (2014) at a scale of 1 : 5000 (Figure 3). Of the land use types classified by Machala *et al.* (2014) soil samples were collected only from arable land, grassland, orchards and forested land. The second stratification layer was the relief typology based on datasets derived from a digital elevation model (DEM) with 30 m resolution. The relief types were defined by means of cluster analysis of four raster datasets derived from DEM: altitude, slope, direction of slope exposure and insolation following the proposed method of landscape typology for the Czech Republic by Romportl and Chuman (2012) and Romportl *et al.* (2013). Based on the maximum within-cluster difference 4 relief types were created: (1) north-oriented slopes and slopes with low insolation; (2) south-oriented slopes above 300 m a. s. l. with high insolation; (3) south-oriented slopes below 300 m a. s. l. with high insolation; and (4) flat areas and gentle slopes. The relief typology was then intersected with the land use/cover map produced by Machala *et al.* (2014). Some changes were made following field observations, because during the field survey some inconsistency in the mapped land use categories was detected. Some land classified by Machala *et al.* (2014) as arable land or grassland and pastures has been left fallow for some time, thus fallow land was added as a new land use category. Furthermore, the forest category was subdivided into a forest and a high mesophilous shrubs/ravine forest category. Thus altogether 6 land use categories were distinguished: (1) beech forest; (2) high mesophilous shrubs (hereinafter referred to as shrubs); (3) orchards; (4) cultivated grassland; (5) arable land; and (6) fallow land. By the intersection of relief typology and land use 15 sampling strata were obtained. In every stratum 4 soil samples from the upper 10 cm of the mineral soil profile (excluding organic "O" horizon) were taken for soil chemistry analysis. Thus in total, 60 samples from 6 land use/cover classes were collected so as to cover the relief heterogeneity. The sampling depth was set arbitrarily to allow a comparison of soils with variable topsoil thicknesses.

Soils were air-dried, sieved to remove the size fraction > 2 mm, and then ground (ball milled). Samples were analysed for pH (H_2O), pH ($CaCl_2$), CEC, sum of base cations, base saturation, accessible

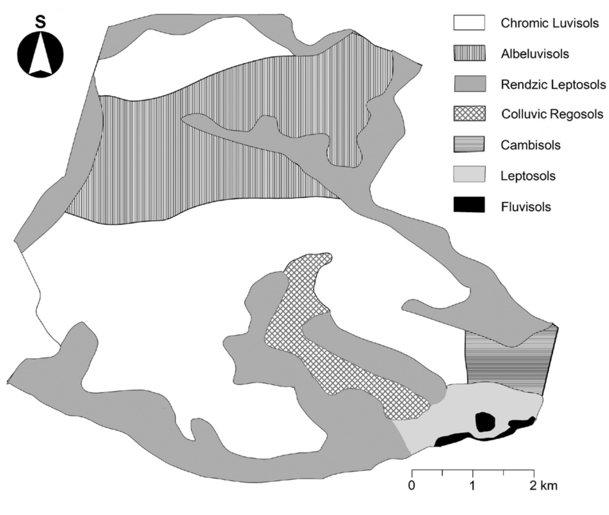

Figure 2. Soil map of the study area based on a field survey of 70 soil profiles done by the authors; soils are classified according to the WRB (2006) soil classification system

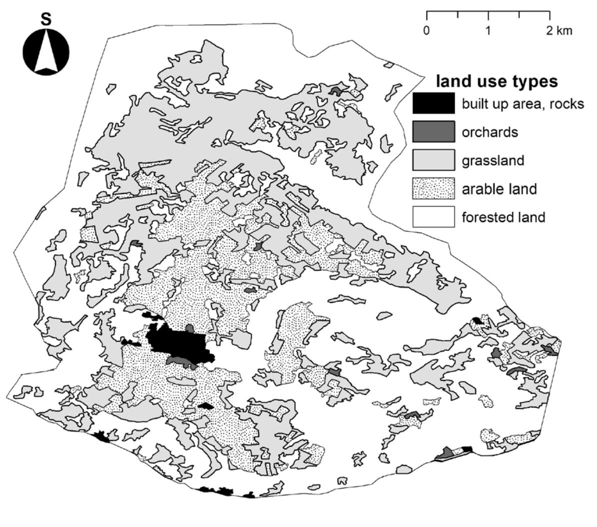

Figure 3. Land use map of the study area

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phosphorus (P), total soil N, and soil organic carbon (SOC); Mehlich III extraction solution (Mehlich 1984) of plant-available concentrations of Ca^{2+}, Mg^{2+}, K^{+} was analysed at the accredited laboratory of the Research Institute for Soil and Water Conservation, Prague. Mehlich III extraction method was evaluated as the most reliable for accessible P determination in the widest variety of soils (Sen Tran *et al*. 1990; Iatrou *et al.* 2015).

Analysis of variance (parametric one-way ANOVA or non-parametric Kruskal-Wallis one-way ANOVA on ranks) together with post-hoc tests in the case of significant results (Tukey-Kramer Multiple-Comparison Test or Kruskal-Wallis Multiple-Comparison Z-Value Test with Bonferroni correction for multiple testing) were used to reveal statistically significant differences in analysed soil chemical properties between land uses. The dependence between land use and relief type and land use and soil type was tested using Pearson's contingency table chi-square test. All analyses were performed by means of SPSS Inc. The correlation of the soil properties was analysed by Spearman rank order correlation and by principal component analysis (PCA) to clearly illustrate the multivariate relationships. The PCA was done by using CANOCO for Win 4.5 (Microcomputer Power, Ithaca, NY).

RESULTS

Soils in the study area are either shallow with high skeletal content on steep slopes or more complex on the limestone plateau where there are shallow non-skeletal soils as well as very deep soils with the strongly texturally differentiated profile that could be classified as Chromic Luvisols and Albeluvisols with truncated profiles, in some places, exposing illuvial Bt horizon. In a valley there are polygenetic soils often enriched with colluvial material. The eastern part of the area is situated on igneous rocks with Cambisols (Figure 2). Chromic Luvisols and Rendzic Leptosols were the most sampled soils which were very similar in measured chemical properties (Table 1)

The dependence between the relief and land use tested using Pearson's contingency table chi-square test showed no significant difference (χ^2 = 6.333, df = 15, P = 0.973). Forest, orchards, shrubs were equally frequent in all relief types (Table 2). Arable land was however more frequent in flat areas with gentle slopes and fallow land was more frequent on north-oriented slopes and slopes with low insolation. There was no significant dependence between soil

Table 1. Mean values and standard deviations (SD) of measured soil properties in soil types in the studied region

	N	pH				C		N		C/N		CEC		Sum of base cations		Base saturation		K		Ca		Mg		P	
		H_2O		$CaCl_2$		(%)						(mmol+/100 g)				(%)		(mg/kg)							
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Chromic Luvisols	23	5.9	0.9	5.4	0.8	2.8	1.3	0.3	0.2	8.8	0.8	24.6	11.1	17.0	13.7	64.0	22.6	218.8	131.2	3582.5	3716.3	156.7	50.0	13.7	14.2
Albeluvisols	8	5.5	0.3	5.1	0.4	2.1	0.6	0.2	0.0	8.9	1.2	17.1	4.7	8.5	6.5	50.3	26.1	150.8	40.5	2049.6	703.3	161.5	27.8	5.8	0.6
Rendzic Leptosols	22	5.9	0.9	5.5	0.9	2.9	1.6	0.3	0.1	9.1	1.1	25.2	10.8	16.8	12.7	61.2	27.4	192.0	101.5	3507.9	3412.6	188.8	84.5	7.7	3 .7
Cambisols	3	6.1	0.5	5.6	0.5	2.2	1.4	0.2	0.1	8.3	2.2	19.7	5.9	13.3	7.2	63.7	21.4	233.0	202.5	2552.0	1100.9	182.3	46.4	136.7	138.5
Colluvic Regosols	4	6.6	0.6	6.1	0.6	2.9	1.7	0.2	0.2	8.6	0.7	31.5	13.3	26.5	13.3	82.5	10.2	235.3	86.8	4514.3	1708.9	231.8	72.0	118.3	115.5

CEC – cation exchange capacity; Cambisol area was touched only by sampling orchards; all samples of Cambisols came from orchards

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type and land use (χ^2 = 22.722, df = 20, P = 0.302) (Table 2).

Soils under different land uses show rather low variability of measured soil chemical properties across all sites (Table 3). Soils are quite similar in analysed parameters however; the analysis of variance and its nonparametric equivalent revealed that several measured chemical properties show significant differences in mean or median values between land uses (Table 4, 5). Soil properties namely CEC, sum of base cations, accessible P, total N, SOC, and the C/N ratio were significantly different under different land uses. On the other hand, pH ($CaCl_2$), base saturation, and plant available Ca^{2+}, Mg^{2+}, K^+ showed no significant differences.

Soils of the study area are in general slightly acid, even acid, and on steeper slopes neutral with pH ($CaCl_2$) value ranging from 4.2 to 8.02 pH units. The pH value was fairly similar except for shrubs and orchards. CEC also showed high variability. As for pH, the highest mean CEC was recorded in shrubs. The differences between land uses in CEC were significant, the post-hoc testing revealed significant differences between fallow land and shrubs and shrubs and arable land. These differences could be attributed to different content of soil organic matter expressed as the content of soil organic carbon. Spearman rank order correlation (Table 4) and the result of PCA analysis (Figure 4) indicate that almost all detected differences can be attributed to different accumulation and quality of soil organic matter which then affect CEC, pH and nutrient sorption.

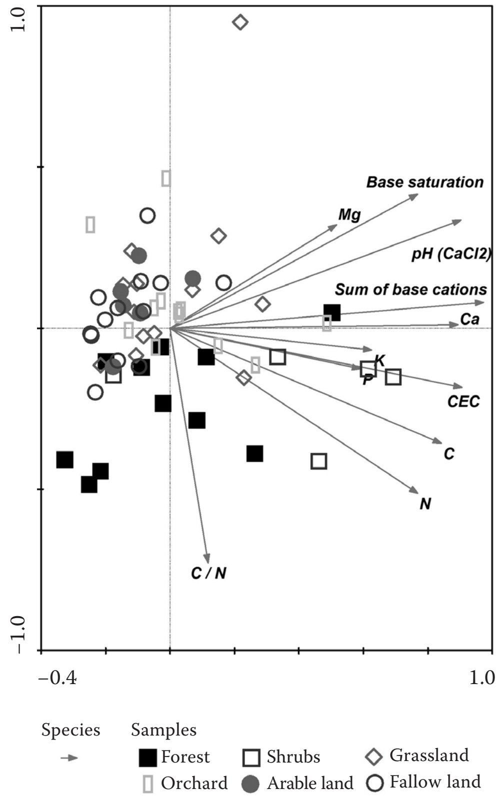

Figure 4. The multivariate analysis showing the relations of measured variables; the first two axes explain 70% of variance; the first axis explains 59.2% and could generally be attributed to base saturation of soils (cation exchange capcity (CEC), sum of base cations); the second axis is related to the quality of soil organic matter as the C/N ratio shows the strongest relation to it

Table 2. Frequency of each land use type within a relief type or a soil type

	Shrubs	Fallow land	Forest	Grasslands	Arable land	Orchards	Totals
Relief types							
South-oriented slopes below 300 m a. s. l. with high insolation	1	3	3	4	1	3	15
South-oriented slopes above 300 m a. s. l. with high insolation	1	2	3	4	2	3	15
Flat areas and gentle slopes	1	2	3	2	4	3	15
North-oriented slopes and slopes with low insolation	1	5	3	2	1	3	15
Totals	4	12	12	12	8	12	
Soils							
Cambisols	0	0	0	0	0	3	3
Chromic Luvisols	2	3	5	4	5	4	23
Albeluvisols	0	2	1	2	2	1	8
Colluvic Regosols	1	1	0	1	0	1	4
Rendzic Leptosols	1	6	6	5	1	3	22
Totals	4	12	12	12	8	12	

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Table 3. Mean values and standard deviations (SD) of measured soil properties in land use types in the studied region

	N	pH				C		N		C/N		CEC		Sum of base cations		Base saturation		K		Ca		Mg		P	
		H_2O		$CaCl_2$		(%)						(mmol+/100 g)				(%)		(mg/kg)							
		mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Forest	12	5.5	1.1	5.0	1.0	3.2	1.2	0.3	0.1	9.9	0.8	28.7	8.8	15.5	13.3	48.0	32.4	228.5	110.1	3642.0	4521.4	148.2	65.8	7.9	3.0
Shrubs	4	6.9	1.0	6.5	1.0	5.1	2.1	0.6	0.3	9.1	1.1	44.1	15.0	39.0	17.5	83.8	19.0	256.2	101.9	8631.6	5495.7	178.0	82.4	26.8	22.1
Grasslands	12	6.0	0.8	5.6	0.7	2.6	1.1	0.3	0.1	9.1	0.8	22.7	9.6	17.3	10.6	72.0	19.6	193.3	86.8	2930.8	1777.7	197.3	88.6	8.6	4.6
Orchards	12	6.3	0.6	5.7	0.6	2.6	1.2	0.3	0.1	8.8	1.1	24.2	7.8	18.4	9.6	72.0	17.0	219.9	184.0	3350.3	1910.4	195.2	49.4	10.6	11.8
Arable land	8	6.0	0.6	5.4	0.5	1.8	0.4	0.2	0.0	8.2	0.5	17.2	4.3	9.4	5.0	53.5	22.5	187.5	59.4	2208.2	844.9	141.8	35.4	13.4	9.8
Fallow land	12	5.7	0.5	5.1	0.4	1.9	0.5	0.2	0.1	8.3	1.0	18.8	4.6	10.1	6.4	51.7	20.0	156.2	64.2	2069.8	763.3	172.6	52.5	6.0	1.4

CEC – cation exchange capacity

The close relationship between CEC and SOC is well known and is shown in our results as well (Table 6, Figure 5). Different accumulation and quality of soil organic matter affect also pH, N concentration and nutrient sorption. So expectedly, the sum of base cations showed the same pattern as pH and CEC. Significant differences occurred between the same land uses as for CEC (fallow land and shrubs; shrubs and arable land). SOC concentrations likewise most of the other soil chemical parameters showed the highest variability and the highest mean value in shrubs. The SOC concentration was significantly different between fallow land and shrubs; fallow land and forest; shrubs and arable land. Shrubs also showed the highest variability of total N concentrations. Significant differences in total N concentration were detected between shrubs and fallow land and shrubs and arable land. The highest mean value of C/N ratio was detected in forest soils and the lowest ratio was detected on arable land. For these two land uses the difference was statistically significant. The differences in C/N ratio were significant also for fallow land and forest, with fallow land showing a low C/N ratio similar to arable land.

Available P, which was supposed to be increased in agricultural land, especially arable land, was only slightly increased on arable land. The fallow land showed the least variability and the lowest concentration of available P. High variability of available P was detected in shrub-covered areas. Significant differences in available P concentrations were found only between fallow land and orchards, and fallow land and shrubs.

Table 4. The results of statistical tests of soil parameters showing statistically significant differences between land uses

ANOVA			
	df	*F*	*P*-value
CEC	5.54	8.214	< 0.05
Sum of base cations	5.54	6.208	< 0.05
C	5.54	7.573	< 0.05
Kruskal-Wallis one-way ANOVA on ranks			
	df	χ^2	*P*-value
CN	5	19.63	< 0.05
N	5	17.23	< 0.05
P	5	12.88	0.025

CEC – cation exchange capacity

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Table 5. The result of post-hoc multiple comparison testing showing in which soil property the land use categories significantly differ (based on Tukey-Kramer Multiple Comparison Test (in bold) or Kruskal-Wallis Multiple Comparison Z-Value Test with Bonferroni correction)

Land use type	Forest	Shrubs	Grasslands	Orchards	Arable land	Fallow land
Forest					C/N	**C**, C/N
Shrubs				P	**CEC**, **sum of base cations**, **C**, N	**CEC**, **sum of base cations**, **C**, N, P
Grasslands						
Orchards		P				
Arable land	C/N	**CEC**, **sum of base cations**, **C**, N				
Fallow land	**C**, C/N	**CEC**, **sum of base cations**, **C**, N, P				

CEC – cation exchange capacity

Other measured soil chemical parameters namely base saturation and concentration of Mg^{2+}, K^+ and Ca^{2+} were not significantly different. However the highest mean concentrations of all parameters were detected in shrubs and the lowest mean concentrations were detected in arable land or fallow land.

The analysed soil chemical properties show high correlations as described above and visualized by the PCA (Figure 4). The analysis separates soil samples along the first ordination axis that shows the strongest correlation between the sum of base cations and CEC, and along the second ordination axis, which is the most strongly related to C/N ratio. It is clear that most of the samples taken in shrubs have a higher sum of base cations, CEC, Ca^{2+}, K^+, SOC and N than soils in other land uses. Forest soil samples show a higher C/N ratio than the other samples. Arable land, cultivated grassland and fallow land are negatively related to these parameters. Soils in orchards are a mix of these agricultural land uses on the one hand and woody vegetation on the other hand.

Table 6. Spearman rank order correlations of measured soil properties (for units see Table 1)

	pH		CEC	Sum of base cations	Base saturation	Ca	Mg	K	P	N	C	C/N
	H_2O	$CaCl_2$										
pH (H_2O)	1.00											
pH($CaCl_2$)	**0.93**	**1.00**										
CEC	**0.59**	**0.62**	1.00									
Sum of base cations	**0.77**	**0.83**	**0.85**	1.00								
Base saturation	**0.75**	**0.84**	**0.58**	**0.87**	1.00							
Ca	**0.82**	**0.86**	**0.82**	**0.92**	**0.76**	1.00						
Mg	**0.63**	**0.71**	**0.51**	**0.68**	**0.66**	**0.70**	1.00					
K	**0.39**	**0.46**	**0.43**	**0.46**	**0.38**	**0.43**	**0.39**	1.00				
P	**0.29**	**0.37**	**0.35**	**0.39**	**0.38**	**0.29**	**0.29**	**0.40**	1.00			
N	**0.49**	**0.55**	**0.85**	**0.74**	**0.50**	**0.69**	**0.50**	**0.42**	**0.52**	1.00		
C	**0.45**	**0.52**	**0.85**	**0.73**	**0.48**	**0.67**	**0.46**	**0.40**	**0.49**	**0.97**	1.00	
C/N	0.11	0.18	**0.54**	**0.38**	0.18	**0.34**	0.19	0.15	0.16	**0.53**	**0.69**	1.00

CEC – cation exchange capacity; significant correlations are in bold

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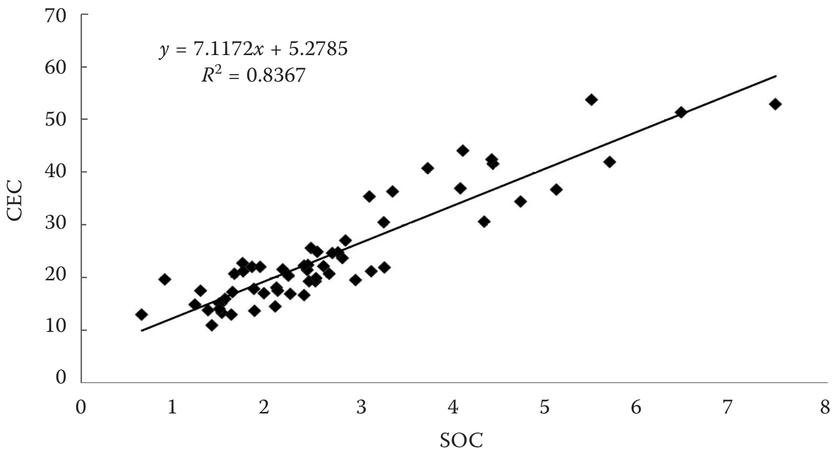

Figure 5. The relation of cation exchange capacity (CEC) and soil organic carbon (SOC) in analysed samples

DISCUSSION

The results showed that land use is associated neither with soil type nor with relief type. The land use is a dominant factor controlling the differences in soil properties. The hypothesis that different agricultural land uses do not differ in soil properties due to the rotation of land uses was not rejected. However, the results supported the hypothesis that permanent forest should exhibit significant differences in comparison with agricultural land uses. The presumed differences between the continuously forested land and the agricultural land were based on the assumption that (*i*) the different land uses were related to originally different soil fertility leading to formerly cultivated fields being established on the best soils, and (*ii*) agricultural management influences soil properties. Contrary to this assumption the results show significant differences only in the concentration of SOC between forest and fallow land and in the C/N ratio between forest and fallow land as well as arable land. The shrub land use category stands out for most of the analysed soil parameters but because of the low number of samples taken from shrubs it is impossible to draw any serious conclusion. As shrubs grow on shallow, less developed soils, soil chemistry is more influenced by variability of the bedrock chemical composition or more specific factors like plant species composition, intensity of grazing on the site or livestock gathering. Livestock gathering is very common in shrubs in the study area. Therefore, we assume that the reason why shrubs show the highest variability and the highest values of most soil parameters is because of a high input of animal excrements. The positive effect of manure or animal excrements on soil nutrient pools was proved by several studies (e.g. Semelová *et al.* 2008; Schlegel *et al.* 2017).

A lower C/N ratio on agricultural land is in line with other published studies (e.g. Verheyen *et al.* 1999; Koerner *et al.* 2009). On arable land N and SOC are being depleted mostly by similar processes, because organic matter is a source of both. They are removed with biomass during harvest, their mineralisation rate is accelerated by aeration during tillage, and they are removed by erosion (McLauchlan 2006). Furthermore, herbaceous vegetation is naturally characterized by lower C/N ratios than forests. Since herbaceous vegetation generally produces more readily decomposable litter, forest soils are generally characterized by 2× higher C/N ratio than grassland soils (Birkeland 1984; Hagen-Thorn *et al.* 2004).

Contrary to our hypothesis, the concentration of SOC differed significantly only between forest and fallow land being higher under forest. Birkeland (1984) as well as De Kovel *et al.* (2000) showed that broadleaved forests in temperate climate produce more biomass and then organic carbon than grasslands, but an important amount of it is fixed in vegetation and does not enter the soil. By contrast, under grasslands the decomposition of roots in addition to litter represents a significant amount of organic matter entering the soil. As a result grassland soils should have higher SOC content as documented e.g. by Birkenland (1984), De Kovel *et al.* (2000). Arrouays *et al.* (2001) also showed that SOC content depends strongly upon vegetation and land use, but also that the SOC content usually covers a wide range of values within soil types depending on soil properties. Soil texture is important because ca 70%

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of SOM is associated with the fine earth fraction (Caravaca *et al.* 1999; Schulp & Veldkamp 2008). In our analysis the soil types classified according to WRB 2006 varied from Rendzic Leptosols, Chromic Luvisols to Albeluvisols (Figure 2). Except for Rendzic Leptosols all studied soils were decalcified and showed silty – silty clay texture with low skeletal content, so most of the variation identified could be attributed to land use or presumably to soil erosion on exposed sites.

Comparison of forest soils and present-day arable land (which was probably turned into fallow land many times throughout its 190 years history) shows that the arable land contains half of the SOC compared to forests. The same is true when comparing fallow land and forest. Many studies have already indicated SOC depletion by cultivation (Caravaca *et al.* 1999; Paz-González *et al.* 2000; Zhang *et al.* 2007; Schulp & Veldkamp 2008; Kalinina *et al.* 2011; Papini *et al.* 2011). The loss of SOM could be very rapid, especially during the first 25 years, and could be as high as 50% of SOC after forest to agricultural land conversion (Matson *et al.* 1997; McLauchlan 2006). The loss of SOC occurs also under grassland to agricultural land conversion. Gregory *et al.* (2016) reported that losses of SOC in the upper 15 cm of soil were 65% after 59 years; McLauchlan (2006) indicated even 70% losses.

In the traditional low intensity farming system in the Romanian Banat, fallowing was used to recover soil fertility. A positive effect of such management on soil properties was proved by several studies (Marinari *et al.* 2006; Reganold 1988); however, it was also found that in the first years after arable land to fallow land conversion when biomass is increasing, nutrient uptake by new vegetation is rapid, and the concentration of nutrients in the topsoil may actually decrease (Styger & Fernandes 2006). In our study area the fallow land shows very similar analysed chemical soil properties to arable land. We do not have the information about the exact length of the fallow period but we assume that the fallow period was either short to accumulate nutrients or that nutrients accumulated in the vegetation were exported in grazed biomass rather than entering the soil pools. Therefore the export of biomass through grazing should be carefully considered if the fallow management is aimed at soil nutrient restoration.

Land use change together with agricultural practices should affect other nutrients and soil properties as well. Forest soils are usually characterized by 2× lower N content than grasslands (Birkenland 1984). However, in our study the concentration of N was very similar across land uses except for shrubs, where the concentration is three times higher than on arable land. Similarly, contrary to our expectations the pH value, which is commonly higher for cultivated soil (e. g. Paz-González *et al.* 2000), was not significantly different between any land uses in our study. The same expectation as for pH applies to P content which is usually significantly increased in arable soils (Caravaca *et al.* 1999; Paz-González *et al.* 2000; Zhang *et al.* 2007). Its elevated values even after many years of cultivation cessation on land that underwent a forest-cultivated land-forest transition could determine former crop fields. Arable land values for P in our study did not significantly differ from permanent forest, they were only slightly higher. The low content of available P could also be a result of immobilization caused by sorption on calcite surfaces and precipitation by Ca^{2+} ions, or in acidified soils by Fe, Al, and Mn ions (Tunesi *et al.* 1999). Other parameters also show depletion of agricultural land. It could be well exhibited on the sum of base cations, CEC and base saturation. Contrary to that Smal and Olszewska (2008)we still do not fully understand whether the changes proceed in the same direction and at the same rate or how long it takes to achieve a state of soil equilibrium typical of a natural forest ecosystem. Therefore, as part of a comparative study of post-arable sandy soils (Distric Arenosols showed on a forest-arable land-forest chronosequence from Poland that arable land had a higher sum of base cations and higher base saturation compared to permanently forested plots. In our study no significant differences in soil chemical properties were identified under different agricultural land uses, probably due to arable-fallow land rotation. Most important differences were detected between permanently forested and agricultural land uses, only the difference in SOC was significant. This soil parameter is often considered as the most important due to its essential effect on other soil properties, especially CEC, sum of base cations and nutrient content, which is shown also in our study. The results discussed above clearly show that the conversion of forest to agricultural land has led to soil nutrient pool depletion in this area regardless of the specific agricultural land use and specificity of agricultural practices. The microclimate change following deforestation influences organic matter decomposition and exposes the soil to water and

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wind erosion. All over the world important and widespread erosion peaks were found with the arrival of the first farmers (Leopold & Völkel 2007; Vanwalleghem *et al.* 2017).

CONCLUSIONS

Although this study is lacking historical data to account for changes in soil chemistry, the analysis of chemical properties of soils after 190 years of forest to agricultural land conversion in a karstic region in the Romanian Banat shows that agricultural soils are depleted of the amount of organic carbon, followed by the depletion of other nutrients. Traditional low intensity farming results in small differences in chemical properties of agricultural soils. The major difference is between permanently forested land and agricultural land. It suggests that the input of organic fertilizers or the input of crop residues in traditionally low intensity farming system is not sufficient and the cultivated land has been depleted of nutrients. The effect is intensified by organic matter removal by harvests, grazing and soil erosion. The insufficient input of organic matter negatively affects soil properties and functions such as cation exchange capacity, nutrient availability, and soil buffering capacity.

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