Quantification of organic carbon pools for Austria's agricultural soils using a soil information system

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Gerzabek, M. H., Strebl, F., Tulipan, M. and Schwarz, S. 2005. **Quantification of organic carbon pools for Austria's agricultural soils using a soil information system.** Can. J. Soil Sci. **85**: 491–498. Within the framework of the project "Austrian Carbon Balance Model", we estimated soil organic carbon (OC) content for the agricultural land of Austria. The basic chemical and physical data were obtained from the national electronic soil information system BORIS (Boden Rechnergestütztes Informtions System). The latter data were obtained through soil surveys performed over the past 10 yr. The BORIS data were corrected for soil gravel content, bulk densities and differences in chemical analytical methods used for soil OC. Our estimation also showed the following ranking for soil OC content (0–50 cm) under different land use systems: vineyards (57.6 t C ha^{-1}) ~ cropland (59.5 t C ha^{-1}) < orchards/gardenland (78 t C ha^{-1}) ~ intensive grassland (81 t C ha^{-1}) < extensive grassland (119 t C ha^{-1}). Although the main portion of soil carbon is stored in topsoils (0–20 cm) in all land-use classes, deeper soil layers (20–50 cm) contribute significantly to the overall inventory (between 18. 2 and 27.2 t C ha^{-1}), but appear to be less influenced by land use. A total OC storage in Austria's agricultural soils of 284 Mt was estimated. A west–east gradient of OC storage in agricultural soils of different Federal Provinces was observed. Under Austrian conditions, extensively used grassland plays an important role for OC-storage. Wide C:N ratios in these soils suggest accumulation of poorly humified organic material and slow OC turnover.

Key words: Carbon sequestration, soil organic matter, soil humus, soil nitrogen content, C:N ratio

Gerzabek, M. H., Strebl, F., Tulipan, M. et Schwarz, S. 2005. **Quantification des puits de carbone organique dans les sols agricoles autrichiens grâce à un système d'information**. Can. J. Soil Sci. **85**: 491–498. Dans le cadre du projet « modèle d'équilibre autrichien du carbone », les auteurs ont estimé la concentration de carbone organique (CO) dans les sols agricoles d'Autriche. Les données chimiques et physiques nécessaires à l'exercice ont été extraites du système électronique national d'information sur les sols BORIS (Boden Rechnergestütztes Informtions System). Les données physiques émanent de levés effectués au cours des dix dernières années. Les données de BORIS ont été corrigées d'après la teneur en gravier, la masse volumique apparente et les diverses méthodes d'analyse chimique employées pour doser le CO. Les estimations révèlent le classement suivant selon la concentration de CO (de 0 à 50 cm de profondeur) dans les sols agricoles à vocation variable : vignobles (57,6 t de C par hectare) ~ terres cultivées (59,5 t de C par hectare) < vergers/jardins (78 t de C par hectare) ~ pâturages intensifs (81 t de C par hectare) < pâturages extensifs (119 t de C par hectare). Bien que la majeure partie du carbone du sol se retrouve en surface (0 à 20 cm), peu importe la vocation des terres, les couches plus profondes (de 20 à 50 cm) en renferment aussi une quantité significative (de 18,2 à 27,2 t de C par hectare), mais paraissent moins affectées par le mode d'exploitation des terres. Les auteurs situent la quantité totale de CO stockée dans les sols agricoles autrichiens à 284 Mt. On observe un gradient ouest-est des réserves de CO dans les sols agricoles des provinces de la fédération. En Autriche, les pâturages extensifs jouent un rôle important dans le stockage du CO. Les hauts ratios C:N du sol laissent supposer l'accumulation de matière organique mal humifiée et un lent renouvellement du C.

Mots clés: Séquestration du carbone, matière organique du sol, humus, teneur en azote du sol, ratio C:N

Soil has a large number of essential functions, for example, for the environment (protection function) and human nutrition (production function). Most of the soil's functions are significantly influenced by the quantity and quality of soil organic matter (SOM). For example, SOM is essential for soil organisms and their diversity, plant nutrition, water-holding capacity, aggregate stability and erosion control. Soil management and land-use significantly influence SOM content and quality, which has been demonstrated in numerous publications (e.g., Machado and Gerzabek 1993; Novotny et al. 1999; Gerzabek et al. 2002). This implies the need for detailed investigations when evaluating the present SOM status of soils under different land use, and especially their potential to sustainably store additional carbon. It is widely recognised that soil texture through physical protection of SOM against decomposition is a key factor governing SOM turnover (e.g., Körschens and Waldschmidt 1995; Aita et al. 1997). Additionally, the chemical nature of SOM, e.g., hydrophobicity, linked to the amount of aliphatic compounds, contributes significantly to its stability against decomposition (Augris et al. 1998; Spaccini et al.

Abbrevations: **AAD**, average absolute deviation; **ACBM**, Austrian carbon balance model; **OC**, organic carbon; **SOM**, soil organic matter

2002). However, in most cases this information is not available on a broad scale, or is incomplete. First assessments of the SOM status of a large region, therefore, need to be restricted to quantitative measures based on carbon stocks and their regional distribution.

In the framework of the project "Austrian Carbon Balance Model, (ACBM)" (Orthofer et al. 2000) estimates of pool sizes of organic carbon stored within agricultural cropland and grassland soils of Austria, as a baseline for 1990, were needed. The main goal of this project was to establish a dynamic model simulating the fluxes and pools of carbon within Austrian agricultural systems. The overall model covers the energy sector, the production and consumption sector, and waste management. Within the project, a full national carbon balance was calculated and subsequently net carbon fluxes to the atmosphere. Using the ACBM it was shown that the net emission, expressed in CO_2 equivalents, calculated using a full carbon account are approximately 13% lower than the emission values derived from calculation according to the IPCC emission guidelines. The major contributions to this difference were the effect of C-sequestration in agricultural products and forest soils and balances of C input and C output from the system.

The soil organic carbon model implemented in the AGRO module of ACBM was adopted from Jenkinson and Rayner (1977). It has to deal with different organic inputs (harvest residues, sewage sludge, compost, farm yard manure, etc.). A large proportion of these inputs is very labile, decomposition is fast and their C is released into the atmosphere within a period of less than a year. The remaining fraction of organic inputs is directly distributed into three different soil pools with specific residence times. The rather small number of compartments and simple structure of the ACBM soil model are seen as a minimum to facilitate estimation of soil carbon dynamics and to represent modifications of these processes by changing agricultural practice and addition of organic amendments. On the other hand, a restriction of parameters and high aggregation of results were needed, because ACBM is a model for the whole carbon system within Austria, containing all sectors like industry, waste, traffic/energy, forest, and agriculture. Calculated carbon stocks for different land use classes were assumed to be in an equilibrium condition. They were used as initial values for the ACBM soil model.

In the present paper, we describe and present a method to estimate soil organic carbon stocks in soils under different land use across the federal provinces of Austria.

MATERIALS AND METHODS

Input Data

The calculations of carbon stocks in Austrian soils were based on soil survey data from most federal provinces of Austria, which are made available in the nation-wide soil information system BORIS by the Austrian Environment Agency. This information system contains more than 1.5×10^6 soil data from more than 40 different surveys and from 15 different sources (Schwarz et al. 2001). The data sets cover more than 10 000 sites in Austria.

Organic carbon contents available in BORIS were used. They originate from soil surveys of federal provinces and are measured by different methods. The sampling grid was different in the federal provinces. In Lower Austria, Upper Austria and Carinthia, the basic grid is 2.75 times 2.75 km, in Burgenland and Styria 3.9 times 3.9 km and in Salzburg and Tyrol it is 4 times 4 km. The sampling itself was performed according to the methods provided by Blum et al. (1989). Sampling sites are exactly marked in 1:10 000 maps. In most cases the following sampling procedure was followed: four soil profiles were dug within a 20-m diameter circle. From the depth layers of 0–20, 20–40, 40–50 cm (arable land) or 0–5, 5–10, 10–20, 20–40, 40–50 cm (grassland) composite samples were obtained and analyzed according to standard procedures (Blum et al. 1989). Data for federal provinces not yet covered by BORIS were extracted from printed reports (Lower Austria, Salzburg, Carinthia) or estimated from neighbouring Provinces (as was the case in Vienna and Vorarlberg). Survey data originate from 1988 to 1993, thus they are assumed to be representative for the baseline year 1990, which we used for our Austrian Carbon Balance Model. The results for the Provinces covered by the Boris database are summarized in Table 1. The nitrogen inventories were calculated from the data collected by Njegic (2001) from Austrian soil inventories.

Additional Information Needed for Pool Size Derivation

The soil bulk density and the gravel content vary considerably in Austrian agricultural soils. For example, in Carinthia, an alpine province (Amt der Kärntner Landesregierung 1999), 12.9% of cropland soils (0–20 cm) show gravel contents above 20%; for the 50–70 cm soil depth, 43.8% of soils had gravel contents above 20%; in grassland, 9.9% of topsoil (0–5 cm) had greater than 20% gravel contents, whereas 61.7% of deeper grassland soil layers (50–70 cm) contained more than 20% gravel. In alpine pasture soils (0–5 cm), 23.1% of samples had values > 20% gravel content, and for deeper layers (50–70 cm) 90% of soils had values > 20% gravel content. These figures are considerably higher than values reported for the province of Upper Austria with less alpine influence: median value of gravel content in cropland soils amounted to 0% (for 0–20, 20–40, 40–60 cm depth layers). For grassland soils the corresponding value is 5% (for all depth layers) (Amt der Oberösterreichischen Landesregierung 1993). In the same investigation for the bulk densities of cropland soils (0–20 cm) an average of 1.35 ± 0.13 g cm^{-3} is reported (range 0.53 –1.65); for grassland soils (0–10 cm) the average amounted to 1.01 ± 0.22 g cm^{-3} (range 0.23–1.49).

Correction procedures were applied to decrease the uncertainties related to different analytical methods for determination of soil organic carbon. The soil inventories were performed by different federal provinces. Thus, in some data sets not all necessary information was available; data had to be derived from literature or empirical estimations.

(i) *Soil bulk density*: We used data from soil surveys where this parameter had been included (e.g., Upper Austria):

Table 1. Organic carbon content in agricultural soils of the federal provinces, contained in the Boris database (status 1999)

Land use	Soil depth (cm)	Median (% OC)	AAD[z] (% OC)	*n*	95% confidence limits lower (% OC)	upper (% OC)	± % confidence range from median
Styria							
Cropland	0–20	1.74	0.36	130	1.67	1.84	4.9
	20–50	0.79	0.29	135	0.66	0.85	12.0
	50–70	0.39	0.20	121	0.33	0.46	16.7
Intensive grassland	0–5	4.49	1.04	186	4.32	4.80	5.3
	5–20	1.97	0.55	186	1.90	2.10	5.1
	20–50	0.85	0.33	179	0.79	0.92	7.6
Alpine meadows	0–5	14.08	5.15	52	13.08	16.41	11.8
	5–20	5.71	3.21	52	5.22	6.82	14.0
	20–50	2.75	1.12	33	2.43	3.90	26.7
Upper Austria							
Cropland	0–20	1.57	0.42	439	1.51	1.62	3.5
	20–40	0.87	0.26	230	0.84	0.93	5.2
	40–60	0.46	0.18	226	0.44	0.49	5.4
Intensive grassland	0–5	4.23	1.56	418	4.12	4.35	2.7
	5–10	2.78	0.99	204	2.61	3.02	7.4
	10–20	1.86	0.70	203	1.68	1.97	7.8
	20–40	0.99	0.42	199	0.87	1.10	11.6
Alpine meadows	0–5	8.12	6.31	14	5.80	21.75	98.2
	5–10	5.68	2.54	10	3.42	9.40	52.6
	10–20	3.31	0.72	10	2.32	4.23	28.9
	20–40	2.00	0.56	10	1.16	2.73	39.3
Burgenland							
Cropland	0–20	1.51	0.71	138	1.44	1.64	6.6
Intensive grassland	0–5	3.62		6	3.08	11.99	123.1
	5–10	2.56		6	2.56	10.61	157.2
	10–20	1.84		6	1.44	6.79	145.4
	20–40	1.05		6	0.46	2.56	100.0
	40–50	0.92		6	0.46	1.51	57.1
Tyrol							
Cropland/grassland	0–20	4.75	1.07	28	4.32	5.52	12.6
	30–50	2.40	0.57	27	2.00	2.94	19.6
Alpine meadows	0–5	10.17	3.92	25	9.05	12.35	16.2
	0–10	8.80	4.23	239	7.80	9.80	11.4
	0–15	6.00	2.29	61	5.76	6.48	6.0
	0–20	5.64	3.36	23	5.40	10.29	43.4
	15–30	5.86	1.56	14	3.16	8.16	42.7
	30–50	2.71	1.37	104	2.40	3.05	12.0

[z]AAD, absolute average deviation from median.

For those Provinces where data about texture were missing, we have chosen the approach of Körschens and Waldschmidt (1995) for estimation. They made regression analyses with an extended data set and found a correlation of 0.95 between OC content and soil bulk density.

(ii) *Gravel content*: As carbon determination is carried out in fine soil (< 2 mm) the gravel content is not taken into account in the OC values (%). The soil bulk density refers to bulk soil, i.e., including gravel. Therefore, density values were corrected for the gravel content (which was assumed to be OC free). Gravel data were taken from available soil survey data and/or estimated from relevant literature.

Selection of Data Sets

We applied the following criteria to select data sets from BORIS:

(i) Method of OC analysis (only data derived by wet oxidation or elemental analyzer were used).

(ii) Soil depth (sampled depth increments). Unusual depth increments, analysed in the framework of special projects and not in the course of the soil surveys were excluded from this study.

(iii) Land use (categories included were cropland, extensively and intensively managed grassland, vineyards, orchards, gardenland). This information is included in the BORIS data bank for the date of soil sampling.

Correcting Methodological Differences for Measuring Soil OC

Differences in OC determination methods were observed between the data sets of different soil surveys of Austrian federal provinces based on OC determination by wet oxidation without additional heating and dry oxidation in an elemental analyzer. The first method is known to yield lower OC values for higher SOM levels when compared with the combustion method (Mutsch 1994, Fig. 1). Correction fac-

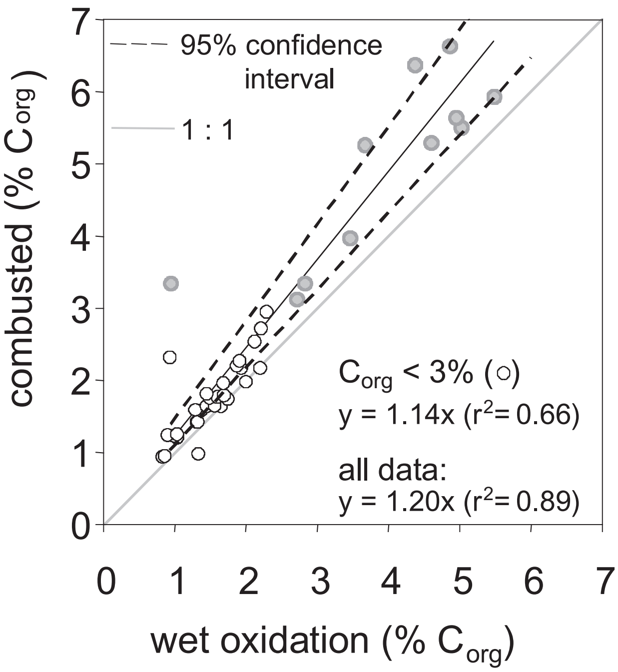

Fig. 1. Relation of OC values analysed by wet oxidation and elemental analyser (combustion) (Mutsch 1994, modified).

tors derived from a regression analysis based on data presented in Fig. 1 were used to normalize the OC data obtained by wet oxidation on the basis of the dry oxidation method. The following factors were used:
up to 3% C: 1.13; 3–7% C: 1.20; 7–9% C: 1.24; 9–12% C: 1.3; 12–14% C: 1.35; > 15% C: 1.40.

Correction values beyond 7% OC were extrapolated from the linear regression line of Fig. 1. The latter approach affected only a small number of values (228 out of 3726, i.e., 6.1%).

Statistics and Calculation Procedures

Analysis of the data sets showed that the distribution of OC content (%) within selected groups is mostly non-normal and biased towards lower OC contents (Fig. 2). Thus, to obtain unbiased estimates, median values ($\tilde{x}$) and the average absolute deviation (AAD, Sachs 1993) from median were calculated (see Table 1).

$$AAD = \frac{1}{n} \times \sum \left| x_i - \bar{x} \right| \quad (1)$$

For calculations of OC stored in a given soil layer, weighted averages of depth layers were calculated to receive values for the depth increments 0–20 cm and 20–50 cm from each federal province. The content of soil OC in tonnes per hectare was calculated as follows:

$$\text{OC } (\%;\ \text{t t}^{-1}) \times \text{soil density } (\text{t m}^{-3}) \times \text{soil depth (m)} = \text{OC } (\text{t ha}^{-1})$$

Calculation of average values (t ha^{-1}) of different land use classes was performed by weighting according to the area of the federal provinces within a respective land use class in 1990 in relation to the total agricultural land within Austria (BMLF 1999).

RESULTS AND DISCUSSION

Regional differences in OC concentrations within a given land-use class are less pronounced (Table 1), than differences between land-use classes. Examples from Styria, and Upper Austria are given in Fig. 3, illustrating that soils under alpine grassland exhibit higher OC values than soils under intensively used grassland or cropland. At least in the case of Styria, confidence intervals (whisker lines) of cropland and alpine meadow soils do not overlap, which proves the statistical significance of differences. These differences also exist for OC stocks (Table 2). A further statistical analysis for OC stocks of land-use classes is not possible, because for the derivation of stocks a number of weighing procedures (sampling depth, aerial extension of federal provinces within Austria) and assumptions (see Materials and Methods Section) had to be made. Land-use classes can be ranked according to their average OC contents (0–50 cm) as follows: vineyards (57.6 t C ha^{-1}) ~ cropland (59.5 t C ha^{-1}) < orchards/gardenland (78 t C ha^{-1}) ~ intensive grassland (81 t C ha^{-1}) < extensive grassland (119 t C ha^{-1}).

The ranking obtained clearly reflects the balance between organic matter input by plant residues and possibly organic manures, mineralization, erosion and soil deposition. Generally, the major portion of OC is stored in topsoils (0–20 cm) in all land-use classes. Variability of median values increase from cropland/vineyards to grassland and orchards/extensive grassland. Deeper soil layers (20–50 cm) show significantly lower carbon contents. When comparing the subsoil C-inventories under different land use, smaller differences were obtained than for the topsoil layers. This indicates that subsoil C is influenced by the present land use, but less so when compared with the topsoil. Recently, C stratification has been suggested as an indicator of soil ecosystem function and especially for the detection of management-induced changes (Franzlübbers 2002). The observed ratio between OC contents of topsoil and subsoil could provide information about the status of a given site with respect to OC increase or decrease after changing the land use. Calculating the stratification ratio (quotient of OC inventories in the 0–20 cm and 20–50 cm layers) provided the following ranking: vineyards (2.15) < cropland (2.27) < orchards/gardenland (2.71) < intensive grassland (2.95) < extensive grassland (3.75). Those land-use classes exhibiting the lowest ratios seem to have the largest potential for SOC sequestration. Of course, the site-specific potential of a soil to store organic carbon, governed for example by clay content, which influences the size of the physically protected organic matter pool, also has to be taken into account (Körschens et al. 1998). The stratification ratio seems to have potential as an indicator for the potential to increase total SOC stocks, but its general applicability needs to be evaluated on a broader scale.

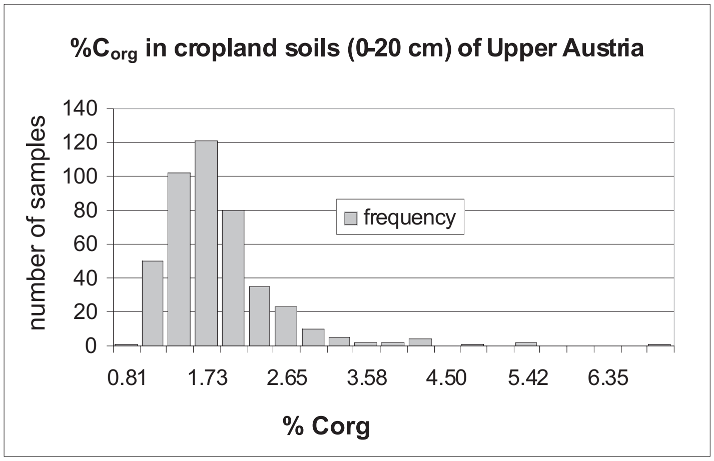

Fig. 2. Typical frequency distribution of OC values within a land-use class (example: Upper Austria; cropland).

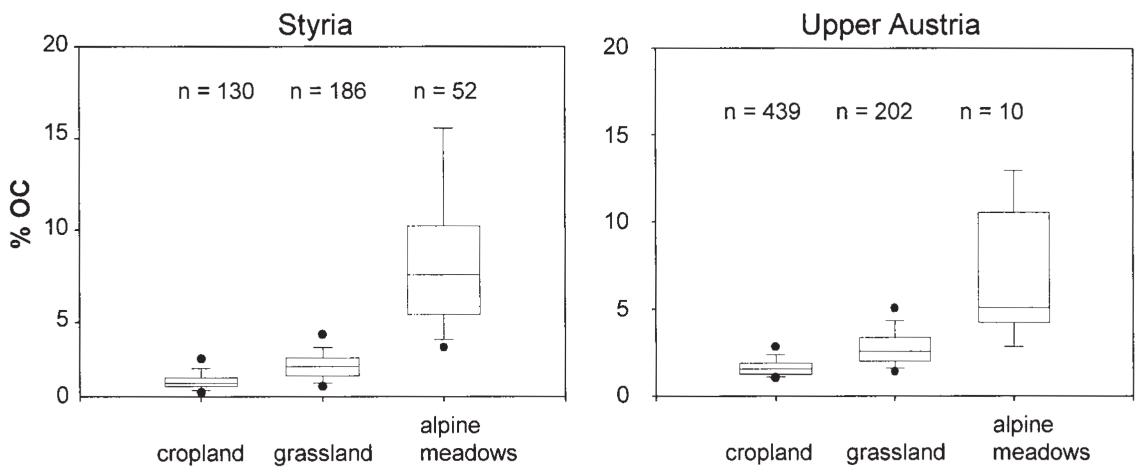

Fig. 3. OC content (%) in different land-use classes from the federal provinces Styria and Upper Austria, (whiskers indicate 95% confidence intervals of median values).

Table 2. Weighted median values of organic carbon contents (t C ha^{-1}) and stored OC-amount (Mt C) in Austria's agricultural soils

	Soil depth (cm)					
Land use	0–20 (t C ha^{-1})	± 0.5 AAD[z] (%)	20–50 (t C ha^{-1})	0–20 (Mt C)	20–50 (Mt C)	Area (10^6 ha)
Cropland	41.3	5.0	18.2	57.8	25.5	1397
Grassland	60.5	9.1	20.5	56.7	19.3	938
Alpine meadows	91.8	15.1	27.2	92.3	27.3	1005
Vineyards	39.3	5.5	18.3	2.1	1.0	52.5
Orchards/gardenland	57.0	14.6	21.0	1.5	0.5	27.1
Total				210.4	73.6	3420

[z]AAD, absolute average deviation from median.

The analysis in OC stocks in Austria revealed significant regional differences. Figure 4 shows that in the federal provinces, OC contents in topsoils increase from the eastern to the western part of Austria. The overall C stocks also increase according to this pattern (not shown). This is due to the decrease of cropland areas from east to west, which follows the climatic gradient from a dry, pannonian climate to humid conditions. It is interesting to note that even within croplands we observed an east–west gradient (Fig. 4). This can be explained by the use of ley farming in the western federal provinces, where cropland and grassland are rotated every few years. The higher OC inventories thus originate

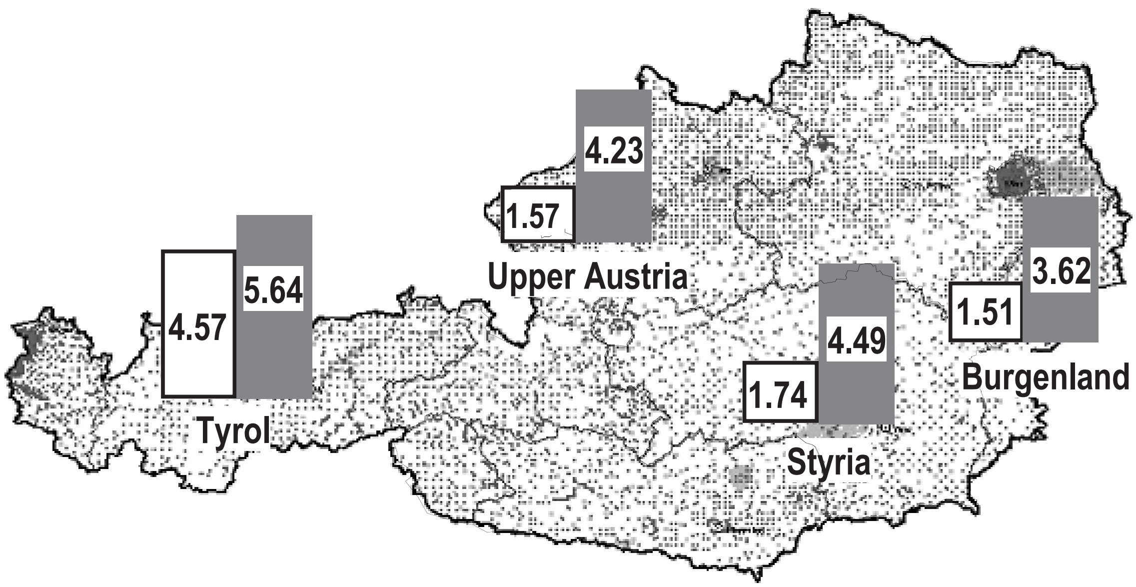

Fig. 4. OC contents (%) in cropland (white bars) and grassland (hatched bars) soils of Austrian federal states (0–20 cm depth).

from recent grassland episodes. Agriculture in the eastern provinces (Lower Austria, Burgenland) is dominated by cropland, ley farming is not usual there.

The estimated total amount of OC stored in the 0–50 cm layer in the agricultural soils of Austria is 284 Mt (Table 2). Of this amount, 42% is located in soils of extensively used grasslands. As well as the relatively large area covered by this land-use type, the high carbon storage capacity of extensive grassland soils should be stressed. Sustainable management practices and the maintenance of this land-use type is of crucial importance if C stocks are to be maintained. The possible impact of climate change on the OC storage capacity of such montane soils should be investigated in comparative studies, to reduce uncertainty of future carbon inventory estimations. It should be stressed at this point that OC storage capacity of forest soils in Austria is, on average, the same (121 t C ha^{-1}, 0–50 cm; Weiss et al. 2000) as extensively used grasslands. Conversion of extensively used grassland to forest would thus seem to have no long-term impact on the overall C storage in Austrian soils. Conversion of cropland to forest, on the other hand, could potentially have a large impact, but is likely to have adverse economical effects for the farmer.

According to the calculation guidance for the Kyoto Article 3.4 "Cropland and Grassland Management" abandonment of grassland leads to a loss of soil carbon. Under Austrian conditions, it is doubtful whether abandonment of grassland, which often takes place in alpine regions due to adverse economics, will lead to a decrease in organic matter content of extensively managed soils. Alternatively, it is not realistic to assume that increased fertilization or amelioration measures would positively affect the current high level of carbon storage in alpine grassland soils. The limited potential for increased C sequestration in alpine meadows may relate to extreme climatic conditions, which in turn control the turnover of organic matter. This illustrates that the generic recommendation in the IPCC Guidelines for National Greenhouse Gas Inventories (Houghton et al. 1996), which suggests the use of appropriate country-specific values, should be followed whenever possible. The use of regional information about soil OC content and the environmental factors governing the C turnover processes will enhance the reliability of OC stocks and OC stock changes.

When comparing C and N stocks in Austrian soils, other differences between alpine soils and all other agricultural land-use classes are observed (Table 3). Whilst OC pools are largest in alpine meadow soils (Table 2), the N pools on average are ranked third and fourth in the 0–20 cm and 20–50 cm layers, respectively. This results in an average C:N ratio of alpine meadow soils of 16.5 in the upper layer. In contrast, all other land-use classes exhibit a nearly constant mean C:N ratio of around 9. In the deeper layer, the mean C:N ratios are distinctly lower than in the upper layer, but the alpine meadow soils again show the highest ratio. Recent results from long-term ^{15}N tracer studies in the Austrian Grossglockner massif showed that nitrogen is effectively recycled in these nutrient-deficient systems and has a long-term behaviour deviating from lowland sites (Gerzabek et al. 2004). It is generally accepted that C:N ratios become lower with an increasing degree of humification (e.g., Beyer and Blume 1990). The wide mean C:N ratios in alpine meadow soils, therefore, suggest accumulation of less-humified organic material and, thus, a slower turnover of the labile soil organic matter pools.

The system of deriving OC stocks as presented in this paper has some potential to follow changes in OC stocks in Austrian agricultural soils in the long-term (decades). Limitations, however, are: (i) the need for further standardization of methods regarding sampling and analyses for future soil inventories and (ii) that the soil inventories of the Austrian provinces are not

Table 3. Weighted median values of N-content in Austria's agricultural soils [calculation based on soil inventory results from Njegic (2001)]

	Soil depth (cm)				
	0–20 ($t\ N\ ha^{-1}$)	20–50 ($t\ N\ ha^{-1}$)	0–20 (Mt N)	20–50 (Mt N)	Area (10^6 ha)
Cropland	4.67	2.43	6.53	3.40	1397
Grassland	6.63	3.57	6.22	3.35	938
Alpine meadows	5.58	2.62	5.61	2.63	1005
Vineyards	4.35	3.49	0.23	0.18	52.5
orchards/gardenland	6.20	4.50	0.18	0.13	27.1
Total			18.77	9.69	3420

redone at regular intervals, as agricultural soil inventories fall under the sovereignty of the federal provinces. A major problem with point (i) will remain the estimation of the gravel content of soils, which is not easy to determine with the necessary precision. Another option would be to use the present approach as a baseline for modelling trends of OC stock changes in Austrian soils due to land-use changes from 1990 onwards. For that purpose a soil C model such as that contained in the Austrian Carbon Balance Model could be suitable. For changes in land use, we suggest using the median OC stock values of the federal provinces, which are bolstered by a significant number of sites and reflect the regional climatic differences in Austria to some extent. A further — from the standpoint of soil science — desireable regionalisation relying on different soil types within land-use classes would yield too few sites. The model calculations, of course, should be validated by the results of the future replications of soil inventories of the federal provinces and the few long-term experiments focussing on soil organic matter still being maintained in Austria.

CONCLUSIONS

(i) In the present paper it was shown that the Austrian national electronic soil information system BORIS can be used as a basis to derive OC stocks of agriculturally used soils. The total OC stock in agriculturally used soils in Austria was estimated (284 Mt).

(ii) Land-use had a significant impact on OC stocks, especially in the topsoil layers. Alpine meadows exhibited the largest OC storage capacity, cropland and vineyards the least. Alpine sites also deviate with respect to their nitrogen dynamics as the highest C:N ratios were observed in this land-use class.

(iii) The regional differences in agricultural management were reflected by a west–east gradient of decreasing OC stocks in cropland, which could be explained by the predominance of ley farming in the western Federal Provinces.

(iv) The described system to derive OC stocks on a regional (federal province) and national level could be used either to follow future changes, given a better standardization of sampling and analytical methods, or as a baseline for modelling OC changes using a soil C model. In the latter case, validation by replication of soil inventories and long-term experiments is needed.

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