Soil & Tillage Research 146 (2015) 296–302

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Land use effects on organic carbon storage in soils of Bavaria: The importance of soil types

Martin Wiesmeier [a,*], Margit von Lützow [a], Peter Spörlein [b], Uwe Geuß [b], Edzard Hangen [b], Arthur Reischl [b], Bernd Schilling [b], Ingrid Kögel-Knabner [a,c]

[a] Lehrstuhl für Bodenkunde, Department für Ökologie und Ökosystemmanagement, Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt, Technische Universität München, 85350 Freising-Weihenstephan, Germany
[b] Bayerisches Landesamt für Umwelt (LfU), 95030 Hof, Germany
[c] Institute for Advanced Study, Technische Universität München, 85748 Garching, Germany

ARTICLE INFO

Article history:
Received 3 June 2014
Received in revised form 1 October 2014
Accepted 6 October 2014

Keywords:
Soil organic carbon
Carbon sequestration
Land use change
Equivalent soil mass

ABSTRACT

Numerous studies have reported substantial changes of soil organic carbon (SOC) stocks after converting forests into agricultural land and vice versa. However, some studies suggested that agricultural soils might contain similar amounts of SOC as forest soils. Losses of SOC induced by cultivation might be overestimated due to shallow soil sampling and application of inaccurate pedotransfer functions. We investigated the impact of different land uses on total SOC storage down to the subsoil on the basis of 270 soil profiles in southeast Germany under similar climatic and pedogenic conditions using an equivalent soil mass (ESM) approach. Land use effects on SOC storage were strongly affected by soil class, which comprised soil types with similar pedogenesis. Both slightly lower (<20%) and even higher SOC stocks were found under cropland compared with forest land for different soil classes. A comparison of different soil classes under grassland and forest land also showed no considerable differences of SOC stocks. Soil cultivation may not generally be associated with a strong decline of SOC, as tillage probably promotes the formation of organo-mineral associations and a relocation of SOC with depth may decrease its decomposition. This finding should be taken into consideration when estimating and managing the emission and sequestration of C in soils. We assume that many studies based on topsoils alone may have underestimated agricultural SOC stocks, particularly when an ESM approach is used. Our results highlight the need for soil type-specific evaluations in terms of interpreting the effects of land use management on SOC stocks.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Land use management is considered to affect the amount of soil organic carbon (SOC) and land use changes can result both in losses and gains of SOC. A conversion of cropland into grassland or forest was proposed as a promising way to sequester atmospheric carbon in soils (Post and Kwon, 2000; Schulp et al., 2008). On the other hand, numerous studies found serious decreases of SOC as a result of cultivation of soils under forest or natural vegetation (Guo and Gifford, 2002; Houghton and Goodale, 2004; Murty et al., 2002; Poeplau et al., 2011). However, recent findings indicated that the reported SOC losses in agricultural soils induced by tillage might be overestimated. A SOC inventory in southeast Germany revealed only slightly lower total SOC stocks in cropland soils compared to forest soils, when both top- and subsoils were considered (Wiesmeier et al., 2012). In general, shallow soil sampling, as well as the application of pedotransfer functions to derive missing soil parameters for the calculation of SOC stocks, is probably responsible for a systematic underestimation of SOC in agricultural soils (Baker et al., 2007; Balesdent et al., 2000; Davidson and Ackerman, 1993; Wiesmeier et al., 2012). However, results derived from SOC inventories are of limited value for the evaluation of land use impacts on SOC storage due to different environments of the studied sites which may distort the effect of land use. Moreover, a comparison of SOC stocks under different land uses has to be based on equivalent soil masses (ESM) (Ellert and Bettany, 1995; Gifford and Roderick, 2003; Lee et al., 2009; Post et al., 2001; Wendt and Hauser, 2013). As soil cultivation is often associated with a change

* Corresponding author. Tel.: +49 8161 71 3679; fax: +49 8161 71 4466.
E-mail address: wiesmeier@wzw.tum.de (M. Wiesmeier).

http://dx.doi.org/10.1016/j.still.2014.10.003
0167-1987/© 2014 Elsevier B.V. All rights reserved.

of bulk density (BD), constant investigation depths under different land uses would result in a consideration of different soil masses for the quantification of SOC stocks.

This study aimed at segregating land use effects on SOC storage down to a depth of 1 m in different soil classes of Bavaria in southeast Germany. From a comprehensive soil data set, 270 soil profiles under similar climatic and pedogenic conditions were chosen for the comparison of SOC stocks under cropland, grassland and forest. The calculation of SOC stocks was based on an ESM approach using the mass of forest soils within a depth of 1 m as reference and respective corrections for agricultural soils.

2. Materials and methods

2.1. Study area

The state of Bavaria is located in southeast Germany and comprises various landscapes. The northwestern part of Bavaria is dominated by the southern German escarpment landscape that adjoins low mountain ranges of the Bohemian Massif in the east. Southwards the Molasse basin ascends to the mountain range of the Alps at the southern border of Bavaria. Elevation ranges between 107 and 2962 m above sea level. Due to its location in central Europe, Bavaria exhibits a suboceanic climate that is characterized by a transitional situation between a maritime climate in the northwest and subcontinental influences in the east. Mean annual temperature (MAT) and annual precipitation (MAP) range between 10 and −3° C and 550 and 2500 mm, respectively, from the escarpment landscape in the northwest to the Alps in the south. Cropland accounts for 34% of the total land area of Bavaria, grassland for 16%, forest for 35% and other uses for 15%. Further information on the study area and its soils can be found in Würfl et al. (1984) and Wiesmeier et al. (2013a, 2014).

2.2. Selection of soil profiles

In order to reveal the impact of different land uses on SOC stocks, soil profiles were selected from a comprehensive soil data set for Bavaria (Wiesmeier et al., 2012). This data set comprises 1460 soil profiles sampled between 1990 and 2004 which were analyzed for SOC, BD, stone content (SC) and further chemical and physical soil properties down to a depth of 1 m or at least to the parent material. From this data set, soil profiles with a sampling depth of 1 m for the six most abundant soil classes were selected with comparable conditions in terms of mean annual temperature (MAT), annual precipitation (MAP) and soil wetness, indicated by the topographic wetness index (TWI) (Sorensen et al., 2006) (Fig. 1). In previous studies, these parameters were identified as controlling factors for the storage of SOC in agricultural and forest soils of Bavaria (Wiesmeier et al., 2013a,b,b). All selected soil profiles were located in regions with MAT of 8–9 °C, MAP of 700–900 mm and TWI values of 3–5 (total range within Bavaria 0–16). In total, 134 profiles were selected for soils with well-developed B horizons (Cambisols), 22 profiles for clay-rich soils (Vertisols, Vertic Cambisols), 25 profiles for soils with clay migration (Luvisols), 52 profiles for soils with initial soil formation (Leptosols, Regosols) and 37 profiles for soils with water stagnation (Stagnosols, Albeluvisols, Planosols). The classification of soil classes followed the German soil systematic (AD-HOC AG Boden, 2005) and the equivalent Reference Soil Groups of the WRB (IUSS Working Group WRB, 2006).

2.3. Calculation of land use-specific SOC stocks using an equivalent soil mass approach

For each soil class, the impact of the land use types cropland, grassland and forest on SOC stocks were compared. SOC stocks

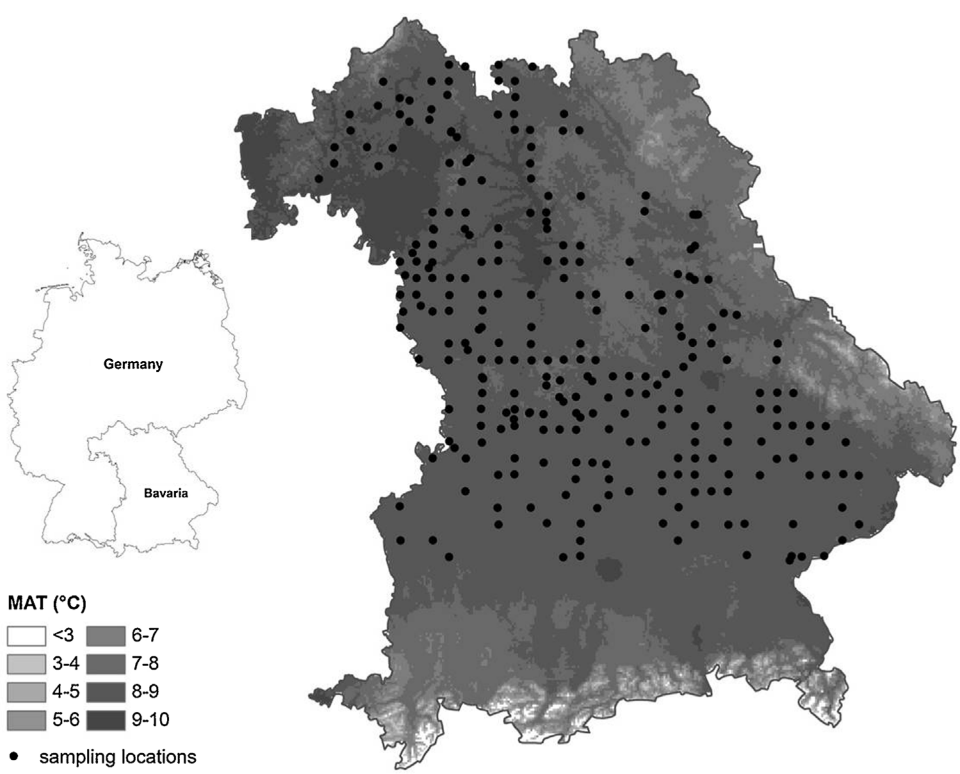

Fig. 1. Map of Bavaria with classes of mean annual temperature (MAT) and location of the sampling points.

Download English Version:

https://daneshyari.com/en/article/305726

Download Persian Version:

https://daneshyari.com/article/305726

Daneshyari.com