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# First pedoanthracological study in the Black Forest, SW Germany

Tatjana Quednau\*, Thomas Ludemann

University of Freiburg, Faculty of Biology, Department of Geobotany, Schaenzlestrasse 1, D-79104 Freiburg, Germany

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## ABSTRACT

For the first time a pedoanthracological study was undertaken in the Black Forest, SW Germany, considering forest soils in the highest altitudes of this region. For this purpose a total of ten soil profiles were studied in the Southern Black Forest, namely each two parallel profiles in high altitudes of five summit areas. Our pedoanthracological approach includes extraction and taxonomic analysis of soil charcoal fragments as well as quantification of soil charcoal concentration. The main aims of our investigation were the verification of significant charcoal residues and their distribution and concentration within the soil on different spatial scales, as well as the taxonomic analysis of single charcoal pieces. In total, 37 g charcoal were extracted from the soil samples, which yielded 2240 charcoal fragments suitable for taxonomic analysis. Most pieces of charcoal have been established of maple (*Acer*), followed by fir (*Abies*) and spruce (*Picea*). Only 31 charcoal pieces of beech (*Fagus*) were found, which represent 1.8 % of total extracted charcoal. The four tree taxa mentioned are the most common one of the potential natural vegetation (mature forests). Species of these taxa continue to be important components in the study areas. Today norway spruce (*Picea abies*) is dominating in the upper montane belt of the Southern Black Forest by far, followed by beech (*Fagus sylvatica*), while silver fir (*Abies alba*) is rare. Currently sycamore maple (*Acer pseudoplatanus*) is frequently found in the upper montane belt, but usually with proportions of less than 10 %. The pedoanthracological results of the five study sites indicate an increase in *Picea*-share geographically from west to east as well as orographically with increasing altitude. Charcoal concentrations of the magnitudes established suggest that for the most part the soil charcoal found is the result of natural forest fires.

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## 1. Introduction

The Black Forest is predominantly characterized by spruce forest landscapes. In many stands norway spruce (*Picea abies*) has been established and raised by forestry. With the exception of several distinct sites with special ecological conditions favourable for conifers, today's dominance of spruce gives not the true idea of the original natural forest cover. However, in the montane and especially the altimontane belts spruce is an important tree taxa of the natural mixed deciduous-coniferous forests, in addition to silver fir and beech. The natural presence and proportions of spruce within the Black Forest and especially in the Feldberg area around the highest summits, have been discussed for a long time. Some authors mention that norway spruce would be the predominant species in the gentle slope region (Danubian system) of mount

Feldberg from an altitude of about 1250 m on, even under natural conditions not influenced by man. Other authors note that beech forests with a high proportion of norway spruce would dominate this region (e.g. Müller, 1939/1940; Firbas, 1952; Lang, 1973, 2005; Ludemann and Britsch, 1997; Ludemann, 2003, 2012a; Ludemann et al., 2007).

For the first time the methods of pedoanthracology have been applied in the Black Forest to provide additional scientific contributions to our knowledge of soil charcoal concentration. The pedoanthracological procedure involves the extraction and the taxonomic analysis of charcoal pieces from the soil as well as the quantification of soil charcoal concentration on a fine spatial level (Carcaillet and Thion, 1996). The soil charcoal extracted is likely the result of natural forest fires, but can also be caused by anthropogenic processes.

Knowledge of the soil charcoal concentration provides important information in the climate change discussion about carbon stock in soils and assumed past or present fire regimes. Moreover, research on the forest history and on the primeval vegetation of the

\* Corresponding author.

E-mail addresses: [tatjana.quednau@gmail.com](mailto:tatjana.quednau@gmail.com) (T. Quednau), [thomas.ludemann@biologie.uni-freiburg.de](mailto:thomas.ludemann@biologie.uni-freiburg.de) (T. Ludemann).

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Black Forest can give implication of the natural tree species composition and especially of the distribution of norway spruce. For their part, indications of the natural tree species composition of a site can supply clues to natural silviculture or the implementation of sustainable conservation measures and naturalness evaluations. In the current study, our principle aims were: (1) the verification of significant charcoal residues and their spatial distribution and concentration within each soil profile and among different soil profiles, as well as (2) the taxonomic analysis of single charcoal pieces.

## 2. Study area

The study area is located in the Black Forest, a low mountain range in Southwest Germany (Fig. 1). We focus on the highest altitudes of the Southern Black Forest, namely on the close surroundings of five of the highest summits: Belchen (BE) at 1303 m a.s.l., Hundsrückens (HR) at 1233 m a.s.l., Toter Mann (TM) at 1320 m a.s.l., a plain west of Kriegshalde (KH) at 1347 m a.s.l. and Hochkopf at 1308 m a.s.l. (HK) (Fig. 1). Considered on a regional spatial scale, the area is situated in the vegetation zone of the montane to altimontane beech and mixed beech forests, where silver fir and beech dominate the natural forest vegetation (Bohn et al., 2000). Moreover, sycamore and norway spruce are important tree species of the natural forests. Currently, norway spruce is the dominant tree species in each of the five study areas.

The study areas are characterized by a typical subatlantic climate of the corresponding altitudes of the low mountain ranges in western Central Europe. The annual average temperature is about 4–5 °C at 1300 m a.s.l. The average annual precipitation comes to 2000 mm. In addition, at high elevations (summit areas) forests are affected by heavy storms and strong wet snow events as well as further ecological conditions of the subalpine climate (Trenkle and Rudloff, 1981; REKLIP, 1995). The geological substratum of the study area forming Palaeozoic igneous and

metamorphic rock, especially gneiss, granite and migmatite (LGRB, 2006; Wimmenauer, 2012). The investigated areas usually have a more or less powerful substrate layer of sandy moraine on the rock, originating from glacial and periglacial processes at the end of and after the last ice-age (Metz, 1985; Wimmenauer, 2012).

Currently, the area is dominated by managed more or less close-to-nature spruce forests. Based on archaeoanthracological studies of past fuel wood use by charcoal burning, it has been concluded that spruce would be the predominant species in the gentle slope region (Danubian system) of mount Feldberg from an altitude of about 1250 m on, even under natural conditions not influenced by man (Ludemann, 1994, 2002, 2003, 2012a; Ludemann and Britsch, 1997; Ludemann et al., 2007). Such altimontane to subalpine spruce-forests grow at the highest locations of the Toter Mann, the Hochkopf and the Kriegshalde plain. In contrast, the summit area of the Belchen currently is predominantly covered by anthropogenic poor acid grassland (*Nardus* pastures). Here the soil samples were taken at the edge of the pasture land in a small spruce forest stand. The current vegetation of the Hundsrückens is characterized by a managed semi-natural mixed spruce-beech forest with high spruce share.

## 3. Material and methods

Site selection, sampling and sample preparation were adapted to the procedure described by Carcaillet and Thion (1996) based on Thion (1992). In the Black Forest wood charcoal production was very common and charcoal kiln platforms with remains of these activities in the soils are widespread in the landscape (Ludemann, 2010, 2011, 2012b). Therefore we selected sample sites far away from such platforms with their highly charcoal enriched soils. Moreover, we avoided slopes and landscape depressions where the soils and their charcoal concentration could be influenced by erosion and kolluvial deposition. For this reason, sample sites have been chosen which are characterized by flat relief features close to

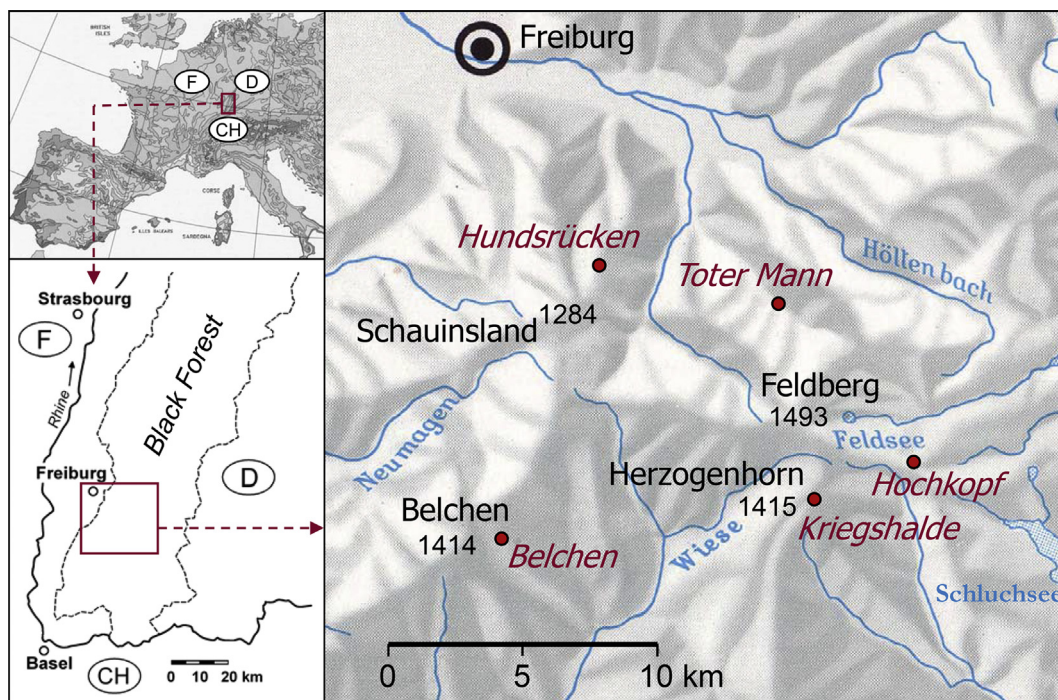


Fig. 1. The five study areas Hundsrückens, Toter Mann, Belchen, Hochkopf and Kriegshalde in the summit areas of mounts Schauinsland, Belchen, Feldberg and Herzogenhorn in the Southern Black Forest, SW Germany.

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