

Main data and general insights of recent soil charcoal investigations on nine sites in Central Europe

Vincent Robin¹ and Oliver Nelle¹

¹ Graduate School 'Human Development in Landscapes', Institute for Ecosystem research, Working group Palaeoecology, Christian-Albrechts-Universität zu Kiel, 24118 Kiel, Germany; vrobin@ecology.uni-kiel.de, onelle@ecology.uni-kiel.de

Summary: *Soil charcoal analyses were performed on nine sites in Central and Northern Germany. The main results, discussion and interpretation are presented here, based on the overall extraction of 330 g of charcoal from 45 soil profiles, and the taxonomic analysis of ca. 11,200 charcoal pieces. Soil charcoals are recorded in various site contexts (soil, altitude, etc.), providing diverse soil charcoal quantities, varying in mg.kg⁻¹ proportion from 1 to more than 3000. The identified taxonomic assemblages, combined with the radiocarbon AMS dating of 67 single charcoal pieces, allowed to postulate that the Central European forests, including broadleaf temperate forests, burned in two main phases since the last glacial phase, one during the late Pleistocene/early Holocene and another during the late Holocene. The human vs. climatic forcing of that past fire history is discussed.*

Key words: *soil charcoal analysis, soil analysis, radiocarbon dating, fire history, forest changes.*

INTRODUCTION

The Holocene vegetation history of Central Europe has been well investigated, leading to a global consensus about the main aspects of forest tree temporal and spatial development since the last glacial phase, and the respective roles of climate and humans on the ecosystems dynamics (e.g. Kalis *et al.*, 2003). Nevertheless, several issues are still the subject of discussion, as a result of new data, closing some gaps, and/or new ways of investigation, such as interdisciplinary (Nelle *et al.*, 2010). Important questions remaining concern the assessment of the Holocene forest/woodland structure and the role of 'mega-herbivores' on those, during the late Pleistocene and the early Holocene (Vera, 2002). Other questions involve human activities, which are known to have an increasing influence on the dynamics and structures of forests/woodlands since the mid-Holocene at least and with human cultural development. Those factors influenced, directly or indirectly, the forest history as important disturbance factors (Pickett and White, 1985). Among those disturbances factors, the occurrence of fire is important.

The role of fire on the dynamics of ecosystems has been well documented for several bio-climatic domains (e.g. Vanni re *et al.*, 2008; Higuera *et al.*, 2009). However, the fire history in Central Europe is still barely documented. Fire history reconstructions based on charcoal records from natural archives are especially rare. Nevertheless, some work has shown that forests of Central Europe were burned during the Holocene period (Clark *et al.*, 1989), as a result of human and/or climatic control. That last aspect of the main control of the past fire regime in Central Europe remains little discussed so far, notably in the light of recent insights about the Holocene climatic variability.

It is in this framework that fire history and related forest dynamics of Central Europe were investigated. To take into account the possibly important heterogeneity in fire history at a local scale (forest stand) due to local use of fire by humans, this investigation has been based on soil charcoal records (i.e. pedoanthracological approach). Despite the fact that soil charcoal analysis does not allow one to obtain strictly chrono-stratified palaeo-records, as from lake sediments, this approach allows one to reconstruct single occurrences of fire events. Moreover, using the same investigation material, it has been possible to identify the type of vegetation burned.

MATERIAL AND METHODS

This investigation was done on nine sites, grouped in two large investigation areas in Central and Northern Germany, with the intention to include a larger range of forest systems (Fig. 1). Soil samples were taken from forest sites under oceanic and subcontinental climate contexts, from 50 to 1140 m asl, and from various types of soils, such as sandy to clay rich soil, and also from sedimentary materials (colluvial layers). At each of the investigation sites, a multi-sampling strategy, with a repeatable protocol, was used, following Carcaillet and Thion (1996) and Bork and Lang (2003).

Soil charcoal assemblages (with charcoal pieces larger than 1 mm) were extracted and analyzed in the laboratory. They were quantified in charcoal concentration by weight of samples, and partly analyzed taxonomically (90 charcoal pieces per layer of sampling). To obtain chronological information, radiocarbon dating was performed on some charcoal pieces for each site.

The charcoal investigations were combined with soil analysis to identify the context of sampling and to assess some aspects of taphonomical issues, which is

important for the interpretation of soil charcoal assemblages.

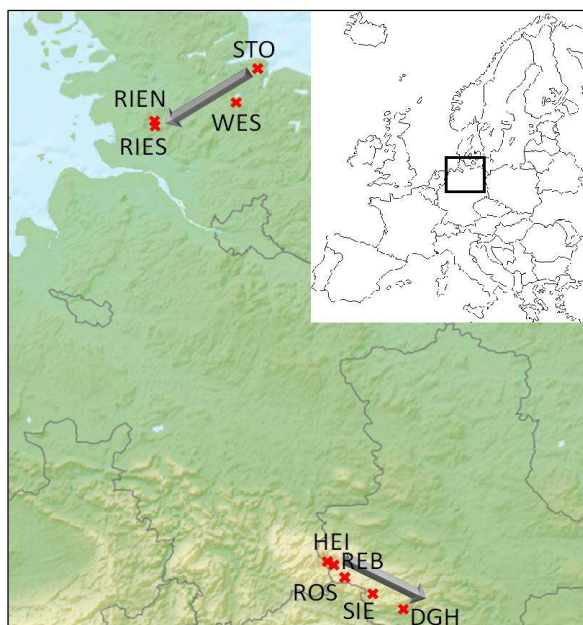


FIGURE 1. Map of localization of the nine investigation sites. Investigation sites in Northern Germany: RIEN (Riesewohld North); RIES (Riesewohld South); WES (Westensee); STO (Stodthagener Wald); Investigation sites in Central Germany: HEI (Heinrichshöhe); REB (Renneckenberg); ROS (Rosentalskopf); SIE (Sieben Gemeinde Wald); DGH (Die Grosse Holz).

RESULTS AND DISCUSSION

Based on an extraction of about 330 g of charcoal, from more than 1700 kg of soil samples and on the taxonomic analysis of more than 11,000 charcoal pieces, the observations are as follows:

Despite a large variability in the soil charcoal concentrations, there are charcoal pieces in any type of investigated soil, from various elevations, latitudes, topographic contexts, etc. This indicates that, in any kind of investigated site contexts, the forest burned several times during the Holocene period. The charcoal records have been formed because of these forest fires. Moreover, the extracted and quantified soil charcoal records have provided, in any investigated sites, enough suitable material for relevant palaeo-environmental reconstruction. The large heterogeneity of the soil charcoal concentration seems to indicate a considerable variability in past fire regimes at the local scale. This might be due to the influence of human use of fire, increasing the past fire regime heterogeneity from site to site.

The taxonomic identification allows one to point out that broadleaf temperate forests burned, since the soil charcoal assemblages of several sites are dominated by *Quercus* and/or *Fagus* pieces, while such temperate forest species are not 'easy flammable' fuel. Further, chronological data indicates ancient occurrences of fire events. The overall radiocarbon date distribution (about 67 AMS C14 dates) indicates two main periods of fire

occurrence, one during the late Pleistocene/early Holocene period and another one in the late Neolithic period and younger, with many more dated fire events. The overall dataset supports the hypothesis of an important and increasing human impact on past fire occurrences since the Neolithic period, and highlights the important role of fires at the local scale, regardless of the ignition factor. With regard to the late Pleistocene/early Holocene period, the fire events also have been dated, with a relatively high number of occurrences on various sites, probably related to climatic forcing, in regards to the burned forest fuel.

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