Assessment of the Holocene fire history of Northern Germany based on various charcoal records, investigated at various spatial scales

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Summary: *The fire history throughout the Holocene was studied for various neighbouring sites in Schleswig-Holstein, northern Germany. Charcoal records from peat sequences with local and regional resolution have been extracted and analysed. Moreover, soil charcoal records sampled on the surroundings of the peat coring places, have been extracted and analysed, providing data in high spatial resolution. Those charcoal records have been quantified, chronologically referenced and compared to each other. Asynchrony of fire signals between the various analysed charcoal records is detected, indicating past fire regime variability, probably in connection to human use of fire.*

Key words: *Fire history, charcoal records, signal spatial resolution, Northern Germany.*

INTRODUCTION

Past fire regime may have had an important impact on the vegetation development, along time, as disturbance event of the ecosystem. Therefore to understand the dynamic of ecosystems it is important to take into consideration the role of past fire occurrences. This has been well investigated for biogeographical domains like Mediterranean areas (Vannière *et al.*, 2008) or Boreal areas (Higuera *et al.*, 2009). But investigation of fire history should not be restricted to ecological systems where fire is described as endogenous factor of dynamics, as natural disturbance event, which is anyway and anywhere an issue of discussion. Only few investigations have been done about fire history in central Europe so far (e.g. Clark *et al.*, 1989; Willis, 2000). And even rarer are the fire investigations dealing with charcoal records from natural archives, specifically analysed, and using recent charcoal records methods (Higuera *et al.*, 2010).

Nevertheless, a general pattern of fire history, at broad scale over Central Europe, has been identified, notably based on charcoal analysis combined with palynological studies (e.g. micro-charcoal counting on pollen slides) providing reliable and important information (Carcaillet *et al.*, 2002; Power *et al.*, 2008).

Based on these investigations, the role of fire occurrence on past dynamics of central Europe ecosystems may be described as considerable. Indeed, despite being less fire sensitive than e.g. Boreal or Mediterranean ecosystems, especially since the mid-Holocene and the establishment of broadleaf woodland, the temperate forest of Central Europe (under oceanic and continental climate) burnt in the past. Human practices (fire ignition and/or fire usage) had played an important role in the past fire regime. Moreover, the increase of fire frequency, since the Neolithic and following the human development, has been identified. This seems to indicate the important anthropic impact on past fire regimes, and consequently on past forest dynamics.

However, the lack of investigations, notably at the local scale, adds to the identified human fire usage 'blurring' the palaeo-records and makes fire history difficult to assess more specifically than the previously general trends. This aspect motivated the research presented in this communication.

METHODS

It has been attempted to reconstruct the fire history on regional and local scale by the analysis of charcoal records from peat sequences of sites with different depositional situation and from different archiving contexts. Comparing fire signal in high spatial resolution (i.e. local scale) to the fire signal in low spatial resolution (i.e. regional scale) may allow identify synchronies and asynchronies in the fire history. This may be a promising approach to formulate at least a hypothesis for the better understanding of the fire palaeo-signal in terms of climate (i.e. more "readable" in low spatial resolution signal) vs. anthropogenic forcing (i.e. more "readable" in high spatial resolution signal).

To investigate and compare precisely low and high spatial resolution fire signals in charcoal records the topographical and geological context of northern Germany provides a relevant and "comfortable" framework, since the young moraine substratum formed a detailed, fine scaled relief variation (i.e. small depressions with lake sediments and/or peat) and also large lakes and peat lands (Nelle and Dörfler, 2008). Therefore, in the northernmost German federal state Schleswig-Holstein, two areas have been selected for sampling. Those include a large open peat land, and nearby small mires in woodland. Moreover, in the surrounding of the cored small mire, soil samples were taken from several soil profiles for soil charcoal analysis.

RESULTS AND DISCUSSION

Peat sequences have been cored with an 'Unsinger piston corer'. From that material, micro- and macro-charcoal records have been extracted and quantified.

From the large mire of 'Kaltenhofer Moor' (Fig. 1) a sequence of more than nine meter length (*ca*. 6.2 m of peat, up to *ca*. 3.4 m of mineral sediment) was cored. The sediment description and the preliminary palynological analysis allows to expect a complete, undisturbed Holocene sediment sequence, providing relevant material to work in high temporal resolution (considering a theoretical linear sediment accumulation/growth, it may be expected a temporal resolution of 13 years per cm along the core). The macro-charcoal analysis, which has been realized so far, indicates that the sequence is quite rich in macro-charcoal pieces allowing postulating regular fire occurrences in the past. Moreover, phases of variable charcoal accumulation value, certainly indicating phases with variable fire frequency, may be observed. This large scale fire signal has been compared to the small scale signal, based on the charcoal record analysed of the small mire peat sequence and to soil charcoal record, both from the Stodthagener forest directly neighbouring the peat bog. These charcoal records allow principally identifying a main fire phase during the Bronze Age, but soil charcoal analysis also allowed identifying fire events during other temporal periods.

FIGURE 1. View of the large peat bog of 'Kaltenhofer Moor' (Picture V. Robin)

This paper aims at the presentation of the methods used in this research project and on the results obtained so far, which however already allow detecting considerable signal variability and asynchrony.

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REFERENCES

CARCAILLET, C., ALWQUIST, H., ASNONG, H., BRADSHAW, R.H.W., CARRION, S., GAILLARD M.J., *et al.*, 2002. Holocene biomass burning and global dynamics of the carbon cycle. *Chemosphere* 49 (8), 845–863.

CLARK, J.S., MERKT, J., HULLER, H., 1989. Post-glacial fire, vegetation, and human history on the Northern alpine forelands, south-western Germany. *Journal of Ecology* 77 (4), 897–925.

HIGUERA, P.E., BRUBAKER, L.B., ANDERSON, P.M., HU, F.S., BROWN, T.A., 2009. Vegetation mediated the impacts of postglacial climate change on fire regimes in the south-central Brooks Range, Alaska. *Ecological Monographs* 79 (2), 201–219.

HIGUERA, P.E., GAVIN, D.G., HENNE, P.D., KELLY, R.F., 2010. Recent advances in the analysis and interpretation of sediment-charcoal records. *PAGES news* 18 (2), 57–59.

NELLE, O., DÖRFLER, W., 2008. A summary of the late- and post-glacial vegetation history of the Schleswig-Holstein. *Mitt. Arbeitsgem. Geobot. Schleswig-Holstein Hamburg* 65, 45–68.

POWER, M.J., MARLON, J., ORTIZ, N., BARTLEIN, P.J., HARRISON, S.P., MAYLE, F.E., *et al.*, 2008. Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics* 30, 7–8, 887–907.

VANNIÈRE, B., COLOMBAROLI, D., CHAPRON, E., LEROUX, A., TINNER W., MAGNY, M., 2008. Climate versus human-driven fire regimes in Mediterranean landscapes: the Holocene record of Lago dell'Accesa (Tuscany, Italy). *Quaternary Science Reviews* 27, 1181– 1196.

WILLIS, K.J., 2000. The Full-Glacial Forests of Central and Southeastern Europe. *Quaternary Research* 53, 203–213.