



Pollen signals of ground flora in managed woodlands



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ABSTRACT

This paper explores the vegetation signals contained in the non-arboreal pollen and spore (NAPS) components of pollen assemblages from Tauber traps placed in woodlands subject to rotational cutting (coppicing) in lowland England. Sets of three Tauber traps were placed in compartments of different ages at multiple locations within each woodland for 1 year, and pollen assemblages recorded along with a vegetation survey using a modified pin-frame method in an area of 10 m radius around each trap array. Cluster analysis suggests that, as expected, the ground layer vegetation broadly reflects the different environmental conditions in the three woods, with the main subdivisions within woods apparently driven by changes in ground cover between the early and late stages of the coppice cycle. Non-arboreal pollen and spores (NAPS) assemblages group according to woodland of origin, with subdivisions which relate to pollen abundance but lack a simple relationship with years since cutting. Indices of Association between NAPS records and plant presence in the area around each array were calculated using presence–absence data for multiple distances of vegetation survey. All values tend towards an asymptote, which is interpreted as implying an effective source area for the single taxon presence–absence indicator values of ground flora taxa in coppiced woodlands on the order of a 10 m radius. Only four taxa, Poaceae, *Ranunculus acris*-type, Cyperaceae, and *Scilla*-type, have an Index of Association (A) greater than 0.5, implying that the presence of pollen can be interpreted in terms of the local presence of the relevant plant taxon with some confidence. Estimates of Pollen Productivity relative to Poaceae are presented for five taxa: Apiaceae, Asteraceae (Cardueae), Cyperaceae, *Mercurialis perennis*, and *Scilla*-type.

Years since cutting does affect the ground vegetation and NAPS assemblage trapped in these woods, but that the effect is more clearly seen at an assemblage level in the vegetation than in the pollen assemblages. The interpretative significance of NAPS taxa does not seem to be in providing information about the local conditions around the sampling point, but in reflecting the ground flora of the wider woodland.

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1. Introduction

Pollen analysis is the main technique used to reconstruct past vegetation on Holocene timescales, from the simplest broad brush identification of whether trees are present in a landscape through to increasingly sophisticated reconstructions of vegetation composition (Trondman, et al., 2015), land-use (e.g. Court-Picon et al., 2006), and the spatial patterning of vegetation (Hellman, et al., 2009a, 2009b). At the landscape scale fluctuations in the ratio of pollen from non-tree plant sources (non-arboreal pollen, NAP or non-arboreal pollen and spores, NAPS) to pollen from tree and shrub functional types (arboreal pollen, AP) are usually interpreted as indicating changes in the proportion of openness in vegetation communities (e.g. Berglund, et al., 1991, 1996). Given differences within and between communities in the amount of pollen produced and its dispersibility, translation of the ratio into land cover

estimates is not trivial (e.g. Sugita, et al., 1999), but the use of taxon-specific pollen dispersal and deposition models has offered an approach for improving reconstructions of landscape openness (Gaillard, et al., 2008; Trondman, et al., 2015).

However, woodland communities also contain plants which produce NAP(S) types. The pollen signal of these types is usually assumed to be minor compared with the AP component but can fluctuate depending on the canopy density and species and on manipulations of the canopy by disturbance factors such as human management. Coppicing, the practice of cutting some trees to the base to encourage resprouting, yielding even-aged new shoots which can be harvested repeatedly (and sequentially in different compartments), is a widely used traditional woodland management method in north-west Europe (Ellenberg, 1988; Rackham, 2003). When coppicing is undertaken in conjunction with allowing some trees to grow to maturity (standards), a woodland can produce both large timber and underwood for construction, fuel, fencing, and other uses. Coppiced woodlands also provide a range of non-timber resources such as fungi, berries, nuts,

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pannage, and other livestock forage, and habitat to support prey animals for hunting for food or sport. Archaeological evidence for the practice of coppicing is extensive and goes back to the Mesolithic period (e.g. Rackham, 1979; Malmros, 1986; Rasmussen, 1993; Meddens, 1996; Pedersen, et al., 1997; Favre and Jacomet, 1998; Carew et al., 2009), and its importance for the production of high-quality charcoal meant it remained an important practice in some areas into the industrial era. Like most traditional land management practices, it began to fall out of use in the nineteenth century, but the restoration or introduction of coppicing became a valued conservation management tool in the later twentieth century (e.g. Peterken, 1993; Rackham, 2003), and is also practiced in an intensive form as a source of carbon-neutral biofuel for power production. Ecologically, the variation in canopy cover and therefore light reaching the ground layer of the woodland is a key characteristic of the coppiced woodland (Rackham, 1990), which will lead to changes in the flowering and pollen production of the NAPS-producing species as well as the coppiced tree species (Waller, et al., 2012). Over a whole landscape, this effect will average out, but when pollen sites with relatively small source areas such as ponds, small mires, or forest hollows (e.g. Sugita, 1994) are considered, fluctuations in the pollen record of NAP(S) taxa may be the result of coppicing rather than reflecting changes in the woodland: open land ratio.

There are multiple possible causes of variations in the proportion of NAP(S) in a woodland pollen assemblage during a coppice cycle. These increases could result from increased pollen production by ground cover plants, through an increase in area covered by those species or greater flowering of existing plants in response to increased light levels reaching the ground. Alternatively, the woodland NAP(S) influx could remain near-constant, but apparent fluctuations be caused by the effects of coppicing on the AP components of the local pollen rain, along with the more open canopy allowing greater input of pollen from a wider landscape, including open communities, during the early stages of the cycle, which later on is intercepted by the increasingly dense and tall canopy of regrowths. The situation is further complicated for pollen types which can originate from multiple plant species. For example, a variation in Poaceae proportions could reflect differences in grass abundance, in the species mixture present, in the long-distance pollen component from open land beyond the woodland, or facultative switching between vegetative and sexual reproduction due to light availability or other disturbance pressures such as grazing (Baker, 2012).

This paper uses data from a study of pollen influx into Tauber traps in coppiced woodlands (Waller, et al., 2012) to investigate the pollen representation of the ground flora components of the vegetation. We aim to determine the representation of changes in ground flora through the coppice cycle in the pollen record of NAPS types, as a tool for extracting better information about past land management practice from the pollen assemblages produced by complex cultural landscapes and to improve the detection of coppice management in long-term pollen records from woodland hollows, small ponds, or mires, or in peat forming beneath wet woodlands.

2. Methods

2.1. Field sites

Three woodlands in East Anglia, UK (Fig. 1), which are currently subject to coppice management, were selected for investigation (for more information, see Waller, et al., 2012). At Bradfield Woods (52°9'N 0°6' W) in Suffolk (Fig. 1b), the coppiced stools consist predominantly of *Corylus avellana* and *Fraxinus excelsior*, with *Alnus glutinosa* co-dominant over an area of about 40 ha. *Primula elatior*, *Filipendula ulmaria*, and *Mercurialis perennis* are common in the ground flora where the wood overlies boulder clay and *Rubus* spp., *Pteridium aquilinum* and *Hyacinthoides non-scripta* dominate in areas overlying sand. The standards are largely *Quercus robur* and *Betula* spp., mostly

less than 70 years old. The majority of Bradfield Woods is managed on a 20 + year rotation. At Chalkney Wood (51°54'N 0°43'E; Fig. 1c) in central Essex, *Tilia cordata* is the main coppiced species, but in some parts of the wood, it is co-dominant with coppiced *Castanea sativa* and less commonly with coppiced *Carpinus betulus*, *Fraxinus excelsior*, *Acer campestre* or *Corylus avellana*. *Quercus robur* is the main standard species, though other species, including *Tilia cordata*, were recorded as 'maidens' in 2007/8. The ground vegetation is dominated by *Hyacinthoides non-scripta* with *Rubus* spp. and *Pteridium aquilinum*. The site is cut on an approximately 25 year rotation. At Hayley Wood (52°10'N 0°49'E) in Cambridgeshire (Fig. 1d), *Corylus avellana* forms the bulk of the coppiced stools with some *Fraxinus excelsior* (ash) and *Acer campestre* (sycamore) coppice beneath a thin canopy of *Quercus robur* (oak) standards (Rackham, 1990). *Prunus spinosa* and *Crataegus monogyna* are common as under-storey shrubs. The ground flora is dominated by *Primula elatior* and *Filipendula ulmaria* in central and northern areas, while *Hyacinthoides non-scripta* and *Mercurialis perennis* dominate or co-dominate towards the western, southern, and eastern boundaries. Coppicing was reintroduced in part of the wood for conservation purposes in 1963–4, with relatively small plots (0.41 ha) cut on a 14 year rotation.

In all three woods, contemporary (annual) pollen deposition at ground level was investigated using 'Tauber' traps, following the design of Hicks and Hyvärinen (1999). Three traps were placed in a cluster (<1 m apart) near to the centre of 14 compartments in each wood, a minimum of 20 m from the compartment edge. The compartments sampled were those coppiced in the previous year and compartments 'aged' up to 7 years (when available) and thereafter at age intervals of approximately 3 years. Traps were set up in October 2006 and collected after a full year.

2.2. Vegetation data

Vegetation data were collected from the compartments in which the traps were set. The ground flora was sampled in March–April 2007 using a modified pin-frame method in concentric rings around the centre of the trap array. Four concentric rings (at 1, 2, 4, and 10 m from the traps) were defined, and each ring was sampled in eight locations aligned 45° to the centre of the traps, with a final sampling location in the centre of the ring by the traps, giving a total of 33 locations. Five points were sampled at each location (the centre and four cardinal points at 30 cm from the centre) giving a total of 165 sample points (see Fig. 2). Species present at each point were recorded on a first hit basis. Any species occurring within 10 m of the centre of the circle but not recorded at any of the points were also noted as present in the relevant distance zone and included in the calculation of the indices of association. The area of survey was chosen for efficiency and on the assumption that the pollen source area for ground cover plants under a woodland canopy would be short, since minimal opportunities for wind entrainment would occur.

Plants were grouped into palynological equivalent (pe) taxa (see Table 1), and percentage cover within each ring calculated.

2.3. Pollen data

This study used pollen assemblages from Tauber traps which were deployed for a single year, allowing precise relationships between the stage of the coppice compartment and the pollen assemblage deposited within it to be studied. Most surface sample studies (see e.g. Broström, et al., 2008) use moss samples which average pollen deposition over an unspecified number of years (e.g. Räsänen, et al., 2004), or averaged pollen influx from multiple years of Tauber trap deployment (e.g. Sugita, et al., 2010). While these methods do reduce the effects of climate-related inter-annual variability in plant flowering (e.g. Jackson and Kearsley, 1998; Huusko and Hicks, 2009), they would have blurred the signal of the coppice cycle which we seek to study due to variability

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