A meta-database of Holocene sediment cores for England

Short Communication

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Abstract

Extracting sediment cores for palaeoecological and archaeological investigations has occurred extensively across England since the early 20th century. Surprisingly, there has been comparatively little collation of these valuable publications and potential sources of data; for example, a search on the European Pollen Database (1st Aug 2014 edition) found just 118 core sites for the whole of Great Britain. Here, using a combination of systematic meta-searching and knowledge of the unpublished ('grey') literature, we have assembled a meta-database of some 763 sediment cores for palaeoecological records, documented across 273 scientific studies. The majority of these (>90%) were sediment cores upon which pollen analyses had been performed, but other types of evidence, such as plant macrofossil and faunal records were also identified. We are making this meta-database publicly available, in the hope that it will assist further investigations into Holocene vegetation history, palaeoecology, geoarchaeology and environmental change.

Keywords

Pollen diagram, Radiocarbon, Palynology, Dating, Climatic change

Background and rationale for the meta-database

Palaeoecological studies have been undertaken in England, and more widely in Great Britain and Ireland, since the early 20th century. Seminal early syntheses were provided by Jessen (1949) of late Quaternary deposits and the floral-history of Ireland, Godwin (1956) of the history of British flora (a subsequent more widely used edition was published in 1975) and Pennington (1969) of the history of British vegetation. Many early studies were focused specifically on aspects of vegetation history, rather than the use of pollen and macrofossils to infer climatic and/or anthropogenic impacts. For instance, there was a sporadic series of papers under the overall title of 'Studies in the post-glacial history of British vegetation' in a range of journals including Philosophical Transactions of the Royal Society and New Phytologist, the first appearing in 1938 (Godwin and Clifford 1938). By the 1970s there was a growing understanding of vegetation history that included studies of plant colonisation in the early Holocene and thereafter, including work from areas with specialised flora such as Upper Teesdale (Turner et al. 1973). These works, although pioneering, suffer from one major drawback in that they preceded the widespread use of radiocarbon dating. They were instead dated by correlation with Godwinian pollen zones, constructed on a very small sample of radiocarbon dates. Nevertheless, the availability of these studies, of which the work of Turner et al. (1973) is a prime example, offers an opportunity to evaluate potential sites for re-analysis with more modern overall approaches. As the spatial coverage of sediment cores increased, so they became used for a number of broad scale studies seeking to elucidate patterns of change within the flora, especially for key species and not just for England but for the whole of the British Isles (Birks 1989) and for Europe as a whole (Huntley and Birks 1983). Thus, the analytical strength of combining palaeoecological records was demonstrated in the literature from an early stage.

From the mid-1970s onwards, studies tended to be more hypothesis driven, looking at specific problems. These included human impacts on the landscape from the Mesolithic through to recent historical changes, with a special interest in the earliest agriculture, or climatic change, particularly during the Lateglacial. Greater numbers of radiocarbon dates were often obtained for individual sites, resulting in better-dated records than previously, and sequences were often analysed with higher temporal resolution, although with a tendency to focus on specific periods rather than to examine the entire Holocene. As a result, we have a good knowledge of vegetation history across a range of regions from which suitable sites have been analysed, although the data are in some cases rather isolated in time and space, especially where there are severe restrictions on the availability of lake or peat sediments. This is particularly true of England when compared to Wales, Scotland or Ireland. In these latter countries, the greater proportion of uplands and the glacial history result in greater numbers of sites where sediments suitable for analysis have accumulated.

Despite the long history of palaeoecological research in England, there has been no concerted effort at the national scale to document and collate these records. The European Pollen Database (EPD, Fyfe et al. 2009), and more recently the European Modern Pollen Database (Davis et al. 2013), both represent invaluable resources for researchers working at the European level, while a catalogue of pollen diagrams has recently been compiled for Ireland (Mitchell et al. 2013). However, a search of the EPD for English records (1st Aug 2014 edition) found just 118 core sites available for analysis, for the whole of Britain. Here, we present the findings of an extensive meta-search of the published literature (and an examination of the grey literature) to determine as many sediment coring sites in England as possible (ESM Table 1). This work was part of a wider project commissioned by Natural England to examine the potential for the palaeoecological evidence base to inform the identification of potential climatic change refugia and areas for ecological restoration (Maclean et al. 2014).

Search protocol and meta-database construction

To ensure we captured as many published studies involving sediment coring (for macro- and micro-fossils) as possible, we conducted a systematic meta-search of the scientific literature using the search engines 'Web of Science' and Google Scholar. We used a number of relevant search terms (ESM Table 2) to identify suitable studies, while also pursuing literature cited within these studies. Because the searches in Google Scholar generated a large number of returns (e.g. more than 75,000 documents for 'Holocene' + 'pollen'), we sorted these returns by 'relevance', restricting our searches to the 100 most relevant. We also sourced a number of additional articles known to the author team and/or outside the peer-reviewed literature. Studies were included in the meta-database if they documented the findings from at least one sediment core including/comprising the Holocene (although in practice almost no cores from our search returns had temporal coverage entirely limited to the Late Glacial, see also Fig. 1c).

The resulting meta-database of studies is provided in the supplementary information (ESM Table 1). Included in the meta-database is information on the study location, publication reference, core ID number (if provided), and details of the sampling and dating techniques undertaken. This information (particularly location information) was quality-controlled and checked for typographic errors prior to inclusion.

Geographical coverage of the meta-database

A total of 273 palaeoecological studies was identified. These studies represented 763 locations from which palaeoecological data were obtained. The majority of these (>90%) were sediment cores upon which pollen analyses had been performed, but other types of evidence, such as plant macrofossil and faunal records were also identified. The number of individual samples examined from each core ranges widely (from 3 to almost 200). Very few sites had more than a small number of plant macrofossil or faunal records, although this may also be a reflection of our search protocol (see ESM Table 2).

The locations of coring sites, together with the number of dated samples associated with these sites, are shown in Fig. 1. There are large variations in the number of sites in different regions of the country, largely in line with a combination of the availability of deposits, adopted research questions and researcher interests. There are particularly abundant data from North East England (especially the North Pennines), Cumbria, the North York Moors and the Humber Estuary area. There is also a moderate amount of data from the Welsh Marches, Dartmoor, Exmoor and areas in the Breckland and Fens. Data from elsewhere are scarce or entirely non-existent, principally due to a lack of suitable deposits rather than untapped resources.

Temporal coverage of the meta-database

Although we searched for studies from both the Pleistocene and the Holocene epochs, most studies considered only the Holocene, with only 30 studies providing data from the terminal stage of the Pleistocene (~15.0 – 11.7 ka cal BP; Fig. 1c). The longest record was estimated as beginning 17,400 ka cal BP (Bennett 1988), although the validity of the older dates from this site (Saham Mere, Norfolk) has been questioned. The rise in temporal coverage of dated sediment cores coincides with the beginning of the Holocene, amelioration in the climate, and the beginning of peat formation. There is a notable Mid-Holocene peak in the coverage of dated cores at 4-3 ka BP (Fig. 1c). Note that dating of cores was not adjusted for year of publication, e.g. a date of 0 kaBP corresponds to AD 1950 for all studies.

Concluding remarks and relevance for nature conservation

Our meta-database brings together over 80 years of palaeoecological research in England. This research extends to 763 coring locations documented across 273 studies. By bringing these studies together, we hope to facilitate further research by providing an internally consistent, simple means of establishing the research history of a particular fieldsite, region of interest, or indeed of England as a whole. It should be noted that the meta-database is a reflection of: a) the spatial availability of suitable deposits, which is variable across England;

and b) the priorities of researchers, which have undoubtedly changed over time (see Introduction). Although we conducted our searches systematically, the resulting meta-database is by no means exhaustive and we would expect further additions to be made in due course. Omissions are likely to include: unpublished work, such as MSc/PhD studies; contract work, such as geoarchaeological studies undertaken through the planning and development process; diatomic (but see Battarbee et al. 2011 for a palaeolimnological meta-database); and studies of tephra (collated by Newton et al. 2007, but updated at http://www.tephrabase.org/). Omissions aside, we hope that our meta-database can assist with the establishment of a robust framework for palaoecological study, highlighting potential spatial or temporal gaps in the evidence, where they exist.

Conservation biology is increasingly conducted at the landscape scale so as to better inform policy goals (Lawton et al. 2010), and the development of statistical and spatial analytical techniques continues apace. Both these research directions are data hungry, and we hope that by making this meta-database publicly available, further insights into Holocene vegetation history, palaeoecology and other priority areas of research will be facilitated. For example, these studies can provide a useful steer for initiatives relating to the management or restoration of degraded ecosystems (Seddon et al. 2014), and the question of what state a particular ecosystem should be restored to. Of note here is the rich history of human disturbance in England, from simple hunting and/or harvesting to fire management and direct vegetation manipulation (examples include Peglar et al. 1989; Bennett et al. 1990). Therefore, it follows that conservation goals designed to return ecosystems to 'natural' states – as perceived in the modern era – must be balanced with pragmatism over anthropogenic drivers of ecosystem status (and change, cf. Manning et al. 2009).

Like many countries with a history of deforestation and agricultural intensification, habitats in England are now fragmented and in variable condition. It has been demonstrated repeatedly that, in order to respond successfully to the multitude of environmental changes underway, species require these ecosystems to be in good condition, and managed appropriately (e.g. Lawson et al. 2014). These management actions should be based on the best available evidence, not only from contemporary studies of the (currently) resident species, and from palaeoecological studies of the site or region, where available. Such studies will often contain valuable information on the persistence of species in the longer-term.

We also hope that our meta-database will assist with efforts to conserve geological diversity. Some commenters have highlighted that coverage of the Holocene epoch in the Geological Conservation Review (GCR), the audit that underpins the protected area network (Sites of Special Scientific Interest) in England, is

out of date and needs to be improved. Just as importantly, we hope that the meta-database will also have real traction outside academia, and become useful for conservation managers, local record centres, and members of the public with a passion for geology or ecology.

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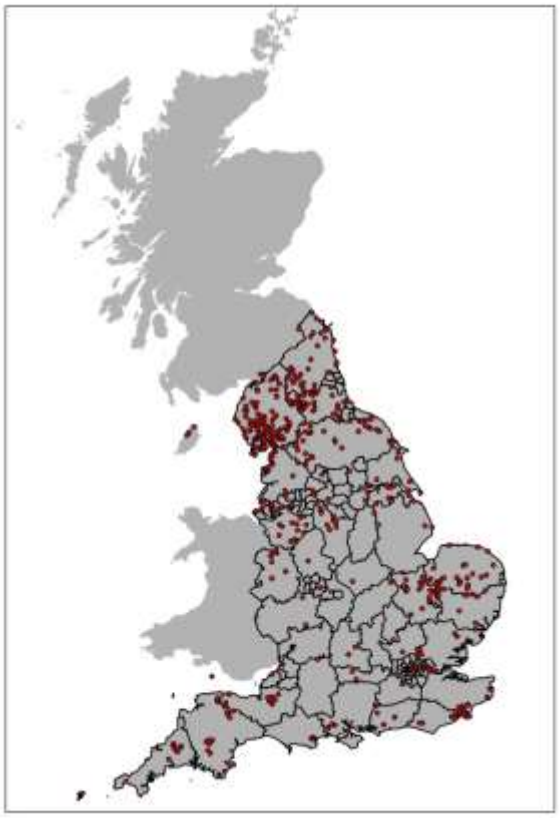
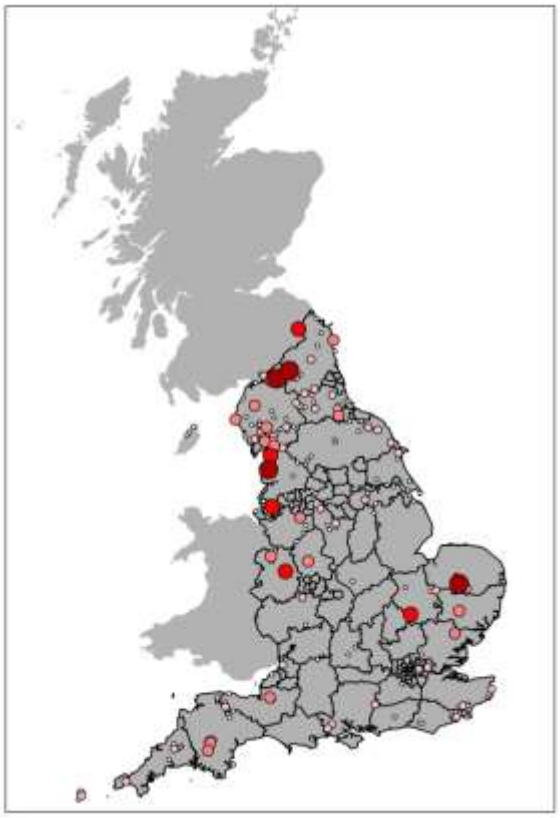
Fig. 1 Location of palaeoecological records derived from literature obtained by systematic searching of Web of Knowledge and Google Scholar, or from the personal knowledge of the authors. The location of all dated and undated sites is shown in (a). The number of dated samples at each site is shown in (b), with the size of symbol proportional to the number of dated samples. Panel (c) shows the number of dated cores available for each millennium over the last 15,000 years.

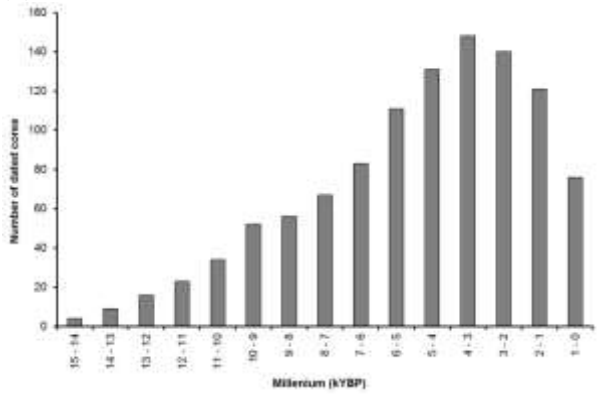
(a)



(b)



(c)



Electronic Supplementary Material Table 1

The English sediment core meta-database

A meta-database, provided as a Microsoft Excel spreadsheet accompanying this manuscript (online), provides details of all studies from which data were extracted. The geographic location, the total number of samples, core ID number and site characteristics are listed for each record. For dated cores, the number of dated samples and their temporal coverage is also given.

Electronic Supplementary Material Table 2

Search terms used to compile the English sediment core meta-database

1	'Holocene' + 'pollen'
2	'Quaternary' + 'pollen'
3	'Pleistocene + 'pollen'
4	'Holocene' + 'palynolog*'
5	'Quaternary' + 'palynolog*'
6	'Pleistocene' + 'palynolog*'
7	'Holocene' + 'fossil'
8	'Quaternary' + 'fossil'
9	'Pleistocene + 'fossil'
10	'paleoecologic*'
11	'pal*o* + refug*',
12	'pal*oecolog* + climat* change'
13	'pollen' + 'Engl*'
14	'fossil' + 'Engl*'
15	'palynolog* + 'Engl*'
16	'glaci* ref*'