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THE INTERPRETATION OF POLLEN FROM URBAN ARCHAEOLOGICAL DEPOSITS

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CONTENTS

Introduction

The definition of an urban site

It is difficult enough to define what is meant by the expression 'urban site' in purely archaeological terms: the status of many settlements is hard to assess, such as those dating from the Roman period (Rivet 1975) while sites dating from other periods, like tells and lake villages, could be regarded as being urban or rural according to viewpoint. In biological terms, however, the expression 'urban site' becomes even harder to define, since what is regarded as a town on archaeological criteria might not appear so on the basis of its flora and fauna --- waste ground in modern towns fairly quickly acquires a 'rural' flora and fauna, while in the past any settlement such as a farm which radically altered part of the landscape, could have given rise to a flora and fauna hardly distinguishable from those of a town today.

Because of this difficulty in differentiating 'urban' and 'rural', this study has not been restricted to sites which would be considered 'urban' in archaeological terms, but has also included archaeologically 'rural' sites in an attempt to detect any biological distinction.

Previous pollen studies of urban archaeological deposits

Pollen from urban deposits in Britain has been studied from time to time, in, for example, material from Godmanchester (Hunts) (Dickson unpubl), Shenstone (Staffs)(Godwin & Dickson 1964-5) and York (Cundill 1971). Pollen analysis has also been integrated with the study of other remains such as plant macrofossils and insects at York (Buckland *et al* 1974, Greig 1979a, Greig in press). Pollen analysis of urban archaeological material has also been carried out on deposits from the Feddersen Wierde (Körber-Grohne 1967) and Hedeby in Germany (Behre 1969) and Bergen in Norway (Krzywinski and Faegri 1979). Apart from these few examples, palynologists have almost exclusively studied naturally formed deposits, so the general attitude towards the study of pollen from archaeological deposits may possibly be best summarised thus: '.... it was thought unprofitable to examine the pollen content ....' (Godwin and Bachem 1962, in a report on plant material from Hungate, York). This lack of interest in pollen from archaeological sites may result from the greater complexities of this kind of work compared with conventional studies of naturally-formed deposits like lake sediments and bog peats. One problem is that there is much less information on the ecology of urban plant communities than there is on rural ones (eg Tansley 1939). Also, most of the information on urban pollen deposition comes from studies of pollen and hay fever, which is not very relevant to archaeological work. On the other hand, many studies have been made of pollen deposition to aid the interpretation of pollen diagrams from natural sites (e.g. Birks & West 1973). There is also some difficulty in many towns in finding deposits in which pollen is sufficiently well preserved. Human habitation tends to favour well-drained sites whilst pollen preservation is favoured by waterlogging or acidity, or, in rare instances by copper corrosion products (Greig 1971, Beal and others, in preparation) conditions only occasionally found in towns.

Pollen dispersal and representation

It is important to discuss some aspects of pollen production and dispersal to set out the theoretical background, before considering how pollen from urban archaeological deposits can be studied. Pollen dispersal (Tauber 1965) and relative pollen productivity and representation (Andersen 1970) have mainly been studied in natural forest vegetation to provide an aid to the interpretation of pollen diagrams. Urban deposits, however, necessarily date from a time when the landscape was already much altered by human activity, and come from a place where such activity was concentrated, so it might be predicted that pollen dispersal, relative productivity and representation in towns would be different from that in forests. Although studies on pollen dispersal and deposition in populated landscapes are proceeding (e.g. Berglund 1973) there are so far very few results available for towns, apart from those presented here.

Some possible pathways of urban and rural pollen dispersal are shown in fig. 1 to illustrate how the principles arising from work on rural sites could be extended to towns, and to summarise some of the results discussed later. The land around this town is shown as a mosaic of pasture and arable land supporting a range of crops. The fields could be enclosed by hedges or fences, or they might be

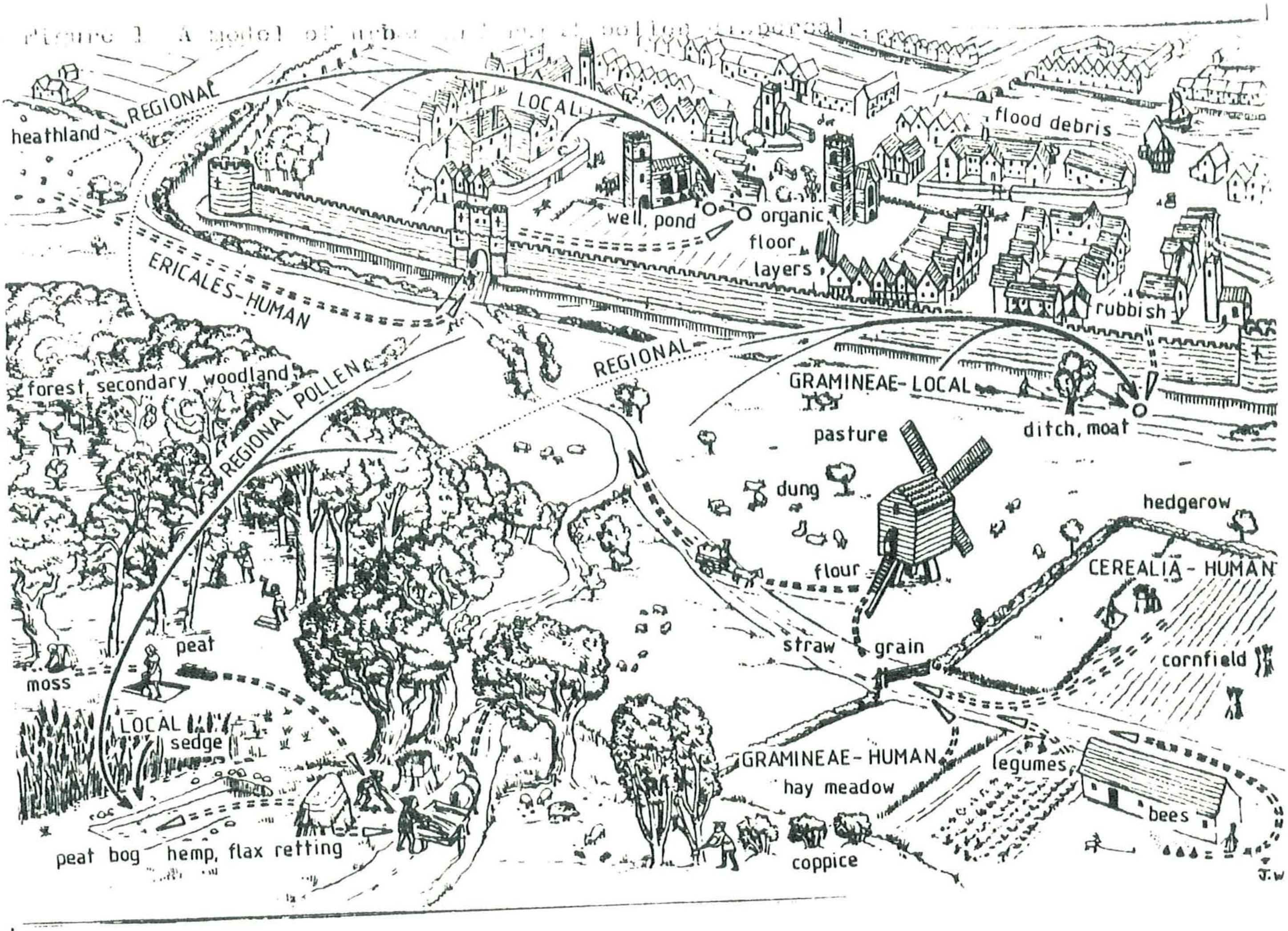

Figure 1. A model of urban and rural pollen dispersal. This shows the main features of a town set in a landscape containing natural woodland, bog, scrub, heathland, pasture and arable land. Possible sources of the pollen arriving by natural means at particular sites are shown by single lines, and pollen dispersed by human agency by double dashed lines. The pollen components are in capitals (see text). The picture is intended to show the generalities of pollen dispersal rather than any particular site or period.

managed on the open field system with fewer boundaries (Bennett 1947). There would probably also be some scrub and wasteland, and perhaps places where the soil had become so degraded that it would only support heathland. There is likely to have been woodland near most towns, too, maintained to provide valuable natural resources such as firewood, fencing, pannage and timber. In this form it would have been very different from the original forest cover; the last essentially primeval forest is believed to have disappeared by about 1150 AD (Rackham 1976).

This varied landscape with its wide range of vegetation would produce pollen of many different types which could become dispersed in various ways. The relative amounts of the various kinds of pollen carried by the wind would only bear an indirect relationship to the relative abundance of the plants producing them. For example, Quercus (oak) and Alnus (alder) produce about eight times as much pollen per unit area of their canopies as do Tilia (lime) and Fraxinus (ash) (Andersen 1970 p 80). There are fewer data for the pollen representation of herbs to compare with those from trees, but wind pollinated plants like Rumex (docks, sorrels) and Urtica (nettle) produce large amounts of far-travelled pollen compared with insect-pollinated ones such as Rubiaceae (bedstraws etc) or Geum (avens)(Bradshaw in press). Thus there is a general scarcity of pollen records from entomophilous plants in most pollen diagrams from natural deposits.

Some of the pollen from the vegetation of a landscape like that in Figure 1 would be carried by the wind for a considerable distance from its source and might be mixed with other pollen and distributed around the whole region; this is the 'regional pollen component' (Tauber 1965). This term was originally applied to the pollen, mainly from trees, which was blown above a forest canopy and could then travel for some distance in the wind before settling. This term may also be applied to pollen which is well dispersed around a landscape like that in Fig. 1.

The composition of the regional pollen landing at a given point would depend upon the proximity of the various types of vegetation and c the nature of the pollen dispersal of the plants in it. For a natural site like a peat bog surrounded by woodland (Fig 1, lower left), the regional pollen would be rich in tree pollen, with smaller amounts from more distant vegetation such as fields. Many pollen diagrams for deposits formed in the last few thousand years show a large pollen component which could be of regional origin, from such a source. Pollen diagrams for town deposits, however, may be expected to have a regional pollen component which is different (Fig 1, top left, centre right).

Not all kinds of pollen are widely dispersed, and many plants liberate small amounts of pollen which may only be at all abundant in the immediate vicinity of the parent plant. The pollen from many insect-pollinated plants is, for example, poorly dispersed in the wind. Another factor leading to poor pollen dispersal is the 'habit' (growth form) of a plant, for low-growing plants are often sheltered so that little pollen is carried into the mainstream of the wind. Such pollen, which has only travelled a short distance prior to deposition, is termed the 'local pollen component'. In natural deposits this pollen usually comes from plants growing, for example, in a lake or on a bog (Moore & Webb 1978 'autochthonous pollen') and it falls directly into the accumulating deposit where it can be preserved and later recovered and detected(Fig 1, lower left). In such a case the local pollen can often be distinguished from the regional (in natural non-fluviatile deposits) by examining macrofossil remains which may confirm which plants were growing there. The local pollen component may be expected to be harder to identify in urban pollen spectra. Some features, like moats and ditches, may have supported vegetation so that the presence of both pollen and macrofossils of wetland plants there may be a sign of local pollen deposition also. Human activities, however, make the understanding of archaeological deposits much more complex than natural ones. The local pollen component in urban deposits can also come from dry-land vegetation growing nearby. Towns would have provided many habitats for various kinds of vegetation, such as weed communities. The scale of this man-made mosaic is much smaller than that which is usually resolved in interpretation of pollen from natural deposits, which adds to the problems.

A third component which is likely to be important in spectra from archaeological deposits is that which has been transported, either directly or indirectly, by human agency. This can be termed the 'human component' in the absence of a suitable pre-existing term, for words like 'anthropogenic' are rather ambiguous and ones coined from

Greek and Latin words tend to be obscure. This 'human component' would include pollen transported with a range of plant materials such as flowers or other plant parts in the many plant products used for building, food etc. It would also include pollen transported by domestic animals, for example in the gut of herbivores. The main characteristic of this component is the presence of pollen in circumstances that cannot adequately be explained in terms of local or regional natural deposition.

Some of the possible sources of the 'human pollen component' are shown in Fig. 1 and the transport is indicated by double dashed lines. Even deposits which may appear to be of wholly natural origin can have a 'human component', for example when there is evidence that flax or hemp have been retted in a lake or bog (Tolonen 1978, Hall et al 1979).

Another example of the'human pollen component' comes from the results of the pollen analysis of samples in a succession which included the occupation layers of a Swiss lake village (Welten 1967). In these cultural layers there were unusually large amounts of pollen of <u>Tilia</u> (lime), <u>Acer</u> (maple) and <u>Hedera</u> (ivy). These were interpreted as evidence that leafy branches (together with the flowers) had been brought to the site for cattle fodder. <u>Ulmus</u> (elm) branches were probably also gathered in this way, but since the flowers would have fallen by the time that the leaves had fully developed, no corresponding peak in elm pollen would be expected. The 'human pollen component' as identified in the present study is further discussed below.

Another pollen component which has been studied in some deposits is thought to result from the activities of insects such as bees (Bottema 1975), which selectively gather pollen and take it back to their nests. This may be termed the 'insect component', and it is also discussed later.

Methods

Avenues of research

There are several ways of studying urban archaeological pollen spectra. One method is to compare spectra from as wide a range of deposits as possible and then to note the similarities and differences between them, to see whether any pattern can be identified. The results from urban and rural archaeological deposits can be compared in this way, and also those from natural deposits like bog peats. The model of pollen transfer illustrated in Fig. 1 can then be tested in the light of such information. This 'extensive' approach (Dimbleby 1962, p 7) has proved very useful in the present work.

Another approach is to obtain series of pollen spectra from each deposit and to integrate the results with other evidence such as that from plant macrofossils, insects, molluscs etc. This 'intensive' approach (Dimbleby 1962) is necessarily very time consuming, and may involve collaboration with several specialists as well as with the archaeologist concerned, but the results can be extremely rewarding ——— see, for example, Greig (1979b), Greig et al (in press), Kenward et al (1978). Thus the intensive approach has also proved to be valuable .

The study of modern pollen transfer is also very important because it can supply practical demonstration of ways in which particular pollen spectra could have arisen (e.g. Fig 5, Krzywinski 1979). This work is in its earliest stages, and it will take a long time to assemble evidence to validate or disprove the various aspects of the proposed model of pollen transfer (Fig. 1). It is not always straightforward to study modern pollen transfer for this purpose, because plant communities in the past may have differed from their modern counterparts. Thus some cornfield weeds which used to be common are now rare, such as Centaurea cyanus (cornflower).

A final approach, which has not been adopted here, is the use of statistical techniques to detect patterns and to examine the data more objectively. Pollen analysis, ' ...despite all the commendable attempts to place the interpretation of pollen diagrams upon an objective plane ....still remains largely an intuitive process (Moore and Webb 1978,118). It remains to be seem whether statistics prove useful in this field in the future.

Sites and deposits examined

The results discussed here are from the analysis of 103 samples from 26 archaeological sites; the full details of these are given in Table 1. The 'extensive' approach is based on results from sites which are mainly in the midlands and Yorkshire/Humberside regions of Britain, dating from the Iron Age to the post-medieval, and both urban and rural. The 'intensive' approach is based on the results

from the studies of pollen

spectra, plant macrofossils, insects, etc. from 7 sites.

The results so far available from studies of modern pollen are discussed in a separate section.

Field and laboratory methods

Sampling for pollen analysis is normally carried out by the palynologist, who is best able to consider the problems of sampling technique and the recording of the relevant stratigraphy and other data. Many of the results discussed here come from series of samples taken from profiles at vertical intervals such as 2.5 cm, 3 cm, or 5 cm. The practice of 'column sampling' with aluminium boxes of 25 x 10 x 10 cm allows a complete profile to be sampled in segments. The boxes are pushed or hammered into the section to be sampled, labelled with details of depth and the top end marked. They are then dug away with the contained blocks of sediment, and wrapped in plastic. This method makes it possible to do much of the sub-sampling and sediment recording in laboratory conditions, which can be useful if time, weather, water inflow or works make sampling and recording difficult. Larger bulk samples of about 2-5 kg are usually collected in addition to the columns, for the recovery of macrofossils; otherwise the number of seeds and beetle remains recovered would be too small to be significant. Single pollen samples can be collected by cutting out a lump of the sediment which may be sub-sampled by cutting out a block of about 1 ccm. However, it is more desirable to replicate sub-samples from a given deposit to determine the variability of pollen content.

Pollen preparation methods are too well known to need further elaboration here (see, for example, Moore and Webb 1978, 22-27), save for a few points which are important in the preparation of archaeological material. Disaggregation of samples is improved by the addition of liquid detergent, and also in the final wash, when it may help to prevent clumping. Hydrofluoric acid treatment (to remove silicates) is usually necessary and may have to be repeated when material is rich in silt and clay. Acetolysis, on the other hand, does not always seem to be necessary.

It is important to record the state of pollen preservation during counting, because it can vary considerably and affect the interpretation of the results——poorly preserved material may appear to have a greater proportion of robust pollen grains if the more delicate ones have disappeared, a case of differential preservation. Another aspect of pollen preservation is its size; sometimes pollen in archaeological material is shrunken and crumpled, and this can make the use of size characters in identification difficult, however the microstructure can usually be used as the basis for identification, especially when phase contrast illumination is used. The pollen reference collection necessary for this kind of work must be extensive, since a much wider range of pollen types may be encountered than in more conventional work (on acid peat material, for example). Apart from pollen and spores, parasite ova and soot particles can provide valuable evidence and should therefore be recorded.

Presentation of results

The data to be considered are complex; apart from the large number of pollen spectra themselves, plant macrofossils (mainly seeds) and insect remains from the same deposits provide useful evidence, and there are the archaeological circumstances of the various deposits to be considered too. This potentially unwieldy mass of information has been presented with a view to clarity: the pollen analyses have been summarised in the form of histograms (Figs 2 and 3), and the original preparations and pollen count sheets are available for checking at Birmingham. Macrofossil results from the Compositae are presented in another histogram (Fig 4), modern pollen results in Fig 5, and the conclusions are summarised in Fig. 6. Insect and archaeological data are presented in the text at the appropriate pqints.

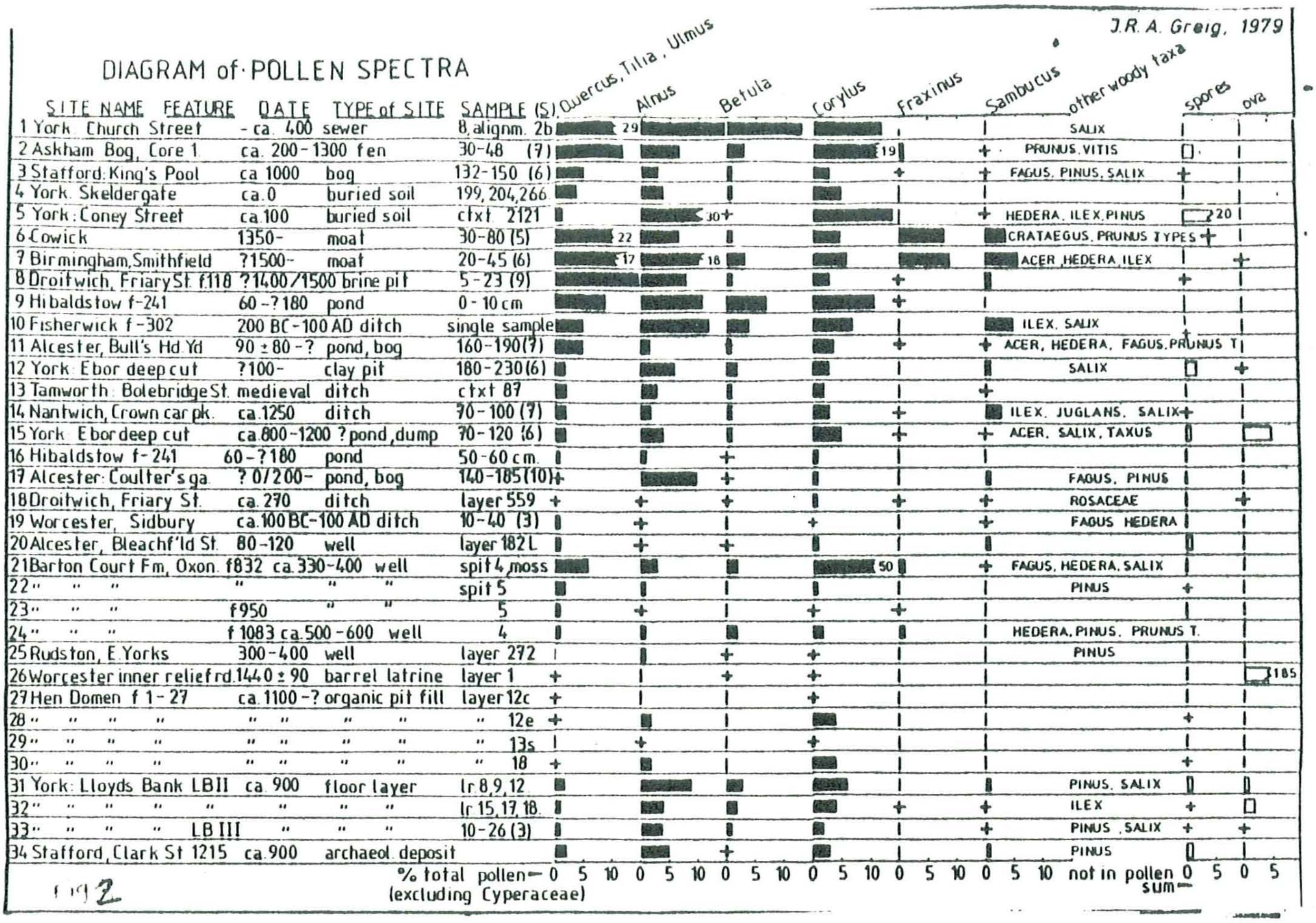

Figure 2. The sample order is determined partly by the type of site (more natural at the top) and partly by tree pollen values (high at the top). Results from some sample series with the same type of pollen assemblage have been averaged. Thus in sample 2, '30-48 (7)' shows that the results presented here are the average from 7 samples, 30 - 48 cm depth in the profile.

Results

The pollen evidence

This is summarised in Figures 2 and 3 and discussed briefly here, because the results of pollen analysis are much more significant when compared with data from plant macrofossils and insects, than if they had been considered in isolation. The most important features of the pollen data are discussed in more detail in the interpretation section.

The pollen results are discussed in the same order in which they appear in the histograms. First are the records of Quercus (oak), Tilia (lime) and Ulmus (elm), which have been grouped together because it was thought that they might be regarded as indicators of forest, since they were the principal trees of the original 'wildwood' (Rackham 1976). In most cases Quercus (oak) is the most abundant pollen type, but there is one spectrum with a high value of Tilia (lime) (1) and another one with high Ulmus (elm) (8).

The amount of forest tree pollen in the spectra varies considerably from site to site: those with larger amounts (> ca 4%, 1, 2, 3, 6, 7, 8, 9, 10, 11, 21) come from natural type sediments like peat bogs and from archaeological deposits in ditches, ponds and wells, both urban and rural. It is surprising that some of the archaeological deposits in towns can contain as much forest tree pollen as do sites in more natural surroundings, where fairly undisturbed forest might be expected to have grown nearby. Thus the relationship between the forest tree pollen values and the type of deposits does not appear to be a simple one.

The pollen spectra with the least forest tree pollen (with values as low as 1%) are mainly from urban deposits (as might perhaps be expected), such as ponds and ditches (16-19), wells (20, 23 - 25) and from organic occupation deposits (26-30, 32,33). The low forest tree pollen values could be a real reflection of the lack of such trees in the vicinity of the sites, or they could result from swamping by relatively large amounts of non-tree pollen from other sources —— such as the local pollen component, or pollen dispersed by human agency (the 'human component'). Layers like floors which accumulated inside buildings (Fig. 1, top centre) might have been shielded from atmospheric pollen fallout by their roofs and so less tree pollen might have been deposited there.

Pollen values of other trees and shrubs seem to vary in a similar manner to those of the forest trees described above, with high and low values in spectra from both urban and rural contexts. Alnus (alder), Betula (birch) and Corylus (hazel) are the most abundant types, and some spectra have especially large amounts, such as a buried soil with 30% Alnus (alder) pollen (5), which is discussed later. Fraxinus (ash) is occasionally abundant (6, 7), another of the trees and shrubs which are common in and around towns today as they evidently were also in the past. Sambucus nigra (elder) pollen is also sometimes relatively abundant, especially in some ditch deposits (6, 7, 10, 14). Elder grows best in nitrogen-rich ground, like a weed, and gives a strong record here even though its pollen is rare in conventional pollen diagrams, and it is insect-pollinated.

Some other pollen types which only appear in trace amounts, such as Acer (maple), Crataegus type (e.g. hawthorn), Prunus typ type (e.g. sloe) and Ilex (holly), appear to be greatly under-represented in the pollen record because of low productivity and dispersal, for they are all insect-pollinated. Such trees and shrubs may, however, have been an important feature of the vegetation in certain places, for example in hedgerows (Groenman-van Waateringe 1978), and the pollen records are therefore much more important than they might at first appear to be. Modern pollen results on the representation of such plants are badly needed. The occasional records of Juglans (walnut) pollen are very interesting because little is so far known about the history of this introduced tree in Britain (Godwin 1975, 248). Finds of walnuts (e.g. Willcox 1977) could easily be from imported food, but the pollen probably represents trees growing in this country. The poor pollen representation of many trees and shrubs shows how incomplete a pollen recprd may be preserved by pollen, and makes it very difficult to estimate how many trees grew near these sites.

Gramineae (grass) pollen is very abundant in most of these spectra, ranging from 10% - 70% of the pollen sum. Since grasses grown in such a wide range of habitats, only a limited interpretation can be based on abundance of their pollen alone, apart from the presence of grassy vegetation. The highest Gramineae values (> ca 35%) come from buried soils (4, 5), pond and ditch deposits (3, 11, 12, 16-19), wells (20, 23, 24) and some occupation deposits (26, 28, 29, 31, 33), not all where signs of grass would perhaps be expected.

Cerealia (cereal) pollen can usually be fairly clearly distinguished from the smaller grains of the other Gramineae (grasses) except when the pollen is very distorted. Although

Figure 3. Pollen spectra

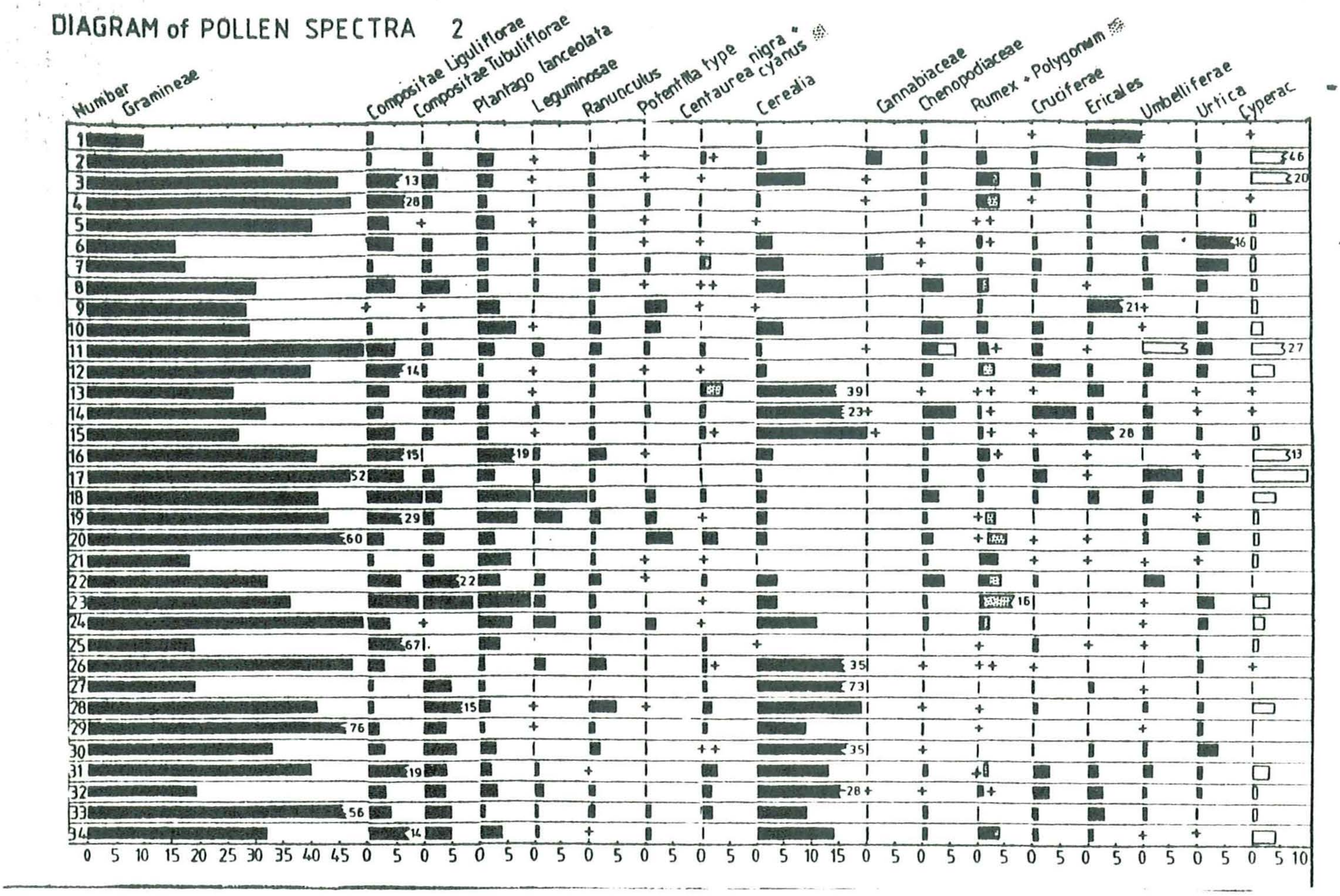

Figure 3. Pollen records of a range of less abundant taxa have been omitted, but are mentioned in the text.

The taxa are arranged in three main groups: Grasses and pollen records thought to mainly represent grassland plants, cereals and pollen records probably representing weeds of disturbed ground, and pollen records probably representing other habitats.

detailed studies of the morphology of Cerealia pollen have been made (Andersen 1972), consistent separation to generic level (i.e. wheat, barley, oats and rye) has not proved possible —— this was tried in the case of some of the material from the Lloyds Bank site, York. Cereal pollen may occur in large amounts, and values of 11% - 79% were recorded in three groups of spectra from ditches and ponds (12-14) and all but two of the occupation deposits (26-28, 30-32, 34), the exceptions having very high Gramineae pollen values instead (29,33). Such high cereal pollen values contrast with the much lower levels recorded from natural deposits like peat bogs (2, 3), and are a characteristic feature of many archaeological deposits, espec all those from towns. Since it is very unlikely that cereal crops were ever grown inside towns, high Cerealia pollen values can usually be interpreted as the result of pollen dispersed by human agency (Figure 1, lower right), and this very significant feature of some archaeological deposits is discussed in much fuller detail later.

Cannabiaceae type pollen appears sporadically in archaeological deposits, but it is very hard to identify it further, separating Cannabis sativa (hemp) from Humulus lupulus (hop). The separation can be made with more certainty when there is an accompanying macorfossil record, as at Askham Bog (2) (Hall and others 1979, Bradshaw and others, in press).

The pollen records of Artemisia (mugwort) (Fig. 4), Caryophyllaceae (e.g. chickweed), Cruciferae (e.g. shepherds purse), Polygonum (e.g. knotgrass), and Urtica (nettle) probably represent weeds of disturbed ground. (So also do some of the Compositae pollen records, discussed below). These plants are much more abundantly represented in pollen records from archaeological deposits than in those from more natural deposits, as might be expected. The variation between archaeological samples, however, does not seem to follow any discernable pattern, so on present evidence it is not possible to tell whether there were, for example, more weeds growing near some some sites than others.

The pollen records from Rumex (docks and sorrels), Ranunculus (buttercup), Potentilla (cinquefoil), Umbelliferae (Umbellifers) and from other pollen types omitted from Fig 3: (Campanulaceae (e.g. harebell), Dipsacaceae (scabiouses), Geraniaceae (e.g. cranesbill), Labiatae (e.g. mint), Linaceae (flaxes), Malvaceae (e.g. mallow), Poterium and Sanguisorba (burnets), Rubiaceae (bedstraws), Scrophulariaceae (e.g. speedwell) and Valerianaceae (valerians) probably represent grassland plants. Once again, there seems to be no discernable pattern in pollen values of these plants, so interpretation of the results is difficult.

Compositae (L) pollen (a group which includes dandelions, hawkbits and many others) has values which fluctuate from less than 1% to 67% of the pollen sum, and in this case there is a pattern: samples with abundant Compositae (L) pollen often also have abundant Gramineae pollen also, and some other pollen records appear to correspond as well.

Compositae (T) pollen (a group which includes daisies, marigolds and similar plants) also varies in abundance in the variosu spectra like that of Compositae (L), although not so markedly. This pattern is further discussed in connection with the plant macrofossil evidence, and in the interpretation.

Ericales pollen (from ling or heather, heaths etc.) is present in small amounts in most of the pollen spectra, but larger amounts (21%, 28%) were found in two cases (9, 15),, the significance of which is discussed later.

Leguminosae pollen records are normally very small in spectra from natural deposits, but relatively large amounts were found in some of the archaeological deposits, for instance 9% (18), and there were significant records (> 1%) in 8 spectra (11, 18, 19, 22-24, 26, 32). Pollen resembling that of the cultivar Vicia faba (broad bean), a very important crop in the past (Bennett 1947), is rarely found in British deposits (see Krzywinski and Faegri 1979, Körber-Grohne 1967).

Plantago lanceolata (ribwort plantain) pollen is ubiquitous in archaeological deposits, with occasional cases of abundance such as 19% (16), and 10% (18, 23). Simularly large amounts have also occasionally been recorded in spectra from natural deposits such as Bishop Middleham, Co. Durham (Bartley and others 1976). The archaeological deposits which had the greatest Plantago lanceolata values were ponds and wells. Pollen of the other two plantains, P. major (greater plantain) and P. media (hoary plantain) is found only in small amounts, which is surprising, since the plants are such common weeds today, perhaps a case of poor representation.

Cyperaceae (sedges etc.) pollen is very often found, occasionally in large amounts, and mainly in samples from moats and ponds (6,11, 16, & 17). These amounts are similar to those obtained from natural deposits where the sediments formed at least partly from the remains of sedge vegetation which grew there. These archaeological deposits may therefore also have had sedge vegetation growing at the margins. Pollen from other wetland plants occurs sparsely in archaeological samples.

Spores of Pteridium (bracken) and other ferns also occur in archaeological deposits, but in this study large amounts were only found in one sample (5), a buried soil. In this case, the spores may have come from bracken growing on the site, or have been brought with soil wash in floodwater (see Peck 1973, 57-8). Some samples (27-30) contained fragments of bracken frond but very few spores —— in this case the bracken may have been gathered when it was young, before spore formation

Ova (eggs) from parasitic intestinal worms have been found in a number of pollen preparations, for they are of a similar size to pollen and survive the pollen preparation process with their diagnostic outer shell layers intact. Two nematode taxa have so far been identified, Trichuris and Ascaris (Jones, this volume 000-000). The largest numbers of these were recovered from a latrine (26), which is not surprising. In other places, ova can provide evidence of the presence of faecal material, as in a pond (15) and an occupation layer (33), although it may not always be possible to distinguish human from animal waste .

In summary, it can be seen that some of the pollen spectra obtained from archaeological deposits (1, 4-10) are quite similar to those from natural sediments (2,3). Some of the other pollen spectra are abviously different, with unusually large amounts of Gramineae, Cerealia, Compositae, *Plantago lanceolata* or Leguminosae pollen, and the significance of these is discussed below.

Pollen and plant macrofossils

The results of pollen analysis alone provide only one part of the botanical information that can usually be obtained from suitable archaeological samples. Plant macrofossils can provide vital clues to the understanding of pollen data, and the converse is also true. Evidence from fruits and seeds is mainly considered here, but leaves, wood, bud scales and whole plants (in the case of mosses and liverworts) can also supply useful information.

Records of many of the common weeds identified to species from macroscopic remains appear to correspond to pollen identified to family of genus level. Thus, weeds like *Stellaria media/neglecta* (chickweed), *Chenopodium* spp. (goosefoots) and *Raphanus raphanistrum* (charlock), the seeds of which are commonly found, may be the source of the pollen records of Caryophyllaceae, Chenopodiaceae and Cruciferae. Likewise, seed and pollen records of *Polygonum* (e.g. knotgrass), *Rumex* (e.g. dock), *Urtica* (nettle), *Potentilla* (cinquefoil), *Ranunculus* (buttercup), members of the Umbelliferae (umbellifers) and, in some cases, Compositae (see Fig. 4) appear to correspond to one another. These macrofossil records provide extra evidence of the plant communities represented by pollen. The amounts of pollen in such cases are often less than 5% total, but the seeds may comprise 20% - 30% of the total seed sum, probably because the weeds produce such abundance of seeds

Sometimes, there are substantial pollen records from plant groups which are not recorded among the macrofossil results, except in trace amounts. There are various explanations for this difference in representation —— one is poor seed survival, for some seeds, like those of Quercus (oak), are not very resistant to decay, while similarly most of the macrofossil records of Ulmus (elm) come from identifications of wood or charcoal (Godwin 1975, 243), again probably because of poor seed survival. Pollen of Artemisia (mugwort), Plantago (plantain), Leguminosae (legumes) and Salix (willow) is often found in archaeological material, but the seeds rarely, if ever, probably because they are not easily preservable. The scarcity of seed remains of Gramineae (grasses), Cerealia (cereals) and Plantago (plantain) may be the result of poor preservability and also because of the difficulty in recognising the fragments, such as cereal periderm. The fossil record of grasses, cereals and the rare finds of legumes come mainly from material preserved by charring (see Hillman 1978, 109), circumstances in which pollen does not survive. Another possible cause of sparse seed records compared with those from pollen is low seed production —— not all plants produce seeds as abundantly as the common weeds, and some hardly ever, like Armoracea rusticana (horseradish). A further factor may be poor seed dispersal, and heavy fruits of plants like Tilia (lime), Ilex (holly) and Corylus (hazel) fall near the parent tree. Only there will large numbers of seeds be present, unless they are carried by water and concentrated in that way ——dispersal by birds and animals would result in a sparse scatter of seeds.

At other times the converse is true, and little or no pollen may be found from plant groups known to have been present from macrofossils remains in the same deposit. Poor pollen survival may be the cause of this disparity in some cases (e.g. *Juncus* (rush), *Populus* (poplar)). Otherwise, low pollen production and poor dispersal, usually from insect pollinated plants, is probably the reason why there are such insignificant pollen records from families like the Boraginaceae (forgetmenots etc.), Labiatae (mints etc.), Papaveraceae (poppies, etc.), Scrophulariaceae (figworts, etc.) and Violaceae (violets, etc.) even though seeds from plants in those groups are often abundant.

The relationship between pollen and macrofossil records of various Compositae groups has proved to be complex, and the results which are so far available have been presented in a histogram (Fig.4). This shows that the records of the various Compositae pollen types are matched by corresponding macrofossil records in some cases, but not in others. This is most evident in the Compositae (L) pollen and macrofossil records (Fig. 4, right): samples 16, 17, 18, 20, and 25 contained pollen but few or no seeds from that group, while many of the other samples (e.g. 24, 26, 28, 29, 30 and 32) contained both pollen and seeds in substantial amounts. This unusual pattern can also be detected in the records of some of the other composites, such as Tubuliflorae and the *Centaurea nigra* (knapweeds) group. Other Compositae records do not show this pattern, either because there were no seed records (*Artemisia* (mugwort)), or because pollen was not found (*Arctium* (burdock), *Carduus* and *Cirsium* (thistles)), or because the records were too sporadic like those of *Centaurea cyanus* (cornflower).

material dating from the 9th-12th century AD (15, 30) and later. The medieval and later occurrence of the remains of cornflower has also been noted in Germany (Knörzer 1976). This unusual pattern in which the Compositae pollen and seed records correspond in some cases, but not in others, does not appear to have been noted before, perhaps because it does not become evident until a large number of samples is examined, as in the present work.

The significance of this pattern is discussed below, after consideration of some other important factors.

Pollen and insect remains

Insect remains (principally Coleoptera (beetles) and Diptera (flies) are often preserved in deposits with pollen and other plant remains, so that a fauna and a flora may be be extracted from the same sample. The evidence from insect remains can be very useful for the interpretation of pollen analyses, and these various lines of research should always be considered as integral parts of the complete biological analysis of a particular sediment. The remains of other insects are also found (e.g. bees, parasitic wasps, and ants) and other Arthropoda (e.g.

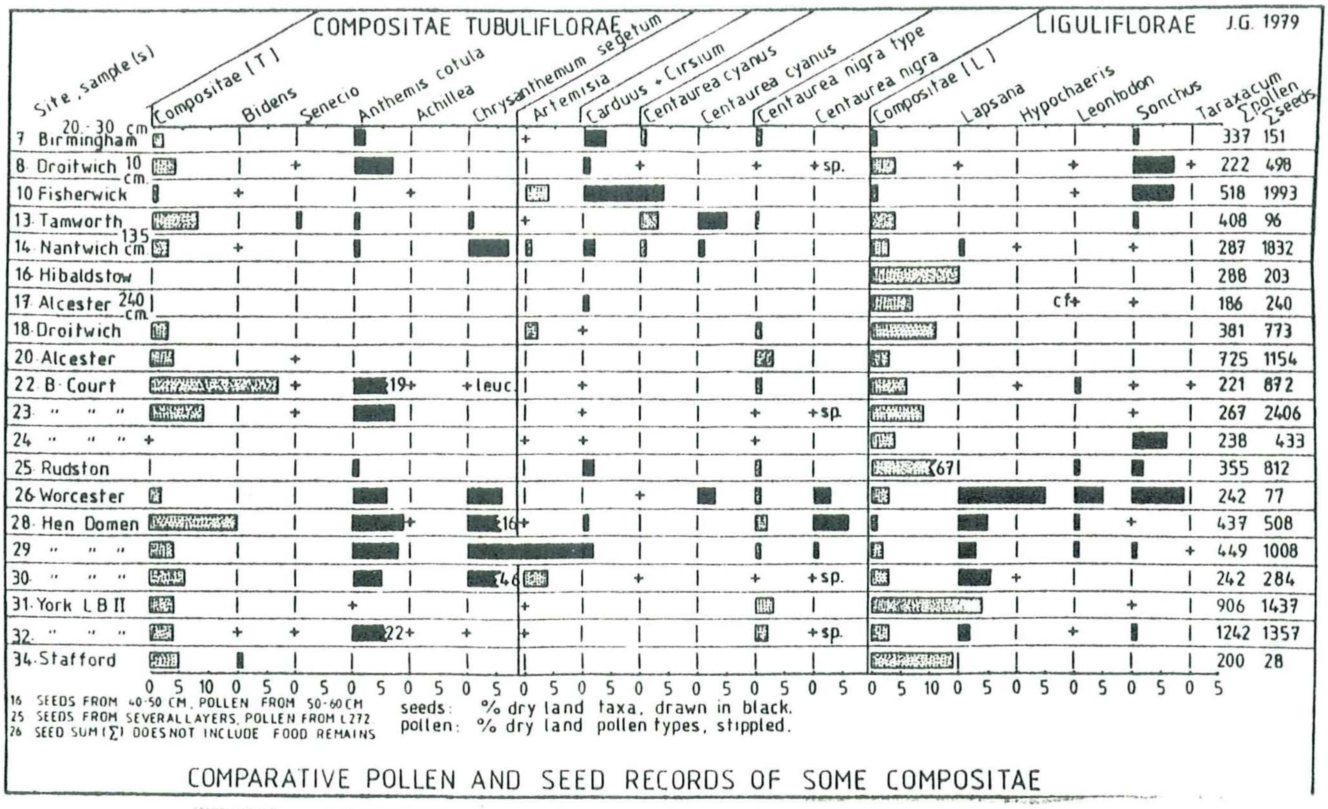

Figure 4. Compositae pollen and macrofossil results. Several pollen types (e.g. *Bidens*-type and *Anthemis*-type) have been combined in Compositae (T). *Artemisia* macrofossils were not found, and the pollen of *Carduus* and *Cirsium* rarely, so the appropriate spaces have been omitted from the diagram.

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The records of Centaurea cyanus (cornflower) are particularly interesting becuuse they represent one of the few important weeds which have distinctive pollen. C. cyanus is a cornfield weed, particularly in rye crops growing on light soils, and it appears to have spread with the increase of rye cultivation which seems to have taken place in the Iron Age and early Roman period. This is seen in pollen diagrams from natural deposits in Germany (Behre 1976), France (Beal and others in prep), and perhaps also in lowland Britain (Bartley and others, 1976). The records of the remains of cornflower from archaeological deposits, on the other hand, seem to date from the medieval period and later. The pollen and macrofossil records presented here do this, and so also do macrofossil records from Germany (Knörzer, 1976), while Pals (1976) notes the unexpected absence of the remains of cornflower from an early medieval site in Holland where abundant rye was found. This difference between the results obtained from natural deposits and from archaeological sites may reflect some change in crop husbandry methods which happened in the beginning of the medieval period, and would be well worth further investigation.

Pollen and insect remains

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spiders and mites), (see Girling 1978, Denford 1979 and in press).

There are different kinds of beetle faunas from archaeological sites (e.g. Osborne 1971, Girling 1977 and Kenward 1978), and a summary from a palynologist's point of view cannot do justice to them. However, one kind of fauna which may add valuable information to that from pollen is one containing a large number of beetle species each represented by small numbers of individuals. Such beetle assemblages are considered to have formed slowly, and in the open, often being extracted from the sediments of ditches (10), ponds (16) and wells (25). The water surface (or well opening) apparently trapped insects from many sources to give such a 'background fauna' (Kenward 1976), and the pollen is likely to have been deposited in a similar manner from regional and local sources. The pollen spectra from such sites are rich in Gramineae (grass), Plantago (plantain) and may be rich in Compositae (L) pollen with few seeds. It may thus be possible to characterise such deposits in terms of fauna as well as flora, and the additional information can be very valuable in interpretation. The evidence from beetles can, for example, show from the abundance of certain dung-inhabiting species that cattle or other stock may have been kept in the vicinity, thus providing the palynologist with certain clues about land use. The presence of certain phytophages (plant feeders) can be secondary evidence of the appropriate food plants, although the botanical results do not always supply corresponding records, and may differ considerably.

Other faunas are species-poor, with some taxa represented by very large numbers of individuals ('superabundants' of Kenward 1978). In such cases, it can often be shown that the insects were associated with the deposit as it formed, because larvae are present, such as fly puparia (Buckland et al 1974, Plate VI). Such a deposit may provide a wealth of information about the ways in which it might have formed and what it may have originally consisted of. For example, fly puparia (maggots) often require considerable warmth to survive, and their presence in a deposit may demonstrate the 'compost heap' conditions that must have prevailed in order to create the right temperature. The pollen spectra from such deposits (26, 28, 29, 30, 32) are often rich in Cerealia (cereal) pollen, providing the basis for another characterisation on the plant and insect remains.

Another example of entomological data of use to the palynologist comes from 'outdoor' and 'indoor' faunas (Kenward 1978). Some occupation deposits contain faunas which are more characteristic of those found outdoors, and which may therefore have formed in the open (31); others, often in the same series of layers, have faunas of insects which are generally found inside buildings and which would not survive in the open (32). This is a useful guide whether the pollen is likely to have come from regional and local sources (where there is an 'outdoor' fauna), or perhaps from elsewhere, when there is an 'indoor' fauna.

Modern pollen studies

Practical results from the study of modern pollen production, dispersal and deposition are very important for the

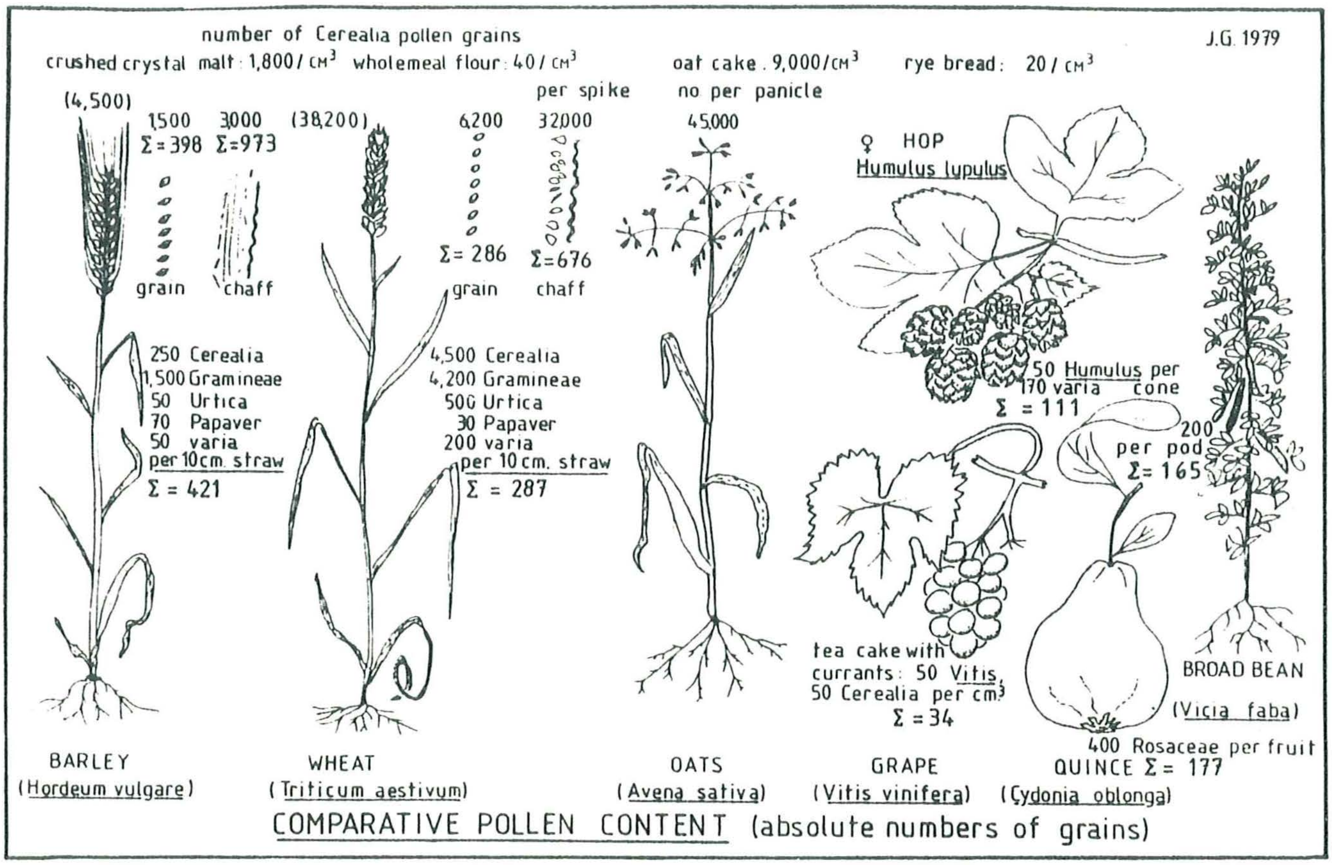

Figure 5. Preliminary results of pollen content. Whole cereal plants were collected at harvest time from fields in Lincolnshire, the grain and chaff separated by hand from a single spike (wheat and barley), and analysed for pollen content. The results from straw are based on culm and leaf. Acid hydrolysis was found helpful in making some of the preparations from food.

understanding of all fossil pollen spectra. Pollen spectra are a necessarily biased and incomplete record of past vegetation; although it is often difficult to demonstrate how certain fossil pollen spectra could have arisen by finding equivalent modern spectra being formed, this is a vital part of pollen analysis (e.g. Birks 1973 282-297). Preliminary results from some investigations into sources of some pollen spectra often found in archaeological material are reported here.

Large values of Cerealia (cereal) pollen often occur in archaeological material (e.g. 13, 26, 27). This, it was suspected (Buckland et al 1974), was pollen which had persisted on parts of cereal plants, and the retention of pollen by barley grains was demonstrated by Robinson and Hubbard (1977). The pollen content of certain foods, and its survival of the human digestive process were shown, in the case of barley meal by Krzywinski (1979). To further investigate pollen content and retention, samples of cereal plants were tested. Following a suggestion that the pollen analysis of bread might be instructive (M.R. Robinson in litt.), preparations were also made from malted grain, flour, oatcake, and some kinds of bread. Furthermore, the persistant flower remains from some ripe <u>Cydonia oblonga</u> (quince), a cone from seeded <u>Humulus lupulus</u> (hop), and a ripe pod of <u>Vicia faba</u>

(broad bean) were prepared.

The results (Fig. 5) show that most of the persistant cereal pollen was retained in chaff, which also contained some extraneous pollen from weeds. Chaff remains in archaeological deposits would therefore prove to be a rich source of cereal pollen, the origin of which might prove hard to detect if, for example, the chaff had been used as animal feed. Wheat and barley grain also retained substantial amounts of cereal pollen, but very little from other plants. Grain products also retained cereal pollen, but much less than might have been expected from the grain results, in the case of wheat flour. In rye bread, cereal pollen was outnumbered by that of Umbelliferae which could have come from Carum carvi (caraway) seeds. The tea cake preparation showed that cereal pollen survives in white bread even though the seed coat has been removed by milling, from malted barley that it survives the sprouting and roasting process in an amount comparable to that of fresh grain. It is evident, then, that cereal and other types of pollen in archaeological deposits could have come from a wide range of grain products used for human food and drink, and animal food, especially where there is evidence of faeces. The results from the straw were very interesting because they show that a surprisingly large amount of cereal and other pollen may adhere to the vegetative parts of such plants. Straw, even without any chaff, could therefore be an important source of cereal pollen in archaeological deposits formed from its remains. It would also be the source of pollen of a range of cornfield weeds, as listed (Fig. 5) and this local pollen component from cornfields could easily be transported by human action. It was interesting to note that the pollen of Papaver (poppy) was found here, although the records from archaeological material are very sparse.

The other modern pollen results show cases of pollen persistance which may not yet have been detected in archaeological material, but which could easily occur. The results from quince show that the persistant remains of flowers can retain significant amounts of Rosaceae and other pollen in fruit such as apples and pears, which could possibly be found in deposits of faeces. The results from hops show that even female flowers retain pollen, so that some Cannabiaceae pollen records found could represent the remains of brewing waste, even if it had been used as animal feed. Other plants which were used in place of hops until supplanted (ca. 1450 in Britain, Corran, 1975) might also leave a pollen record, such as Myrica gale (sweet gale), fruits of which were found in quantity at Svendborg, Denmark (Jensen 1979 71-3). The persistance of Vicia faba pollen on the pods of broad beans is interesting, for the pollen of the legumes is poorly represented compared with that of other plants like cereals. Beans do, however, appear to produce enough pollen so that remains like bean straw are detected by pollen records when they occur in archaeological deposits (Körber-Grohne 1967). Macrofossil evidence (Hillman 1978) and a lack of pollen records, suggests that beans were not as widely grown in Britain as in other countries (e.g. Germany, Norway). Pollen persists in some surprising materials, such as the tea cake preparation which contained an appreciable amount of Vitis vinifera (grape) pollen from the raisins, showing that even fruit which has no persistant flower parts can still contain pollen. The remains of honey can also contain pollen, as shown by Dickson (1978).

Sample	Urban / Rural	Tree and shrub > 30%	Compositae (L) > 5%	Plantago lanc. > 3%	Leguminosae > 1%	Compositae pollen, not seeds	Diverse insect fauna	Gramineae > 35%	Compositae pollen and seeds	Cerealia > 10%	'Superabundant' fauna	parasite ova > 1% pollen sum	Ericales > 15%	main characteristics
1.	U	+												human-dispersed natural
2.	R	+												natural
3.	R		+					+						natural: small catchment
4.	R		+					+						" " " " " "
5.	U	+						+						natural
6.	R	+												" "
7.	U	+							+					mixed: s-c + human
8.	U	+							+					" " " " " "
9.	U	+		+			+						+	" " " " " "
10.	R	+		+			+		?					mainly natural: s/c
11.	U				+			+						natural: small catchment
12.	U		+					+						" " " " " "
13.	U								+	+				human dispersed: Cerealia
14.	U								+	+				" " " " " "
15.	U									+		+	+	" " " " " "
16.	U		+	+		+	+	+						natural: Gramineae-local
17.	U		+			+		+						" " " " " "
18.	U		+	+	+	+		+						" " " " " "
19.	U		+	+	+			+						" " " " " "
20.	U					+		+						? natural: Gramineae-local
21.	R	+		+			+							mixed natural spectra
22.	R		+	+	+		+							natural: Gramineae-local
23.	R		+	+	+		+	+						" " " " " "
24.	R			+	+		+	+	?	+				mixed: Gram.-loc. + Cer.-hu.
25.	R		+	+		+	+							natural: Gramineae-local
26.	U				+			+	+	+	+	+		human: Cerealia + hay
27.	R									+				human: Cerealia
28.	R							+	+	+	+			human: Cerealia + hay
29.	R							+	+		+			" " " " "
30.	R								+	+				human dispersed: Cerealia
31.	U		+			+	+	+						natural: Gramineae-local
32.	U				+				+	+	+	+		human dispersed: Cerealia
33.	U							+						indeterminate
34.	U		+	+		+				+				mixed: Gram.-loc. + Cer.-hu.

NATURALLY-DISPERSED ← || → HUMAN-DISPERSED

Figure 6. A summary of the results: the main characteristics of the samples studied, and a brief interpretation of the pollen source.

Natural deposits Interpretation.

The various lines of evidence, already discussed individually, can now be brought together (Fig 6) to test various aspects of the model of pollen deposition (Fig. 1). The results from 'natural deposits' should be useful in providing background information on the vegetational state of the countryside around a town. It can, however, be difficult to fulfill this aim: the upper levels of places of the greatest value to the urban archaeologist, like lowland peat bogs, representing the most recent deposits, may have had peat cutting, hemp retting, drainage ditching or other disturbance. Thus the first conclusion about the study of 'natural deposits' is that it is very important to study the plant macrofossils and insect remains as well as the pollen in order to have sufficient information on the extent to which such deposits can really be said to be natural in origin.

It is also wise to sample such deposits by coring in different places so that there is evidence from two or three profiles (as at Askham Bog) so that disturbance is more likely to be detected from differences between the various results.

np The amount of background information on the countryside which can be obtained from such pollen diagrams also depends upon the pollen sources: modern pollen results, for example those from the uppermost (modern) deposits in the moat at Cowick (Greig, unpubl.), show that a few trees growing over a site like this, such as Alnus (alder), can deposit large amounts of pollen even though the surrounding countryside is largely treeless (e.g. 10 cm from surface, Alnus=34% pollen sum). Such a local pollen rain, coming from boggy woodland, could be the source of much of the tree pollen in 'natural deposits' (such as 2, 3), or in the buried soil with large amounts of Alnus pollen (5) which could have come from local vegetation or from flood water. The regional pollen rain, with its evidence of the state of the countryside as a whole, may therefore be the less obvious aspect of such pollen diagrams. These effects of disturbance and local pollen rain probably dominate the results from such sites to so great an extent that it is very difficult to tell what the surrounding countryside would have been like, except in very general terms. Various types of disturbance are illustrated in Fig 1, lower left.

Semi-natural deposits

In the case of semi-natural deposits like ditches and ponds, where a man-made feature has filled with sediment which may have accumulated there by natural processes, the likelihood of disturbance is obvious from the archaeological context of the deposit. Here, too, evidence from plant macrofossils, insects and other remains can be very useful in determining how a deposit formed and where the pollen might have come from. Some of the pollen spectra from these semi-natural deposits such as those from soils (5,6), moats (6,7), a ditch (10) and one from a pond (9) are similar to those from 'natural' deposits discussed above, consisting mainly of tree, shrub and grass pollen. Similarly, the tree and shrub pollen can often be shown to be mostly of local origin when corresponding macrofossil remains are also found (e.g. 7). The vegetation of the landscape as a whole would probably be represented by the large amounts of pollen from herbs such as grasses, composites, plantains, etc. which might have come from a largely treeless countryside. Thus it may be possible to make a fairly precise interpretation of such pollen spectra ——— the signs of trees and shrubs in most of the examples mentioned above can be interpreted as the result of local rather than regional woodland. The faint signs of insect-pollinated trees and shrubs of hedgerows, although sometimes slightly amplified by macrofossil evidence, are hard to interpret in any detail, at present.

Some of these spectra have unusually high values of Compositae (L) (3, 4, 12), Plantago lanceolata (9, 10), Leguminosae (11) or Gramineae (3, 4, 5, 11, 12) pollen compared with most conventional pollen diagrams. This is probably because such sites, which cover small areas (less than 100 m from sampling site to dry land) have less pollen from local bog surface vegetation than do more extensive sites. Conversely, the dry land vegetation is much closer, and is therefore better represented in the pollen rain there. Small natural sites with Compositae (L) rich spectra include peat bogs (Aberaeron, Taylor 1973) and buried soil (Greig and Keeley 1980). High Plantago lanceolata values have also been obtained from buried soils (Dimbleby 1973, Groenman-van Waateringe 1978) and from peat bogs such as Clarach (Taylor 1973) and Hallowell Moss (Donaldson and Turner 1977). This last site had large Leguminosae pollen values in the upper levels. Such 'small catchment' pollen spectra are discussed more fully below.

The pollen spectra from the Roman sewer at York (1) seem to be exceptional because they contain more forest tree pollen (especially that of Tilia, lime) than any other discussed here, even the 'natural' deposits (2,3). The site is in the middle of Roman York, however, not a place where the signs of an apparently undisturbed lime forest might be expected. Two of the sewer spectra also contained large numbers of fern spores, which could be a sign that some pollen had been washed into a watercourse with soil (Peck 1973) and then transported into York, perhaps in the water supply channelled from a stream flowing through an area of forest some distance away (Greig 1976). Another possibility is that some of the pollen came from peat laid down at the time of the forest maximum (ca. 3000 BC), and brought into Roman York, for these spectra are similar to some obtained from Askham Bog (AB2/45: 18% Tilia). Tilia-rich pollen spectra have also been reported from material interpreted as the remains of honey (Dickson 1978).

Another example of a site with unusual pollen spectra is the well from which a sample of moss (21) contained far more tree and shrub pollen than that from the rest of the sediment (22). In this case the ecological affinities of the moss (for woodland) add to the evidence from the pollen spectrum obtained from it, showing that the moss probably collected the local pollen rain in woodland where it would have grown, and was then gathered and brought to the site (the well) — a clear example of a human pollen component.

A final example of unusual pollen spectra from a semi-natural site comes from the sediments of a possible brine-pit (8) with very high values of Ulmus (elm) pollen.

This pollen is not normally present in more than trace amounts in archaeological samples, so a series of spectra with 10%-25% Ulmus is noteworthy. Elm trees might have grown over this particular site, or alternatively elm wood may have been collected for some industrial process, such as the manufacture of brine pipes.

Archaeological deposits: 1. Spectra with high Gramineae etc.

These spectra are characterised by an abundance of Gramineae (grass) pollen (> ca. 35%), Compositae (L) (> ca. 5%), Plantago lanceolata (ribwort plantain) (> ca. 3%), and sometimes Leguminosae (> ca. 1%). The results from plant macrofossils (Fig. 4) show that deposits with this pollen spectrum type often have very few seed remains to correspond to the abundant pollen record of Compositae (L). This is also true, but to a lesser extent, of the Compositae (T) pollen and seed records. Deposits with this type of pollen and plant macrofossil assemblage can also be characterised by results from the study of insect remains, for they often have the species-rich 'background' type of fauna. The results with most of these features are summarised in Fig 6:(16, 17, 18, 19, 22, 23, 24, 25, 31, 34). The archaeological features from which these samples came are ponds, wells and ditches, and a few occupation deposits.

This type of assemblage does not appear to have been noted before, because there are so few cases where the results from pollen, seeds and insects from the same deposits have been studied together. Such results from individual sites might have been regarded as exceptional, but when they appear from such a range of different sites they add up to a significant pattern. Individual features (such as high Compositae (L) values) have already been mentioned as features of 'small catchment' sites.

The simplest explanation for the origin of this type of flora and fauna is that the pollen, seeds and insects all arrived in the forming deposits by the same means. The similarities between the pollen spectra and some of the features of 'small catchment' natural sites suggests natural deposition, and this view is supported by interpretations made of 'background faunas', which are confirmed by the results obtained by trapping modern death assemblages in places like roof gutters and drains. These demonstrate that the 'background fauna' can accumulate in the same manner today as it is believed to have done in the past (Kenward 1975, 1976, 1978). Similar studies of modern pollen rain in towns badly need to be done, but without such confirmation it would appear that the pollen in such deposits comes mainly from rather local sources on dry land, in contrast to the mixed dry land and wetland pollen spectra from the semi-natural and natural deposits. It therefore seems appropriate to refer to this pollen spectrum type as 'Gramineae / local'.

There are other possible sources of at least some of the pollen in this 'Gramineae/local' spectrum. The palynology of hay and herbivore dung is to be studied although it is probably more important in connection with the next spectrum type (see below). Pollen could also have been carried by insects, for it has been suggested that bees could be responsible from abundant Compositae (L) pollen in some archaeological deposits (Bottema 1975) but in the mostly waterlogged spectra considered here bee nests are not a likely source of this pollen. Pollen could also have been carried by insects such as bees and pollen eating beetles like <u>Meligethes</u>, which could have dropped into the deposits with their pollen loads. This is a difficult possibility to test, but insect pollen loads might be expected to provide highly local pollen concentrations in deposits, unlike the series of very similar spectra which are usually obtained. One spectrum (not presented here) contained 45% Sambucus nigra (elder) pollen, and might possibly have arisen in this way.

The reason for the divergent pollen and macrofossil records of the Compositae is not yet clear —— one explanation for the abundant pollen but scarce seeds might be that the deposit was formed early in the year, or from material gathered then, when the plants had flowered but not yet set seed. A more likely hypothesis is that the pollen came from composites(like Hypochoeris (catsear), Leontodon (hawkbit) and Taraxacum (dandelion) which have a very efficient seed dispersal mechanism (the 'dandelion clock') which scatters the seeds so widely that they are not concentrated in any one place. This may explain why seeds of these plants are usually found in such small numbers compared with those without a 'clock'. Larger concentrations of these seeds would only occur in deposits formed from the remains of plants which had been gathered up with other vegetation, as in hay or straw, so that natural seed dispersal could not occur.

Such apparently natural 'Gramineae / local'assemblages would appear to come from vegetation with grass, composites, plantains and legumes (perhaps clovers). These plants are typical of the vegetation of short grassland such as would be found on grassy banks in and around towns today. It remains to be seen whether modern pollen studies can confirm and amplify this interpretation.

Spectra from archaeological deposits: 2. High Cerealia etc.

This second distinctive spectrum type is mainly characterised by abundance of Cerealia (cereal) pollen (> ca. 10%). Further evidence comes from the moderate values of Compositae pollen with a corresponding seed record (especially in the case of Compositae (T)), (see Fig. 4). Deposits from which such plant assemblages are obtained often also have a characteristic insect fauna consisting of few taxa, some of which are present in very large numbers of individuals ('superabundants'). The presence of immature insects shows that they were actually living in the deposit as it formed, as does the fauna of a compost heap today, rather than having fallen into it. Such 'indoor' faunas often come from organic occupation deposits. These characteristics are summarised in Fig. 6, showing that samples 13, 14, 15, 30 and 32 are typical examples. This kind of spectrum is so distinctive that it was noticed when results from the study of pollen, seeds and beetles from such a site became available (Buckland and others 1974). It is clear that much of the pollen has probably been dispersed by human agency, so this spectrum type may be termed 'Cerealia / Human'.

One interpretation of this spectrum type is that it represents a deposit formed from the remains of straw or chaff. The great retention of pollen by cereals shows that this is possible (Fig. 5), and further evidence comes from the macrofossil record (Fig 4) which shows the abundant seed remains of plants which were troublesome cornfield weeds in the past, such as Anthemis cotula (stinking mayweed), Chrysanthemum segetum (corn marigold), species of Sonchus (sow thistle) and Centaurea cyanus (cornflower) (this last only in medieval deposits). Straw was probably used (and re-used) for a number of purposes, such as for flooring, roofing, animal bedding etc. and much work remains to be done to try to tell more than merely that it was present.

Another source of the large amounts of cereal pollen in such deposits is from the remains of cereal foods. The retention of cereal pollen in grain and food has been shown (Fig 5), as has its survival of passage through the human gut (Krzywinski 1979), so faeces containing the remains of grain products could also be the source of some of the cereal pollen in such deposits. This likelihood is demonstrated if there are also parasite ova in the pollen preparations, and high power micr oscopy of fragments of periderm can show which cereals were present (Körber-Grohne 1964). Animal faeces could also contain pollen, if stock had been fed grain, or straw, or perhaps brewing waste, and work is needed on the palynology of various kinds of dung to investigate the possibilities of identifying such materials.

Spectra from archaeological deposits: 3. Gramineae/Cerealia

This spectrum type has, as its main characteristic, a large amount of Gramineae pollen, together with other signs that most of the pollen was human-dispersed (26, 28, 29: Fig 6), in contrast to the other spectra with high Gramineae pollen values discussed above. It can be interpreted as representing the remains of grassy material such as hay, and the lack of present knowledge about what hay might have consisted of in the past makes it an interesting subject for further study.

The remains of hay might be expected to be variable, according to the type of meadow from which it came, and the system of management in operation. Some meadows which are maintained by an ancient system of management are floristically interesting, such as Pixey Mead, Oxon (Tansley 1939, 568), and it is possible that future work on archaeological remains might demonstrate the presence of hay crops from such places. A further problem in the study of the remains of hay is that it contains a range of plants which are mainly wild, and remains of these could have come from local vegetation as well as from hay.

Another complication is that very little is known about the palynology of animal dung, and the amount of pollen from meadow plants which could be transported in this way. Insect remains often supply good evidence whether dung was present.

Spectra from archaeological deposits: 4. Ericales

Ericales pollen (includes ling, heather, heaths etc.) represents a group of plants which are unlikely to have grown in towns, yet high pollen values (20-30%) are sometimes obtained from urban deposits, and there is often a macrofossil record to show that the pollen came from whole plant parts rather than from the atmosphere (9). It appears that heather was brought into towns for a variety of uses such as for flooring or roofing material, another example of a human-dispersed pollen component (Fig 1, upper left.).

Discussion

The characterisation of natural, semi-natural and some archaeological pollen spectra and associated plant macrofossil and insect assemblages serves to provide an outline to show what a potential there is for urban pollen analysis. These typical spectra, however, only concern a few of the pollen records of the many obtained, and the others may prove much harder to characterise and to interpret. Furthermore, some important aspects of archaeological deposits may prove hard to detect from pollen records. These are discussed below.

Weeds

Although some kinds of man-made deposits seem to give clear palynological clues as to what they contained, other plant materials are harder to trace. The pollen records which probably represent a range of weeds and grassland plants (e.g. Chenopodiaceae (goosefoots), Cruciferae (e.g. shepherds purse), Polygonaceae (e.g. knotgrass), *Ranunculus* (buttercups), Umbelliferae (e.g. hemlock) and *Urtica* (nettles)) seem to have no discernable pattern and neither do the corresponding macrofossil records either. Such weeds are likely to have been present in plant material brought in from fields (e.g. straw, hay) as well as in weed communities growing in the towns themselves. The lack of pattern in the records may be a reflection on the many different sources of the pollen and seeds of such plants, and so the interpretation of weed records is so far proving to be very difficult.

Wetland vegetation

The pollen records from archaeological deposits do not often have strong signs of the presence of wetland vegetation such as sedges, yet the evidence from plant macrofossils and insect faunas can be abundant. Pollen retention in some plants, like the Cyperaceae, seems to be much lower than in the case of the Gramineae, for high Cyperaceae pollen values only seem to occur in deposits which had been wet enough for the plants to have grown there, such as ponds (11, 17). Floor deposits seem to have much lower Cyperaceae values, even though some of them appear to have been built up from flood deposits, like some of the Lloyds Bank site floor layers at York. The pollen records of other aquatic taxa such as Ranunculus trichophyllus type (e.g. water crowfoot) are also very low, even when abundant macrofossils are recovered, so it is difficult to detect wetland vegetation by pollen analysis alone.

Mixed deposits

Archaeological deposits are, by their very nature, liable to have been disturbed or made up of a mixture of different materials, and this heterogeneity make interpretation very difficult. Even if the remains of fairly pure plant products, like thatch, straw, hay or faeces were found, they would present enough difficulties in interpretation; when a deposit might represent a mixture of such substances with a contribution from local plant communities, and even the remains from industrial processes, formed indoors and then dumped outside, the problem becomes extreme. The difficulties of work on such deposits (often organic occupation material) serves to emphasise the point that pollen results should not be considered in isolation, and nor should those from plant macrofossils or insects either —— the integrated approach is the only way of assembling enough evidence upon which to base an accurate and detailed interpretation, so far as it is possible. A latrine deposit (26), for example, which contained the expected evidence of faeces and the remains of cereal food, had an insect fauna which was not associated with this aspect of it. It showed that the plant matter in the latrine had probably been indoors, perhaps as floor covering, for the insects could not have lived in the faeces. The plant macrofossils showed that hay and straw had been present, and a range of stones of food plants which would not have been swallowed, but rather spat out on to a floor. The results from this deposit therefore show something of the fields and orchards in that area, the domestic floors, and finally the faecal deposit itself, and its epidemiology.

Urban and rural sites

The results from this work can be examined in relation to the archaeology of the sites from which the samples were obtained: some sites which are rural on archaeological grounds, such as the Roman farmsteads at Barton Court and at Rudston, had wells from which were obtained Gramineae / local pollen spectra (22, 23, 25), as did some archaeologically 'urban' sites like Hibaldstow, Droitwich and Worcester (17, 17, 18). Pollen spectra of the 'Cerealia/human' type were also obtained at both rural sites like the motte and bailey castle at Hen Domen (26, 28) and urban sites such as at York (30, 32). Conversely, pollen spectra with large tree pollen values which occur most often in material from rural sites, also come from urban material such as a buried soil (5) or in a pond(9). It therefore seems that there is no palynological (or indeed biological) distinction between the results obtained from sites which would be considered, on archaeological grounds, to be either urban or rural.

Roman and medieval sites

More significant, perhaps, are the differences between the results from Roman and from medieval sites; the Gramineae/local type of spectrum came mainly from Roman deposits (16, 17, 18, 19, 22, 23, 25), while the Cerealia/human spectrum was obtained from medieval sites only. One site, with deposits which seem to span the whole period, has pollen spectra first of one type, then of the other: the lower layers of the Ebor deep trench, considered Roman (King 1975), have some of the Gramineae/local pollen characteristics (12), while the upper layers which seem to be medieval have some of the 'Cerealia/human' pollen characters (15). This seems to agree with documentary records which may relate to the same site '..... James Birkeby enjoined to cleanse the common sewer in his garden and to sett a suffysent grait at his garthyng door at Saint Ellyng Lane end ', in 1580 (York City Records). The 'Cerealia / human' type of pollen spectrum is also to be obtained from faecal deposits from latrines, which are a typically medieval type of structure (Atkin and Smith 1979).

The striking differences between pollen spectra from Roman and from medieval deposits seems to confirm the traditional view that rubbish accumulation was a major problem in medieval settlements (Keene, this volume).

Roman sites were apparently so clean perhaps because there may have been much less use made of organic materials in Roman times, for the use of brick, tile and pottery then gave way to medieval practice with wattle and daub walls, thatch roofs, herb-strewn floors and many wood and leather containers in place of pottery. Even so, the presence of domestic animals on Roman times would still have led to the need for fodder and bedding, and a corresponding requirement for the disposal of dung. Perhaps animals were not so extensively kept in towns as they were later. The archaeological evidence from Roman towns shows that rubbish disposal was highly organised, so that water supply and drainage systems provided a means for the disposal of liquid waste, such as the Roman sewer system at York (Whitwell 1976). Solid waste seems to have been taken outside the towns for disposal, as at Cirencester where quarry pits were used (Esmonde Cleary 1979). Thus the palynological information seems to agree with that from archaeology, in this instance, but the reason why so many Roman sites seem to have been surrounded by short grassland is still a mystery.

Methodology and future work

The treatment of pollen by components, although the divisions must remain largely theoretical, is probably logical, because the source of the different pollen types is so important in interpretation. The results show that the scheme of pollen dispersal (Fig 1) appears to be justified.

The intensive approach provides a very useful method for obtaining enough data for a full interpretation, but it is also extremely time-consuming. If it had been relied upon too heavily, results could only have been considered from a few sites, and some of the pollen spectrum types identified and discussed here might have been dismissed as rare exceptional occurrences or have been missed altogether. On the other hand, over-emphasis of the extensive approach would have resulted in a great range of pollen spectra without the vital evidence from seeds and insects to confirm and help interpret such data. The extensive approach has proved valuable in showing important differences between parts of rather uniform profiles (9 :16, 12 :15) which can demonstrate the need for more intensive study. Both approaches need to be applied with caution, to make sure that they are cost-effective —— pollen analysis could be useful in testing a series of samples from a particular site in the minimum time in order to show the potential for more intensive work. Series of samples from moats and ponds seem most likely to be uniform in content and therefore to need a selective approach (7, 8, 14).

This study has posed more questions than it has provided answers to existing ones, but that is only to be expected in a fairly new line of study. More results are badly needed from extensive, intensive, modern pollen and, above all, integrated studies to show whether these preliminary results demonstrate the general pattern of pollen spectra from archaeological material. Then, the ideas put forward in present work can be further tested and perhaps amplified, and more plant materials identified by their pollen spectra.

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SITES AND SAMPLES DISCUSSED TABLE 1

1. York, Church Street (Roman sewer). Excavated December 1972, pollen analysis from 3 samples by J. Greig: average Σ 200, results in Greig (1976), excavation : Whitwell (1976), finds: Macgregor (1976).

2. Askham Bog, nr. York (SE 570 480)(peat bog). Excavated July 1976 (cores 1 & 2) and July 1977 (core 3), pollen analysis by J. Greig, 7 samples from AB1 presented here, average Σ 373, results in Kenward and others (1978), Hall and others(1979) and unpubl.

3. Stafford, King's Pool (SJ 925 234)(peat bog). Excavated May 1977, 0-350 cm, pollen analysis by S.M. Colledge, average Σ

4. York, Skeldergate (?pre-Roman buried soil, excavated 1977, pollen analysis of 3 spectra by J. Greig, average Σ 267, results: Greig (in press).

5. York, Coney Street (Roman buried soil) excavated 1976, pollen analysis of 1 sample by J. Greig, Σ 495, results in Greig (1979a).

6. Cowick, nr. Snaith, Humberside (SE 652 206)(medieval moat). Excavated May 1976, 110 cm profile sampled every 5 cm, 5 spectra presented here, analysis by J. Greig, average Σ457, results unpubl.

7. Birmingham, Smithfield market site (medieval/post medieval moat), excavated May 1975, 60 cm section sampled by S. Limbrey, 6 samples presented here, analysis by J. Greig, average Σ 431, results in Ancient Monuments Laboratory report 2919.

8. Droitwich, Worcs, Friary Street (Hereford & Worcester County Museum, site No. 600)(? medieval brine pit) Excavated October 1977 24 cm section sampled every 2 cm, pollen and macrofossil analysis of 1 sample by J. Greig, pollen analysis of 9 samples by S.M. Colledge,(average Σ 206) , unpublished. Archaeological interim report, Worcester Museum News Sheet, 1979.

9, 16. Hibaldstow, Lincs. (SE 957 027)(pond in small Roman town). Excavated 1977, 60 cm. section sampled every 10 cm by P.C. Buckland. Pollen and plant macrofossil analysis by J. Greig, average pollen Σ 472, results in: Ancient Monuments Laboratory report No.2678, insect analysis by M.A. Girling, unpublished.

10. Fisherwick, Staffs (SK 187 082)(ditch associated with Iron Age settlement. Excavated April 1975, pollen and plant macrofossil analysis by J. Greig Σ 250, results in Greig(1979b). insect analysis, P.J. Osborne in Smith (1979).

11. Alcester, Warks, Bull's Head Yard site (? Roman and later pond or river channel). Excavated March 1977, 60 cm profile, sampled at 2 cm interval. Pollen analysis by J. Greig, 7 spectra presented here, average Σ 527, unpublished.

12, 15. York, Ebor Brewery site, Aldwark: Ebor Deep Trench (? pond deposit; see King 1975). Excavated November 1974, 230 cm profile sampled at 5 cm interval. Pollen analysis by J. Greig, 12 spectra presented here, average Σ 322, unpublished.

13. Tamworth, Staffs, 71 Bolebridge St. site (medieval ditch), excavated April 1978, single sample from Layer 87 sampled. Pollen (Σ 410) and plant macrofossil analysis by S.M. Colledge (unpublished).

14. Nantwich, Cheshire, 'The Crown' car park site (medieval ditch). Excavated June 1978, 70 cm profile sampled at 5 cm interval, pollen (average Σ 439) and plant macrofossil analysis by S.M. Colledge, interim report: McNeil Sale(1979).

17. Alcester, Warks, Coulter's Garage site (? Roman pond deposit). Excavated May 1979, 150 cm profile sampled at 5 cm interval by P. Booth, pollen (average Σ 313) and plant macrofossil analysis: L. Woodwards (1979).

18. Droitwich, Worcs, Friary St. Bowling Green site (Hereford and Worcester County Museum site No. 600 (Roman ditch). Excavated June 1978, single sample from Feature 530, layer 559 collected. Pollen (Σ396) and plant macrofossil analysis by J. Greig, unpublished.

19. Worcester, Sidbury (Hereford and Worcester County Museum site No. 177) (Roman ditch). Excavated August 1977, 50 cm profile sampled at 5 cm interval. Pollen analysis of 3 samples so far completed (average Σ 406) by J. Greig, unpublished

20. Alcester, Warks, Bleachfield St, Explosion site (Roman well). Excavated April 1977. Layer 182 L sampled, pollen (Σ737) and plant macrofossil analysis by S.M. Colledge, unpublished.

21-24. Barton Court Farm, near Abingdon, Berks (SU 506 973) (wells). Excavated 1976, Feature 832 spits 4 & 5, Feature 950 layer 5 (Roman), and Feature 1083 layer 4 (Saxon). Sampling, plant macrofossil and insect analysis by M. Robinson (Robinson, in press), pollen analysis (Σ 306), J.Greig: Ancient Monuments Laboratory Report No. 2846.

25. Rudston Roman villa, E. Yorks (TA 089 668) (Roman well). Excavated 1966, sampling and insect analysis by P.C. Buckland. Pollen (Σ 359) and plant macrofossil analysis by J. Greig, results in Stead(1980).

26. Worcester, Inner Relief Road site (medieval barrel latrine). Excavated December 1975, pollen (Σ 243, ova 450) plant macrofossil and parasite ova analysis by J. Greig, insect analysis by P.J. Osborne, cloth studied by E. Crowfoot, interim results: Ancient Monuments Laboratory Report No. 2439.

27-30. Hen Domen, Montgomery (SO 214981)(pit in motte and bailey castle). Excavated August 1975, sampling, pollen (average Σ 362) and plant macrofossil analysis by J. Greig, insect analysis by M.A. Girling, flies analysed by P. Skidmore, results: Greig and others(in press).

31-33. York, Lloyd's Bank site, 6-8 Pavement (Anglo-Scandinavian floor layers). Excavated March 1973. Pollen analysis (average Σ 318): J. Greig, plant macrofossils: D. Williams, insects: P.C. Buckland, H.K. Kenward. Preliminary publications: Buckland and others (1974), Kenward (1978). Final reports in preparation.

34. Stafford, Clarke St. site (Saxon occupation site). Excavated August 1975, Pollen (Σ 200) and plant macrofossil analysis from sample 1215 by J. Greig, unpublished.