The paleoecology of alluvial hay meadows in the Upper Thames valley

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Introduction

The traditionally managed alluvial flood-meadows of the Upper Thames Valley have a colourful flora which has long attracted considerable interest from botanists (Baker 1937, Tansley 1939, McDonald 2007, McDonald this volume). They belong to the *Alopecurus pratensis - Sanguisorba officinalis* grassland community, MG4 (Mesotrophic Grassland 4) of the National Vegetation Classification (Rodwell 1992).

MG4 is a species-rich mixed community of tall grasses and dicotyledonous herbs. Some of the more abundant grasses are Meadow Foxtail *(Alopecurus pratensis*) and Red Fescue *(Festuca rubra*). Great Burnet (*Sanguisorba officinalis*) is a particularly characteristic herb but other plentiful dicotyledons include:

Meadow Buttercup (*Ranunculus acris*)	Ribwort Plantain *(Plantago lanceolata*)
Yellow Vetchling *(Lathyrus pratensis*)	Devil's- bit Scabious (*Succisa pratensis*)
Red Clover *(Trifolium pratense*)	Oxeye Daisy *(Leucanthemum vulgare*)
Meadowsweet *(Filipendula ulmaria*)	Knapweed *(Centaurea nigra*)
Common Sorrel *(Rumex acetosa*)	Autumn Hawkbit *(Leontodon autumnalis*)
Yellow Rattle *(Rhinanthus minor*)	Dandelion *(Taraxacum officinale* agg.)

MG4 is a lowland grassland community of seasonally flooded ground with a deep alluvial soil. Underlying river terrace gravels enable sufficient of the fine alluvial profile to drain in summer for a good rooting depth without giving problems of drought. The flooding maintains the base status and fertility of the soil. The vegetation is influenced by a management regime which involves the meadows being shut up for hay at the end of February, mown in early July and then the aftermath grazed from August onwards.

Such grassland was formerly very widespread on the floodplain of the Upper Thames Basin but has now largely been lost as a result of grassland improvement or drainage and conversion to arable. There had been speculation amongst botanists that the floristically diverse vegetation of MG4 took several thousand years to develop. Experimental work, however, suggests that with appropriate management and a source of seeds for the community members, grassland which would be classified as impoverished MG4 results in a few decades (McDonald, this volume). Nevertheless, the traditional management regime of three meadows upstream of Oxford, Oxey Mead, Yarnton or West Mead and Picksey (Pixey) Mead, has been documented back to the 12th century (Gretton 1912, McDonald 1988, McDonald 2007).

A consideration of the origin of the hay meadows of the Upper Thames Valley needs to cover both the creation of appropriate geological and hydrological conditions for MG4 to thrive and also the palaeoecological record. Since MG4 relies on human management for its existence, there is also the question as to which natural communities supplied its members.

Methods of investigation

Extensive gravel extraction and archaeological excavation in advance of it have given many exposures of the stratigraphic sequence of the floodplain river gravels and the overlying alluvial clays. It has sometimes proved possible to obtain radiocarbon dates on organic remains within the sediments. There are many examples of datable archaeological deposits which have been found within the alluvial clays on the floodplain.

Some evidence for past hydrological change has been given by the state of preservation of organic remains in deposits that are now below the level of the permanent water table. If peaty material is present, the water table has remained above the level of the deposit since it formed. If organic remains are absent, there has been an episode when the level of the water table was below that of the deposit. Evidence for flooding can by given by the deposition of shells of riverine aquatics and by the alluvial sediments themselves.

The water table of the floodplain is sufficiently close to the surface that former river channels and archaeological features such as pits and ditches which cut into the river gravels often have undecayed waterlogged organic material at the bottom. Within the organic material are preserved pollen grains and macroscopic plant remains including seeds. Pollen is very useful at giving the broad vegetational picture for the area around a deposit although many taxa cannot be identified closely from pollen, making the differentiation between hay meadows and other categories of grassland difficult. Seeds tend to be derived from a much smaller catchment than pollen unless they have been transported amongst plant debris by human activity. Seeds do have the advantage that most can be identified to genus and many to species. Unfortunately, it is difficult to make close identifications on grasses.

In addition to plant material, insect remains particularly Coleoptera are usually preserved in waterlogged organic deposits. The range of taxa present partly reflects the vegetation contemporaneous with the deposit. Of particular relevance here, heavily grazed pasture is reflected by a high proportion of scarabaeoid dung beetles such as *Geotrupes* spp., *Aphodius* sp. and *Onthophagus* spp. whereas ungrazed grassland including meadowland is reflected by a greater proportion of legume-feeding weevils from the genera *Apion* and *Sitona* (Robinson 1983, Robinson 1991).

Many of the sequences of alluvial clay which have been investigated on the floodplain of the Upper Thames Basin have been sufficiently calcareous for mollusc shells to be preserved in them. In addition to shells deposited from the river, there are shells of snails which lived on the floodplain. The latter can be divided into two groups (Robinson 1988), one being of amphibious and "slum" aquatic taxa such as *Lymnaea truncatula* and *Anisus leucostoma* which thrive in pools of flood water in the winter and spring, retreating into cracks during the summer, and the other being of terrestrial taxa. The study of the modern molluscan faunas of floodplain grasslands in the Upper Thames Valley has shown that fully terrestrial faunas are absent from closely grazed pasture, possibly because summer conditions are too dry and exposed for snails of damp grassland to thrive and winter conditions are too wet for the xerophile snails of open habitats (Robinson 1988). In contrast, a fauna of snails which could be regarded as typical of damp grassland, such as *Vallonia pulchella* and *Trichia hispida*, occurs in the traditionally managed hay meadows.

Some evidence of the communities from which the hay meadow flora was derived can be obtained from the palaeoecological investigations of pre-Neolithic assemblages of plant remains. Further information can be derived from a consideration of present-day natural and semi-natural plant communities.

The geological and hydrological sequences

The Upper Thames drains part of a belt of Jurassic and Cretaceous sedimentary rocks which strike from Dorset northeast to the Wash and dip to the south-east. The Jurassic limestone hills of the Cotswolds comprise the watershed to the north-west. The Thames runs eastwards across a vale of Oxford Clay and, further south, Gault Clay, collecting various tributaries from the Cotswolds such as the Rivers Coln, Windrush and Evenlode, before turning to a south-easterly direction at Oxford towards the chalk escarpment of the Berkshire Downs and the Chilterns. The River Cherwell, which drains the eastern end of the Cotswolds, joins the Thames at Oxford. The Upper Thames cuts its way through the Chalk at the Goring Gap below which it is termed the Middle Thames.

The Upper Thames and the lower reaches of its tributaries are flanked by extensive gravel terraces, in places more than 3km wide. The gravel is mostly limestone from the Cotswolds and terrace aggradation occurred during cold periods of the Pleistocene on the beds of braided channels migrating across the soft bedrock of the clay. The lowest and youngest of these terraces is the Northmoor Terrace, which is Devensian (last glaciation) (Bridgland 1994). Towards the end of the final cold episode of the Devensian, Late Devensian Zone III (Loch Lomond Stadial or Younger Dryas), part of this terrace was reworked and lowered, creating what became the modern floodplain (Robinson and Lambrick 1984). Radiocarbon dates of 11,250-10,450BC and 11,200-9600BC were given by Late Devensian Zone III palaeochannels related to this process (Robinson 1992a). The modern floodplain extensively flanks the Thames and in places is up to 2km across.

During the early and mid Holocene (the Post-Glacial, from 9400BC onwards), pedological processes predominated over alluvial accretion on the floodplain (Robinson 1992a). Brown-earth soils of clay, silty clay loam and sandy loam developed above the gravel. Although these palaeosols tend to be thin, they often show evidence of decalcification. Examples of these soils have been found beneath prehistoric monuments on the floodplain. At Drayton, the gravel upcast from a Neolithic cursus ditch sealed a well oxidised calcareous brown-earth which was only 0.08m thick (Barclay *et al.* 2003). South of the Thames opposite West Mead an early Bronze Age barrow had been constructed above a brown-earth soil of clay loam which was 0.30m thick (Bowler and Robinson 1980).

The earliest evidence for a rising water table on the floodplain is from a middle Bronze Age pair of ceremonial ditches at Yarnton with radiocarbon dates clustering around 1400 BC (Robinson, unpublished). There is also clear evidence for a rising water table in the headwaters of the Thames at Latton, near Cricklade (Robinson 1999). A radiocarbon date of 1376-929BC was obtained from organic sediments in a palaeochannel which had previously been dry and had trees growing on its bed.

The rising water table of the floodplain continued into the Iron Age. By the middle Iron Age (350-1BC), seasonal inundation was occurring on the lower lying areas of the floodplain. At both Farmoor (Lambrick and Robinson 1979) and Yarnton (Robinson, unpublished) flood waters were depositing shells of flowing-water molluscs, at Farmoor in an enclosure ditch dated to 360BC-AD90. Magnetic dating of the alluvial sequence at Drayton suggested that the alluviation of the floodplain was underway by 50BC (Barclay *et al.* 2003). The average rate of accumulation of clay sediment at Drayton was around 0.5mm per annum from about AD1 to AD400. This slowed down to a rate of 0.2mm or less between about AD400 and AD800. The sedimentation rate returned to an average of 0.5mm per annum from at least AD800 until AD1100 and probably continued at this rate until some time between about AD1400 and AD1500. There are many examples of prehistoric archaeological features buried beneath the overbank alluvial sediments and of Roman to medieval archaeological features interstratified within these sediments (Robinson and Lambrick 1984). Although seasonal flooding has continued until the present day alluviation largely seems to have been complete in the medieval period.

Palaeoecological evidence for meadow-like vegetation

The only late Devensian Zone III plant assemblages so far analysed from the Upper Thames Valley have been limited in content although they included remains of arctic-alpine species such as Dwarf Birch *(Betula nana*). Much more diverse floras from the end of this period were shown by pollen of organic sediments from the Middle Thames Valley at Moor Farm, Staines (Keith-Lucas 2000) and Thames Valley Park, Reading (Keith-Lucas 1997). As well as by *B. nana*, a tall-herb meadow-like community was represented by plants such as Great Burnet *(Sanguisorba officinalis*), Meadowsweet *(Filipendula ulmaria*), Sorrel *(Rumex acetosa* tp.), Greater Knapweed *(Centaurea scabiosa*) and Scabious *(Scabiosa* sp.).

Woodland began to become established in the Upper Thames Valley with the rapid climatic amelioration around 9400BC at the start of the Holocene. Initially tree cover was sparse. For example at Mingies Ditch, on the floodplain of the Windrush above Standlake, a deposit dated to 9150-8250BC gave pollen and macroscopic plant evidence for Pine *(Pinus* sp.), a tree species of birch *(Betula pendula* or *pubescens*), Aspen *(Populus* cf. *tremula*) and willow or sallow *(Salix* sp.) but there was also a high proportion of grass pollen (Allen and Robinson 1993). Vegetational succession continued and the tree canopy became more closed. A deposit of 6600-6230BC on the same site gave evidence for *Salix* carr growing on peat fringing the river and Oak *(Quercus*)/ Elm *(Ulmus*)/ Hazel (*Corylus*) woodland on the floodplain (Allen and Robinson 1993). There was little indication of grassland.

By the later Mesolithic, woodland of Alder *(Alnus glutinosa*) predominated on the lower areas of the floodplain. Roots of alder can sometimes be found preserved in the gravels of the floodplain. An organic deposit from a palaeochannel of the Windrush at Mingies Ditch dated to 5630-5340BC contained abundant remains of alder suggesting dense alder woodland (Allen and Robinson 1993). Hazel was also present. It is thought likely that the higher areas of the floodplain supported oak woodland.

With the coming of the Neolithic around 4000BC, there was significant tree clearance in the Upper Thames Valley for agriculture and ceremonial activity. Pits related to Neolithic tree clearance were found on the floodplain at Drayton (Barclay *et al.* 2003; Robinson 1992b). Bones of domestic animals and a few cereal grains carbonised during crop processing were also found at Drayton. However, there is no evidence from waterlogged deposits for the character of Neolithic grassland.

There is surprisingly little evidence for the early Bronze Age (2000-1500BC) environment of the Upper Thames Valley. There are many early Bronze Age ring ditches (ditches around burials or burial mounds) on the river gravels. They tend to contain a layer of fine stone-free soil in their fill suggesting they experienced a long phase of stable conditions which is assumed to have been grassland (Robinson 1992b). Tubers of the grass Onion Couch *(Arrhenatherum elatius* var. *bulbosus*) are often present amongst the carbonised plant remains from the cremation burials associated with the ring ditches. This grass is characteristic of ungrazed or very lightly grazed grassland but it does not withstand heavy grazing. Perhaps the ring ditches were set amidst lightly grazed grassland from which tussocks of *Arrhenatherum* were collected for the funeral pyres. Such grassland would probably have had much in common with hay-meadow vegetation.

Waterlogged evidence is available for grassland on the floodplain in the middle Bronze Age from the pair of ceremonial ditches at Yarnton dated to around 1400BC noted above (Robinson, unpublished). There were seeds from a range of plants of well-drained circumneutral grassland. They included:

Meadow Buttercup *(Ranunculus* cf. *acris*)	Creeping Cinquefoil *(Potentilla reptans*)
Bulbous Buttercup *(R.* cf. *bulbosus*)	Selfheal *(Prunella vulgaris*)
Mouse-ear Chickweed *(Cerastium* cf. *fontanum*)	Hawkbit *(Leontodon* sp.)

There were sufficient scarabaeoid dung beetles to show that the grassland was being grazed but a relatively high proportion of weevils from the genera *Apion* and *Sitona* suggested that the grassland was not closely grazed. Hay-meadow species such as Yellow Rattle *(Rhinanthus minor*) and Knapweed *(Centaurea nigra*) were absent but the plant community seems to have shown some similarities with MG5 *Cynosurus cristatus-Centaurea nigra* of the National Vegetation Classification (Rodwell 1992). The numerous seeds of Hawkbit *(Leontodon* sp.) would not be typical of modern mesotrophic pastures such as MG6 *Lolium perenne - Cynosurus cristatus* grassland.

Lightly grazed grassland which included Oxeye Daisy *(Leucanthemum vulgare*) grew on the Thames floodplain at Wallingford in the late Bronze Age. Macroscopic plant remains were analysed from organic sediments dated between 1000-800BC from a palaeochannel of the Thames adjacent to a settlement at Whitecross Farm (Cromarty *et al.* 2006). A calcicolous element to the grassland was suggested by Salad Burnet *(Sanguisorba minor*).

A middle Iron Age (*c.*350-1BC) ditch on a high area of the floodplain at Yarnton, which was probably above any contemporaneous flood levels, contained a diverse range of grassland seeds and insects (Robinson, unpublished). Conditions were very open and the composition of the grassland seems to have been similar to that described for the site in the middle Bronze Age at least 1000 years earlier. Scarabaeoid dung beetles, especially *Aphodius* spp., showed that grazing by domestic animals was occurring. However, the range of grassland insects, such as the plantain-feeding weevils *Ceuthorhynchidius troglodytes* and *Mecinus pyraster*, vetch and clover-feeding weevils from the genera *Apion* and *Sitona*, and the grass-feeding leaf beetle *Crepidodera ferruginea*, all suggested that the grassland was not being closely grazed.

Some middle Iron Age farmsteads on the floodplain at Farmoor were also set amidst open grassland but they were experiencing seasonal flooding (Lambrick and Robinson 1979, Lambrick and Robinson 1988). There was strong evidence from both the macroscopic plant remains and the insect remains that this grassland was pasture. The wettest of these farmsteads was apparently surrounded by *Holcus lanatus-Juncus effusus* rush pasture (MG10), with numerous seeds of the tussock-forming rushes *(Juncus effusus* gp.), Silverweed *(Potentilla anserina*) and docks *(Rumex* spp.). However, there were just a few seeds from tall dicotyledons which are favoured in hay meadow such as Meadowsweet *(Filipendula ulmaria*) and Great Burnet *(Sanguisorba officinalis*). They possibly grew within the protection of the tussocks. Similar overgrazed marsh pasture surrounded middle Iron Age enclosures on Port Meadow (Lambrick and Robinson 1988), a late Iron Age (AD1-50) settlement at Thornhill Farm, Fairford (Robinson 2004a) and a late Iron Age / early Roman (AD1-125) settlement on a gravel island above the floodplain at Claydon Pike, between Lechlade and Fairford (Robinson 2007). However, there was no evidence from these sites for tall grassland dicotyledons.

The earliest evidence for the management of grassland as hay meadow comes from Claydon Pike. There was a major re-organisation of the layout of the settlement in the early 2nd century AD and it took on a more Roman character. There was a wide range of palaeoenvironmental evidence available from both the settlement and some of the outlying ditches (Robinson 2007). Three pits within the settlement contained cut hay which included stems of grass and sedge along with pods of vetches and vetchlings *(Vicia/ Lathyrus* sp.) and calyces of clovers *(Trifolium* spp.). There were also many seeds and pollen from potential hay-meadow plants including:

Meadow Buttercup (*Ranunculus cf. acris*)	Ribwort Plantain *(Plantago lanceolata*)
Meadow Rue *(Thalictrum flavum*)	Small Scabious *(Scabiosa columbaria*)
Fairy Flax *(Linum catharticum*)	Oxeye Daisy *(Leucanthemum vulgare*)
Meadowsweet *(Filipendula ulmaria*)	Greater Knapweed *(Centaurea scabiosa*)
Yellow Rattle *(Rhinanthus* sp.)	Common Knapweed *(C. nigra*)
Selfheal *(Prunella vulgaris*)	Hawkbit *(Leontodon* sp.)

A ditch on the floodplain contained a similar range of plant remains. Scarabaeoid dung beetles had fallen from 19.5% of the terrestrial Coleoptera in the previous phase, which was pastureland, to being absent from the 2nd century AD ditches on the floodplain. Clover and vetch-feeding weevils of the genera *Apion* and *Sitona* which are favoured by hay-meadow conditions comprised 13% of the terrestrial Coleoptera. Evidence from an early Roman trackway ditch suggested that the hay meadow at Claydon Pike extended as far west as Thornhill Farm (Robinson 2004a). It was argued that one of the purposes of the early Roman settlement was to supply hay to the nearby town of Cirencester (Miles *et al.* 2007).

Hay meadow was probably not a very widespread category of vegetation on the Thames floodplain during the Roman period. However, a waterlogged deposit of what is now realised to have been cut hay was found in a second century pit on the edge of the First Gravel Terrace at Farmoor and a large fourth century scythe blade, potentially indicative of hay making, was found at the end of a Roman trackway overlooking the floodplain (Lambrick and Robinson 1979, Lambrick and Robinson 1988). Macroscopic plant remains from Drayton suggested that the Roman vegetation of the floodplain was *Cynosurus cristatus-Caltha palustris* flood pasture, MG8, a type of grassland which includes some tall plants which do grow in meadowland (Lambrick and Robinson 1988).

When the new route of the A40 was constructed in the 1930s it cut through Oxey Mead. The area which lay north of the road was ploughed up and scheduled for gravel extraction, providing an opportunity to investigate the origin of the mead (Robinson 2004b). The low lying areas of the mead had a thick covering of alluvial clay which sealed an Iron Age palaeosol which in turn was above the floodplain gravel. This soil was sufficiently waterlogged to enable the preservation of some seeds from the vegetation which grew on it. They suggested marshy pasture, with many seeds of the tussock rushes *(Juncus effusus* gp.). Other seeds included Silverweed *(Potentilla anserina*) and Mint *(Mentha* cf. *aquatica*).

A palaeochannel which was formerly a minor parallel channel of the Thames ran along the northern and eastern sides of Oxey Mead and silted up between the end of the Iron Age and the medieval period. The majority of seeds from the sediment sequence were from aquatic and waterside plants. There were too few seeds of terrestrial plants to show changes in grassland composition over these periods. Although pollen showed grassland to have been a major component of the landscape, it was not possible to differentiate between pasture and meadow from the pollen. However, there were changes in the coleopteran fauna which could be related to changes in grassland exploitation. Scarabaeoid dung beetles comprised around 4.6% of the terrestrial Coleoptera in the lower part of the sequence and about half this percentage in the upper part. In contrast, weevils of the genera *Apion* and *Sitona* (excluding the mallow and nettle-feeding species of *Apion*) rose from an average of 2.2% of the terrestrial Coleoptera in the lower samples to 5.3% of the terrestrial Coleoptera in the upper samples. Other weevils which feed on grassland herbs and are favoured by hay meadow conditions such as the plantain-feeding *Gymnetron labile* and *G. pascuorum* were absent from the lower samples but were well represented in the upper samples. The insect results suggested that there was a change in the character of the grassland of the site from pasture to hay meadow between Samples 3/7 and 3/6 of the sequence. Calibrated radiocarbon dates of AD230-530 for Sample 3/7 and AD660-1010 for Sample 3/6 imply a mid-Saxon origin for the hay meadow of Oxey Mead.

The upper part of the alluvial sediments on Oxey Mead itself contained shells of the molluscs noted as being characteristic of floodplain hay meadows including *Succinea* or *Oxyloma* sp., *Vallonia pulchella*, *Limax* or *Deroceras* sp. and *Trichia hispida* or *T. plebeia*. There are many sites on the floodplain of the Upper Thames Valley where such an assemblage of shells has been recorded from the upper part of alluvial deposits or from alluvium overlying Roman contexts (Robinson 1988). Given the dating of the overbank alluvial sequence of the Upper Thames Valley, this could imply that hay meadows became extensive in the late Saxon or early medieval period.

Detailed evidence for the composition of medieval hay meadows in the Upper Thames Valley was given by the waterlogged contents of a well on a gravel island surrounded by floodplain at Claydon Pike (Robinson 2007, Lambrick and Robinson 1988). The deposits contained a coin of 1473-77. The remains in the well had not been brought to the site amongst cut hay, they had mostly fallen in from the local vegetation. There were so few seeds of non-grassland plants as to suggest that the well was set in an expanse of species-rich meadowland. The seeds included:

Meadow Buttercup *(Ranunculus* cf. *acris*)	Ribwort Plantain *(Plantago lanceolata*)
Mouse-ear Chickweed *(Cerastium* cf. *fontanum*)	Oxeye Daisy *(Leucanthemum vulgare*)
Fairy Flax *(Linum catharticum*)	Knapweed *(Centaurea nigra*)
Common Sorrel *(Rumex acetosa*)	Hawkbit *(Leontodon* sp.)
Cowslip *(Primula* cf. *veris*)	Dandelion *(Taraxacum* sp.)
Yellow Rattle *(Rhinanthus* sp.)	Jointed Rush *(Juncus articulatus* gp.)
Selfheal *(Prunella vulgaris*)	Sedge *(Carex* spp.)

As in the Roman deposits from this site, there were also pods of. vetches and vetchling *(Vicia/ Lathyrus* sp) and floral parts of clover *(Trifolium* sp.). The pollen and insect evidence fully supported the results from the macroscopic plant remains.

Discussion

The Late Devensian evidence suggests that the flora of the traditionally managed hay meadow of the floodplain of the Upper Thames Valley had much in common with naturally occurring cold-tolerant tall-herb grassland. Indeed, most of the members of MG4 and MG5 have modern distributions which extend far to the north in Europe (Tutin *et al.* 1964-80). While for present-day hay meadows it is management which prevents scrub succession and provides protection against late spring/ early summer grazing, in Late Devensian Zone III, the sub-arctic climate held back woodland development and this was a period of low grazing pressures from large herbivores. Late Devensian insect assemblages contain a much lower proportion of scarabaeoid dung beetles than Mid Devensian assemblages.

With the climate amelioration of the Holocene, the grassland communities of the Upper Thames Valley were gradually shaded out by woodland. The extent to which grassland plants managed to maintain a presence in the region during the mid to later Mesolithic (between about 7500 and 4000BC) remains unknown. Some plants of hay meadow such as *Filipendula ulmaria* and *Succisa pratensis* will grow in the light shade of small openings of damp woodland created by fallen trees. Others, such as *Leucanthemum vulgare* show somewhat ruderal tendencies and thrive on crumbling steep river banks although they do need full illumination. However, it is thought unlikely that all the members of what were to become the hay meadow community were able to persist locally.

With the creation of open grazed habitats from the start of the Neolithic onwards, grassland became re-established in the region. However, it must be stressed that there is no evidence for grassland being managed as hay meadow before the Roman period. Some grassland was sufficiently lightly grazed that it developed a diverse flora in which many of the dicotyledons were able to set seed. The flora of this grassland probably had some similarities to hay meadow. Other potential hay meadow plants probably found refuge in rush tussocks on heavily grazed pasture on the floodplain.

It must also be remembered that the relevant hydrological and soil conditions for MG4, winter flooding and a covering of fine alluvial sediments above the river terrace gravel, did not become widespread on the floodplain of the Upper Thames Valley until the Roman period. Indeed, it is possible that there was not a sufficient depth of alluvial soil over much of the floodplain to support MG4 before the end of the Roman period.

Once grassland on the floodplain was managed for hay production in the early Roman period, a distinctive hay-meadow flora seems to have developed rapidly. However, from the archaeobotanical evidence, it is not possible to determine whether the Roman and medieval hay meadow was MG4 *Alopecurus pratensis-Sanguisorba officinalis* grassland, or a category of traditionally managed hay meadow which occurs on a range of lowland circumneutral brown-earth soils (Rodwell 1992). No examples of *S. officinalis* were found in either the Roman or the medieval examples to confirm the hay meadows were indeed MG4 while the occurrence of *Scabiosa columbaria* and *Centaurea scabiosa* at Roman Claydon Pike suggested a calcicolous element absent from both MG4 and MG5.

Two factors favoured the development of hay meadows on the floodplain in the Roman period. The first was the changing hydrology such that the floodplain was not being managed to its best potential. There was damage to pastureland caused by overstocking under wet conditions from the middle Iron Age onwards and early Roman ploughing was occurring in waterlogged soils which had become unsuitable for cultivation (Robinson 1992a). Once some alluvium had been deposited on the floodplain it would become ideal for growing hay. The cutting of hay and grazing of the aftermath when the soil was not waterlogged would have prevented damage to the soil. The other factor was the rise of towns which created an increasing demand for fodder especially for horses.

Following the end of the Roman period, urban life collapsed in the Upper Thames Basin in the 5th century AD. However, from the 9th century AD onwards, Saxon urban centres developed, renewing the demand for hay. By the medieval period, hay was important as winter fodder on rural settlements as well as being used in towns and so meadowland became the major use of the floodplain of the Upper Thames Valley. Indeed, floodplain became some of the most valuable agricultural land in the region.

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