The Management of Archaeological Sites in Arable Landscapes BD1701

Final Project Report
Supporting Documentation

Appendix F:
Case Studies of Archaeological Damage from Arable Activities

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Appendix F
Case studies of archaeological damage from arable activities

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1 TYPES OF DAMAGE TO ARCHAEOLOGICAL SITES CAUSED BY DIFFERENT ARABLE ACTIVITIES

1.1 Introduction

1.1.1 This Appendix provides a more detailed account than was possible in the summary paper CSG15, of how arable agriculture can affect different types of archaeological remains and provides detailed illustrative examples. Examination of this evidence enabled the Models to be developed as discussed in Appendices G and H and provided the basis for the discussions and recommendations included within the main report CSG15.

1.2 Cultivation of previously uncultivated archaeological sites

1.2.1 The cultivation of previously uncultivated archaeological sites is probably the most serious type of threat within the context of this subject. Unploughed sites are normally the best preserved and survive very close to the ground surface. If a site is ploughed, the depth of archaeological remains beneath the current ground surface will depend on the depth to which it has been cultivated.

1.2.2 Figure 1 shows Madmarston Hill (Oxon.) from the air both as unploughed earthworks before it was ploughed and as cropmarks after ploughing. Figure 2 shows what was left of the ramparts on the ground after cultivation.

1.2.3 Hart (1981) gives a clear demonstration of the destructiveness of ploughing a site for the first time:

In the last ten years shorter-stemmed and stronger varieties of corn have become available. These are suitable for use in the highland regions of North Derbyshire and in the last two years there has been an increase in arable of approximately 1,000 acres. It takes two ploughings to break the virgin sods and after a third ploughing the shallow soils have been disturbed to bedrock depth, leaving little or no archaeological strata other than pit, ditch or posthole fillings, cut into the secondary soils or natural rock (Hart 1981, 5).

1.2.4 The Past under the Plough (Hinchcliffe 1980) recorded that at Bishop’s Cannings Down (Wilts.) 0.10m of archaeological deposits were lost from a previously undisturbed archaeological horizon, after only 5 seasons of ploughing. Ploughing had destroyed all pre-existing occupation levels and therefore all stratigraphic relationships, with only 1% of finds remaining in the subsoil. Likewise at Brigstock (Northants.), trial trenches excavated over a wide area revealed that some of the archaeological sites were in such bad condition that they had virtually been destroyed by ploughing, despite the fact that ploughing had only occurred 6 times in the space of 100 years (Bellamy et al. 1983).

1.2.5 The preparation of land prior to ploughing can also be enormously damaging. Cultivation of reclaimed areas for the first time often involves drainage operations (see below) and use of large earth moving machinery. There are cases where burial mounds have been flattened with bulldozers prior to cultivation, eg Sale’s Lot Long Barrow at Withington (Glos.) (O’Neil 1966), originally 117 ft long, 60 ft wide and 3 ft high. This fate also befell the prehistoric earthworks near Badbury Rings in Dorset (Gingell et al. 1987). A more recent example involved a Neolithic long barrow at Uplowman Road, Tiverton (Devon) where the mound was levelled prior to cultivation, before it could be scheduled, with the result that only the underground
remains were left for scheduling (Smith 1990). At Thelveton in Norfolk a farmer claimed a loss of memory as mitigation for instructing contractors to flatten scheduled earthworks associated with a Roman settlement resulting in the site being ploughed to a depth of 8-10 inches (Broughton 1998).

1.2.6 The flattening of earthworks not only destroys their physical remains and makes them more vulnerable to accidental damage, but can also alter our perceptions of them:

> There is typically also a scale- and attitude-related loss with the destruction of earthworks, because people stop investigating plough-levelled remains in ways that relate them intimately and routinely to the remaining fabric of the landscape - buildings, roads, planting etc (P Everson pers. comm.).

1.3 Understanding cropmarks/soilmarks

1.3.1 One of the legacies of ploughing previously unploughed archaeological sites is that they are subsequently often only visible from the air as cropmarks or soilmarks. (Figure 3). These sites will have had their upper layers destroyed, but will often retain much of their below-ground integrity intact, and can therefore still retain significant archaeological information. Most sites in arable areas in fact only survive as cropmarks/soilmarks, but there is very little provision within either policy or legislation to protect these monuments from further arable damage. Figure 4 shows a typical cropmark as seen from the air showing a Neolithic cursus and Bronze Age round barrow at Drayton St Leonard, (Oxon.). Figure 5 illustrates the sort of archaeological remains commonly found just below the ploughsoil, seen here at Larkwhistle Farm, Brimpton (Berks), showing a Middle Iron Age enclosure and two hut circles (A Hardy pers.comm).

1.3.2 The identification of cropmarks/soilmarks from aerial photographs can be a useful tool for archaeologists. The study of cropmarks over whole landscapes allows an insight into past landscape utilisation and the types of settlement that formerly existed.

1.3.3 The study of cropmarks can also provide insights into the condition and survival of archaeological remains below the ploughsoil. Features seen on early photographs that have been photographed regularly since, have shown a preponderance of visible features immediately after initial ploughing. This is often followed by a gradual decrease in detail as the tops of ditches and other features are truncated by the plough and removed through soil erosion (Van de Noort and Ellis 2000, 180).

1.3.4 During work in the Walton Basin (Powys) on the site known as Hindwell I, part of one cropmark showed as a ‘tramline’ cropmark (where two darker lines form the edge of the ditch). Tramlines such as this have been identified as being a product of plough degradation, where the upper ditch silts have been dispersed, exposing the lower, finer-fractioned and water retentive soils at each side of the ditch. Subsequent excavation of the feature proved this theory correct and it was estimated that 0.3m may have been lost from the upper levels of the ditch by erosion and ploughing (Gibson 1998; 1996).

1.3.5 In a study of cropmarks in Angus, it was recorded that where cropmarks appear very clear on aerial photographs, excavation often revealed that the features below the ploughsoil were poorly preserved, but where the cropmarks appeared ‘fuzzy’, excavation showed these features to be in better condition (D Alexander pers. comm.).

1.3.6 There have also been instances where cropmarks have been identified from recent aerial photographs, but when excavated no features survived. It may be complacent
therefore to suppose that because cropmarks are visible that there are still the remains of archaeological sites below the ploughsoil. Perhaps what is being seen in some cases are the very last remnants of features and deposits influencing crop growth before they disappear (Taylor 1994). This phenomenon was seen during a study of soil marks near Winchester (Hants.) where such ‘ghost’ features were identified. Here evidence indicated that such soil marks may appear as ground surface expressions of ditches that have been removed by plough damage but where dispersal of ploughsoil is minimal. Such soil marks may be only short-lived if plough depth continues to increase (Taylor 1979; R Palmer pers. comm.). A similar situation was seen during work carried out for OA on the Cambridge County Farms Estates (Abrams and Macaulay 2001, 10, reproduced in full as Appendix Jv), where soil erosion had contributed to the disappearance of half a circular feature seen previously on aerial photographs.

1.4 Lateral erosion on archaeological sites

1.4.1 Sites that exist as islands within cultivated fields are vulnerable to gradual encroachment by ploughing, sometimes only a furrow at a time, destroying upstanding monuments bit by bit. Encroachment by ploughing is known to alter the shape of upstanding monuments gradually, making their interpretation and identification difficult. For example, at Hazleton long barrow (Glos.) ploughing gave the barrow an artificially rectangular shape (Saville 1990).

1.4.2 Eventually this gradual encroachment, if not halted, can lead to the total loss of a monument. If the earthwork survives to a reasonable height this gradual chipping away can lead to the undercutting of an upstanding monument, causing mini-collapses every time the plough bites. This has been recorded at Horslip, Beck Hampton and South Street long barrows, all near Avebury (Wilts.), where ploughing had not only denuded the mounds, but also eaten into their sides (Ashbee et al. 1979). At Cherbury Camp Iron Age hillfort (Oxon) it was recorded that the tail of the rampart had been ‘shaved’ by cultivation by between 5-10 feet (Lewis and Miles 1985, 116). In Cambridgeshire almost all round barrows isolated in fields are being damaged by close ploughing (or simply ploughed over) (Taylor 1994,76). As part of the management and condition survey of the Avebury World Heritage Site (OAU 2000b) numerous barrows were identified where ploughing was causing lateral erosion to upstanding earthworks. Figure 6 shows this happening at Barrow 5937 within the World Heritage Site and Figure 7 shows a similar fate at Scutchamer’s Knob (Oxon.) (see also Figure 3 for an aerial shot illustrating this at Cranborne Chase, Dorset).

1.4.3 Encroachment can also occur accidentally around upstanding monuments, as the visible earthwork is often only a small part of the overall archaeological resource. A burial mound for example will often have an associated, but unseen ditch around it, or there might be associated settlements, field systems or other ritual monuments in the near vicinity, which may often be unrecognisable at ground level.

1.4.4 Lateral erosion can be seen in many places, including at the Four Stones in the Walton Basin (Powys). Here ploughing has avoided the standing stones, but close ploughing has appreciably lowered the land surface around them, so that they appear to stand on a slight knoll or spur. The ploughing which caused the lowering of the ground around the stones would have badly damaged any features associated with them (Gibson 1998). This phenomenon can also be seen at Winterbourne Steepleton (Wilts.) where recent ploughing has disturbed the intricate relationships between upstanding monuments, and buried settlement traces (Woodward 1991).
1.4.5 At Long Hoe Hill long barrow (North Lincs.) a bank forming an enclosure protected the above-ditch sediments from the damaging reduction in soil level by ploughing seen in the adjacent fields (at least 0.6m of height difference was observed). The excavator observed that in Lincolnshire today many barrows without definite banked enclosures are clipped by ploughing, causing the relationship between the barrows, their associated quarry ditches and the long land-use history contained within the archaeological layers above the old quarry ditches, to be lost (Phillips 1989, 188).

1.4.6 At the Rollright Stones (Oxon.) ploughing has occurred to within 0.5m of the railings protecting the Whispering Knights standing stones. This has resulted in the ground surface being lowered on the south side by about 0.50m since 1920 (Lambrick 1986). More rapid erosion has occurred in the last 10 years, when ploughing has encroached even closer to the stones, resulting in up to 0.15m of soil being washed away from the base of the stones within the protective railings (Figures 8 and 9). This loss has been recorded over the years through periodic surveys (a graphical representation of these results can be seen in Appendix Jvii) (Rollright Trust 2002).

1.4.7 At Wyke Down, Cranborne Chase in Dorset four detailed barrow surveys were undertaken where the effects of lateral encroachment by ploughing were recorded, including the occurrence of ‘truncation steps’. OA commissioned a short report on the results of this survey (French 2001), reproduced in full as Appendix Jiii.

1.5 Deeper ploughing (or subsoiling) of existing arable or grass leys on already cultivated sites

1.5.1 Any form of disturbance which penetrates deeper than the extant ploughsoil can cause damage to underlying archaeology. Particular culprits, in addition to ploughing and subsoiling, can include roots of crops such as sunflowers, energy crops, potatoes and sugar beet and the preparation work for and harvesting associated with certain crops such as potatoes (see below).

Deep mouldboard ploughing

1.5.2 The type of implement and cultivation technique used will often influence the extent of new damage to archaeological sites. For example, if the site is deep ploughed the damage can be very widespread, whereas if the site is subsoiled the damage can vary considerably depending on the soil conditions, the way the implement is used and the type of archaeological site affected. Deep ploughing is often carried out to deepen the ploughsoil by including subsoil within it and to break-up soil pans.

1.5.3 Photographs showing scouring caused by deep ploughing and subsoiling can be found in Appendix Ji. Figures 10 and 11 show plough scouring across two recently excavated sites at Stanwick Roman villa (Northants.) and Leiston Abbey (Suffolk).

1.5.4 Deeper ploughing on a farm is often associated with the introduction of new technology or new plough equipment. For example, at Ardleigh in Essex when tractors first replaced horses, the new plough cut c 0.10m deeper into the soil, increasing the ploughsoil depth from 0.20m to 0.30m. The farmer stated at the time that this led to the discovery of much archaeology on the farm, including Roman and Bronze Age pottery which subsequently led to the excavation of a large Bronze Age cremation cemetery (Brown 1999, 4).

1.5.5 In the environs of the Roman town of Silchester, it was recorded that:

*The depth of cultivation has been seen to be an important factor, affecting the recovery of material. LP6805 has been regularly walked for eight years, yet it was only in the last two seasons that any material was recovered.*
Conversation with the ploughman revealed that the depth of ploughing had been increased from nine to twelve inches... The effect of this extra penetration was startling; nearly 12 kg of pottery were recovered, about 25% of which was pre-Conquest, including the earliest material yet found (Corney 1984, 245).

1.5.6 The Orsett Causewayed enclosure (Essex) was deep ploughed/subsoiled every three years. On excavation the effect of this deep ploughing was examined. It was found that the entire site was striated by east-west and north-south plough marks, 0.06-0.10m wide and 0.70m apart, and that ditch fills were being dragged by the plough into the surrounding natural and vice versa. It was recorded that the maximum penetration below the ground surface of these plough marks was c 0.40m: 0.15m below the upper surface of the remaining archaeological deposits (Essex CC nd).

1.5.7 At Goose Acre Farm (Oxon), a scheduled Roman settlement site was ploughed to a greater depth in one season by a ‘heavy handed ploughman’, much to the annoyance of the farmer. The resulting destruction caused vast quantities of building materials and pottery to be brought to the surface, presumably causing much damage to the underlying archaeological deposits (Miles 1980). Similarly one episode of deep ploughing on a field near Coughton (Warks) lifted up a medieval stone road surface, clearly recognisable as such when seen on the surface of the ploughsoil (Figure 12).

1.5.8 At Tower Hill (Oxon) a bronze hoard was first discovered through a single episode of unusually deep ploughing instigated in an attempt to incorporate straw into the ploughsoil. This event disturbed and scattered the hoard which had previously been buried in the surface of the bedrock. Subsequent excavations revealed that the upper surface of the chalk was fissured, stained and coloured indicating decay, with evidence of repeated episodes of gouging by modern ploughs (Miles, et al. forthcoming). Conversations with the farmer revealed that deep ploughing was regularly undertaken in the area to increase ploughsoil depth by bringing up decayed chalk bedrock into the ploughsoil. The fertility of these inorganic ploughsoils was maintained using large amounts of chemicals.

1.5.9 At Gosbecks Roman site (Essex) both plough and subsoiler marks were recorded during excavations in the 1970s over both the temple and theatre. By comparing the results of these excavations with those carried out previously in 1936, it was estimated that in the area of the temple the rate of erosion over the site from deep ploughing and subsoiling probably amounted to a loss of 0.15m of archaeological deposits in the 40 intervening years. Similar comparisons looking at the depth of the mound covering the theatre from 1948 to 1977 suggested that erosion of the profile had caused a loss of c 0.15-0.20m of material in the intervening 30 years (Crummy and Smith 1979).

1.5.10 As part of the Wroxeter Hinterlands Project (White forthcoming) an archaeological investigation of Duncote fort, a rectilinear double-ditched enclosure thought to be of Roman date, was carried out in the 1990s. One of the objectives of this work was to compare the results with those of excavations undertaken in 1975. The excavations showed that in the intervening 20 years the ploughsoil had doubled in depth and that whereas in 1975 many internal features survived within the enclosure, they had all been destroyed by the 1990s. The only features to survive were the deeper ditches of the enclosure itself. A similar result was recorded at Berrington/Cross Houses, where an evaluation was carried out on the site of an extensive field system and barrow field, identified and plotted from aerial photographs. Excavation revealed no surviving archaeological features, finding instead deep ploughing marks only. White concludes that ‘both field system and enclosure have either been severely damaged by
modern ploughing or have been totally erased since they were first recorded 30 years ago’ (ibid).

1.5.11 Similarly comparisons between excavations carried out at Barrow Hills Radley (Oxon.) in the 1930s and 1980s showed the archaeological stratigraphy below the subsoil was much deeper in the 1930s than seen in the 1980s. For example, in the 1930s features and truncated deposits existed above the subsoil, including buried ground surfaces and the remains of the barrow mound. In the 1980s no barrow soil survived, nor did any deposits that were not cut into the subsoil. This was thought to be the result of progressively deeper ploughing on the site (Barclay and Halpin 1999).

1.5.12 Cemeteries in particular suffer badly from the effects of deeper ploughing episodes. At Cleatham Anglo-Saxon cemetery (Lincs.), excavations in 1984 revealed limited plough damage to the shallower cremation urns only, and that the urns within the subsoil were intact and well preserved. On returning to the site in 1985 for further excavation, a change was observed in the preservation of the archaeological deposits. In 1985 the subsoil could be seen to be deeply grooved at 0.5m intervals and the urns within the subsoil were now being damaged. The resulting investigations revealed that the farmer had, in the intervening year, deep ploughed the site to remove panning caused by the use of heavy agricultural machinery within the field (K Leahy pers. comm.).

1.5.13 At Owmby (Lincs.) part of a stone coffin was brought to the surface as a result of an episode of slightly deeper ploughing (Figure 13). Subsequent excavation of burials in the same area revealed that the skeletons had undergone significant damage by this ploughing (Figure 14) (McAvoy 2002). English Heritage have kindly prepared a report summarising work undertaken at Owmby with a specific focus on damage caused by cultivation for the purposes of this study. This has been reproduced in full as Appendix Jix.

1.5.14 At Barrington cemetery (Cambs.) damage caused to graves by cultivation was documented in detail during excavations. In reporting this damage Malim and Hines (1998) classified agricultural damage into four main categories:

- normal ploughing, detected as swathes cut through the skeletons, dislodging or scattering articulated bones
- pan busting which could be seen as a single plough scar running through the skeleton (often not displacing other parts of it)
- old damage where graves were cut by drainage pipes inserted in the 1840s.
- Compression, caused by the use of heavy machinery causing most of the larger post-cranial bones and most of the skulls to be broken and dragged out of position. The skulls had suffered most because many had originally been ‘pillowed up’ in their graves, resulting in severe crushing and loss of bone fragments.

1.5.15 At the Spong Hill Saxon cremation cemetery (Norfolk), initial excavations in 1954 were undertaken to rescue cremation urns disturbed by ploughing. By 1968 Spong Hill was being deep ploughed, and this had produced a fresh scatter of pottery sherds over the field. The subsequent excavations revealed that 2262 cremations, 57 inhumations and a contemporary settlement lay within the field. Many of the urns had been crushed in situ; others slightly higher in the soil had been all but destroyed, with only their bases surviving. Some of the damaged cremations even had potatoes in them, left over from the previous year’s crop (Rickett 1995). The damage caused to cremations by ploughing is illustrated in Figure 15, taken during excavations of the Roman settlement and cremation cemetery at Westhawk Farm (Kent).
1.5.16 In Suffolk and Norfolk, a close relationship is maintained between the County Archaeological Services and local metal detectorists and the first indication of the presence of an Anglo-Saxon cemetery is often through metal detectorists finding metal grave goods in the ploughsoil. These sites are frequently found after an episode of deeper ploughing has brought the metal artefacts to the surface. This policy of close co-operation between metal detectorists and the County Archaeologist has led to the discovery in Norfolk of 6 new early Anglo-Saxon cemetery sites in 2000, 24 in 1999 and 24 in previous years (H Geake pers. comm.). Most metal detected finds are attributable to quite a narrow date range, often narrower than pottery finds. Examples occur where 4th-century metal work is found in the first year of metal detecting a plough damaged site and where over the years the date of these finds gets progressively earlier, implying the plough is biting a little deeper each year into earlier and earlier deposits.

1.5.17 Apart from an obvious increase in archaeological artefacts suddenly appearing on the surface of the ploughsoil, one way of assessing whether deeper ploughing or subsoiling is causing new damage to an archaeological site is through the presence of freshly disturbed subsoil/bedrock on the surface of the soil (Figure 16). This was seen to be occurring at Hambledon Hill causewayed enclosure (Dorset) prompting its excavation. Plough furrows were recorded running across the remaining subsoil surface and of the 97 pits excavated only the bases of these features survived. It was estimated that c 0.30-0.40m of soil had been lost from the original ground surface since the Neolithic period. The author of the excavation report concluded that ‘the archaeology of such a surface can only be said to be in a terminal state and its recording an immediate necessity’ (Mercer, 1980b 23).

1.5.18 Excavations carried out in 1978 on the Scheduled Roman town of Verulamium (Herts) indicated that although plough damage had occurred in the past, it had stabilised, and it was predicted that the site would not be damaged further unless future ploughing occurred to a greater depth than 8½ inches. In 1987 new concentrations of fresh artefacts and building materials were observed on the surface of the ploughsoil, indicating that deeper ploughing was taking place. Several of these ‘new’ concentrations were dominated by particular types of material - pottery, food remains and building debris, suggesting that in situ deposits such as middens or stratified levels were being affected (Niblett undated).

1.5.19 Increasing concern expressed about the continued damage to the site led to investigative work being commissioned by English Heritage. A series of test pits were excavated across the north-western part of the SAM, specifically to assess the new on-going plough damage. This showed that over much of the site modern ploughsoil directly overlay in situ archaeological deposits and that these deposits were being actively damaged as a result of deep ploughing (OAU 2000c).

1.5.20 The resulting report commented that:

*The majority of these concentrations [of artefacts] overlay, or were close to, buildings identified from aerial photography. The foundations of these buildings are likely to have been of flint and mortar (hence their paler appearance on air photographs). The suggestion that the plough is normally ‘raised’ over areas of masonry, thus safeguarding archaeological deposits, cannot therefore be substantiated* (OAU 2000c, 16).
1.5.21 The report records six main strands of evidence which suggested continuing damage by ploughing:

- previous work in 1978 in one of the fields showed the presence of an old ploughsoil acting as a buffer, protecting archaeological features underneath it. By 2000 this had been ploughed away
- extensive new concentrations of artefacts not present in earlier surveys were recovered (see above)
- many artefact concentrations showed no abrasion suggesting they had only recently been brought up into the ploughsoil
- areas where previously identified artefact concentrations no longer existed, indicating the destruction of underlying deposits
- occurrence of defined streaks of natural gravel subsoil on the surface of parts of Field 2 which could only have resulted from the deposition of this subsoil material during the most recent episode of ploughing
- the fill of the plough scars across the subsoil and archaeological features being identical to the modern ploughsoil; if it represented earlier plough scarring the fill would be different (OAU 2000c).

1.5.22 As part of this project a model was compiled showing variations in ploughsoil depth plotted against surface contours, showing by implication those areas at highest risk of plough damage (Figure 17). This can be compared with the distribution of deposit types found during the test pit evaluation showing areas where ploughsoil came down directly on top of archaeological deposits and where archaeological deposits were protected by a layer of old ploughsoil, etc (Figure 18).

Subsoiling

1.5.23 The damage that subsoiling an archaeological site can do varies a great deal between sites, depending on its application and on the types of archaeological deposits present. Subsoiling is often carried out to break up soil pans which have formed below the base of the ploughsoil. On some subsoiled archaeological sites disturbance takes the form of mixing of soils and reworking of buried objects so that they no longer reflect their original stratigraphic position. On other sites, especially cemeteries, a great deal of damage can be caused. For example at Warborough Roman cemetery (Oxon.) c 2000 acres were subsoiled once, leading to a lead coffin being dragged to the surface, badly bent and with the lid cut in two by the subsoiler (Harman et al. 1978) (Figure 19). Subsequent excavation trenches designed to examine in detail the effects of this subsoiling, indicated that 25% or more of the skeletons within the field had been damaged by this one subsoiling operation. Figure 20 shows how subsoiling on the site looked from the surface.

1.5.24 It was ascertained during these excavations that the subsoiler had been set to work to a depth of 0.20m-0.50m to break up a soil pan. The excavations revealed that the subsoiling caused disturbed lines of broken-up loose soil to a depth of 0.52-0.56m, with V-shaped profiles 0.05m wide at the bottom and 0.40m wide at the top. The subsoiling was executed across the axis of the graves, therefore badly damaging sections of the bodies. It was predicted at the time that if the process was subsequently repeated at right-angles to the previous episode, as is the norm (i.e. along the axis of the graves), the damage would be much greater as the tines would affect whole burials, not just sections of them (Miles 1980).

1.5.25 Subsoiling depths can vary; during investigations at Northfield Farm (Oxon.) subsoiling had penetrated to a depth of, on average, 0.70m below the ground surface. The effects of subsoiling have also been recorded at the Iron Age enclosure at Burslea Grange, Holme-on-Spalding Moor (Yorkshire) (Halkon, 2001 see Appendix Ji).
1.5.26 During a survey of cropmarks in the Perth area (Scotland), Burke (2002) recorded subsoiling scars in excavation trenches located to investigate a prehistoric enclosure recorded on aerial photographs. The scars were distinct from normal plough furrows in that they contained a mixture of topsoil and subsoil and penetrated some 0.18m into the subsoil, c. 0.50m below the ground surface. Wider excavation in this area revealed that the whole of the surface of the subsoil had been heavily scarred by plough furrows, subsoiler scars and field drains. All these modern intrusive features had cumulatively caused significant damage to the below-ground archaeological deposits. Many of these scars ran at right-angles to each other, creating a lattice effect on the subsoil surface (ibid).

1.5.27 In a study of the effects of ploughing on crop-mark sites in the Milfield Basin (Northumberland) (Waddington 2001) subsoiling and deep ploughing were identified as the most destructive agricultural techniques affecting the archaeological resource. Archaeological evaluation of cropmark sites showed that in many cases the most valuable archaeological deposits had been heavily truncated or destroyed altogether. Many of the sites being affected by this process were Scheduled Monuments, including that at Coupland, where bright orange-brown sand and gravel was regularly witnessed being brought to the surface by subsoiling, and where the plough zone averaged between 0.4-0.45m in depth. Its Scheduled status has obviously not protected it from this destruction and the landowner claims that it has been subsoiled on a regular basis since it was Scheduled.

1.5.28 It has been argued by some that subsoiling/deep ploughing to break up soil pans is not actually necessary. At Orsett (Essex) deep ploughing was undertaken to remove a reputed build-up of pan in the subsoil. However, excavations revealed that the panning actually occurred at c. 0.60m below the ground surface, well below the depth of deep ploughing and would only have impeded crop growth and/or drainage in two small areas of the field (Essex CC nd).

1.5.29 Similarly, at Woodham Walter enclosure complex (Essex), panning was recorded at a depth of 0.20-0.60m, which resulted in the field being subsoiled to a depth of c. 0.38-0.46m. It was argued by archaeologists at the time that this pan only occurred in localised areas of the field and that the pan had not prevented the extra crop growth necessary to produce clear cropmarks visible from the air. They suggested that this implied that subsoiling was unnecessary as panning was not such a problem as to affect crop performance (Essex CC nd).

1.6 **Potato cultivation**

1.6.1 Potato growing requires deep ploughing and a series of cultivation and harvesting techniques that are beyond the scope of conventional ploughing in terms of disturbance of the ground:

- Subsoilers may be required to loosen the ground and improve drainage, reaching depths of between c. 0.3-0.9m
- Potatoes require good seed-beds and de-stoning of the soil can occur
- The seedbeds are constructed by bed-formers
- Further disturbance occurs at harvest with a flat share passing under the seedbed to lift the potatoes.

1.6.2 All these techniques disturb the integrity of the soil and any archaeological deposits within or below it, to a depth greater than normal ploughing would achieve (Figure 21). De-stoning also destroys archaeological stratigraphy and disturbs artefact distributions, sometimes entirely removing artefacts from the field.
1.6.3 White (2001) has undertaken an analysis of potato growing in Herefordshire (full text in Appendix Jii) which showed conclusively that the growing and harvesting of potatoes is particularly destructive to archaeological sites. The study also draws attention to the fact that the amount of land given over to potatoes in the county has increased significantly since 1998 (see also Appendix H for map showing other areas of the country where potato growing has increased). One of the consequences of this recent trend is that previously unploughed/permanent grassland sites are often being ploughed up for the first time and used to grow these potatoes, as previously uncultivated land is more likely to produce unblemished crops, being free from the pests that often damage potato skins.

1.6.4 White (ibid) has also identified the fact that these pasture fields are often located on valley sides on soils which are not deep (one of these new potato fields was excavated at Cradley, located at c 200m OD with only 0.25m of ploughsoil over bedrock). He predicts that the cultivation of these former hillside pastures will lead to an increased risk of soil erosion and the further thinning of the ploughsoil (see below). White identifies a further risk to archaeological remains through the fact that potato fields often have to be irrigated just prior to harvest to prevent bruising to the crop. This may lead to damage occurring to the soil structure, rutting and compaction, caused by heavy machinery working on wet soils (see Appendices D and E). White also points out that increasingly large contractors are brought in to cultivate and harvest these crops, who often use state of the art, large machinery necessitating the removal of historic field boundaries and further adding to the problems of compaction and rutting and with the loss of field boundaries, soil erosion.

1.6.5 White comments that:

Clearly factors such as topography, slope, and the depth of ploughsoil will not prevent a potato crop being cultivated. The implication of this is that previously uncultivated areas, especially within the pastoral hill-farming community in the south-west of the county, be converted to arable cash-crops, such as potatoes’ (ibid, 38).

1.6.6 As part of this work Herefordshire Archaeology has undertaken a series of evaluations to demonstrate and understand the precise impact that potato growing has on the archaeological resource; details of this illuminating piece of work can be found in Appendix Jii).

1.6.7 Concerns about potato growing were raised as far back as 1998 in Worcestershire. In British Archaeology (Denison 1998) an article recorded that there was a perception amongst conservationists in the county that the rate of pasture loss was accelerating as they were increasingly being ploughed up to a depth of c 0.5m for potatoes. Examples quoted included:

- the ploughed deserted medieval village, which included the remains of a ridge and furrow field system at Vowchurch, where the farmer removed eight hedges thought to date from the 14th century and ploughed the land for potatoes
- cropmarks thought to represent a late prehistoric settlement near Eardisland recently obliterated by potato ploughing.

1.6.8 Also in this article a link was made between the increase in the growing of potatoes on old pasture and the BSE outbreak. Duncan Brown, SMR Officer for Worcestershire, is quoted as saying that:

[it] was frightening to contemplate the number of long-established pastures now being ploughed for potatoes. Pasture has always been ploughed up, but
what worries me is the scale of what’s happening now in Herefordshire, and probably everywhere else affected by BSE (Denison 1998).

1.6.9 Numerous people consulted as part of this study raised similar concerns about potato growing and especially the associated effects of de-stoning fields. During a study of cropmarks in the Milfield Basin (Northumberland), Waddington (2001) has also identified a recent shift towards root crops, particularly potatoes and carrots which has led to a dramatic increase in both subsoiling and ploughing across the valley (see also above). Particularly severe effects have been identified on archaeological sites on the sand and gravel terrace, the alluvial floor and on the Cheviot slopes.

1.6.10 The problem has also been flagged up by archaeologists working in East Anglia, where whole estates have recently been de-stoned prior to growing of potatoes (H Geake pers. comm.), eg at Subourne (Suffolk) where red earth and saltworking debris of a saltern site were exposed in de-stoning trenches c. 0.46m deep (C Pendleton pers. comm.). Pendleton also draws attention to the fact that ‘there are also numerous examples of finds [being retrieved] from sugar beet, potato and carrot harvesting machines, washing and processing plants’ (Pendleton 1999, 64).

1.6.11 At Blaxhall (Suffolk) two pieces of Anglo-Saxon brooch were found in 1988 by metal detectors. This same area of land was subsequently de-stoned for the first time in 1995 for potatoes, after which it was metal detected again. This resulted in a further 10 pieces of brooch being found along with many other metal finds, indicating that fresh archaeological deposits had been disturbed during the growing of this first potato crop (Figure 22) (H Geake pers. comm.).

1.6.12 Recently at Bromholm Priory (Norfolk) the farmer changed the plough depth from the normal 0.30m to 0.36m to prepare the field for potatoes, planted by contractors using large-size baulks. Archaeologists carrying out ongoing non-intrusive survey work in the field subsequently noted a dramatic increase in the areas of orange sand (the underlying natural) spread across the ploughsoil surface and the appearance of a skeleton pulled up by the plough. The crushed remains of a pelvis, vertebrae, some still articulated, and ribs were seen still orientated in their original Christian east-west burial orientation, having been flipped over by the plough travelling an east-west direction (Dr Pestell, pers. comm.). This confirms White’s concerns (2001) that just one episode of ground disturbance associated with the growing of potatoes can cause a significant increase in the destruction of an archaeological site.

1.6.13 At Newton Cliffs (N. Lincs.) excavation revealed that across the site archaeological deposits survived best under the headlands of the fields. However, under one headland the artefact-rich rich horizon had been totally truncated by ploughing. This was thought to be the result of one season’s deeper ploughing in preparation for one season’s potato growing, where the field was ploughed into deep trenches, truncating the archaeological deposits by c. 0.8m (Garton 1989).

1.6.14 In East Yorkshire, OA commissioned P Halkon to pull together previous work undertaken on a series of Roman sites at Hayton which have been affected by potato growing (Halkon 2001 included as Appendix Ji). Figures 23 and 24 clearly show the effects of de-stoning at one of these sites, Burnby Lane, where large quantities of Roman tile from a hypocaust, mortar, worked stone and pottery were brought to the surface. Subsequent discussions with the landowner revealed that a ‘Grimme Tornado’ de-stoner had been used on the site.

1.6.15 A Roman road side settlement was also investigated as part of this work and the detrimental effects of potato cultivation on the site can clearly be seen by comparing two aerial photographs, one taken before de-stoning for potato cultivation in 1990 and
the other taken after de-stoning (Figures 25 and 26). These photographs show that in 1990 the cropmarks were very sharp and distinct, but that after de-stoning they appear blurred with far fewer features showing. This blurring is thought to be representative of the resultant mixing of soils at the archaeological horizon reflecting the destruction of the associated archaeological stratigraphy. Parts of this site have now been archaeologically investigated, the results of which clearly show the considerable damage done to the subsurface features by this process and how in some areas de-stoning had penetrated to a depth of c 0.5m (Halkon 2001, 7).

1.6.16 At Owmbly (Lincs.) blue glass chips were inserted into 1m test pits at depths of 0.2 - 0.4m, during excavations of the Scheduled Roman and Late Iron Age settlement (Figure 27). After just one episode of potato cultivation, chips were seen scattered across the field surface from all of the test pits with depths of up to 0.35m, showing the extent of disturbance. The glass chips could be seen to have moved a surprising distance, instigating a further experiment where the chips were placed in front of a potato harvester and their positions subsequently plotted after being taken up and redeposited by this machine. The plot showed that the furthest chips were found to be 9.2m and 11.2m away from their point of origin, replicating the movement seen previously in the field. Regular monitoring of the chips has now taken place and in one area dispersal has been recorded at distances of up to 27m and 28m in two directions from their original insertion point over two years (Figure 28) (McAvoy 2002, reproduced in full in Appendix Jix). The capacity for these operations to move the chips so far from their origin will both affect artefact assemblages and make it harder to locate sites from their artefact scatters (see below).

1.7 Sugar beet

1.7.1 Sugar beet also involves particular problems. The land often requires subsoiling, and the crop is often harvested in wet weather (September to December) which can lead to damage to the soil structure caused by heavy machinery running over the wet ground - ie. rutting, compaction etc, as well as directly disturbing the soil to lift the crop. Sugar beet cultivation can also contribute to soil erosion, especially on light soils, as a smooth seed-bed is required and the crop is slow germinating, encouraging run-off and wind erosion resulting in the thinning of soils. Harvesting often involves the removal of significant amounts of soil from the fields. A recent DEFRA paper states that ‘less is removed here than in other European countries, these losses are still substantial - 35,000 tonnes per year, all of which is repatriated back to agricultural land or used in other applications (DEFRA 2002i, 10) (see below for implications of such losses). The archaeological effects of sugar beet growing are therefore broadly similar to potatoes, but erosion problems tend to be greater.

1.8 Energy crops

1.8.1 Energy crops are being promoted by DEFRA as part of the UK’s contribution to reducing reliance on fossil fuels. The cultivation of biofuel crops on arable land and set-aside is supported through the EDRP Energy Crop Scheme which supports cultivation of Short Rotation Coppice (SRC) and Miscanthus. Whilst there has been a study into the rooting habits of SRC (Crow 2001b) and Miscanthus (Riche and Christian 2001a), their effect on below-ground archaeological remains has yet to be investigated. In trials undertaken to date the majority of willow and poplar roots appear to be restricted to the topsoil; however, the potential damage of deeper penetrating roots when planted in areas where there may be archaeological deposits forming softer and more easily penetrated deposits, is not yet understood. In the case of Miscanthus, the majority of roots were found to grow in the top 0.60m of soil, the zone where most archaeological deposits would be located. Further root growth was
also found penetrating to 1.80m (Riche and Christian 2001a). This is much deeper than disturbance caused by ordinary arable crops, and roots extending to this depth could adversely affect archaeology below the topsoil.

1.8.2 Serious archaeological damage could also arise from grubbing out of old short rotation coppice stools and Miscanthus rhizomes, whereas less damage may be caused by spraying with herbicide and discing. There is also concern that these crops will be planted in wetland environments due to their copious need for water to ensure efficient growth. Riche and Christian (2001b) note that if Miscanthus and other winter harvested biomass crops are grown on a large scale it will be important to consider their water requirements, and any effects on ground water reserves. If grown in wetland areas this could seriously affect the preservation of archaeological sites in wetland and peat areas, where ground water levels are already dropping (see below) (Van de Noort et al. 2001).

1.9 The effective deepening of cultivation caused by soil erosion, natural solution and compaction

Soil erosion (and see section 3)

1.9.1 Over the last 50 years the overall area of land in arable cultivation has been falling, but in the last 10 years the loss of archaeological monuments has been climbing steadily. One of the reasons for this is thought to be the destruction of monuments through the cumulatively destructive relationship between ploughing and soil erosion (Darvill and Fulton 1998).

1.9.2 Where soil loss is occurring through erosion or weathering, even when a consistent plough depth is maintained, the plough will automatically penetrate deeper into the subsoil. This can lead to the subsoil (and archaeological deposits) being continually brought into the ploughsoil to maintain ploughsoil depth. Soil erosion can occur both within the micro-context of archaeological earthworks, and the macro-context of natural slopes within fields, or across whole landscape. This process of erosion has been occurring over a long period of time; however, on some sites where the right conditions apply, erosion can be significant and can occur at a much faster rate.

1.9.3 Soil erosion can be caused by weathering processes such as solution, wind erosion and water erosion, and by physical erosional processes such as tillage erosion. Erosion is most serious on light soils, especially on slopes, but can also be serious on flat land, where wind erosion can be a problem. Erosion from the top of slopes can be serious in that the soil cover at the top of the slope is much reduced therefore leaving buried archaeological sites much more vulnerable (discussed more fully below). However, soil erosion downslope can also offer protection to sites at the bottom of slopes, caused by a build up of soil in the form of colluvium. Erosion is most common on cultivated bare soils and less common on established pasture. Details of erosion issues can be found in Appendix Ei and Eii and are also discussed further in Section 3.5.

1.9.4 The best way to demonstrate how this erosion affects archaeological sites is by looking at sites that have been excavated at different times and where plough depths have been compared. An example of this process can be seen on one of the milecastles associated with Hadrian’s Wall. Comparison between photographs taken during excavations in the 1930s and again in 1999, showed that the ploughsoil in 1930 was much deeper than it was in 1999. This had led to the plough biting deeper into the ground which in turn led to the comparatively poor condition of the archaeological remains in 1999 (P Austin pers. comm.) (Figures 29 and 30).
1.9.5 At Barrington cemetery (Cambs.) the cemetery was first found in the 19th century when 11 skeletons were excavated between 1840-60. It was recorded that these skeletons lay beneath 18 inches (0.46m) of soil. In 1987 small-scale excavations recorded further skeletons, but this time the skeletons lay below only 9 inches (0.24m) of soil, half the depth of soil reported from the last century, indicating a rapid erosion of the topsoil (Malim 1992b).

1.9.6 Recent excavations of a small Roman villa at Whitley Grange (Shrops.) revealed considerable archaeology surviving under the ploughsoil. The site was originally partially excavated in the 1890s, after the farmer continually struck masonry with his plough. The excavation records show the ploughsoil over the site as being c 0.6m; however, during the recent excavations in 1995 the ploughsoil had been reduced to only 0.2m, indicating substantial topsoil erosion over the century.

Compaction

1.9.7 Soil compaction also causes what is in effect a thinning/reduction in the depth of the ploughsoil, leading to the plough biting deeper into below-ground deposits. No work has been undertaken specifically to look at the effects of this on archaeological sites, but there has been some research on the more general aspects of compaction, especially with regard to crop growth. Some of this research can be used to establish the basic principles associated with compaction, which enable its potential effects to be put into an archaeological context.

1.9.8 The vulnerability of specific soil types to compaction varies from year to year depending on weather, state of the topsoil, cultivation regime etc. However, all soils are prone to compaction, from sandy soils to clay ones, and their susceptibility is mainly dependent on how they are treated by farmers. For example, harvesting when wet can be devastating for topsoil structures (see section on potatoes above where the soil can be purposively wetted prior to harvest). The worst conditions for causing compaction are therefore a combination of wet soils and heavy machinery (Dr. R Evans, pers. comm.):

Undoubtedly, compaction by cultivation will reduce the topsoil thickness. Most soils under permanent grass for many years and not too heavily grazed will have a bulk density of c 1.0. If it goes under the plough, its density is likely to increase to c 1.3, which will result in a reduction in thickness from an initial plough layer of say 25cm thickness to one of 19.2cm. There would be a chance therefore, I would guess, that archaeological remains that were formerly just below the initial plough layer (ie 25-32.5cm) will be brought within ploughing depth (32.5 divided by 1.3 = 25). On that basis, compaction probably is an issue that archaeologists should be looking at (ibid).

1.9.9 Compaction also leads to the necessity of subsoiling to reflate the soil and remove any compaction pans, as discussed above. Compaction either in the ploughsoil or just below plough-depth also serves to reduce water infiltration through the soil leading to increased run off and therefore contributes to erosion down slopes (see Appendices Ei and Eii). Areas of compacted wheelings, headlands and tramlines in particular contribute to this, as was seen at the small Roman town at Ariconium (Herefordshire) (see below).

1.9.10 Rutting left by tractors, also caused by working soils when wet, was recorded impressed into archaeological features at Sheffield’s Hill cemetery (Lincs.) (K. Leahy pers. comm.) and the imprints of ruts were found extending c 0.05m into the top of the bedrock and features during excavations carried out at Garforth in West Yorkshire, under a ploughsoil depth of 0.40m (WYAS 2001b).
Natural soil erosion by solution

1.9.11 It was observed in the 1950s that differential erosion was occurring between subsoil under an earthwork and that in the surrounding area, especially in chalk areas, usually resulting in the subsoil under the earthwork being higher than that away from the earthwork. This often gave the false impression of a surviving upstanding monument, whereas all that survived was the upstanding subsoil formerly protected by the earthwork. For example, at the western end of the Stonehenge cursus a slight rise was seen in the field topped with richer vegetation which was thought to be a barrow. The mound was subsequently totally excavated but no mound material or buried soil remained. The slight rise was formed by the upstanding subsoil which had originally been protected by a burial mound. Recent ploughing had removed what remained of the mound and only a few inches of chalky ploughsoil existed on the surface of the rotted natural chalk (Christie 1960). Another ‘ghost mound’ was excavated on the Berkshire Downs, at Park Farm; no stratigraphy survived and the modern topsoil lay immediately over the raised natural. The modern topsoil over the mound contained artefacts from prehistoric to modern date (Richards 1990a). This differential erosion may be associated with natural solution accelerated by modern agricultural techniques (for discussion on this see Atkinson 1957; Proudfoot 1965; Groube and Bowden 1982).

1.10 Physical damage of artefacts in the ploughsoil

1.10.1 There have only been a few detailed studies looking at how the mechanical processes of cultivation affect the condition of artefacts within the ploughsoil. It has however been observed that freshly disturbed artefacts brought to the surface by ploughing from an archaeological horizon can often become badly abraded and in some cases totally destroyed soon after entering the ploughsoil (Figure 32). Figure 33 illustrates this and provides a comparison between the condition of two Iron Age horse bits; one found in good condition during building works in a farm yard and the other in much poorer condition taken from the ploughsoil.

1.10.2 At Manor Farm, Chalton (Hants.), an experiment was set up by Dr. Reynolds to look at, amongst other things, how modern cultivation techniques can affect pottery sherds. The field was first ploughed in 1968 and every subsequent cultivation intervention was recorded during the experiment. The field was normally ploughed in September, leaving any pottery brought to the surface vulnerable to frost action throughout the winter. Seed-bed preparation took place in the spring with a chisel plough and spike harrow which levelled the seed-bed; the seeds were sown and the ground rolled. The compression of the seed-bed caused by the rolling caused damage to pottery, by both friction and pressure, especially in its weakened state after being attacked by frost in the winter. Reynolds recorded that in the case of very coarse Iron Age pottery with its high percentage of inclusions, a winter’s exposure was enough to break down their fabric to the point where any movement caused their destruction (Reynolds 1989).

1.10.3 Results of fieldwalking undertaken on the same field in 1968, 1978 and 1988 showed that the number of sherds increased from 95 in 1968, to 280 in 1978 to 323 in 1988. However, the total weight of the pottery collected was less in 1988 than in 1968 and 1978, indicating that the pottery pieces collected were much smaller in size. This suggested that the pottery was becoming increasingly fragmented the longer it was left in the ploughsoil. This was confirmed by the fact that in 1968 the pottery’s mean sherd weight was 9.35 g, in 1978 it was 3.16 g and only 2.01 g in 1988.¹

¹ OA commissioned an update to this work looking at how the situation had changed by 2000, but this was unfortunately curtailed by the sad death of Dr Reynolds.
1.10.4 Dr. Reynolds concluded from this that:

In order for the agro-chemicals to be most effective and, therefore, economic, the organic levels of the soil are reduced to between three and seven percent.\(^2\) This naturally reduces the particle size of the soil, the by-product being the threat of erosion across all arable regions. Similarly because of the reduction of particle size the soil itself becomes more abrasive. ... However, in terms of pottery survival and therefore, site locations, the situation is further exacerbated by the earlier and earlier cultivation times as plant hybridisation develops increasingly successful varieties of cereals. During the winter months when widely fluctuating temperatures in the soil are the norm, it is not unusual to see ploughs, both turnover and chisel, discs, rollers and power harrows working hard to produce a fine tilth for early cereal planting. The sheer power of the latest generation of farm machinery pulverises the soil and with it all the material therein.... Its severity is relatively limited in time to the last decade or so (Reynolds 1989, 25-6).

1.10.5 Reynolds also recorded from his work that pottery was most vulnerable to destruction when it was brought to the surface of the ploughsoil. He calculated during his experiment that between 11.1% and 14.7% of the pottery in the ploughsoil was reaching the surface after each cultivation. Therefore, after 5 seasons of ploughing 50% of pottery in the ploughsoil would reach the surface and after 10 ploughings 75% would have surfaced. Similarly, in a study undertaken to look at the effects of only two seasons’ ploughing on artefacts at a site in Wiltshire, it was demonstrated that 11.6% and 9.91% of the artefacts were surfacing after each season’s ploughing (Clark and Schofield 1991, 96-100).

1.10.6 Results from excavations at Marcham Road, Abingdon (Oxon.) also illustrate the vulnerability of Iron Age pottery to destruction from arable processes. Here, fieldwalking prior to excavation revealed a considerable amount of Romano-British pottery but no Iron Age pottery in the ploughsoil. On excavation only four Romano-British features were found amongst hundreds of Iron Age pits, ditches and gullies etc, all containing pottery (Hinchliffe 1980). Similarly in the Yorkshire Wolds, where cultivation has occurred since the 1840s, prehistoric archaeological sites are marked by large scatters of stone and flint implements, but pottery and bone are rarely found, presumably because they have not survived within the ploughsoil.

1.10.7 The physical destruction of artefacts through cultivation has also been recorded in a less systematic fashion elsewhere. During the Stonehenge Environs Project (Wilts.) it was observed that within areas of historic cultivation (ie. areas which have been ploughed since the 18th-19th century), prehistoric pottery was almost totally absent. This is in contrast to Robin Hood’s Ball, (Wilts.) an area which was only recently ploughed, where 2000 sherds of prehistoric pottery were recovered from a relatively small area (Richards 1985). Adjacent to this site, ploughing was halted after one season, on an area of previously unploughed, ancient downland, allowing archaeologists to record the artefacts brought into the ploughsoil after just this one episode of ploughing. An initial search of the area revealed considerable quantities of prehistoric pottery, which were visibly deteriorating very rapidly on exposure to the elements (Richards 1985).

1.10.8 Similar problems have been highlighted in Suffolk. In the sand/peat soils of the fen edges, it has been observed that pottery in the ploughsoil only survives for c 25 years

\(^2\) This sentence appears to be misleading – organic levels have been reduced as a result of continuous arable farming and not done deliberately?
at the most (Pendleton 1999). At Barham (Suffolk), four archaeological sites were revealed after ploughsoil stripping, despite only 1 sherd of pottery being discovered during initial fieldwalking over the site. When the features below the ploughsoil were excavated they were found to contain c 1,140 sherds of pottery, suggesting that despite the site being heavily plough truncated, all pottery previously brought up into the ploughsoil had been lost (ibid).

1.10.9 Comparisons in the survival rates of pottery within different soil types based on how long they have been ploughed have also been made in East Anglia. Here, clay soils have been ploughed longest and most intensively; sand based soils less, and soils at fen edge locations least of all. From extensive fieldwalking in all these areas Pendleton has recorded that in the fen edge locations c 1 sherd of prehistoric pottery survives per 450m², compared with c 1 per 1,480m² on sand based soils to c 1 per 10,134 m² on loam/chalk, clay based soils (ibid 63).

1.10.10 At an Iron Age and Romano-British temple complex at Rothwell Top (Lincs.), a comparative study was carried out between coins found by metal detectorists on the site from 1984-8 and those from 1987-92. It was clear that coins found in the later survey were in poorer condition, with 51% of those found in 1987-92 being broken, compared to 29% in the earlier survey. The cause of this deterioration was thought to be the frequent use of heavy tractor-drawn machinery such as ploughs, harrows, rollers, seed-drilling machines and harvesters (including pea-picking, sugar-beet and potato lifting machines). The study concluded that even in a relatively short period, 8 years in this case, continuous cultivation can cause an increase in damage to artefacts from something like one quarter to one half. Comment was also made that within the next 10 to 50 years, the greater number of thin metal coins on many such sites will have been pulverised beyond recovery (May forthcoming). As a result of his work, May comments that:

'It seems that the proportion of fragmentary coins to complete ones is higher now than it used to be on many other Lincolnshire sites, and indeed the quantities of objects found by metal detectors is declining too (J May pers. comm.).

1.10.11 Similarly, in Suffolk, metal detectorists have noted a marked deterioration in the condition of copper alloy artefacts over the last 20-25 years since detecting started. The cause of this decay is thought to be a combination of mechanical force, such as power harrows, and chemical attack from fertilisers etc reacting with soil moisture to create acidic or alkali conditions (J Newman pers. comm.).

1.11 Chemical effects on buried archaeological artefacts and deposits

1.11.1 Where archaeological artefacts have lain in the soil for a long period of time they will have reached a chemical equilibrium with the soil around them which allows their preservation. Any change in the chemical make-up of the surrounding soil is likely to upset this balance and can cause the artefacts to decay. Bone and metal objects are especially vulnerable to this process.

1.11.2 Soils under an arable regime will frequently be subjected to inputs of a variety of agri-chemicals (herbicides, pesticides and fertilisers). The exact effect of chemicals on archaeological artefacts has not been studied extensively. However, the limited work that has been carried out has shown that buried artefacts (especially those made of metal) and human bone are suffering active destruction as a result of the chemical action of fertilisers, nitrates, and weedkillers. Objects are especially vulnerable in areas of low fertility where chemicals are used more extensively (Dobinson and Denison 1995). It is also known that the decomposition of crop residues within the
plough zone releases a series of acids which attack clay colloids, although, the interaction and effect on pottery from this process has never been studied (Boismier 1997). Another potential problem identified comes from the spreading of pig slurry onto fields to fertilise soils. Slurry is known to contain a high degree of ammonia, which will build up in the soil therefore changing its chemical structure. It is suggested that this may be one of the reasons why objects containing silver are showing rapid degradation.

1.11.3 The mechanics of cultivation have also been identified as being responsible for changing soil structure and chemistry. Aeration of the soil caused by breaking it up can change the soil’s chemistry and where artefacts enter the ploughsoil from a sealed context below, they are exposed to higher oxygen levels, fluctuating temperatures, moisture (leading to freeze thaw action) (see above) and changing humidity. All these factors may help to damage artefacts. Similarly in wetland areas, where the presence of waterlogged anaerobic conditions normally inhibits bacterial and fungal attack on surviving organic archaeological and palaeoenvironmental remains, any changes to the soil and water chemistry are likely to affect the survival of such remains, with some chemical contaminants likely to accelerate the destruction of such objects and deposits (CBA 2001e) (and see below).

1.11.4 Waddington has identified an additional threat to artefacts in the Milfield Basin (Northumberland), where recently it has become common practice to spray sulphuric acid onto fields after the harvest. Although no studies have been done to assess the effect of this on archaeological artefacts, it is known that acid will destroy ceramics, bone and other organic material. He concludes that:

Perhaps one dose of acid may not be enough to obliterate such residues but the cumulative impact of such substances could have far reaching consequences for the archaeological and palaeoenvironmental resource (Waddington 2001, 11).

1.11.5 In a study of metal detecting and archaeology undertaken in 1995 it was recognised that no systematic surveys had been carried out on the degradation of metals in soils and that most of the information on the subject at the time was impressionistic. For example, it was recorded that some specialists independently reported a gradual but noticeable decay in the quality of material in the last 10 years. For example, David Holman reported that Iron Age coins found from the high pasture downlands in Kent were usually in excellent condition whereas those found from the low-lying arable areas were generally in much poorer condition (Dobinson and Denison 1995, 52).

1.11.6 Certainly at Barrington Anglo-Saxon cemetery (Cambs.) progressive deterioration of artefacts over time has been observed. Artefacts excavated from the cemetery 100 years ago were extremely well preserved with robust original surfaces. Similar artefacts of copper-alloy and iron, excavated during the recent investigations at the site, showed much more evidence of decay. It was thought possible at the time that the presence of fertilisers and other chemical agents in the modern soil contributed to this more advanced state of decay (Malim and Hines 1998).

1.11.7 A series of recent studies in Europe have now been set up to look at the problems of metal corrosion in soils, examining whether in fact this corrosion has increased recently and what specifically is causing it. The issues and factors involved are complex and the studies are all in their early stages, but several basic points can be drawn out which can be related to the agricultural process and have relevance here.

1.11.8 The results of these studies reiterate the point that many archaeological artefacts have been buried for centuries under quasi-stable conditions involving slow but steady
corrosion. In this state they will reach a chemical equilibrium with the surrounding soils and little decay will occur. However, industrialisation and relatively recent changes in agricultural practices have caused dramatic changes in burial conditions, leading to changes in the chemical make-up of the soils which destroy the stable equilibrium that metal objects have achieved with their surroundings which will in turn lead to their rapid decay. The processes identified as leading to this decay include:

- the changes in the acidification of soils caused by the application of fertilisers (see below)
- the results of atmospheric pollution leading to acid rain polluting soils leading to the acid buffering capacity of many European soils being exceeded, causing previously stable soils to turn into a much more damaging environment for artefacts. This has been particularly recognised in Sweden where there has been a gradual increase in corrosion of copper alloy artefacts over the last 40 years, exemplified by the differences in the condition of artefacts found at Birka in the 1990s and those excavated 115 years ago (Fjaestad et al. 1997, 32)
- fluctuations of groundwater leading to similar changes in the chemical equilibrium in soils
- and the most rapid threat, caused by agricultural practices, which bring artefacts into contact with the atmosphere after centuries of burial, where they begin to dry out and shrink, react with the air or crumble as they lose the support of the surrounding soil and are subject to exposure to an oxidising environment.

1.11.9 One of the detailed case studies contributing to these conclusions looked at the decay of metal objects in relation to soil pollution in Germany. The results of this study showed that in the last few years metal objects show far greater corrosion damage than similar objects excavated from archaeological sites c. 50 and 100 years previously. The study draws attention to the fact that:

‘the decay of metal in soils depends on the redox potential (the rapid change caused by the input of organic matter, microbic activity, humidity and aeration), the PH values, as well as the immense influence of salt concentrations (electrolytes). The acidification of soil that promotes soil corrosion is increased by acid rain and the development of acids due to the oxidisation of certain common fertilisers.... Intensive fertilisation of land with liquid animal waste can produce high acid input that can be as high as acidic rainfall’ (Scharff and Huesmann 1997, 17).

1.11.10 The study went on to look in detail at several thousand iron artefacts taken from c. 1000 recent excavations in Germany. Analysis showed that in Germany the increase of chloride-induced damage is restricted mainly to excavations located in agricultural areas which had been intensively fertilised in the past (and in cities, villages and alongside main roads where salts were added in the winter). It concluded from this that as most fertilisers are chloride-bearing it is probably this which is responsible for this increasing deterioration of metals. This conclusion was supported up by the fact that artefacts found in forests and natural meadows, which only have a minor chloride content, were less damaged. A study of copper and copper alloy objects led to similar results:

*The state of a great number of coins of Celtic auxiliaries from the Romancamp Delbrück-Anreppen in Westphalia, which were excavated in recent years, has deteriorated within 25 years as compared to coins of the same types, excavated in 1968/69: they are in a far better, stable condition. Since about the year 1970 liquid animal waste (containing ammonia) was brought out as a manure in abundance. Besides the acidic rain, this is a*
possible reason for the additional acidity of sandy soil, which only has a small buffer capacity (Scharff and Huesmann 1997, 20).

1.11.11 It goes on to draw attention to the damage that can be caused to artefacts when wetlands are drained:

Even more dramatically, draining of wetlands containing substantial quantities of reduced sulphur minerals can produce very rapid oxidation: sulphate flushed out as sulphuric acids can thus lead to extreme acidification of soils. The effects on artefact preservation can be dramatic because metal solubility is a stronger non-linear function of pH (Wagner et al 1997, 23).

1.11.12 Even less is known about how chemicals added to soils can affect archaeological deposits. From his experimental work carried out at Sutton Hoo looking at related issues of soil chemistry P Bethal (pers. comm.) comments that the:

‘work of actually measuring the effects of chemical additions to the soil, on any buried archaeology, has never (to my knowledge) been quantified. It is, however, possible to make some clear statements about the potential of such effects:

• There will definitely be alterations to decay trajectories of some classes of archaeological material, if agro-chemicals are added to soil with the result of altering the pH of that soil. This will have most effect when the soil and its archaeology have been stable for a long time, before the pH-altering materials have been added.

• The addition of chemicals to agricultural soils will have an effect on the relict chemical signature of any previous activity reflected by the underlying archaeology.

What can be done is to at least maintain a record of any chemical applications to soils which contain archaeological remains. In this way (eventually) an observational record of change can be built up over time, as sites are excavated. As a mitigation strategy, farmers can only be discouraged from making drastic changes to the chemistry of soils which contain known archaeological remains, including alteration to the water regime. In general, the current measures in force to limit soil pollution also help to reduce the threat of chemical contamination of archaeological remains’.

1.12 Movement of artefacts

1.12.1 Often the only way to identify the presence of an archaeological site in a ploughed field is from artefact concentrations on the surface of the ploughsoil. These artefacts can not only indicate the presence of an archaeological site below the ploughsoil but also that the site is, or has in the past, been damaged by the plough. Although archaeological sites are often located by artefact scatters, it is thought by some that continuous ploughing over a long period disperses these artefact scatters, so making the location of sites effectively disappear, unless fresh finds are brought up through further cultivation damage. Boismier (1997), who has studied this effect through case studies and computer modelling, explains this process in detail and offers guidelines on the usefulness of artefact scatters in identifying sites over time. This subject is also discussed in Schofield 1991 and Haselgrove et al. 1985.

1.12.2 Detailed studies looking at whether cultivation destroys this relationship between artefact scatters and sites often reach very different conclusions. For example, at
Baggots Park in Staffordshire (Crossley 1968; Crossley pers. comm.), it was found that ploughing did not disperse artefact clusters but moved them backwards and forwards across the same area therefore still maintaining the relationship between site and scatter. In contrast, at Hoxne (Suffolk), an episode of ploughing led to the discovery of the Hoxne Hoard (Suffolk). In 1992, immediately after the hoard was discovered, an area of c 30 m radius centred on the find spot was intensively metal detected by the Suffolk Archaeology Unit revealing 61 additional Roman coins. Metal detecting was carried out again after ploughing in 1993, when a further 84 Roman coins were recovered and the process was repeated after ploughing in 1994 with 68 Roman coins found. All these coins had been disturbed from the hoard itself and were distributed widely across the field by agricultural processes.

1.12.3 Subsequent excavation on the site involved plotting the distribution of material disturbed by ploughing since the hoard was first discovered. This revealed that:

‘The concentration of finds in the topsoil occurred within a relatively narrow band (an elongated oval), orientated east-west, with the main assemblage covering an approximate area of 480m² and an increased frequency nearer to the original find spot. In rare instances some finds have been moved up to 20m from the original source and possibly further, to outside the limits of the excavated area’ (Forrest 1995),

1.12.4 and that:

‘The modern ploughing, until 1990, was aligned north-south but no north-south scoring of the natural was observed. The ploughing from 1990 was aligned east to west and it was probably at this point or shortly after that the hoard was struck, a point borne out by the east-west distribution of small finds in the topsoil and the relatively small movement of the main body of finds in a north-south orientation. The crop drilling, being north-west south-east, did not follow the plough alignment, and this could have been responsible for a slight north-south spread of the finds in the very top horizon of the topsoil and could have affected only a very low percentage of the finds during the four years since the hoard was disturbed’ (ibid).

1.12.5 In a study of the long-term effects of ploughing on the distribution of Bronze Age artefacts in northern East Anglia from the three main zones (clay, peat and sand as above), Pendleton concluded that artefact scatters over an archaeological site may remain intact for a while, but this does not last indefinitely, as ploughing over long periods of time will destroy this relationship (Pendleton 1999, 67).

1.12.6 As a relevant aside to this work, Pendleton quotes Mike Harding, who has fieldwalked large areas of the Suffolk clayland, and who comments that the easiest way to ascertain whether there are any archaeological sites and/or artefacts surviving in a field is to merely walk the headlands, where any artefacts remaining will have been dragged by the plough (ibid 62).

1.12.7 The differences in opinion regarding the usefulness of fieldwalking to identify and analyse sites from artefact distributions, are still being discussed. However, whatever the results of these studies, it remains clear that there will be cases where continued ploughing will disperse clusters of artefacts, which will eventually lead to the loss of information about the location of sites, and maybe even to the loss of the sites themselves.
1.13 Ancillary ground disturbance and impacts associated with arable

1.13.1 Many ancillary ground disturbances associated with farming are carried out free from planning restrictions and whilst many do not cause as much widespread damage as cultivation they can be very archaeologically destructive on a localised scale. They can also affect the setting of archaeological sites and monuments.

Drainage

1.13.2 Within arable landscapes, especially on claylands, one of main ancillary threats from agriculture is the necessity for inserting deep drainage. The disturbances caused by these drains have been outlined by Spoor (1980). Pipe drains can be installed with or without trenches. Where trenches are used a trencher cuts a trench 0.2-0.3m wide, the soil is removed, the pipes are laid and the trench is backfilled. The machinery used to lay trenchless pipes (mole drains) are simply tines which open up the soil to allow the pipes to be laid. The soil then falls back into place, with little re-arrangement of the soil, leaving the pipe in a trench c 0.10-0.15m wide. Pipe drains are usually laid at depths of 0.75-1.25m and mole drains drawn at depths of 0.50-0.60m. The pipes are usually spaced at 30-40m on sandy soils and up to 5m apart on clays. Mole drains are usually spaced at 2-3m. Pipe drains are expected to last 40-60 years, whereas mole drains are usually renewed every 5-6 years.

1.13.3 The insertion of mole drains has a similar effect on archaeological sites to subsoiling (see above). Laying ceramic, plastic or tile pipe drains is also destructive as they require deep trenches. The insertion of trenchless drains not only causes damage by the removal of soil from the trenches but also in the general loosening of the ground round about. The resultant criss-crossing of a field by drains effectvively severs stratigraphic relationships within a site as well as destroying any archaeological deposits in their path.

1.13.4 It is not just modern drainage which can cause these problems. At Chignall St James Roman villa (Essex), excavations revealed several phases of hand-dug pipes laid since the 19th century, with pipes ranging in diameter from between 2 to 3 inches. Later drains were observed on the site dating to 1965 which were 4 inches in diameter. The early pipe trenches varied between 3-4 inches and were c 0.75 m below the plough surface. Mole drains were also laid through the site to a depth of 0.60m and at intervals of 2.70m. It was recorded during the excavations that the effects of the mole drains on archaeological deposits were less severe than the earlier hand-dug drains, although it was thought that if they were used in a cemetery the consequences would be disastrous. Most of the archaeological features excavated were cut by the drains, and it was not uncommon to find a one metre length of ditch cut by at least 3 separate drains (Essex CC nd).

1.13.5 The impact of drainage was also studied during a survey of plough damage on cropmark sites in the Milfield Basin (Waddington 2001). It was recorded that more drains were being inserted into the fields in the area as a result of the recent intensification of farming, especially in the alluvial floodplain, the boulder clay and on the damp parts of the Cheviot slopes. This drainage had adversely affected both the archaeological and palaeoenvironmental resource, both physically from the drains themselves and from the drying out of waterlogged deposits caused by the effectiveness of the inserted drainage systems; a problem seen in many areas of the county, including the alluvial floodplain of the Thames Valley. Work in the Milfield Basin has witnessed linear drains regularly cutting through archaeological features and at Flodden Hill an entire network of drains criss-crossed an enclosure and caused truncation to its associated features. Waddington concluded by saying that:
Drainage works, usually undertaken by farmers themselves, are difficult to monitor and have been shown to have had a significant impact on crop-mark sites (Waddington 2001,10).

1.13.6 There are numerous examples where damage from drainage has been observed on archaeological sites. For example at Coelbren (Glamorgan) an agricultural drainage scheme cut through the flanking ditches of a Roman fort (Darvill 1986), and Figure 34 shows a field drain cutting a Roman corn drier alongside the A421 (Oxon.).

1.13.7 The creation of water abstraction ponds for irrigation, the digging of slurry lagoons and the digging of ditches and dykes can also cause significant archaeological damage. In the Fens, Honnor and Lane (2002 and see Appendix Jiv) draw attention to the damage caused by the cutting and recutting of dykes leading to the physical removal of large areas of soil. For example, the Black Sluice Internal Drainage Board maintain some 779km of watercourse over an area of 45,527ha. At an average width of 6m this has led to the extraction of c 567ha of land in an area where archaeological sites are very numerous (circa one site every 16ha). This does not take into account the effect of digging and recutting of the extremely numerous private ditches, farm and field dykes and which also will have removed vast areas of fen (ibid).

Hedge Removal

1.13.8 Traditional field boundaries are of agricultural, ecological, historic, landscape and amenity importance and contribute significantly to local distinctiveness (DEFRA 1999, 1). They represent a very important component of the historic landscape and contain much of the story of its development. Vast numbers have been lost over the last 50 years; some have been reconstructed but this cannot restore their historical and archaeological significance, though it can help to alleviate their visual and nature conservation interest.

1.13.9 The removal of hedges and field boundaries to allow easier access for large machinery and to increase arable acreage for production, not only detracts from the diversity of the countryside, but can also cause the destruction of archaeological sites once protected by these features. Often boundaries utilised, or were sited on, earlier features such as ditches or upstanding monuments, therefore effectively sidelining and protecting these features from cultivation. These features may still be present preserved within the hedge/boundary. For example, Figure 35 shows the line of a Roman Road within the World Heritage Site at Avebury which has been partially preserved where the field boundary has been retained but ploughed away where the boundary has been removed.

1.13.10 On many farms hedges have been removed and a fence erected. The fence only offers protection to any archaeological remains directly below it, whereas the hedge would have offered more widespread protection. In cases where fences have replaced hedges over upstanding monuments, the monument is often ploughed up to the fence line on one or both sides, leaving an upstanding ridge or bank along the line of the fence, representing the only surviving part of the upstanding monument. An example of this can be seen on the West Dorset Ridgeway (barrow 28), where ploughing up to the fence line has effectively half-sectioned the barrow, destroying one half in the process (Woodward 1991, 5). A similar case has been recorded by French (2001) on Cranborne Chase, where one side of a barrow is ploughed and the other side lies protected under pasture (see Appendix Jiii, Figure 8).

1.13.11 Hedges can also protect buried archaeological features underneath them. For example, at Bishop’s Cannings Down, excavation of an unploughed headland revealed the presence of an occupation horizon which had been destroyed elsewhere.
within the field away from the former boundary (Hinchliffe 1980). At Barton Court Farm (Oxon.), excavation revealed that under the field boundaries a gravel surface was seen to survive 0.5-0.10m higher than where found in the rest of the field (Miles 1980).

1.13.12 Excavations at Stanwick (Northants.) revealed a Roman mosaic partially destroyed by plough furrows (Figure 10). It is thought the mosaic and associated villa were originally protected from medieval ploughing by being under a medieval headland. In fact it has been suggested that the headland was deliberately created here, due to the difficulties in ploughing over the masonry associated with the villa. The damage was therefore thought to have occurred only after the removal of this headland in the post-medieval period and subsequent ploughing through (B Kerr pers. comm., noting comments from excavator D. Neal).

1.13.13 One further example of the protection offered to archaeological sites from medieval headland boundaries is graphically illustrated by work undertaken at Cotswold Community Centre (Glos.). Figure 36 clearly shows the paucity of buried, surviving archaeological remains in the centre of the field in comparison with the mass of features recorded under the headlands.

1.13.14 Historic hedges and walls, where they run across slopes, can also provide a barrier to the downslope movement of soil caused by soil erosion. This results in a build up of soil on the upslope side of the hedge/wall which will then offer protection to any archaeological deposits below this build up of soil, leading to sites on the upslope side of a boundary being far better preserved than on the downslope side. The subsequent removal of these boundaries and the resultant ploughing through of the soil, often results in the levelling out of this differential, leaving the former upslope areas with less soil to protect any archaeology surviving below. The removal of historic boundaries also removes wind barriers, therefore increasing the effects of wind erosion and also increases the likelihood of waterborne and tillage erosion downslope (see below, Appendix E and Figures 37 and 38).

1.13.15 The removal of historic boundaries, once widespread in the 1970s and 80s, is now becoming less common, although it is still occurring. Historic hedges are also now to some extent protected by The Hedgerow Regulations (1997). However, the criteria under which hedges are protected are limited and can still leave some historic hedges vulnerable to destruction in areas where early documentation is not available or where enclosure did not take place. These regulations also do not protect other types of historic field boundary, including walls, banks, ditches and dykes. They also do not protect 19th century enclosure hedges, which are prevalent throughout much of Midland England. These criteria are now in the process of being reviewed.

**Burrowing, Scrub Invasion and Visitors**

1.13.16 While not directly part of the arable farming regime, burrowing animals, particularly rabbits and sometimes badgers are a common threat to sites in predominantly arable landscapes, especially where sites are isolated and neglected, for example, where a site has been fenced off from its arable context and grassed over with no further management input. Infestations of burrowing animals can be very severe, destroying much of the integrity of monuments if allowed to develop unchecked (Figure 39). At Stonehenge WHS (Wilt.) animal burrowing accounted for 35% of damage to sites within National Trust Stonehenge Estate (National Trust 2001).

1.13.17 Historic Scotland (1999) has produced a Technical Guidance note on ‘Burrowing Animals and Archaeology’, which includes information on the damage caused by rabbits, rats, moles, badgers, foxes and puffins. It highlights the three main results of
this damage: disfigurement, destabilisation and irretrievable loss of information. In Eastern Scotland it is recorded that:

_The damage caused by burrowing animals, particularly rabbits, has recently been recognised as one of the greatest threats to earthwork conservation in eastern Scotland_ (ibid 2).

1.13.18 Visitor erosion is primarily a problem for well known and very accessible sites. At Avebury WHS (Wilts.) visitor erosion accounted for 4% of all damage to sites within the WHS with animal burrowing accounting for 16% (OAU 2000b).

**Topsoil Movement**

1.13.19 Quantities of soil are often removed with crops from fields during the harvesting of crops such as sugar beet and potatoes (see also above). This soil is often washed and re-used at different locations, for example, British Sugar offer the soil from beet washing free to farmers. The loss of this soil from fields containing archaeological sites will cause the gradual thinning of the ploughsoil, therefore leaving subsoil remains more vulnerable to the plough. This soil can be used for landfill, levelling hollows and soil improvements (especially on poorer soils such as the Breckland and coastal sandy soils), or on land with shallow soils. Whilst this imported soil may help protect subsoil archaeology on the recipient site, it could also prove to have a detrimental effect by changing the original chemical make-up of the pre-existing soil (see above). It could also affect interpretation of topsoil archaeology on these ‘improved’ sites, especially as even with washed soil, artefacts often pass through the washing process, to be redeposited at the new location (C Pendleton pers. comm.).

**Turf Growing/Stripping**

1.13.20 Commercial turf growing also has the potential to damage buried archaeology in three ways. Firstly, physically stripping and removing the upper surface of the soil has the effect of thinning the ploughsoil with the resultant potential deeper penetration into archaeological deposits in the subsoil. Secondly, the process often involves the intensive use of chemicals to compensate for the lack of rotation, to ensure fertility and prevent weed growth. On areas of ex-heathland in south-east Suffolk, turf is now grown as a commercial crop on a large scale. Accumulative damage caused by this process has been observed at Sutton Hoo and Snape Anglo-Saxon Cemeteries (Suffolk), both on light soils already prone to thinning by wind erosion (J Newman pers comm.). Thirdly, the need for a fine tilth for turf growing can lead to mechanical damage to vulnerable artefacts.

**Boulder Clearance**

1.13.21 Stone/boulder clearance is often carried out to make cultivation easier, reduce damage to machinery and make planting more productive. This operation can unintentionally damage archaeological sites. In 1978 stone removal led to an originally well preserved stone circle at Moel Goedog (Gwynedd) being badly damaged. Darvill (1986) quotes the unfortunate episode which occurred in 1980 in Dyfed, affecting several archaeological sites, where stone clearing was carried out by contractors who found they could charge the farmers for clearing the stones and then sell the stones on to a coastal protection scheme. Some of this stone removal was undertaken with machines designed to clear stones, causing damage to a standing stone at Parc Maen where the machines churned up the ground so badly that a Beaker cremation burial was brought to the surface.
1.13.22 In the Chalk Downs it was common practice to dispose of sarsens by removal and burial. It is also common to remove large chalk wedges from the ground for use as clamps for storage.

**Farm Buildings and Farm Road Construction**

1.13.23 Farm buildings, provided they are used for agriculture, can be erected on any site (except where statutory constraints exist eg SAMs, National Parks etc) and be built of any style, up to 465m² in size, without planning permission, regardless of their impact on the rural landscape or archaeology. One of these buildings can be erected every two years for an indefinite period of time (National Association of Housing, *et al.* 1997). Improvements to existing farm buildings, as well as the construction of new ones, can cause damage to below-ground archaeological sites and monuments. Government grants were formerly widely available to carry out this type of construction work, although these have been drastically cut since 1984.

1.13.24 The construction of new farm roads capable of supporting large agricultural machinery, such as cultivation equipment and combine harvesters, can also be archaeologically destructive, and these may also be built without planning permission. Darvill quotes the example of Ffridd Brynhelen (Clwd) where a well-preserved settlement, burial and field system was bisected by a road which was bulldozed through several upstanding archaeological features. Darvill also comments that the construction of new heavy duty roads allows heavy duty machinery to access previously inaccessible areas, therefore posing a new threat to archaeological remains in these areas (Darvill 1986).

**Other Activities Associated with Arable Farming**

1.13.25 There are other permitted developments applicable to farmers, which although not extensively utilised could potentially be destructive to archaeological sites.

- The use of land for any purpose for not more than 28 days in a year is permitted development unless it involves a market or car/motorcycle racing, where the period is reduced to 14 days. Such temporary activities, especially motor sport racing, can cause enormous damage to below-ground archaeological sites, especially when the ground is wet.

- Excavation for fish ponds associated with fish farms can be carried out under the General Development Order provided the depth of the pond does not exceed 2.5m or an area of 0.2 hectares. Up to 10,000 tonnes of soil/subsoil/geology can also be removed without mineral controls. Any archaeological deposits in these areas would be totally destroyed.

- Although the transportation of waste to a farm for dispersal has been prevented by the 1988 General Development Order, waste can still be brought onto a farm for dispersal as long as it is not called waste or can be used for agricultural improvements. The dumping of waste on farms is a problem as it can mask earthworks, which may lead to their abandonment and destruction (data from National Association of Housing, *et al.* 1997).
2 THE THREAT TO WETLAND ARCHAEOLOGY INCLUDING THE LOWERING OF WATER TABLES AND PEAT WASTAGE

2.1 Archaeological potential of wetlands

2.1.1 The archaeological potential of wetlands is very high:

*It is now being realised that dryland sites, largely bereft of environmental evidence and with limited cultural material, offer only about 10 per cent of the information available in a waterlogged deposit... all the (waterlogged) remains are threatened by agricultural techniques and a lowering water-table* (Hall 1987, 1).

2.1.2 Unlike wildlife habitats, waterlogged archaeological remains cannot be restored through rewetting once they have dried out, the information present will just disappear;

*The significance of wetland monuments lies in a) the preservation of organic archaeological remains that are usually not found in free-draining soils, b) the presence of a sedimentary matrix that provides additional protection against physical destruction and c) the palaeoenvironmental material in the matrix or the context of the resource that allows for dating and environmental construction.* (Van de Noort et al. 2001, 3).

2.1.3 The preservation of these remains relies on maintaining a high water table which:

- ensures the preservation of a wide range of materials by the creation of an anaerobic environment which prevents the natural decay of organic material through the activities of biological agents
- reduces the likelihood of the chemical degradation of organic materials, determined by the acidity of the environment
- excludes burrowing and activities of animals living underground
- prevents erosion, desiccation and degradation of peat soils which both contain and protect beneath them a rich archaeological landscape.

2.1.4 One of the main threats affecting the survival of wetland archaeological sites is the cycle of drainage, resultant peat wastage and associated agricultural use of these soils. The main wetland landscapes, that are threatened by agriculture are the Somerset Levels, the East Anglian Fens, the peatlands of the northwest and the Humber wetlands.

2.1.5 The problem is deemed so serious that English Heritage commissioned a desk-based assessment on the Monuments at Risk in England’s Wetlands (MAREW) in 2000 to provide a general picture of the condition of England’s wetland archaeological resource and the risks it faces (Van de Noort et al. 2001).

2.1.6 The report records that the density of archaeological sites in these wetlands is very high. In the lowland peatlands MAREW estimates that the density of archaeological sites in the North West wetlands is just below c 1 site per km². In the Somerset Levels the estimated resource lies at 1 site per 2.2km². The total estimated archaeological resource in the lowland peatlands is estimated at 4200 monuments, of which a significant proportion are likely to include wet-preserved remains. An additional number of unknown sites will be deeply buried, and this is estimated at an additional number of c 2940 monuments. In the alluviated lowlands of the Fens and the Humber Wetlands the monument density is estimated at 1 site per km². On this basis the
number of known monuments is 7400 monuments, of which possibly up to a third include wet-preserved remains. It is possible that the number of unknown deeply buried sites may result in a 2-fold increase in the number of monuments in these alluviated wetlands (ibid).

2.1.7 MAREW estimated that in the last 50 years:
• 8010 monuments have been damaged by drainage
• 2020 monuments have been lost to peat wastage i.e. peat wastage is responsible for the loss of 500 to 600 years of wetland monument history
• 2180 monuments have been damaged by conversion of pasture to arable
• 2950 wetland monuments have suffered wholesale destruction (mainly sites in lowland peatlands) through peat wastage
• peat wastage, resulting from agricultural practices including drainage and conversion from pasture to arable, has been the greatest single cause of wholesale destruction of wetland monuments over the last 50 years
• 10,450 wetland monuments have suffered damage, desiccation and partial destruction over the last 50 years. This includes those damaged by drainage (9020) and ploughing (1650)
• drainage, in particular, therefore has been the greatest single cause of damage, desiccation and partial destruction of wetland monuments over the last 50 years.

2.1.8 MAREW comments that current designations are insufficient to safeguard the waterlogged components of wetland monuments and concludes that:

‘the greatest impact on the wetland archaeological resource is from drainage of land for agriculture and the subsequent drying out of the archaeological remains and peat wastage from agricultural land’ (Van de Noort et al. 2001, 3).

2.1.9 In the last 10-20 years or so the problems encountered in wetland areas have been deemed so serious that a series of projects have been funded by English Heritage to assess the problem:
• The Somerset Levels Project
• the Fenland Project - established to undertake surveys in the 400,000 ha of low-lying Fenland of Cambridgeshire, Lincolnshire and Norfolk
• the North West Wetlands Survey covering Cumbria, Lancashire, Merseyside, Greater Manchester, Cheshire, Shropshire and Staffordshire
• the Humber Wetlands for an area of c 400,000 ha of land in the Humber Basin lowlands.

2.1.10 The results of these surveys have been drawn on heavily here to provide the examples of the problems encountered.

2.2 The conversion of the wetlands

2.2.1 Conversion from wetland to pasture or arable causes damage to archaeological monuments by:
• Introducing them to the threat of the plough
• a lower water table will threaten waterlogged deposits and will cause desiccation of peat and soils leading to shrinkage and erosion which brings deeper buried sites in reach of the plough
• both changes in water table and landuse conversion result in changes to the water chemistry and acidity, which will also affect the preservation of the archaeological resource (Ellis 1993, 106).
2.2.2 Before 16th -17th century land drainage projects, c 25% of the land mass in England could be described as ‘wetland’ (Van de Noort 1996, 133). The conversion of wetland to arable has been going on in piecemeal fashion since the medieval period, with large scale reclamation occurring since 1600. However, this process has accelerated in the last 30-40 years as a result of grants given to farmers to improve land through drainage, often on lands where the survival of important waterlogged archaeological sites is dependent on them remaining undrained. This combined with the ‘Dig for Victory’ Campaign of World War II has led to the numerous upstanding earthworks seen 50 years ago being destroyed by ploughing in living memory (Taylor 1994, 71-2):

‘Government agencies, established in the 1950s, such as the Land Drainage School and the Field Drainage Experimental Unit, both funded by MAFF, have studied the optimum operation of field drainage. Their work and government grant-aid to agriculture have resulted in a phenomenal increase in the area drained year by year, and field drainage operations can be encountered throughout the Humber basin lowlands today’ (Ellis 1993, 107).

2.2.3 This is illustrated in Figure 40, which shows a comparison between a Roman settlement at Hacconby Fen (Lincs.) as an earthwork and then as a cropmark after having been ploughed in the 1950s.

2.2.4 For all of England’s wetlands it has been calculated that 72% are used for arable (an increase of 8% of total land-use since the 1930s) and 12% are used as pasture (a decrease of 15% since the 1930s). This reversion has affected 165,000 ha of pasture over the last 50 years (Van de Noort et al. 2001, 12 and 16). In the Humber Wetlands the process of drainage and conversion continues. In 1973 many areas classified as Grade 3 agricultural land had by 1993 been drained and improved and are now in continuous agricultural use. Grade 4 and 5 land is now only very rarely found; for example in Humberside 46% of grassland disappeared between 1974-1985 through conversion to arable (Ellis 1993, 108). Within the Humber Wetlands it has been pointed out that land drainage is so effective that very few, if any, archaeological sites have escaped the effects of desiccation entirely (Van der Noort 1996 134).

2.2.5 Honnor and Lane (2002) have undertaken a study for OA as part of this project which included a detailed examination of the trends in agriculture, including conversion of pasture to arable, and the effect that this has had on archaeology, through a detailed look at the changes in three parishes in Cambridgeshire. The results of this study are very useful to show how the problems and processes seen at a local level reflect and illustrate what is happening in the wider context of wetland arable areas. The study looked specifically at the areas of Deeping, Pinchbeck South and Moreton Fens (full text can be found in Appendix Jiv).

2.2.6 The conversion of wetland to both arable and pasture also leads to an increase in groundwater pollution through the application of fertilisers. This causes an increase in concentrations of phosphorus, nitrogen and other agricultural chemicals in the groundwater, which will lead to changes in the acidity of the soil. This will in turn lead to changes to anaerobic environments, with the resultant loss of material whose preservation is dependent on the acidic conditions eg insect cases, pollen, leather, wool, skin and hair and also, to a lesser extent, wood.
2.3 **Lowering of the water table and loss of waterlogged deposits**

2.3.1 The wetland projects mentioned above have looked in detail at the rates and effects of the lowering of the water table on archaeological deposits.

**The Fens**

*Up until the mid-1980s, many of the internal drainage boards were deepening and widening drainage dykes throughout the region on a 5-7 year continuous cycle. In many cases, the setting of levels in the cuts, dykes and ditches was controlled by individual judgement and existing land-use, rather than according to any overall scheme. If drainage on this kind of scale continues, organic artifactual and environmental remains, whose continued preservation depends on the maintenance of anaerobic environments, will degrade and eventually disappear from the record* (French 2000, 5).

2.3.2 MAREW records that:

*Hydrographs from the Environment Agency can be used to show general changes in groundwater tables. On the basis of this data, it is clear that the groundwater table has been lowered by 2 to 3 m over the last 50 years in the alluviated lowlands of the north-west and south-west.... it seems that the main fall in the water table occurred after 1970.... Virtually no lowland peatlands or alluviated lowlands remain completely free from the effects of drainage* (Van de Noort et al. 2001, 16).

2.3.3 From 1981-88, as part of the Fenland Survey, 2500 archaeological sites were identified from fieldwalking and survey of these a sample of 150 were physically evaluated. From the results of these evaluations it was reported that the water table was in general found to be c 1m below present field surfaces and in well-drained siltlands, this fell further to c 1.50 m below (Hall and Coles 2000). Once the water table falls below the depth at which archaeological deposits lie then these deposits will dry out and 90% of their information will be lost (see above).

2.3.4 A survey of dyke edges in Cambridgeshire allowed the examination of soil profiles of 41 archaeological sites. Here it was found that well-preserved waterlogged sediments and archaeological contexts were the exception rather than the rule. It was observed that unlike the Netherlands where groundwater tables are generally maintained at 0.5-0.75m below the ground surface, water levels in the Fenland are kept at substantial depths (ie. 2-4m) below the ground surface. Only where there was a combination of archaeological features cut deep into relatively impermeable subsoils or in deeply incised palaeochannels were waterlogged remains encountered (French and Pryor 1993).

2.3.5 A monitoring exercise looking at the effects of modern drainage operations on archaeological deposits has been carried out at the Neolithic cursus at Etton in Cambridgeshire, originally undertaken to monitor the effects of falling watertables caused by gravel extraction. The water levels were monitored through a series of boreholes across the Neolithic enclosure for a period of two years. Within four months of pumping water from the quarry, the water table at the cursus had dropped to 1m below the archaeological deposits. These had initially been protected by waterlogging and this drop seriously affected the preservation of the waterlogged archaeology at this depth (French and Taylor 1985). The project demonstrated dramatically how fast the ground water level fell and how quickly this proved destructive to the preservation of the archaeological resource encountered, which at
Etton included waterlogged wood and other organic residues, such as food remains on Neolithic pots, fabric, string and netting, all damaged or destroyed by being dried out. English Heritage are funding several other monitoring investigations into the effect of hydrological changes in the Fens, one at Market Deeping in Lincs and another at Willingham/Over in Cambs (French 2000, 6).

2.3.6 In a further study carried out in south Cambridgeshire it was recorded that the water tables have fallen so low that a survey carried out in 1983 of medieval moated sites, showed that many were totally dry, even in winter. Similarly at Fowlmere, moated sites which had held water in the 1980s were excavated in 1992 and found to contain no waterlogged deposits at all, a result once more of falling water tables in the area (Taylor 1994).

2.3.7 Honner and Lane (2002, Appendix Jiv) observed that water levels are now regarded by farmers and the Internal Drainage Board as being at an optimal level in many areas of the Fens. However, from the point of view of the archaeologist these levels are too low. For example, in Moreton Fen where the water level is maintained at 1.20-1.50m below the ground surface, the water levels on archaeological sites in the area lie well below the archaeological resource eg the Morton saltern site. The Internal Drainage Board predicted that little change would take place in the water levels in the future, leading to a continuation of low watertable levels and a necessity to further reduce the OD heights of water in the remaining peat areas to compensate for peat shrinkage.

The Humber Wetlands

2.3.8 The Humber Wetlands total approximately 330,000ha of which 200,000ha may contain former or current waterlogged environments and the area included 5000 known archaeological sites in 1995. This area has been subject to drainage from the 17th century onwards leading to arable use and associated threats to archaeological deposits. In fact land drainage and subsequent changes in landuse were identified within the Humber Wetlands project as being the greatest threats to the archaeological resource in the area. The survey resulted in a worrying conclusion that:

> it is anticipated that in the coming decades a significant proportion of what is presented here [ie archaeological sites] in this publication will disappear

(Van de Noort and Ellis 1998, 4).

2.3.9 Hydrographs from boreholes were studied as part of the Humber Wetlands survey. Variations in water levels over a period of time were looked at for two boreholes. At Cherry Tree Farm, Hatfield Chase, the lowest annual groundwater level in the 1960s was c 0.5m OD; during the 1970s it fell to -1.2m OD, and between 1979-1988 the lowest level fluctuated between -0.5 to -1.0m OD. Since 1988 it has fallen further to a record low in 1992 of -1.7m OD. The results of this survey showed that for sites with archaeological and palaeoenvironmental material, fragile organic material will only now survive under -1.7m OD, and that timber structures above -1.7mOD may survive for the moment but will deteriorate fast. From these results it was predicted that within this area, without remedial action in the near future, more than 2m of potentially rich archaeological stratigraphy will have been lost since the late 1960s through falling watertables (Ellis 1993, 109).

2.3.10 From hydrographs examined at Stainforth Hagg, a similar change was recorded. Here the water level fell dramatically from 7m OD to 4.2m OD between 1972-6, probably the result of local drainage, and has fluctuated ever since between 4-5m OD. This would have led to a loss of c 3.5m of waterlogged archaeological stratigraphy in this area.
Somerset Levels

2.3.11 At Greylake, King’s Sedge Moor, a Late Bronze Age human disposal site associated with waterlogged wooden structures has been excavated on pasture. The excavations showed that water levels are falling in areas of pasture as well as arable. The monitoring of the water table in this area showed that water levels in 1998 were 0.75m below the ground surface, well below archaeological deposits, leading to decay occurring within the archaeological resource. The author stated that the life expectancy of this important archaeological site was very limited and similar studies in the region led to similar conclusions (Brunning 2001).

2.3.12 Further work carried out in the Somerset Levels suggests that falling water levels not only cause the drying out of waterlogged deposits, but can also cause the leaching out of the colours in the soils and affect their structure. It is these different colours and textures which define most archaeological deposits. If these disappear the information contained within stratigraphic relationships will be lost (D Jordan pers. comm.).

2.4 The effects of peat erosion

2.4.1 Centuries of drainage have succeeded in transforming wet organic peat and silt landscapes into dry fertile arable land suitable for cultivation but vulnerable to wind erosion (Figure 41). As a result many metres of soil have been lost through wind erosion and shrinkage causing the whole landscape to be lowered. As the land has shrunk and eroded, archaeological monuments that were once deeply buried and protected have begun to emerge to fall within the reach of the plough.

2.4.2 French further explains:

> Peat wastage occurs as a result of desiccation and coincident oxidation, in combination with much increased micro-biological action. The whole process is hastened by wind erosion. Peat and sandy peats, especially when they are exposed in the spring and early summer, are especially susceptible to wind erosion’ (French 2000, 4).

2.4.3 The drainage of wetlands leads to a cycle of desiccation and erosion. Drainage ditches have to be continually lowered to keep pace with the shrinkage/lowering of the peat soils therefore causing a further cycle of desiccation and erosion. Often wind-blown peat will cause the silting of these drainage ditches which in turn necessitates their deepening and so the process continues.

2.4.4 Regardless of whether drainage is slowed in the wetlands, the fertility of much of the peat ie. the organic content, has already been irreparably destroyed through this process of deflation and microbial decay, leaving only mineral material remaining. French (2000) records that in many places in the Fens, the underlying fen clay or marine derived clastic material is being ploughed up onto the surface, and in these places the peat resource has been destroyed and has become an inorganic mineral ploughsoil. French also notes that:

> often, where it [peat] does just survive the farmers are actively encouraging its destruction by subsoiling to increase its mineral content (ibid, 5).

2.4.5 This erosion of the organic content of soils makes them generally much less stable and increases the process of erosion by wind and water. In arable areas of the Fens the organic content of these ploughed peats has dropped to 1-2%, as opposed to 5-10% in pasture soils. This falls well below the 3-4%, thought to be the barrier below which soils may become liable to structural instability. This accelerated organic loss...
is thought to derive from improved drainage and aeration of ploughed soils which causes increased oxidisation. Even if these soils were re-wetted they would never regain their stability which is reliant on their organic content.

Thus the intensively drained soils of much of the southern Fenland region are extremely fragile and in many areas largely past conservation, if non-existent........A recent survey of wind blows in the Cambridgeshire Fenland and Nottinghamshire between 1968 and 1977 indicated that moderately and severely damaged crops occurred about one year in every two for each month from March to May. In another survey of farms on erodable sands or peats in Lincolnshire and Nottinghamshire, 36% of the total area surveyed was liable to erode, although it only affected small parts of the fields. The type of crop also influences the susceptibility to erosion, with the smooth seed beds and slow germination for crops such as sugar beet, carrots or onions being more prone to windblow than land sown to cereal crops (ibid, 4-5).

2.4.6 All three parishes in the Cambridgeshire survey undertaken by Honnor and Lane (2002) show serious peat wastage. They comment that the peats in Moreton Fen have been wasted and lowered to such an extent that only the last vestiges of this organic mantle still exist over what was formerly the central part of the Fen, revealing the underlying patterns of former roddens (former saltmarsh creeks) which date from the Bronze Age and Iron Age. Peat wastage has also led to the obliteration of the Bourne-Morton Roman canal in this area. Similarly along the edge of Deeping Fen, there are indications that the pre-peat archaeological landscape is emerging as a result of desiccation, in the form of round barrows protruding from the peat. At Bourne South Fen, between Deeping and Morton Fens, the lowering of land levels and shrinkage rates have been calculated recently at 0.30m in 10 years (Miles 1976, 24) and Honnor and Lane have compared this rate with historical accounts of fen peat wastage and its drainage (Appendix Jiv) (Honnor and Lane 2002, 5).

2.4.7 The South-East Fen Edge and Dyke Surveys have also been used as an aid to monitor the effects of desiccation on various archaeological deposits. The area examined lies just to the east of Peterborough where a huge buried landscape is just emerging from the fen, as a result of erosion and desiccation. The landscape is now all arable and it has been calculated that in the mid 17th century, prior to conversion and drainage, the peat fen would have been c 2.5 and 4.5m above OD. Now it has fallen to between c -1.0 to +1m OD. This has left much of the archaeology that would have been protected and waterlogged in the 19th century now vulnerable. The effects of this are illustrated through three case studies, seen in freshly cut sections of dykes in this area (French and Pryor 1993).

• At North and Flag Fens the existing dykes have cut sections through Northay Island. Examination of these dyke sections showed that the prehistoric buried soil is overlain by upper peat only c 25-65cm thick. Close by, Dyke 10 cut through a Bronze Age wooden platform which was overlain by alluvial and peat material c 2m deep (height of present day land surface). Here it is thought that at least 1m (a conservative estimate) of peat has been lost from the modern surface through desiccation and deflation. Later Roman deposits associated with the 1st century Fen causeway are currently lying at the top of this sequence and are about to be truncated by ploughing.

• At Borough Fen (Site 7/Dyke 5) two thirds of a mid-Iron Age earthwork survives in an area of pasture. This part of the site is a Scheduled Monument with its principal rampart standing to 1.5m, enclosing a roughly circular enclosure of c 3.8ha. The eastern third is under arable and is not Scheduled and is only visible as a soil mark. The interior of this earthwork, which lies in pasture, is now
upstanding to 1m above the surface of the surrounding ploughed peat and alluvium. Originally it would have been beneath the surface of the surrounding fen, but has effectively risen as the surrounding fen has been subject to drainage, ploughing, peat shrinkage and wastage. The monument is not included on a map of 1637 suggesting that the peat and alluvium completely obscured it at that date.

- Also at Borough Fen, a barrow group originally lay buried by alluvium and peat. The area has been subject to severe drainage, and the subsequent shrinkage of the peat component of the overlying and surrounding soils has led to the exposure of the upper third of the barrow mounds. Two of the barrows were sufficiently upstanding to modern machinery that in 1986 their tops were bulldozed flat, and the same fate is now feared for the others. The barrows have also suffered from intensive leaching and very effective recent drainage, which will have had a detrimental effect on the preservation of botanical evidence associated with the barrows.

2.4.8 In the Somerset Levels peat wastage also occurs. Anchor points positioned to monitor water levels show peat losses ranging from between 0.04m and 0.071m per annum since 1977. Over a period of 100 years this rate of wastage would result in a loss of 0.44m to 0.79m of peat:

All of the waterlogged archaeological sites on the levels and moors designated as SAMs exist within 90cm of the ground surface and are therefore likely to be totally destroyed by desiccation within this period if this wastage rate is applicable across all the peat areas (Brunning 2001 12).

2.4.9 Brunning (pers. comm.) also records that arable fields in this area are invariably lower than their pasture field neighbours. It has been estimated, using information from peat extraction areas in the Brue valley that the density of archaeological sites is c 3.4 sites per km² (likely to be an under estimation). In areas where peat deposits have been identified there are a total of 1066 entries on the County Sites and Monuments Record. Of these only 115 retain their waterlogged archaeological remains, of which 53 still survive with their waterlogged remains in situ, the remainder having been destroyed either by peat wastage or other processes. Of the 53, some have undergone limited investigation, and all showed varying degrees of damage through desiccation and associated cracking and decay of organic material. Some of the Scheduled sites that may be lost include Glastonbury Iron Age Lake Village, 11 prehistoric trackways, a further two prehistoric settlements and a Roman or medieval causeway (Brunning 2002).

2.4.10 In the North West Wetlands it is estimated that one-fifth of the peat in Lancashire was lost between 1964-1985, based on the current wastage rate of c 10 mm per year (Burton and Hodgeson 1987, 50-1). The same or higher levels of damage occur elsewhere in the region, and agricultural improvements form the greatest threat to lowland peats (Hall et al. 1995).

The major threat to the smaller mosses, particularly those in enclosed land, and to the margins of the larger, unenclosed mires, is agricultural drainage, much of it instigated in the last century. The scale of the threat is long term although, as repeated work at Ehenside Tarn has shown, it has an insidious effect: desiccating deposits, artefacts, and palaeoecological sequences. In addition, there are small, isolated areas of arable which cause physical damage to deposits and the oxidation of surface peat layers. (Hodgkinson et al. 2000, 165).

2.4.11 One of the areas worst affected by peat erosion in the Humber Wetlands is the Hull valley. It has changed from a pasture-dominated landscape, with annual flooding of
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Appendix F Case studies of archaeological damage from arable activities

Water meadows, to one dominated by large featureless arable fields and an artificially controlled water table. The level of the water in the canalised River Hull was several metres higher than the surrounding fields in the winter of 1998-99, illustrating the rate of shrinkage that has occurred in the area through drainage and desiccation. The poor level of preserved waterlogged deposits found in recent archaeological excavations reflects these changes, although exceptions were found (Van de Noort and Ellis 2000, 1). This is in an area that prior to the Humber Wetlands Survey was thought to have a high archaeological potential. This deterioration is thought mainly to be due to the:

...that the water in the River Hull and the ground water table in the floodplain are normally kept well below the pre-drainage levels resulting in the advanced and probably accelerated desiccation of waterlogged archaeological sites which only 10 years ago suggested significant potential for archaeological research eg the Bronze Age woodland remains at Wilfholme Landing (Van de Noort and Ellis 2000, 253).

2.4.12 This contrasts with the Vale of York where drainage and landuse appear to affect the archaeological resource to a lesser extent than was previously thought, partially because the Vale still contains large areas of extant wetlands which are protected from damaging operations (Van de Noort and Ellis 1999, 281).

2.5 Peat wastage rates

2.5.1 There is now a considerable body of data showing the extent of peat wastage in wetland areas caused by the ongoing destructive cycle of drainage, desiccation and arable use described above. These have been summarised here:

- At the Holme Fen post in the Fens, 3.9m of peat wasted away between 1848 and 1950. The present Holme Fen iron post replaced the original wooden post and stands exposed 3.88m above a ground surface that lies c.2.28m below sea level (Hall 1987, 2).
- In the mid 17th century, prior to drainage, the peat fen in Cambridgeshire would have been c.2.5 - 4.5m above OD. Now it has fallen to between c.-1.0-+1m OD (French and Pryor 1993). The ground level of peat in the Cambridgeshire Fens has therefore fallen by up to 4.60m in places since 1652 (French 2000, 5).
- New drainage schemes cause very rapid peat wastage, up to 0.22m per year, which then slows to a longer-term average of c.10-18mm per year (French 2000, 5).
- The Soil Survey for England and Wales has now estimated that where lowland peat is under arable land use, the wastage of peat through drainage, ploughing and erosion is likely to be between 10mm a year in Western England and 13.7mm a year in Eastern England (Van de Noort et al., 2001, 16).
- Seale (1975) estimated that in the Ely District, 55% of soils are organic with a thickness of >0.30m; with a wastage rate of say 18mm per year, only about 20% of these soils will remain by the first decade of the next millennium. Whether this is proving an accurate estimate is not known.
- Robson and George (nd, 5) quoted reported wastage of 1.8cm per year. Their colleague on the Soil Survey, A. Herbert, recorded wastage of 0.75cm per year on shallow (<90cm) cultivated peat and 2.1cm per year on deeper (>90cm) cultivated peat at undisclosed locations in the Fenland.
- During their survey of Lowland Peat for the Soil Survey, Burton and Hodgson (1987, 91) suggested that in AD 1630 there existed in the Fenland some 1480km² of peat which, in 1985, had reduced by a remarkable 84% to only 240km². If wastage of cultivated peats continues at the current average rate (as calculated by
Richardson and Smith (1977) it is estimated that, by the year AD 2050, the area of remaining peat will be reduced by a further 66% (Honnor and Lane 2002, 14-15).

- The soil survey for England and Wales (Burton and Hodgson 1987, 50-51, from MAREW) records that for the northern Lancashire peatlands one fifth of the extent of peatlands under agriculture has been lost over a 20 year period (1967-87), or a 1% lateral loss of lowland peats per year.
- At Chat Moss in Greater Manchester a figure of 30mm a year is suggested for peat wastage (Hall et al. 1995).
- In the Somerset Levels, it has been estimated that since the 19th century between 4-6m of peat has been lost through peat wastage and extraction. Much of the wastage probably followed the initial extensive drainage of the wetlands in the 19th century (Brunning 2001, 14).
- Much less work has been carried out in England on peat soil loss in permanent grassland. However, in Central Europe peat soil waste by oxidation has been measured at rates of 1-2cm a year and a Polish study found loss under grass was half that for loss under arable (Brunning 2001, 13). Brunning predicts that peat wastage in pasture fields, is occurring at rates of between 44cm and 79cm a century, while the figure for arable fields could be around 2m to 3m a century (Brunning 2002).

2.5.2 In the Borough Fen area of the North Level French and Pryor draw attention to the fact that:

the thickness of the peat recorded in the British Geological Survey’s borehole logs has declined in the ten years since the survey from an average depth of c 50-60cm to 20-30cm. The latter figures have been observed and recorded constantly during the dyke survey in the past five years. This gives an approximate figure for peat wastage of c 20-30mm a year. If this continues, by the turn of the century (ie. 2000) much of the subsoil in Borough Fen will be brought to the surface by the plough, and the organic soils that now cover many of the fields will be gone. Indeed in some fields of clay fen is already being ploughed up (French and Pryor 1993, 11-12).

2.5.3 MAREW summarises all this data by stating that:

........ with 72% of lowland peatlands under arable, the annual loss of peat is between 15.1 million and 20.7 million m³, for 10mm and 13.7mm annual wastage respectively. Over the last 50 years, the volume of peat lost through wastage lies between 755 and 1035 million m³. This translates into a peat wastage figure of between 0.5 m and 0.69 m over the last 50 years, or to 1.5m for selected areas such as Chatt Moss. If the rate of peat ‘growth’ is 1m/millenium (or 1mm/year), then in the last 50 years, between 500 and c700 years of archaeology and palaeoenvironments have been lost, and as much as 1500 years in the case of Chatt Moss (Van de Noort et al. 2001, 16-17).

2.5.4 Brunning, the Somerset Levels and Moors Archaeologist, offers a more direct prediction: All known waterlogged sites of national importance in the Somerset Moors will be destroyed by the end of the century if current rates of peat wastage continue (Brunning 2002).

2.5.5 These wastage rates suggest that over many former wetland areas, depending on the original depth of the peat itself, the potential for any peat deposits to survive in the near future is limited. This has very serious connotations, not only for the archaeological resource but also for the agronomic, economic and social fabric within these areas.
3 INTRINSIC SITE FACTORS THAT INFLUENCE DAMAGE TO ARCHAEOLOGICAL SITES IN ARABLE LANDSCAPES

3.1.1 Such intrinsic site factors include the type and condition of archaeological remains, previous cultivation, vulnerability to erosion caused by climate, topography, and soil/bedrock type.

3.2 Type and condition of archaeological remains

3.2.1 An understanding of the depositional and post-depositional processes relating to different archaeological sites is important in our understanding of how certain sites can be totally destroyed by a limited episode of ploughing, while on other sites evidence still remains.

Sites with no cut features

3.2.2 There are certain types of archaeological site or occupation activity which may totally disappear as a result of just one episode of ploughing. Such activities include those which have taken place solely on top of old ground surfaces with no elements penetrating into the subsoil (for example early prehistoric sites such as hunter-gatherer activity areas, post-built houses built on sill beams etc). Historic ground surfaces lying preserved under the current ground surface are extremely important both for the archaeological remains that lie on their surface but also for the palaeoenvironmental remains within them. Such evidence is extremely vulnerable to destruction from ploughing.

Sites with vertical layers of stratigraphy and occupation horizons

3.2.3 Most sites initially would have had layers of vertical stratigraphy (layers of archaeological deposits surviving one on top of the other) associated with them. On complex sites which have been protected in the past from damage, a build up of these surfaces can exist, for example, successive layers representing floor surfaces in buildings, road surfaces, yard surfaces, layers of building rubble etc. These sites are also very vulnerable to ploughing, in that one episode of plough damage or the gradual deepening of cultivation can remove many of these important archaeological layers many of which may be only a few centimetres thick.

Upstanding earthworks

3.2.4 The successive erosion of earthworks will occur when they are ploughed, as each year the plough repeatedly flattens them out or encroaches on their edges (see above). Often these earthworks will have protected historic buried ground surfaces or layers of stratigraphy beneath them, which will become increasingly vulnerable as the earthwork is destroyed. Observations on the effects of cultivation of earthworks (especially barrows) indicate typical rates of erosion of 0.002m to 0.005m per year. For example:

- Neolithic Causewayed enclosure in Sussex: banks being eroded at c. 0.04m per year with initial erosion being most rapid at c. 0.05m per year (Drewett 1975)
- In Norfolk: the mean annual erosion of earthworks from ploughing has been calculated at 0.022m per year (Lawson 1980)
- Walton Basin: 6 barrows lowered by ploughing by between 0.3m to 0.95m over the last 20 years (0.015-0.05m a year) (Gibson 1998)
- Rockbourne long barrow, (Hants.): in 1982-1991 height of earthwork was lowered from 2.16m to 2.10; from 1991 to 2001 further lowered to 2.05m therefore the annual rate of erosion can be calculated at 0.005m to 0.006m per
year (Cromwell 2002, also see report kindly produced by English Heritage for this study, in Appendix Jviii)

- Alfriston Neolithic burial mound (Sussex): 2m high in 1914 and 1934 but only 0.25m of mound left when excavated in 1974. Rate of erosion by ploughing calculated at c 0.05m a year though it is suggested that the annual rate was probably greater in first few years as the mound was steeper with more hill-slope erosion occurring (Drewett 1975; 1980).

3.2.5 An examination of the morphology of barrows offers an insight into how different types of earthworks are affected in different ways by cultivation. In a series of excavations on the West Berkshire Downs the relatively well preserved barrow, Lambourn 19, was thought to owe its survival to its large diameter and the fact that it was built of a ‘plough resistant clay compound’. In contrast the inner loam core of the Hodcott barrow proved very vulnerable to destruction after its protective chalk ‘envelope’ had been removed by ploughing (Richards 1990a). Similarly barrows made up of soil from their associated surrounding quarry ditches will survive better in some areas than others, depending on the resilience of the underlying quarried material. Barrows built of stones, ie. cairns, will prove more resistant to the plough, as long as they are not robbed for their stone rubble. In contrast, if barrows have no ring ditch and are built up of scraped-up topsoil only, they can very easily disappear without trace. Such a process was observed from the excavation of a round barrow at Alfriston, East Sussex (O’Conner 1977). Similarly, barrows built of sandy soils are very vulnerable not only to plough damage but also to other forms of erosion such as rabbit burrowing, as seen at the round barrow at Harpley (Norfolk) (Lawson, 1976).

The ‘Threshold effect’

3.2.6 This is relevant to earthworks, but also to all archaeological sites and occurs where one further season of plough erosion can wipe out the remaining, and perhaps the most important, evidence of an archaeological site (Figure 31). With earthworks it can be particularly hard to judge when this stage is reached. With small, often Scheduled, upstanding mounds it is often difficult to tell if the earthwork itself represents just raised areas of natural subsoil which have in the past been protected by a mound that no longer exists, or whether they contain archaeological evidence which would be worth continuing to preserve. If archaeological remains do survive, these rather unimpressive monuments are very vulnerable to destruction. Only one episode of slightly deeper cultivation could destroy any surviving mound material or buried soil, and therefore destroy any archaeological evidence that there was once a feature at this point.

3.2.7 This was seen to have occurred during excavations at a barrow at Harpley (Norfolk), where although the barrow mound was visible as an earthwork prior to excavation, virtually no mound material survived in situ. This led Lawson (1981, 29) to conclude that a modern ploughsoil can be as thick as 0.35m, hence it is probable (at least on chalk), that an old ground surface under a barrow, with all the information that it contains, will not survive ploughing once the mound has been reduced to less than 0.50m, once the higher level of the protected subsoil surface is taken into account. This illustrates the problems in judging the ‘Threshold Effect’.

Buried structures eg. walls

3.2.8 Where the remains of stone walls have survived below the ploughsoil, but are then brought within cultivation depth, it is possible that initially they will be strong enough to resist the plough (as seen at Waltham Villa near Whittington, Glos.). It has also been observed that when ploughing, a farmer may lift up his plough in stony areas, ie. over a wall etc, to protect his plough from damage. This was observed at Bryn Eyre
(Anglesey), where excavations revealed the stony areas to be in much better condition than surrounding deposits for this very reason (D Longley pers. comm.). However, continued contact with the plough will cause gradual weakening of upstanding walls, leading to their collapse as they yield to the plough. This often happens after the introduction of new, more powerful machinery which instead of bouncing off walls will be strong enough to break through them.

3.2.9 At Catsgore, a Romano-British settlement near Somerton (Somerset) it was observed that:

A second type of destruction by ploughing was noted where wall foundations were constructed of lias slabs pitched at an angle in a shallow trench. These walls were often well preserved where they ran across the contours and in the same direction as the plough but were frequently destroyed where they followed the contour lines and were cut into at right angles by ploughing; in the latter instance the plough will meet with much less resistance and is able to uproot quite solid foundations (Leech 1976, 94).

3.2.10 The presence of stone debris and walls can also affect monument survival in more general terms. In a study of the deserted medieval villages (DMVs) of England, many were found to have been abandoned and left as pasture or scrub, rather than destroyed and ploughed, due to the debris and stone left by the houses hindering the conversion of these fields to arable. It was often only in the 19th and 20th centuries that the earthworks were levelled, the debris removed and the villages destroyed as the equipment became more able to undertake such tasks easily. Often for this reason DMVs with clay buildings were destroyed far earlier than those with stone foundations (Beresford and Hurst 1971).

Cut features, pits ditches etc

3.2.11 Where a site has already been badly damaged by ploughing all that may remain of a previously stratified site are features (ditches, postholes, pits and deep burials) cut into the subsoil or geology just below the ploughsoil itself. Some of these features can be very shallow and easily removed by one season’s slightly deeper ploughing, while others are deeper and more resilient.

3.2.12 Archaeological sites with only cut features remaining are very common in arable areas, but as many excavations have shown, they still can provide important archaeological information. Even these features will eventually be destroyed by successive deeper ploughing and other activities such as subsoiling and drainage works. However, with the exception of burials, proportionally less information is lost through plough damage on this type of site than on the more vulnerable sites described above.

3.3 Previous cultivation/land-use

Early plough damage

3.3.1 Not all damage to archaeological monuments from cultivation is of recent date. It is clear that later prehistoric, Roman and medieval cultivation all damaged earlier deposits.

3.3.2 Ploughing in some parts of Wessex has been practised since the Neolithic period, with the earliest plough furrows seen dated to the Beaker period, c 2000 BC. Until AD 500 light ploughs were used, with wooden ards which were capable of producing quite deep furrows once the overlying turf was broken. In the Roman period more specialist ploughs were introduced for distinct tasks. Plough damage has therefore
been quite widespread since at least the Roman period and probably earlier although the limitations of technology in these early periods limited the scale of such damage. Clear examples of early plough damage can be seen:

- on parts of the Dorset Cursus
- on an Iron Age enclosure on Overton Down (Wilts.)
- within the Hillfort at Ogbury (Wilts.)
- at an Iron Age settlement enclosure at Little Woodbury (Wilts.) (Bowen 1980)
- at Waylands Smithy Long Barrow (Oxon.), ploughed in the Iron Age or earlier
- at Ram’s Hill, where a late Bronze Age negative lynchet overlay the earlier Bronze Age defences (Richards 1978, 61)
- in the Slack Valley (Yorks.) where Romano-British ploughing had destroyed several Iron Age barrows (Manby 1980).

3.3.3 The Thames Valley also has a long history of cultivation probably due to the easily worked and fertile nature of the valley floor. In fact very few upstanding earthworks remain in the valley, the only trace of their existence coming from cropmarks seen on aerial photographs. Aerial photographs show many areas where later farming systems have totally disregarded earlier features, indicating that the earlier features had already been ploughed out and levelled. Excavations have revealed a similar story; at Devil’s Quoits stone circle (Oxon.), Roman and medieval farmers buried the late Neolithic standing stones prior to laying out their cultivation strips over the site (Miles 1980).

3.3.4 The development of the ridge and furrow method of cultivation in the medieval period often caused at least the partial destruction of earlier sites. For example, at Avebury it is thought that this method of cultivation may have destroyed part of the eastern end of the Avenue. Ridge and furrow can also selectively protect earlier sites and this is discussed below.

3.3.5 It has been suggested, through studies particularly on the South Downs, that this early ploughing caused significant soil erosion:

> The major research findings of this study are that the greatest loss of soil is likely to have occurred under arable agriculture during the Bronze and Iron Ages; land-use rather than climate is the main factor influencing the long-term erosion rates; autumn sowing is confirmed as a probable cause of increased late prehistoric erosion… (Favis-Mortlock et al. 1997, 88).

3.3.6 Early cultivation can also have the effect of distorting our impression of the original distribution and location of monuments. Upstanding barrows often only survive in upland areas on poor soil, leading to the assumption that the existing concentrations of surviving features reflects their original distribution. However, the continuous cultivation of the more fertile soils over the last 1000 years may have destroyed all trace of barrows in lower-lying areas therefore distorting our view of their original distribution. For example, in the Yorkshire Wolds where medieval ploughing was widespread, many barrows in the parishes of Fimber, Fridaythorpe and Wetwang have been destroyed by early ploughing, with only those on poor soils preserved as earthworks (Manby 1980).

19th - early 20th century cultivation (Figures 42a and b)

3.3.7 Steam ploughing, undertaken in the early 20th century, has been recorded as extending deeper into the ground than even modern ploughing. Evidence for steam ploughing has been identified during work at the Woodham Walter enclosure complex in Essex. Here the farmer informed archaeologists that no deep ploughing had occurred on the site, but the excavation revealed ploughsoil to a depth of 0.35-40m (Essex CC nd).
Steam ploughing was suspected after the discovery of quantities of coal at the edges of the field, implying that a steam engine once stood there. This was later confirmed when the site was subject to further excavations at a later date by the presence of pieces of coal from the base of the ploughsoil (Buckley and Hedges 1987, 15).

3.3.8 Prior to the introduction of the steam plough in 1890, a common method of soil tilling was the Derby Digger, a system in which a single, long plough-share was attached to a steel cable which was wound round a steam-driven drum. The cable was secured in four places around the field and pulled around by the rotating drum. The subsequent ploughed strips were achieved by moving the corner posts progressively inwards towards the centre of the field. At Chignall St James Roman ‘villa’ site (Essex), it was the use of the Derby Digger which was judged to have caused most damage to archaeological deposits, and which had penetrated to a depth of c 0.45m (Essex CC nd).

3.3.9 Local ground conditions have often led to localised methods of arable-related destruction. For example, in one area of the Mendips (Somerset) 19th-century enclosure of the upland areas could only have taken place after drastic improvement of the soils. The area to be improved in this case contained a variety of soil types, some acidic and some underlain by a rust-coloured layer of iron-enriched clay. Two methods of improvement were tried. One method involved the technique of heavy liming and deep ploughing. John Billingsley, the main proponent of this method, ploughed his 3-4000 acres 4-5 times then spread 50,000 bushels of lime onto it. However, the method considered most effective was to shallow harrow and plough the land, then throw it into a series of mounds and gutters to expose the rust-coloured iron pan crust. The land was then either used for potatoes or the crust was destroyed by pick axes and thrown up onto the mounds of black silt. This broke up the iron pan and mixed the soil types together. Although an effective way of improving the land both these methods, where used, would have had serious consequences for any archaeological evidence within the soil (OAU 1998).

3.3.10 Similarly at Danebury Iron Age hillfort (Hants.), the interior of the hillfort was damaged by what appeared to be 17th-century attempts to marl the soil. Trenches 0.6m wide and 5m long were found in parallel batches only a few centimetres apart. They were hand dug with shovels through the topsoil and 0.002m into the underlying chalk bedrock (Cunliffe 1984, 14).

**Protection of sites by old ploughsoil**

3.3.11 Often sites, far from being destroyed by earlier arable practices, have been protected from later damage by these practices. During investigations at Horton (Wilts.), strip lynchets, probably dating to the Romano-British period, masked and protected an earlier Iron Age ditch (Wood et al. 1959). At Black Patch (East Sussex), the upstanding earthworks had been bulldozed flat and little was expected to have survived; however, the bulldozed material overlying the site had actually served to protect the below-ground remains from the subsequent plough damage (Drewett 1982).

3.3.12 During excavations at the Roman settlement and cemetery at Barton Court Farm (Oxon.) parts of the site had been protected by a lynchet, built up since the Roman period to over 1m high. This lynchet served to protect the features below it, including a Roman wall, the only evidence for which away from the lynchet, was a scatter of plaster. The survival of baby burials was also greater under the lynchet than in the rest of the site (Miles 1980). Similarly at Catsgore (Somerset) it was recognised that middens and wall foundations dating up to, and from, the time of abandonment of the
settlement, were well preserved in the one area of the site where they were sealed by a
lychet and thus protected from plough damage (Leech 1976).

3.3.13 Where deeper ploughing has occurred on an archaeological site in the past and has
resulted in a thick layer of ploughsoil, this can protect the site from later, shallow
ploughing. Excavations at Verulamium Roman town (Herts.) in the 1970s showed
that surviving wall tops and associated archaeological layers were separated from the
base of what was then the modern ploughsoil by a layer which represented earlier,
dereper plough disturbance (Niblett nd). Similarly at Brampton (Norfolk), site of a
Roman town and kiln field, the current ploughing extended to a depth of 0.30m, but it
also overlay an earlier undisturbed layer of old ploughsoil which protected the
archaeology from further damage. This deeper phase of ploughing was thought to
have occurred during the 1940s when the site was deep ploughed and marled (Green
1977).

The protection afforded by ridge and furrow

3.3.14 Medieval cultivation in the form of ridge and furrow has led to severe damage to
some archaeological sites under the furrows (see above) but can protect sites under
the ridges. It has been shown that up to 50% of old land surfaces can survive under
these ridges (Palmer 1996). However, ridge and furrow is itself being destroyed at a
rapid rate. A study undertaken by Northants Heritage recorded that in
Northamptonshire in 1940, most parishes were made up of between 34-77% ridge and
furrow. In 1990 this figure had fallen to between 8-21%, a rate of destruction which
implies that if nothing were done, there would be no ridge and furrow in the county in
50 years time (Hall 1993).

3.3.15 In a similar study carried out in Warwickshire and Worcestershire, up to 67% of ridge
and furrow that had survived up until the mid 20th century had been lost, mainly to
arable, at an annual rate of loss of 2-3% per year during the last 40 years (Hurst, 1997
unpub). Similarly a recent survey in the West Midlands revealed that of the 2000
townships identified within the study area in 1996, as few as 104 retained more than
18% of their original ridge and furrow and of these only 43 retained significant areas
of ridge and furrow. Comparison with 1950 revealed that most of this destruction had
occurred in recent decades. New air photos commissioned in 1999 showed that by
this date, of the 43 best examples cited above, only 20 townships (as opposed to 31)
retained more than 23% survival, and only 6 townships (compared with 9) retained
more than 40% of their original coverage (Anderton and Went 2002, 54).

3.3.16 Examples of where ridge and furrow and their associated headlands have caused
differential preservation could be seen during recent excavations at Barton Court (see
above), Watkins Farm, Northmoor and at Gravelly Guy (all Oxon). At Watkins Farm
a zone of better preservation c 15m wide was discovered when an Iron Age enclosure
was excavated. This zone was interpreted as having been protected under a medieval
ridge and furrow headland, whereas the rest of the site had been truncated by
ploughing to the natural gravel (Figure 43).

3.3.17 Palmer (1996) suggests that, once levelled by modern ploughing, the material from
the medieval ridges will still initially protect any earlier archaeological sites below
the ridges from modern ploughing, but the continued ploughing of levelled ridge and
furrow causes even this protection to be reduced over time. This, he argues, can lead
to sub-surface features from earlier settlements affecting crop growth, therefore
causing cropmarks, allowing identification of any archaeological features below the
medieval ridge and furrow to be apparent for the first time. This is especially the case
in clay areas, where the ridges would originally have been higher, by up to a metre,
than in gravel areas, and would therefore have provided more of a protective blanket when ploughed out.

3.4  How soil type/bedrock can affect archaeological survival

3.4.1 Soil type can influence the necessity for, and type of, drainage required and the need for subsoiling. Loamy and silt soils are prone to the formation of surface crusts or caps, but these will be removed by normal ploughing. Lighter, fine and sandy soils are prone to the formation of iron panning at their base, which has to be removed by subsoiling. Clay soils are less affected by natural weathering, but they are very susceptible to animal and machinery damage causing compaction, especially when wet (see above). The higher the clay content, the poorer the drainage and the lower the organic content, all factors which contribute to the formation of subsurface compaction pans which are often then removed by deep ploughing or subsoiling (see Appendices D and E).

3.4.2 A series of excavations carried out as part of the Wroxeter Hinterlands Project (Shrops.) (White forthcoming) provide an insight into how different soil types can affect the survival of archaeological deposits in arable areas. Here two sites excavated on sand, Duncote and Berrington, could be seen to have suffered very badly from plough-damage to the point where it was virtually pointless to excavate. At a nearby site, Whitley Court, preservation was greater, as it was at two other nearby sites, all of which were on clay. White concluded that sites on clay appear much more resistant to plough damage than those on sandy soils (R White pers. comm.).

3.4.3 At Ridgeway, Cradley (Herefordshire), differences in the depth of ditch deposits from the same feature were recorded across the site. Where the ditch was cut into a clay subsoil, it was 1.5m deep. Where the ditch was cut into the solid bedrock it was 1.8m deep, indicating that the solid bedrock offered more protection from plough damage than the clay subsoil (White 2001). A similar picture was recorded during excavations at Angmering (West Sussex) (S Foreman pers. comm.).

Chalk

3.4.4 Chalk soils do not retain their fertility once they are brought into an arable regime. Fertility is often maintained by deep ploughing to marl the topsoils, by bringing up the richness from the underlying chalk. This is notoriously destructive to archaeological sites lying below the original topsoil/ploughsoil. This type of damaging operation triggered rescue excavations at Gussage-all-Saints (Wilts.), Hambledon Hill (Dorset) (Mercer 1980b) and Chalton (Hants.) (Benson and Miles 1974). The alternative procedure, often carried out in conjunction with the above, is to add copious amounts of fertiliser, with the resultant detrimental effect this has on artefacts in the soil and the environment. It is not uncommon in chalk areas to see fields after ploughing, white with chalk, with barely a stain of organic soil (Figure 44). Groube and Bowden (1982, 20) sum this up by recording that the soil bulk is derived from deep ploughing the chalk rock into the top horizon and fertility is added from a bag. This process is not only destructive to the proven rich archaeological resource of the Downland, but also to the land itself.

3.4.5 Chalk downlands are often very rich archaeologically but are also important when preserved in their natural uncultivated state for both their historic landscape and ecological potential. Much of the Chalk downlands were under permanent, old pasture until quite recently. It is now estimated that less than 1% of the Berkshire Downs, 2% of the Hampshire downland and under 3% of the Dorset chalk downland remains under permanent pasture (Yorston et al. 1990, 67).
Limestone

3.4.6 In the Cotswolds plough damage survey, undertaken in the 1970s, it was recorded that on the Cotswold limestone:

the natural thinness of the ploughsoil, commonly between 20-30 cms, means that all modern ploughing will affect the bedrock, either by direct contact between ploughshare and rock or by the stimulation of natural erosion of the bedrock. The effect of this is that archaeological features cut into the bedrock suffer progressive reduction, and above-bedrock features such as wall-footings will only escape damage fortuitously. Above-ground earthworks subjected to ploughing are liable to be even more vulnerable than the bedrock surface, because of the looser nature of their composition, whether it is earth or limestone rubble (Saville 1980a, 4).

3.4.7 Excavations of an Iron Age settlement at Guiting Power revealed the ploughsoil to be only 10-20 cm deep. Immediately below the ploughsoil the subsurface of the limestone bedrock was very ‘brashy’ and undergoing active erosion by weathering and recent agricultural activity, evidenced by the plough grooves on the surface (Saville 1974). Many shallow archaeological features were found, truncated through a combination of both cultivation erosion and solution.

Acid sands and gravels and uplands

3.4.8 Marginal expansion of the arable area into uplands, heaths and moorland not only exposes a greater area of land to the destructive processes associated with cultivation, but also often involves disruptive preparatory works, such as the removal of field boundaries and hedgerows and drainage. In upland areas, Darvill records that ‘Drainage schemes, stone clearance, reclamation of moorland, conversion of pasture to arable, the grubbing out of hedges and walls, and reseeding (of grassland) cause the most damage’ to archaeological sites (Darvill 1986, 47). Another potential problem affecting archaeological deposits, artefacts and the environment in these marginal areas once they are brought into cultivation is the amount of chemicals which have to be applied to maintain their fertility.

3.4.9 In some counties, barrows and other upstanding monuments are more likely to survive within peripheral areas such as heathland and moorlands, as it is not until recently that modern agricultural techniques have allowed profitable farming of these areas. This is illustrated by a study carried out in Norfolk where it was calculated that at least 220 barrows, more than one third of the population known in 1974-6, were situated on heaths. However by 1981, only 54 barrows remained in this environment, due to the ploughing up of these heathlands (Lawson 1981).

3.4.10 The survival of archaeological sites in heathlands, once ploughed, is also jeopardised by the fact that there is a tendency for podzolisation to occur in the light heathland soils, which will impede drainage, a process accelerated by initial vegetation clearance, and requiring destructive deep ploughing or subsoiling as a cure.

3.4.11 Moorland is one of the last undisturbed areas of the country where many upstanding monuments still survive. In Cleveland, the use of experimental fertiliser on these upland soils was carried out in the 1970s by ICI on their experimental farm at Wilton Down. In 1980 Crawford predicted that if these trials proved successful, any spread of agriculture into upland moorland would be disastrous for the survival of the many barrows existing in these areas (Crawford 1980). Bodmin Moor has decreased in size by 50% since 1813. Between 1960 and 1980, 10km² of the moor was destroyed, leading to the gloomy prediction that only the most resilient tors and sterile land would be left in 150 years (Johnson 1983, 7). Up until recently the edges of
moorlands were increasingly being encroached upon by agriculture with only a fraction of archaeological sites destroyed by these encroachments ever discovered. This encroachment has now on the whole stopped.

3.5 The effects of topography, climate and soil erosion on archaeological sites

3.5.1 Factors affecting soil erosion are discussed in full in Appendices Ei and Eii. Included here are specific examples which show how archaeological sites have been affected by these processes.

3.5.2 To reiterate the point made above, any form of erosion that erodes and thins the ploughsoil will effectively result in any archaeological deposits below the ploughsoil becoming increasingly vulnerable to the effects of cultivation as the plough effectively has to bite deeper into the subsoil to maintain ploughsoil depth.

Wind erosion

3.5.3 During a study of cropmark sites in the Milfield Basin (Waddington 2001) wind erosion was identified as being a contributory factor to damage caused to archaeological sites through cultivation. This was recognised both during the excavations and through direct observation of soil being regularly deposited on roads and against field boundaries. Light sandy soils, with a low clay content were identified as being at particular risk. Waddington records that ‘wind erosion is most severe after ploughing and prior to the growth of a crop’, especially between September and March, coinciding with when the winds are strongest.

3.5.4 At Forham All Saints (Suffolk), ploughing is maintained at a constant depth but wind erosion is continuously lowering the ploughsoil (Hinchcliffe 1980). Sites such as this, where the soil is light and sandy, and where the fields have been enlarged by the removal of boundaries, are especially vulnerable to wind erosion. For example, at a cemetery site at Sheffield’s Hill (Lincs.), wind erosion of the light sandy soil caused a reduction in the surface of the soil, which in turn led to the plough penetrating the archaeological deposits below (K Leahy pers. comm.).

3.5.5 Aeolian deposition can also be useful in preserving sites. The southern edge of the Vale of Pickering has been subjected to extensive areas of aeolian soil movements since the late Neolithic. In some areas extensive spreads of buried soils have been preserved underneath thick deposits of blown sands. For example, at West Heslerton blown sands have preserved a palimpsest of buried soils and features dating from the Neolithic to the medieval periods, leading in one case to the almost total preservation of an early Bronze Age barrow (Powlesland 1988).

3.5.6 Similarly excavations at Newton Cliffs (Lincs.), where the soils were sandy and light and prone to being blown by the wind, a substantial variation was discovered in the depth of topsoil between two of the trenches excavated (c 1.2m as opposed to 0.6m). This was attributed to differential erosion and deposition of the wind-blown sandy soil on the site (Garton 1989).

3.5.7 In the light Breckland and Sandling soils wind erosion has been recorded in the form of massive sand storms, the effects of which have been documented over the last 400 years, with redeposited sands reaching 8-9 ft high. This has led to the burial of early archaeological sites, for example West Stow Anglo-Saxon village (Suffolk) (Pendleton 1999, 440).
Soil erosion and topography

3.5.8 The effect of slope on the survival of an archaeological site can be variable. Archaeological sites located at the top of slopes are very vulnerable to erosion as the covering soil erodes downslope. This movement of soil downslope leads to material, known as colluvium, being deposited at the base of the slope, or against any obstruction across the slope. Where colluvium has been deposited, the overburden may protect and mask archaeological sites underneath. The presence of alluvium on valley floors will have the same effect. On the actual slopes themselves, soil cover is made thinner through being eroded downwards, leading to the plough digging deeper into underlying deposits.

3.5.9 Andrew Burke of Stirling University has undertaken a detailed study of cropmarks near Perth (funded by Historic Scotland), during which he looked at the interaction of topography with the survival of cropmarks. He has kindly allowed OA to use information from his draft progress report (Burke 2002). As part of this process he undertook detailed contour surveys within his study area and related this to the results of auger transects and trial trenching across areas of known archaeology. He was therefore able to show the exact correlation between slope and depth of topsoil and to further tie down the link between slope, depth of ploughsoil and survival of archaeological features (Figures 45-48).

Burke concludes from his work that:

*The second key objective of this section of the research is to identify cropmark sites or parts of cropmark sites at greatest risk of damage from ongoing agricultural use. The excavations have demonstrated that the condition of the subsoil surface is closely related to the depth of the topsoil above it, which in turn is closely related to topography. It is likely that cropmark sites situated at knoll summits or on slope shoulders are at risk, as this is where topsoil is likely to be shallowest, while cropmarks located at slope foots are likely to be protected by the increased depth of topsoil. Of course, the actual risk posed to the archaeological features will also be heavily dependant on the types of cultivation being undertaken (Burke 2002, 49).*

3.5.10 His work also clearly demonstrates the importance of studying micro-topography across the field, in that localised areas of convexity are greater risk from plough damage than areas of concavity (Figure 47).

3.5.11 Jonathan Bowes has also been looking at similar issues (Stirling University, funded by NERC and Historic Scotland). The aim of his work was to assess the rates of soil truncation caused by soil erosion and the risk it poses to buried Neolithic sites across cultivated land in his study area measuring 60 x 70km.

3.5.12 The project consisted of two parts. Firstly, erosion/deposition was modelled across the arable study area, which took into account topography and its effect on waterborne and tillage erosion. From this work Bowes felt that it is tillage erosion that is by far the most important significant damaging process. The second part of this study consisted of a field scale study which also included looking at the differences in Caesium$^{137}$ activity within cultivated soil and undisturbed sites, which allowed the calculation of average annual erosion/deposition rates from the last 30 years. These observed erosion/deposition values were then used to optimise/validate the initial water and tillage erosion models (J Bowes pers. comm.). His model also takes into account the effect of field boundaries on water erosion and deposition.
patterns, a factor which is considered very significant in order for the model to be accurate.

3.5.14 Bowes concluded that:

> topographic analysis on and around the sites is all that is needed when dealing with plough damage. It is the rate of change in slope (convexity and concavity) that drives the rate of soil loss from a point in the landscape. On top of this of course is plough depth and plough speed etc (J Bowes pers.comm.).

3.5.15 He uses the findings of this study to discuss whether it is possible to estimate the level of damage occurring to a cropmark site without excavating it.

3.5.16 Topographic modelling and ploughsoil depths were also looked at during archaeological work by English Heritage at Owmby (Lincs.) where assumptions were made on the extent of plough damage based on depth of ploughsoil and ongoing cultivation depth (this work has been reproduced in full in Appendix Jix) (McAvoy 2002). Similarly see Verulamium above (OAU 2000c).

3.5.17 Slopes can be categorised as follows:
- Low slope/flat - less than 2 degree angle
- Gentle slope = 2-5 degrees
- Mid slope = 6-15 degrees
- Steep slope = 15-46 degrees

3.5.18 Defining the amount of slope needed for soil erosion is important when trying to predict archaeological survival. Anything in the mid-slope range upwards is likely to trigger soil movement therefore making archaeological sites on these slopes vulnerable to damage. The occurrence of erosion on less steep slopes is less clear cut and depends much more on the type of soil, drainage, cultivation regime, compaction, crop cover, field boundaries, time of sowing etc (Appendix E).

3.5.19 For example, at Icklingham Roman villa (Suffolk) substantial soil movement can be seen to be occurring despite a slope of exactly 2 degrees. The soil here is mainly sand and gravel and C Pendleton (pers. comm.) has observed that a 1m thick deposit of plough wash has moved downslope. Also in Suffolk on the sandy soils of the Brecklands, deep layers of hillwash (c 0.30m thick plus) have been deposited following a single thunderstorm in areas with very slight slopes. A 1m deep gorge resulted after just two days of heavy rainfall at Bromswell in the Sandlings (Pendleton 1999, 44).

3.5.20 Excavations associated with the insertion of a pipeline in the Lower Welland Valley, (Suffolk) revealed that hillwash was occurring in a landscape considered by most to be flat. The field survey showed that wide flat lynches have accumulated upslope of hedge lines, even on relatively gentle slopes. Visually this resulted in gaps in cropmark coverage at the base of the gentle valley slopes below the 20m contour line. An estimate was made here of the resultant colluvial accumulation over the last 2000 years, as being between 0.25-0.5mm a year and the time required for the formation of lynches c 300-800mm in height was thought on this basis to be c 500 years (Pryor et al. 1985).

3.5.21 In the Milfield Basin on the Cheviot slopes (characterised by intensively farmed, small fields on steep profiles), the build up of lynches at the base of many of the fields averages between 1.5-3m indicating a very high level of soil movement (Waddington 2001, 9). At Buckles, Frocester a rare, buried possible Mesolithic
ground surface and feature were discovered c. 1.6m below colluvium formed at the base of a slope (Darvill and Timby 1985).

3.5.22 Many sites display these characteristics; at Cotton Henge, Raunds, it was concluded that:

excavation revealed a close relationship between topography, the depth of ploughsoils and the severity of truncation to the archaeological features: on the higher contour areas, the overburden is as little as 0.2m, ranging to over 1 m downslope (Humble 1994 177).

3.5.23 Even small changes in topsoil depths caused by soil creep or erosion can dramatically affect the survival of archaeological deposits. At Liglok Field, Westhide (Herefordshire) the field had been mainly under cereals for the past 30-40 years. During the last 10 years farming had intensified, resulting in the removal of field boundaries and a change in plough direction from ‘along slope’ to ‘cross slope’ coinciding with the use of heavier machinery and deeper penetrating ploughs. At the base of the slope the ploughsoil was recorded as being 0.35m-0.40m deep over the subsoil where well-preserved features were discovered, including a well-preserved Roman furnace. A trench cut into the slope of the hill revealed the ploughsoil to be c. 0.25-0.3m thick. A further trench excavated on a flat spur on top of the hill slope found the ploughsoil to be only 0.2m deep over the subsoil and the features recorded here were severely truncated. It was concluded that the archaeology in these upper trenches could soon totally disappear with repeated soil movement and ploughing (White 2001, Appendix Jii).

3.5.24 However, the presence of a slope does not always lead to the formation of colluvium. As part of the Stonehenge Environs project, investigations revealed that in the dry valleys there was a total lack of substantial colluvial deposits. It is thought that the relatively immobile land surface in the Stonehenge area has worked against colluvium and hillwash occurring (Richards 1985b).

Effects of slopes on a micro-scale

3.5.25 Differences in preservation can also occur as a result of slopes within an archaeological site itself, usually caused by the presence of earthworks. At Grimthorpe Iron Age hillfort in Yorkshire, the only archaeological deposits to survive were those immediately behind the earthwork rampart. Their survival was caused by soil eroding from the top of the rampart to the bottom, therefore protecting archaeology in this area (Stead 1968).

3.5.26 The large-scale excavations at Danebury (Hants.) also showed differential survival, with two zones of preservation; a peripheral zone around the ramparts where stratified deposits had survived well in quarry hollows and where they have been protected by silt washing down from the ramparts, and a central zone where erosion processes had removed not only the stratigraphy but in some cases the original chalk surface (Cunliffe and Poole 1991). A similar situation was seen at the Iron Age settlement at Brigstock (Northants) (Jackson, 1983) and at a series of small defended enclosures in Dyfed (Williams et al. 1998, 148).

Soil erosion/creep and the movement of artefacts

3.5.27 Soil erosion downslope can also affect the distribution of artefacts from archaeological sites. In the Milfield Basin, Waddington (forthcoming) has been looking at lithic scatters, from fieldwalking and test pit data, in relation to the detailed micromorphology of the study area, which lies on a slope. He records that lithics were under-represented in the study area as many had been transported downslope.
areas of flat and gentle slope remain relatively stable while areas of moderate and steep slope experienced erosion and transportation of material. The dominant process on colluvial footslopes was the accumulation of material.... Therefore it can be postulated that the areas of flats, upland flats set back from the break of slope, non-colluvial footslopes and gentle slopes are the areas where the surface lithic population is most representative of past human activities. In contrast, areas of steep and moderate slopes and the slope shoulders above them under-represent the volume of the lithic population when sampled (Waddington forthcoming 90-91).

3.5.28 Allen (1991) has also looked at this issue. In experiments 873 flints, weighing between 15.2g and 122.4g, were spread over a 2 x 45m strip along an 11-degree slope. After four years over 60 flints, over 80% of which were struck flints and blades, had moved 50m downslope. He comments that such movements would distort any finds of artefacts found during fieldwalking and hinder the accurate location of archaeological sites beneath the ploughsoil (Allen 1991, 47). In East Anglia, at Washbrook, the problem of downslope movement of artefacts was graphically illustrated where excavations were targeted on a recorded find scatter. However, on excavation, it was discovered that the site was not under the find scatter but a considerable distance away, upslope.

3.5.29 At a more basic level the annual movement of artefact scatters can also be used to monitor soil movement. In Suffolk examples of ‘rings’ of artefacts or subsoil have been found on slopes, which every year move further and further downslope. This was seen at the Roman site at Icklingham (Suffolk) (J Plouviz and C Pendleton pers. comm.).

Archaeological examples of other factors influencing preservation on slopes

3.5.30 The presence of steep slopes can lead to the ploughman using the ploughshare as an anchor to brake the tractor as it runs downhill. This can cause the plough to dig into the soil more deeply than normal leading to localised damage to archaeological deposits in these areas. This could clearly be seen to have happened during excavations at Hambledon Hill (Dorset) (Mercer 1980b).

3.5.31 During excavations at Catsgore, a Romano-British settlement near Somerton (Somerset), observations were made on the specific effect ploughing was having on the archaeological deposits. The author of the report noted several significant variations in plough damage caused by the site being on a slope:

*Where buildings were constructed on platforms terraced along and projecting beyond the original profile of the hillside, subsequent ploughing has tended to restore the hillside to its former profile; thus many buildings suffered the greatest destruction of their foundations and floors on the downhill side, while the uphill side was relatively well-preserved. Excavation of Building 3.6 showed the process at an advanced stage (Leech 1976).*

Effects of alluvium
3.5.32 Alluvium forms on river floodplains and is caused by a series of silts being deposited by rivers during flooding, which are left on the floodplain after the river has receded. Where these silts are deposited in sufficient depth over archaeological sites, they can protect sites from plough damage, but also mask their presence (Figure 49). The reasons for the formation of alluvium can vary from one catchment area to another, but alluviation, at least in some areas, is often considered to be the result of erosion in the catchment area caused by an increase in cultivation.

3.5.33 During archaeological investigations on the floodplain at Yarnton (Oxon.) it was revealed that post-Roman alluviation had sealed earlier, prehistoric sites on the floodplain. Excavation revealed that prior to the deposition of the alluvium the prehistoric remains had been truncated by Roman ploughing and it was this episode of ploughing that was responsible for the prehistoric site being identified during recent fieldwalking. This phenomenon is explained by the excavator:

> It seems likely, however, that between 0.10m and 0.20m of the prehistoric ground surface was truncated, and it was at this stage that the flints found in fieldwalking were incorporated into the overlying layers. Roman ploughsoil was overlain by alluvium which was cultivated in both the medieval period and in the later part of this century. Modern ploughing is sufficiently deep to cut down into Roman ploughsoil, thus bringing prehistoric finds from that horizon to the present surface (Hey 1998).

3.5.34 However, it was also noted that, more typically, surface scatters of prehistoric pottery were not identified during fieldwalking where they were covered by reasonably deep layers of alluvium (i.e. c 0.30m thick or greater – 0.30m representing the depth of modern ploughing on the floodplain) (Hey 1998).

3.5.35 Within the Thames floodplain area alluvium deposited in the late/post Roman period has been seen covering and protecting (or partially covering) many early prehistoric monuments: Buscot Wick Cursus, Causewayed Enclosures at Aston, Bampton and Shifford, and the barrows at Wytham and Port Meadow. At the Roman settlement at Puckeridge-Braughing (Herts.) the lower-lying Roman levels (Site D) were largely sealed beneath a deposit of post-Roman silt distributed over large parts of the lower-lying ground to the west of Ermine Street. This had preserved the deposits below it, where even occupation layers survived. Within the excavated area the alluvium reached a maximum depth of 0.50m, while a test pit c 15m further west showed it to be over a metre deep (Potter and Trow 1988).

3.6 Case study showing the interplay between site intrinsic factors, including cropping

3.6.1 In an extensive archaeological study of the area around the small Roman town of Ariconium (Herefordshire), work from previous excavations and the results of an erosion report undertaken by ADAS were drawn together to assess the survival of the archaeological resource in the light of the identified combined threat of soil erosion and cultivation. The study found that the type of soils present on this site played an important part in the site’s susceptibility to erosion. They are well drained and easily cultivated and known to be vulnerable to both sheet and gully erosion on cultivated slopes, especially after heavy storms, with gullies being cut down into the bedrock in extreme cases.

3.6.2 The site was first discovered through ploughing in the 18th century and various parts of it were investigated in 1922, 1929, the 1960s, 1989, and in the 1990s. Substantial, newly disturbed material was recorded as being brought to the surface in the 1980s and 1990s, which coincided with initial episodes of deeper ploughing when potatoes were first introduced.
3.6.3 A pipeline excavated through the site in the 1990s clearly illustrated the problem of soil erosion and cultivation damage on the site. The pipeline ran from the top of the slope to the bottom. At the top of the slope, the archaeology was buried beneath a very thin topsoil layer. Here the archaeological features were clearly seen to have been damaged by ploughing, with only deeply cut features surviving. At the base of the slope, well preserved and stratified Roman deposits were identified including structural remains and metalled surfaces, buried under up to 1m of topsoil and colluvial accumulation.

3.6.4 Another strand of evidence which suggests ongoing plough damage was represented by artefacts picked up over time on the fields. Anecdotal evidence suggests that early finds of coins and pottery mainly dated to the 3rd and 4th century AD. Those coins found recently now mainly (99%) date from the 1st - 2nd century. This indicates that the later (and therefore higher) deposits have now virtually been ploughed away, leaving the lower deposits, dating to the 1st and 2nd centuries, vulnerable to damage (Jackson 2000, 193).

3.6.5 In most of the fields where erosion occurred and archaeology was recorded, it was concluded that the erosion, in the form of wash, rill and gullies, would have had a significant impact on the archaeological deposits present and would continue to do so if no changes in the management of the fields were introduced. The fact that part of the site is scheduled does not offer any protection from either the ploughing or the erosion that is occurring. The ADAS report highlights the key factors involved which have influenced this erosion and therefore archaeological survival on the site.

3.6.6 The ADAS survey records cereals (mainly autumn sown), sugar beet and potatoes grown in large fields, averaging 13.6ha. Erosion occurred in 5 of the 10 fields looked at and generally occurred between October and January where no crop cover was present, following late harvested potatoes or beet. In some cases erosion was severe and in any one field ranged from 7-131m³ (12-220 tons of soil), with rills c 0.10m deep occurring with corresponding fans of redeposited topsoil. Sometimes soil was washed into adjacent streams or roads. Larger rills were recorded in some fields, eg 7 rills c 0.5m wide and 0.3m deep affecting 15% of Field 6, and Field 1 where a gully was recorded 200m long, 0.5-3m wide and 0.2-1.2m deep. The key factors involved were identified as:

- Soil type - the well drained soil type, defined by the ADAS survey as being in the moderate erosion risk category
- Slopes - in general slopes over 3 degrees were susceptible but even with a slope as gentle as 2 degrees erosion occurred. Breaks in long slopes such as hedges and ditches were noted as being factors which could reduce this problem
- Rainfall - sufficient rainfall had to occur to initiate erosion. In this case the threshold for erosion to occur was rainfall at c 5mm/hour onto already wet fields, conditions which mostly occurred within the period between October and January
- Crop cover - where stubble or sugar beet tops were left on the fields through to cultivation in February/March, the risk of erosion was considerably reduced. However, this pattern is hard to maintain when a rotation of potato/cereal/rape is used. The risk greatly increased where potatoes or late-lifted crops were followed by late drilling for the subsequent crop, leaving the soils exposed during the wettest months. The growing of sugar beet also led to a deeper plough depth and increased problems of compaction as heavy machinery passed over the wet soil
- Soil management cultivations - compaction either in the topsoil or just below the plough-depth served to reduce water infiltration through the soil, leading to increased run off. Areas of compacted wheelings, headlands and tramlines were noted as being particularly susceptible.
Removal of historic hedgerows - in one field, field boundaries were removed post-1965, and in another field, a boundary was removed which crossed the top of a valley slope. This would originally have acted to cut water run-off before it hit the steeper slopes below, therefore reducing the erosion risk (Jackson 2000).
4 BIBLIOGRAPHY
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Figure 1. Madmarston Hill (Oxon.) before and after ploughing (© Cambridge University Collection).

Figure 2. Remnants of ramparts at Madmarston Hill (Oxon.) seen on the ground after ploughing.
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Figure 10. Plough scarring across mosaic at Stanwick Roman Villa (Northants.).

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Figure 12. Medieval road near Coughton (Warks.) brought to the surface by ploughing.
Figure 13. Coffin damaged by deep ploughing at Owmby (Lincs.).
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Figure 14. Skeleton damaged by ploughing at Owmby (Lincs.).
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Figure 18. Distribution of deposit types at Verulamium (Herts.).

Key
A Modern ploughsoil/topsoil overlies natural subsoil directly. Archaeological deposits, if ever present, have been completely removed (though features cut into the natural may survive in part).
B Modern ploughsoil/topsoil overlies in situ archaeological deposits directly. These deposits are either being actively eroded or are at immediate risk of such erosion.
C Modern ploughsoil/topsoil overlies a deposit or deposits thought likely to lie close to natural subsoil. Such deposits usually contain a significant mixture of redeposited natural subsoil. They may possibly mask underlying archaeological features, particularly where these are cut into the natural subsoil, but it is likely that general deposits, if ever present, would have lain higher up the stratigraphic sequence and have been largely or completely removed.
D Modern ploughsoil/topsoil overlies probable earlier ploughsoil. Such deposits, of uncertain date, may shield underlying archaeological deposits and features, though the earlier ploughing may also have caused damage to them, as is indicated by the presence of fragments of artefactual and other material in such deposits.
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Figure 23. Excavations at Burnby Lane, Hayton (Yorks.) showing the effects of de-stoning (©P. Halkon, University of Hull).

Figure 24. The 1996 excavation at Burnby Lane, Hayton (Yorks.) showing a further area of de-stoning damage (©P. Halkon, University of Hull).
Figure 25. Crop marks of the Roman roadside settlement at Hayton, (Yorks) July 1990 prior to potato de-stoning and planting (©P. Halkan, University of Hull).

Figure 26. Crop marks of the Roman roadside settlement at Hayton, (Yorks,) July 1996. The buried features revealed as parch marks are noticeably more blurred here than in 1990. Between the time the two photographs were taken the field was de-stoned once in preparation for the planting of potatoes (©P.Halkan, University of Hull).
Figure 27. Glass chip station at Owmby (Lincs.).
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Figure 28. Glass chip experiment showing chip movement in field caused by potato harvester at Owmby (Lincs.).

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Figure 30. Milecastle 19 on Hadrian’s Wall showing plough depth in the 1990s.
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