3
The significance and limitations of the project data

by Alison Deegan

The project has produced a varied and exciting dataset in a flexible digital environment. The objective of this chapter is to detail the known external influences on the record of cropmarks, soilmarks and earthworks in order that the resultant biases can be isolated, and to reveal patterning of archaeological significance.

Quantifying the results

The main constituents of the NMP data are the linear features, predominantly ditches and banks, and area features, such as pits, mounds and platforms. The GIS-based methodology employed has enabled database information to be attached to each mapped feature, including whether it was identified as a cropmark, soilmark or earthwork. Thus the smallest recording unit, referred to here as an "object", can be used to study the relative distribution of archaeological cropmarks, soilmarks and earthworks. As ridge and furrow is so ubiquitous in the aerial photographic record, and would thus distort all analysis, and because the project only recorded it in limited circumstances, such field system evidence is excluded from all of the quantifications, distributions and discussions below. Figure 3.1 illustrates the distribution of objects recorded this project.

Sources of information

NCC has generated extensive digital data documenting historic and present land use, most recently through the HLC project. This study draws upon these datasets, particularly those relating to the main period of aerial photography, between 1948 and 2000, and especially to the period of intensive NCC reconnaissance between 1978 and 1996. The HLC data for the early 1950s, based on the Ordnance Survey 1:25 000-scale mapping, have been used as an indication of the land use near the beginning of the period of photography because, at the time of writing, there are no extensive digital datasets for the 1940s. This, together with the HLC data for the 1880s, from the Ordnance Survey 1st edition 1:10 560 mapping, and from the 1928 Land Utilisation maps (Field and Holland 1928), gives an overview of the county at the end of the 19th and the first half of the 20th centuries. Digital mapping in the SMR also charts the modern extent of woodland, urban development and quarried land. NCC has also digitised surface (drift and solid) geology from the unpublished British Geological Survey 1:10 000 or 1:10 560-scale mapping, including, importantly, the extent of made ground.

With the exception of sheet SP66, for which a 1:25 000 survey is available, the largest scale soil survey coverage available for the whole of the county is at 1:250 000 scale (Soil Survey of England Wales (SSEW) 1983). The latter is too coarse for this study, but the SSEW soil descriptions have been useful in defining the characteristics of the soils and underlying geology.

The present study also makes use of data extracted from the Ordnance Survey Landline and Mastermap series, the MultiMap seamless vertical aerial photograph coverage for 2000 and the Land Cover Map 2000 (Centre for Ecology and Hydrology 2000).

Influences of geology and soils

The modern county has a complex surface geology (*see* Panel 1) which significantly influences the distribution and frequency with which cropmarks, soilmarks and earthworks occur.

Cropmarks

The average density of archaeological cropmark objects across the county is 4.5 per km^2. The density is greatest on the

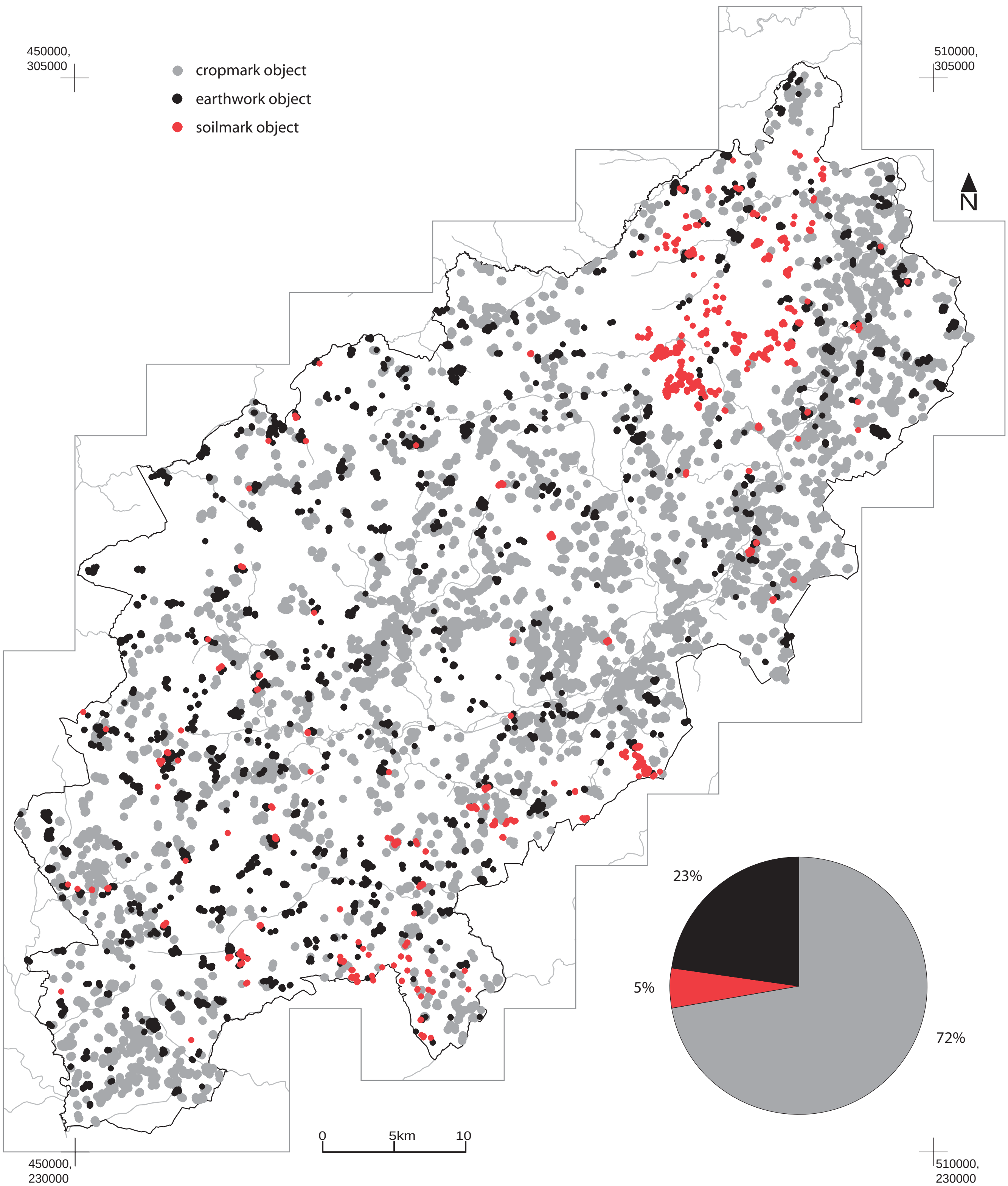

Fig 3.1
The distribution of cropmark, soilmark and earthwork objects (excluding ridge and furrow).

Table 3.1 The relative distribution of cropmarks, earthworks and soilmarks on each of the surface geological strata encountered in Northamptonshire (based on the NCC geology data variously dated from 1941 to 1977)*

geology	*area km²*	*number cropmark objects*	*cropmark objects per km²*	*number earthwork objects*	*earthwork objects per km²*	*number soilmark objects*	*soilmark objects per km²*
1st terrace	36.08	663	18.38	42	1.16	11	0.30
2nd terrace	18.86	160	8.49	59	3.13	7	0.37
3rd terrace	1.45	17	11.75	1	0.69	0	0.00
alluvial fan	2.25	20	8.91	0	0.00	1	0.45
alluvium	139.74	370	2.65	216	1.55	16	0.11
boulder clay	745.63	1826	2.45	624	0.84	447	0.60
calcareous tufa	1.47	0	0.00	14	9.51	0	0.00
cornbrash	22.60	401	17.74	35	1.55	12	0.53
glacial lake	2.90	28	9.67	10	3.45	0	0.00
glacial sand and gravel	80.38	457	5.69	76	0.95	8	0.10
Great Oolite Clay	22.65	62	2.74	17	0.75	16	0.71
Great Oolite Limestone	102.96	862	8.37	177	1.72	41	0.40
head	3.37	0	0.00	7	2.08	0	0.00
Kellaways Clay	4.86	15	3.09	10	2.06	0	0.00
Kellaways Sand	6.55	31	4.73	7	1.07	0	0.00
Lower Lias siltstone and silty mudstone	1.35	0	0.00	0	0.00	0	0.00
Lower Estuarine Series	51.86	393	7.58	96	1.85	16	0.31
Lower Lias Clay	89.85	95	1.06	172	1.91	7	0.08
Lower Lincolnshire Limestone	46.53	171	3.68	67	1.44	8	0.17
Marlstone Rock Bed	43.06	303	7.04	50	1.16	3	0.07
Middle Lias Silts and Clays	106.22	258	2.43	238	2.24	14	0.13
Northampton Sand and Ironstone	194.74	3067	15.75	322	1.65	26	0.13
opencast mining	52.43	71	1.35	6	0.11	3	0.06
Oxford Clay	41.65	31	0.74	29	0.70	25	0.60
reservoir	4.17	0	0.00	0	0.00	0	0.00
unsurveyed	57.53	198	–	35	–	69	-
Upper Estuarine Clay	66.00	207	3.14	209	3.17	15	0.23
Upper Estuarine Limestone	25.37	279	11.00	58	2.29	1	0.04
Upper Lias Clay	384.88	747	1.94	742	1.93	28	0.07
Upper Lincolnshire Limestone	4.99	11	2.21	10	2.01	3	0.60
total area/objects	2362.38	10743	4.55	3329	1.41	777	0.33

* This table excludes geological strata that outcrop over less than 1km² in the whole county; Upper Lias Thin Nodular Limestone (1 cropmark object), Made ground (11 earthwork objects), Landslip (3 earthwork objects); Limestone Raft, Mid Lias Limestones & Sandstones, Kellaways Beds, Lacustrine Deposits and Peat (all no objects).

permeable geologies: the gravels of the river terraces, Cornbrash, Northampton Sand and Ironstone and Great Oolite Limestone (Table 3.1 and Fig 3.2). Over 28% of all cropmark objects were recorded on the Northampton Sand and Ironstone. On these geologies the difference between the nutrient-rich, water-retaining archaeological fills and the very freely draining nutrient-poor soils is most marked (*see* Panel 2). In free-draining areas, individual crop plants that are rooted in localised archaeological deposits, such as pit and ditch fills, will continue to thrive long after surrounding plants have begun to wilt and it is this difference that is visible from the air. Localised variations in topsoil depth can also effect cropmark formation; even on

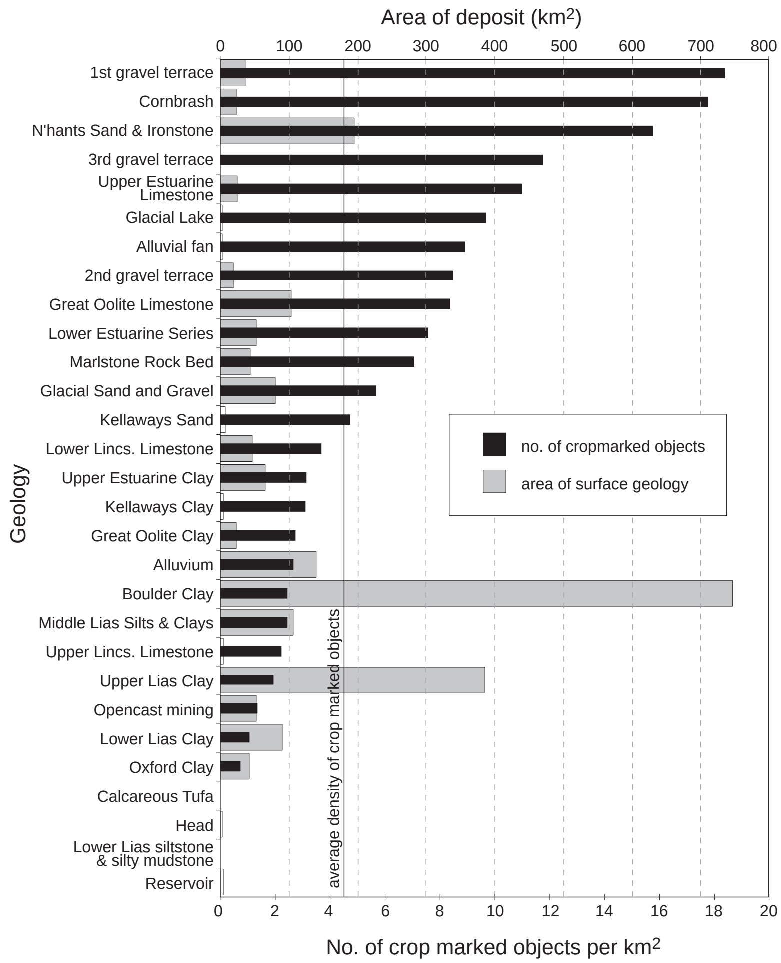

Fig 3.2
The total area covered in km² by each of the surface geological strata and the average number of cropmarks per km².

well-drained soils, an accumulation of hill wash in a hollow, for example, masks buried archaeological features.

The density of cropmark objects falls below the county average on the heavier, slower draining soils of the impermeable geologies: the boulder clay, Oxford Clay, Great Oolite Clay, Middle Lias Silts and Clays and Lower Lias Clay. Soils developed on clay geologies contain negatively-charged particles that attract water. In periods of SMD the release of water from the soils to the plants is moderated by the increasing surface-tension created by the charge, preventing sudden water-stress (Jones and Evans 1975, 3). Thus in clay areas the plants rooted in archaeological deposits have little advantage over their neighbours and visual differences in their growth and ripening is less common.

Looking at the boulder clay statistics in more detail, with fewer than 2.5 objects per km² (*see* Fig 3.2) the overall density values are low, but it is a very extensive geology and thus 17% of all cropmark objects occur on the boulder clay (*see* Table 3.3 in panel 3.1). Only the highly permeable Northampton Sand and Ironstone has produced more cropmark objects than the boulder clay, but their distribution across the boulder clay is not even (Fig 3.3).

Across the extensive boulder clay deposits covering the Nene–Ouse interfluve cropmark objects are well-distributed. complex networks of cropmarks in this area, although often less-well defined than those on more permeable geologies, reveal Roman and Iron Age settlements and field systems (Fig 3.4). In this area there are 5.3 cropmark objects per km², a figure higher than the county average and more than double the average for all boulder clay.

North of the Nene there are extensive boulder clay deposits, but rarely have they yielded cropmarks to the same level as seen south of the Nene. Indeed, in the north-eastern parts of Rockingham Forest archaeological cropmarks are all but absent. In the west of the county areas of boulder clay deposits are far more fragmentary and heavily interspersed with other permeable and non-permeable geologies. This situation is reflected in the sporadic occurrence of cropmark sites on boulder clay.

The available geological and soils data offer no clues as to why some areas of boulder clay should produce significantly more cropmarks than others: the soils of the HANSLOPE (411d) and RAGDALE (712g) soil associations are common to the three areas described above. Both are slowly permeable calcareous clayey soils produced from Chalky Till (SSEW 1983). The boulder clay in the west of the county also bears ASHLEY (572q) and BECCLES 3 (711t), both of which share the characteristics of the HANSLOPE and RAGDALE soils. Soilmark photography and field-walking studies, such as that at Brigstock (Foster 1988), have demonstrated that these differences do not reflect the choices of prehistoric and Roman settlers and farmers, so unidentified variations in soils character or the impact of more recent land use practices need to be considered.

On the valley floodplains deposits of fine, silty alluvium covering otherwise well-drained soils are a significant impediment to site visibility. It is important to remember that major alluviation in the Nene Valley did not apparently begin until the late Saxon period or early medieval period, and that previously the valley floor was characterised by the exposed and irregular

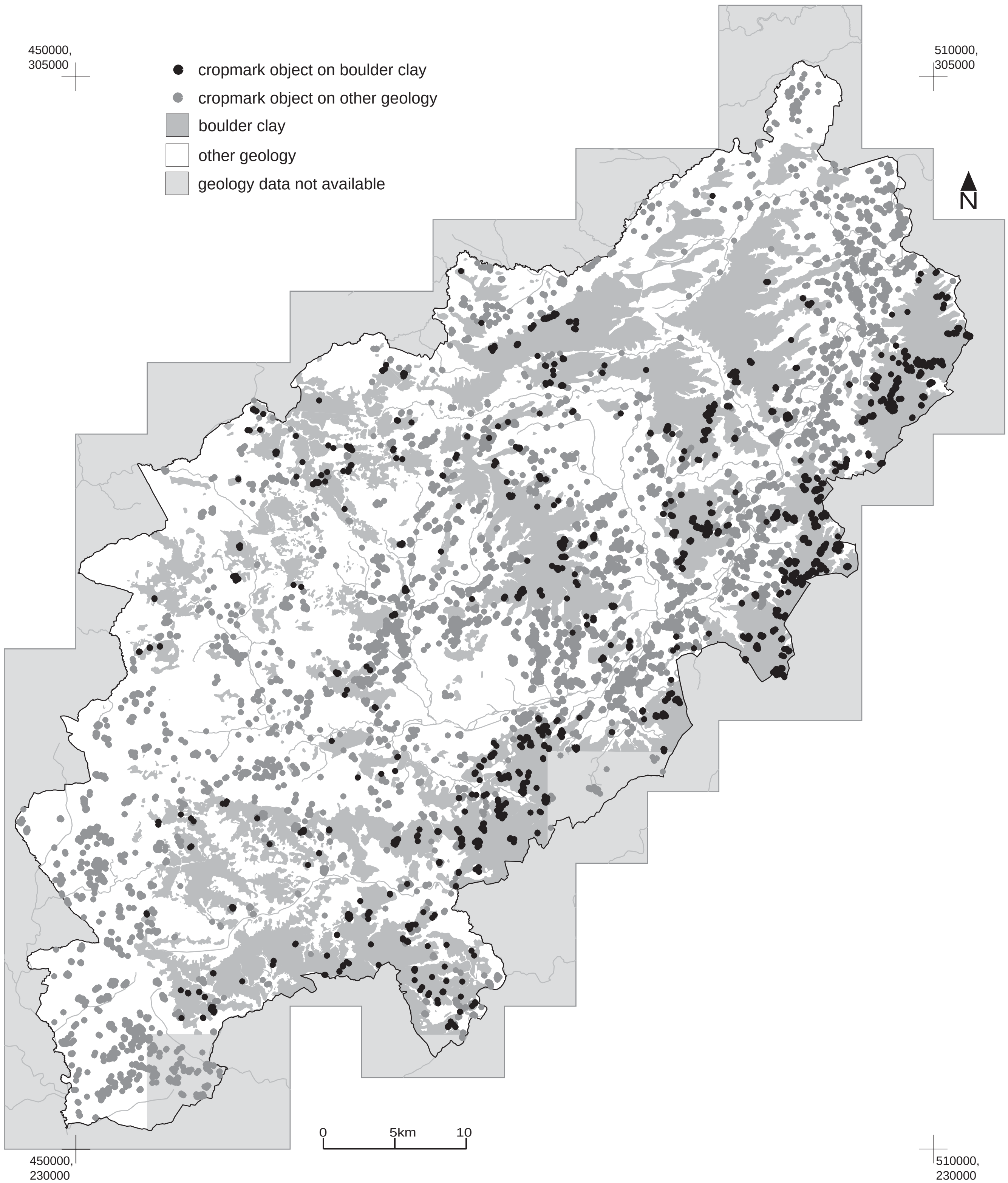

Fig 3.3
The extent of boulder clay and distribution of cropmarked objects.

Fig 3.4
These faint and diffuse cropmarks on the plateau to the east of Raunds, probably Iron Age or Roman settlement and agricultural enclosures, are typical of cropmarks in the boulder clay (NCC photograph TL0271/005 28 July 1986 NCC copyright).

topography of the gravel terraces (Brown 2005). The depth of the alluvial deposits along the major valley floors is variable and gravels come to the present ground surface in parts, often unrecorded on the BGS mapping. Cropmarks often form small ‘islands’ where the alluvium is more shallow, or absent. Where the alluvium is deeper, Roman or earlier archaeological remains are rarely, if ever, detected by aerial survey or other non-intrusive prospection techniques, although as a consequence of their burial they are likely to be much better preserved.

Clearly geological and soil permeability are a key factor influencing the occurrence of cropmarks above buried archaeological sites. Using this data it is possible to define those areas that, in the absence of any other obstacles, are most and least likely to produce cropmarks. This analysis shows that the soils and geology of just one-third of the county are conducive to cropmark formation (Fig 3.5).

Parchmarks

The distribution of parchmarks is strongly linked to that of the earthwork settlement remains from the medieval and post-medieval periods. There is a strong geological factor in the distribution of parchmarks, but this is via the availability and use of building stone rather than an influence on the formation of this type of cropmark.

Soilmarks

Soilmarks, although far more rare than cropmarks, have made a significant contribution to the study of medieval settlement remains and, in restricted areas, the medieval charcoal industry and settlement and field systems of the Iron Age and Roman period. The latter has been particularly important in areas where cropmarks rarely develop.

The average density of soilmark objects across the county is 0.3 per km^2 and there is very little variation between the different geological strata (*see* Table 3.1 and Fig 3.6). Boulder clay covers nearly a third of the county and produced 57% of all soilmark sites, but again the distribution of these sites is very uneven.

The overall distribution of soilmark sites is concentrated in a few main clusters, giving a more widespread but much sparser distribution of isolated sites (Fig 3.7). Any association with geology is typically from intermediate agencies: hence the concentration of Iron Age and Roman soilmarks on the boulder clay is a result of the medieval woodland surviving almost exclusively on extensive areas of that geology, and hence the sites escaping medieval cultivation; while the charcoal hearths are there because of the presence of the woodland. A significant qualitative difference has been observed between the crisper, clearer soilmarks in the main clusters (Fig 3.8) and the more indistinct, dispersed soilmarks seen elsewhere, probably a result of how recently the sites were first ploughed up. Importantly the pattern of the main soilmark clusters compliments rather than mirrors the distribution of cropmarks on the same geology (*compare* Figs 3.3 and 3.7).

Earthworks

The variation in the distribution of earthwork objects between different geological strata is relatively small compared to that observed for cropmarks (Fig 3.9). The significance of the distribution on calcareous tufa is greatly exaggerated by the presence of a few earthwork sites on such a minor deposit (*see* Table 3.1). Together the boulder clay and Upper Lias Clay produced

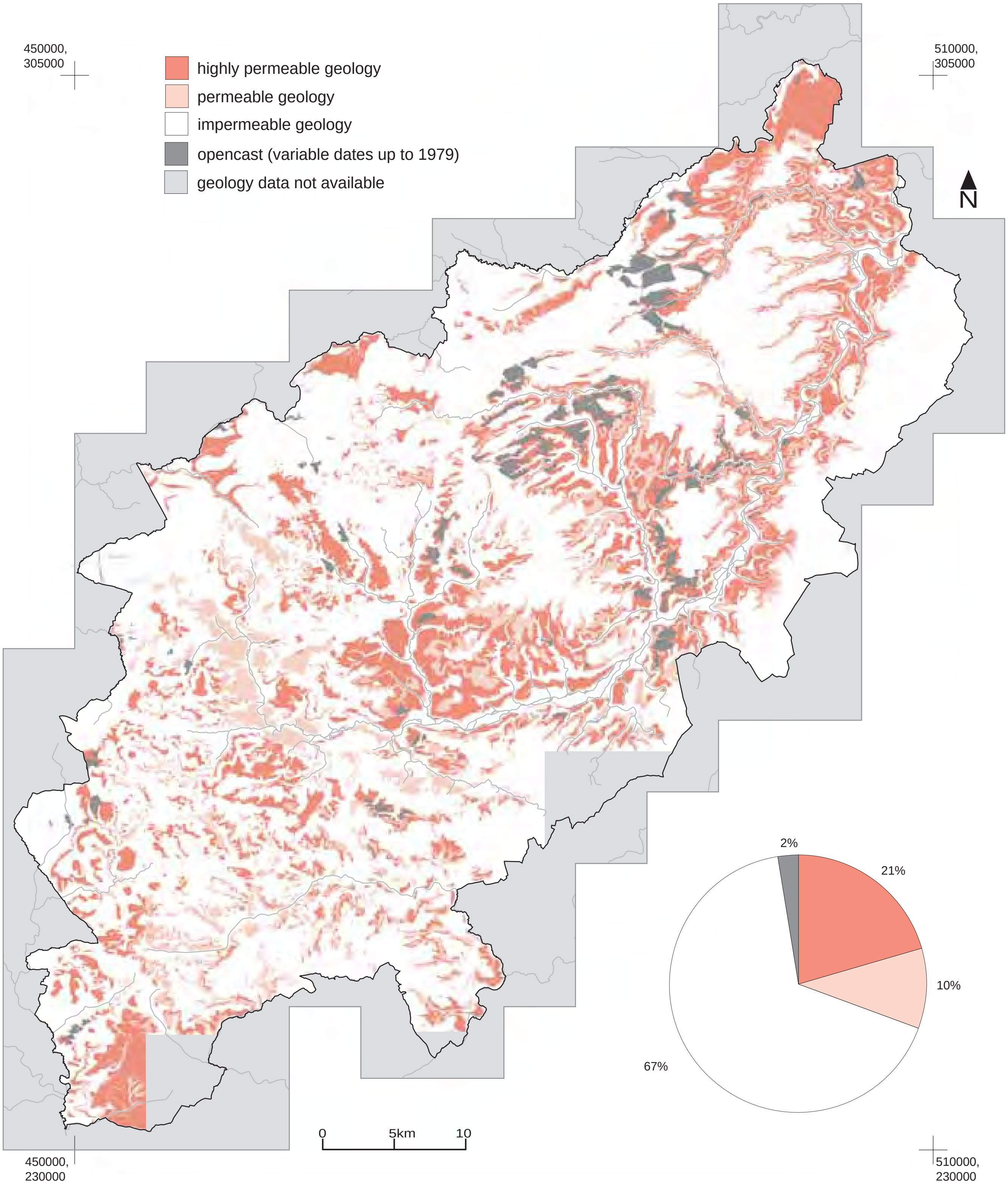

Fig 3.5
The main zones of permeability based on surface geology and soil type.

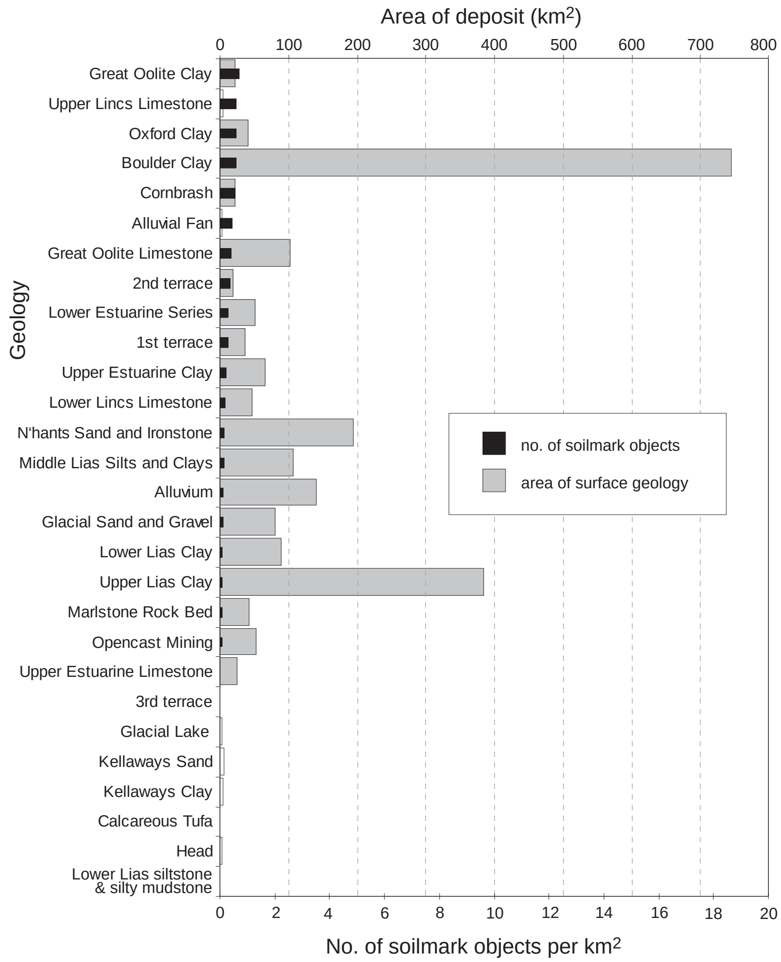

Fig 3.6
The number of soilmark objects per km^2 on each of the surface geological strata encountered in Northamptonshire.

over 40% of objects, but as they cover nearly 50% of the county this is perhaps not overly significant. Certainly substantial banks and ditches may survive better on heavy, tenacious clay soils, but the indirect influence of the soils and geology on the land use subsequent to site abandonment is undoubtedly more significant.

Climatic conditions

Mean temperature, sunshine hours and precipitation levels and hence the potential Soil Moisture Deficit (SMD) vary little over such a relatively small and compact county situated beyond the maritime influences from the west. (Hodge *et al* 1984, fig 7).

Locally, the higher ground to the north-west may be slightly wetter than the south and east, but these differences are unlikely to have had a major impact on the relative distribution of cropmarked archaeology. Snow cover is slightly more persistent in the north and west of the county, a few hours or several days making the difference to the opportunity to arrange reconnaissance in time, but the impact of this on the record of earthwork sites has been negligible. There are no significant variables in the weather patterns of the county that would bias the record for soilmarks.

On a regional level Northamptonshire enjoys a relatively low level of precipitation. The Pitsford Weather Station has recorded average rainfall of 586mm per year between 1961 and 1990 (www.northantsweather.org.uk). In comparison, the Meteorological Office records averages of more than 2000mm for the Lake District, 1005mm for St Mawgans (Cornwall) and 584mm for Lowestoft (Suffolk) over the same period (www.met-office.gov.uk). In general, cropmark reconnaissance in Northamptonshire has proved to be productive even in some years when high early summer rainfall has led to a poor showing of cropmarks in other areas of the country. When conditions have been favourable across the country, results from Northamptonshire have generally been very good, although occasionally thunderstorm tracks have caused localised reconnaissance failures.

Land use

In normal circumstances buried, levelled and upstanding archaeological features will only be visible from the air when under crops or grass. Archaeology under woodland or urban development will be masked, and where these conditions have prevailed throughout the period of photography no cropmarks, soilmarks or earthworks can have developed or survived. Quarrying will generally destroy archaeological remains and so the aerial photographs cannot reveal any features that were on ground removed before the mid-1940s. However, land use in the county has not been static during the period of photography and this makes calculating the potential visibility of archaeological features more complicated. For land converted from arable and pasture to development, extraction or even woodland, the later the date of the conversion the more likely that features now masked or destroyed will have been recorded on photographs pre-dating those changes. Conversely, the earlier that woodland was converted to new pasture or arable during the period of photography, then the greater opportunity for exposed features to be recorded.

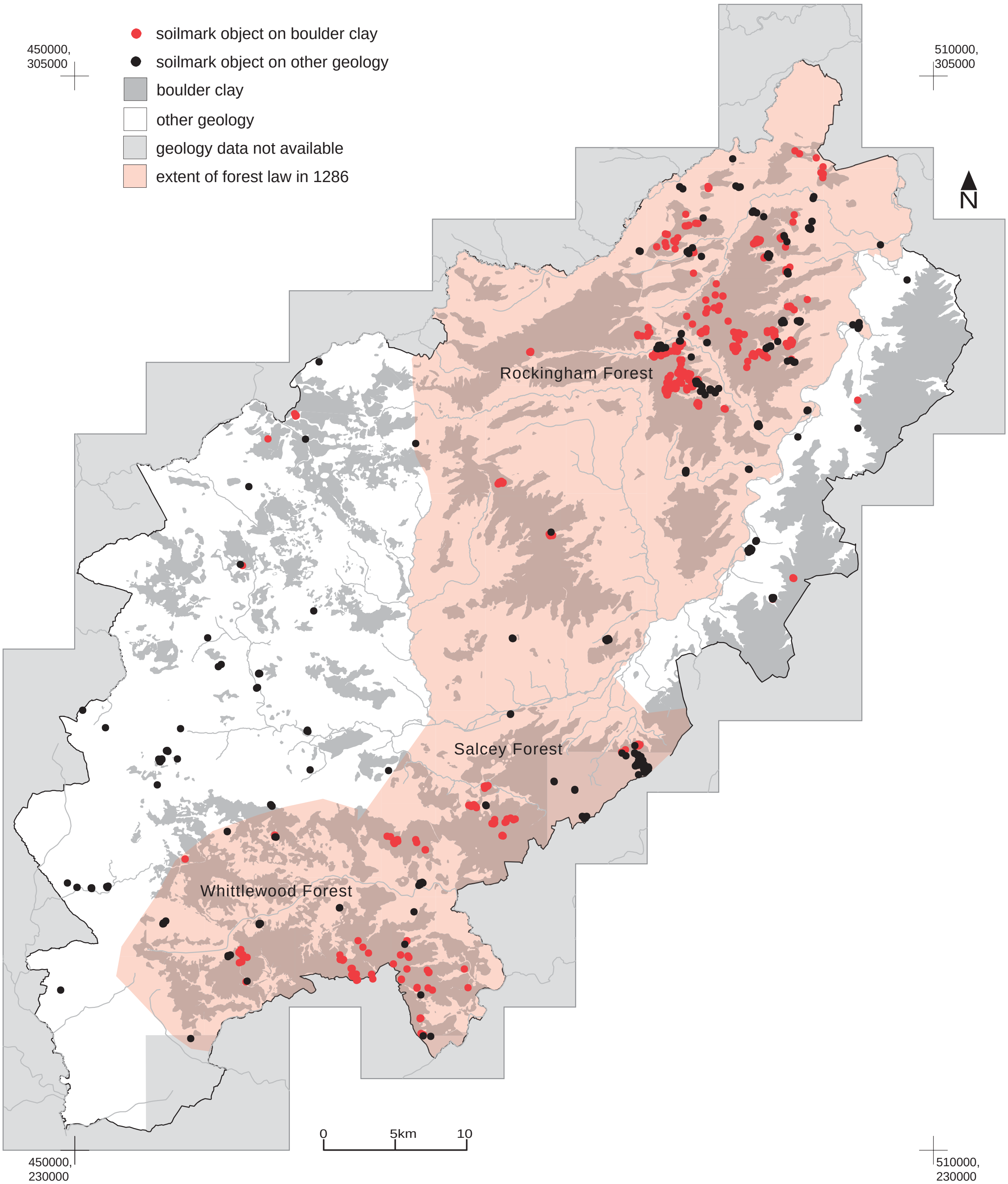

Fig 3.7
The extent of boulder clay and ancient forest and the distribution of soilmark objects.

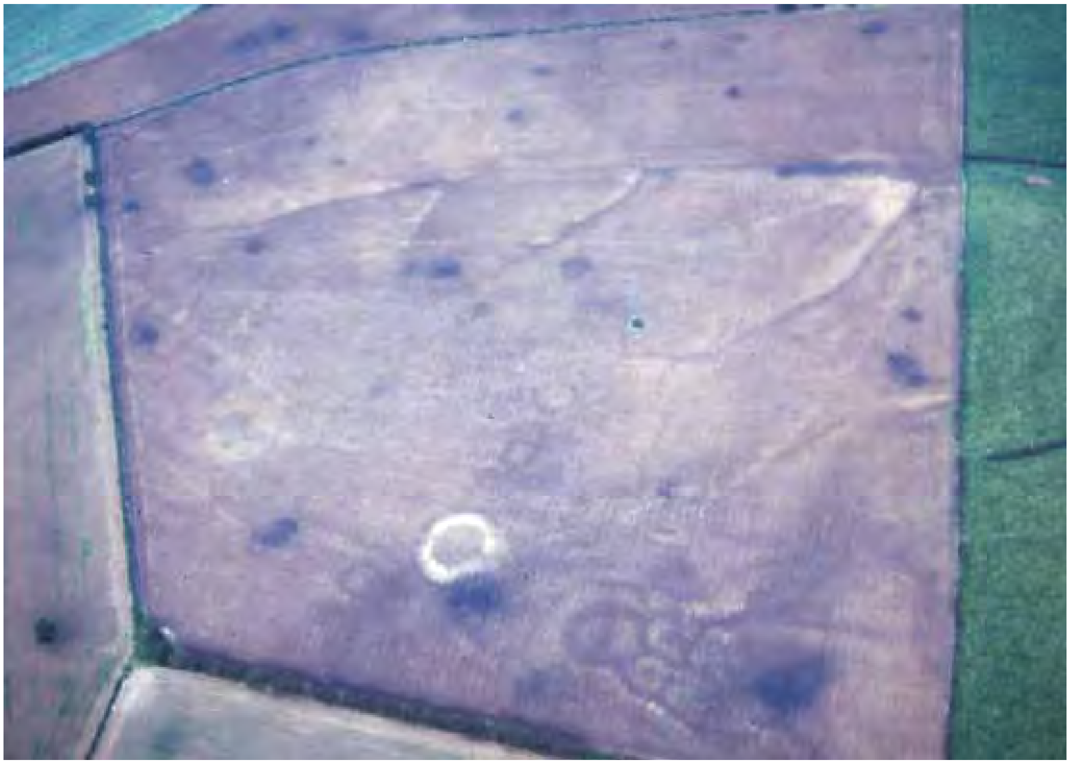

Fig 3.8
The light soilmark of one circular embanked enclosure and the dark soilmarks of various other mainly conjoined ditched enclosures, all of Iron Age date, together with the numerous intense black patches of soil revealing medieval charcoal burning hearths. These soilmarks, in the medieval Great Park at Brigstock, are typical of those recorded in much of the formerly wooded areas which escaped medieval ploughing and have only been intensively cultivated since the mid-20th century (NCC photograph SP9284/117 24th July 1987 NCC copyright).

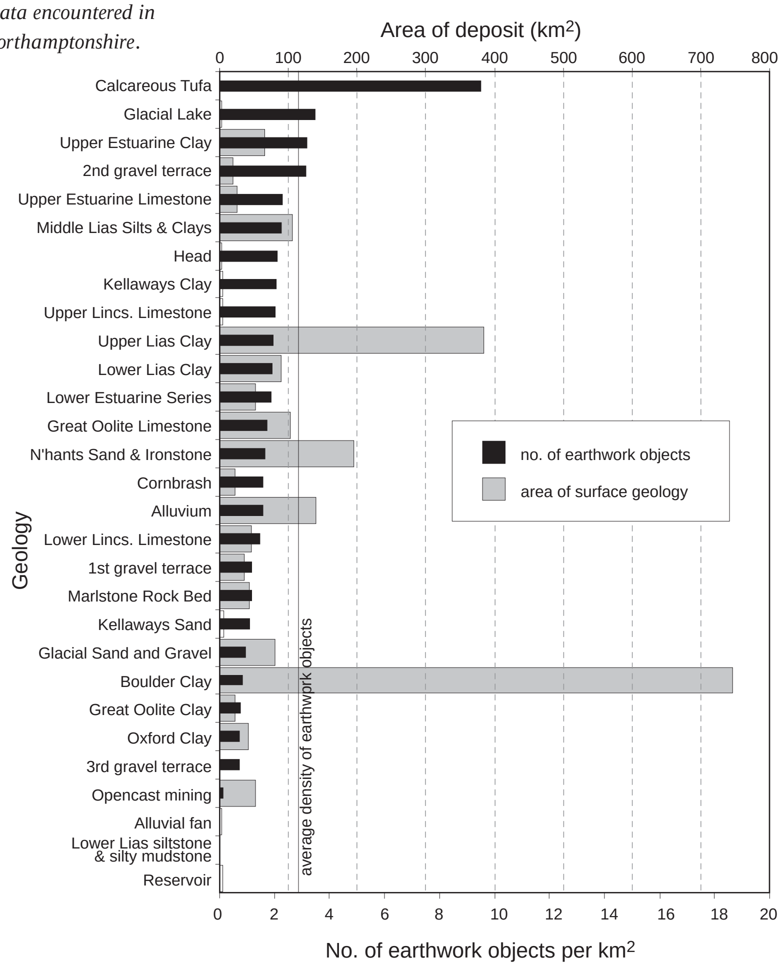

Fig 3.9
The number of earthwork objects per km² on each of the surface geological strata encountered in Northamptonshire.

Agriculture

The pioneering Land Utilisation Survey of the County Northamptonshire in 1928 mapped the extent of arable and grassland on a field-by-field basis (Beaver 1943). It showed that arable cultivation was widespread on the lighter soils on the permeable geologies: around Northampton, along the Nene Valley downstream of Northampton, in the Ise Valley and in the far south-west of the county. Significantly, crops were also grown on the boulder clay-capped watershed between the Nene and the Great Ouse, in contrast to the predominance of pasture on the boulder clay to the north and west of the county. It was noted above that relatively high density of cropmarks were recorded in just this area and the long history of modern ploughing compared to other boulder clay areas may have been a contributory factor, although conversely such early cultivation may reflect a subtle difference in the land use capability that also influences cropmark formation.

The summary of land use based on Agricultural Census parish statistics, compared with the picture from 1927, shows that there had been a substantial reduction of pasture in the intervening decades (Foard 1980b, fig 7). It is estimated that in the 1980s 38% of land was under cereal crops, 5% under other arable crops and 32% under agricultural grassland (Hodge *et al* 1984, table 4). In 2000, the Land Cover Map showed that 24% of the county was under cereal crops, 29% other arable crops and 30% covered by grasses, although this underrepresents the massive loss of permanent pasture as recognised from mapping of ridge and furrow survival (Centre for Ecology and Hydrology 2000; Hall 2001b). It would seem that this represents a real increase in the land that has been cultivated, and thus the number of fields capable of producing cropmark or soilmark evidence at some time, other conditions permitting. The most significant development has been an increase in arable cultivation on the uplands in the north and west of the county.

It is possible to define those areas that had undergone little or no ploughing since enclosure, until the end of the last millennium, from the data of the Open Fields project, which mapped ridge and furrow survival in the 1990s. Although not all permanent pasture has ridge and furrow, its distribution is a reasonable indicator of the general distribution of permanent pasture, and hence where soilmarks and cropmarks will generally be absent, although ditches and pits underlying extant ridge and furrow can produce marks in grass in exceptional conditions (Palmer 1996). However, this situation has rarely been observed in Northamptonshire, probably because most of the concentration of surviving ridge and furrow is on the heavy and impermeable clay land. Nearly all of the cropmarks recorded in permanent pasture were parchmarks caused by buried structures and surfaces.

The extent of arable land recorded in 1928 was actually a very substantial contraction of the land that had been under the plough during the medieval period, when in most townships over 85% of the land was under open field arable (Foard *et al* 2005). Such widespread ploughing hastened the levelling of most pre-medieval landscapes, except where they were protected by deep alluvial deposits or within woodland areas that were never ploughed.

Land that is under pasture today does not necessarily have a high potential for the survival of medieval and later earthworks because much of the pasture has been under cultivation during the 20th century. The presence of massive undulating earthworks may actually impede any attempt at cultivation, but this is rarely enough to deter cultivation, and many such sites have been levelled in the second half of the 20th century, as at Coton in Raventhorpe (*see* Fig 3.15), Kingsthorpe in Polebrook, Downtown in Stanford, Hemington and Lilbourne. The loss rate of ridge and furrow remains has been even more dramatic over this period.

Woodland

According to the HLC 1950s data and modern sources, woodland has covered *c* 4.5% of the county during the period of aerial reconnaissance (Fig 3.10). Since circa 1950 there has been some change, just over half a percent of woodland having been removed for other land use and a similar percentage been planted in different locations, but the impact of this on the distribution of cropmarks, soilmarks and earthworks is negligible. Over 70% of woodland lies on impermable geology, mainly the boulder clay, and so its presence is unlikely to have had a significant negative impact on the distribution of cropmark sites. However, some woodland masks features that may otherwise have appeared as soilmarks or earthworks if they were under crop or grass, as can be seen from the distribution of charcoal hearths in Rockingham Forest (Foard 2001a).

The historic presence of woodland and other unploughed zones are fundamental to the survival of pre-medieval earthworks and the appearance of the better soilmark sites. The woodland that was extant in the 1950s was a substantial contraction from that of the early 19th century, which in turn was the remnant of the more expansive medieval woodlands (Foard *et al* 2005). The pressures for arable cultivation in the medieval period had ensured that woodland was restricted to the least productive soils: those on the heavy, poorly-drained boulder clay (Foard 2001a, 42). The ancient woodland, including the medieval deer parks, was largely protected from cultivation and often even where cleared they remained as pasture until the middle of the 20th century.

Such areas can be identified through the integration of a variety of datasets. Detailed mapping of the medieval furlongs in Rockingham Forest, undertaken by Hall reveals those areas that escaped ploughing. This is complemented by the extents of the deer parks and medieval woodland, as reconstructed from cartographic and archaeological sources. The conclusion that

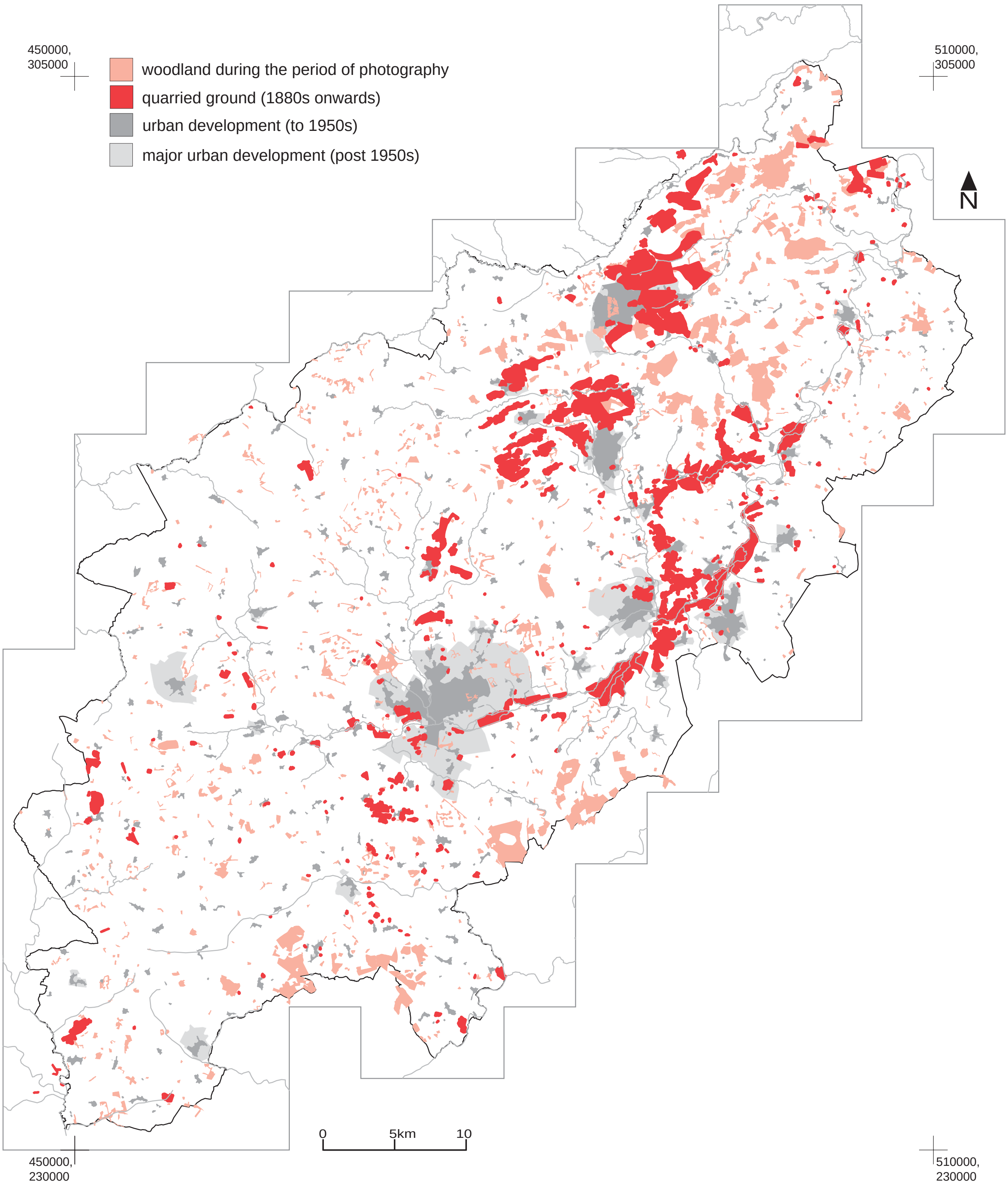

Fig 3.10
The extent of woodland during the period of photography (units of woodland > 1 hectare), the extent of pre- and post-1950s urban development and the extent of quarrying 1880s to 2000 (derived from HLC from the 1880s and 1950s; Field and Holland 1928; NCC geological and land use data).

areas devoid of ridge and furrow were formerly under woodland is also supported by historic map analysis and by the concentrations of charcoal burning hearths (Foard 2001a, fig 11; Foard *et al* 2004a, 2005). Such data enable the mapping of the areas that escaped ploughing from the medieval period until the 20th century (Fig 3.11). In these circumstances pre-medieval remains survived in pasture until recent times and, based on rapid survey of the woodland across the county, can be seen still to survive in remaining ancient woodland (Hall 2001b). There is a strong correlation between these zones and the clusters of soilmarks (excluding those for charcoal burning hearths). When these previously well-preserved remains finally succumb to ploughing, the soilmarks they produce are clearer and sharper. Although initial ploughing, and sometimes an increase in plough depth in previously ploughed areas can produce soilmarks, continued cultivation mixes the soil, ensuring that soilmarks are progressively dissipated.

Thus, in areas that have been ploughed in the medieval period and later, which covers the majority in Northamptonshire, soilmarks other than of ridge and furrow are infrequent and faint. In areas of former ancient woodland the newly truncated features show crisp and clear but, in time, these soilmarks also fade as material is dispersed across the ploughed area.

Development

Between 1931 and 2000 the population of the county more than doubled, from 309,474 to an estimated 625, 895 (Beaver 1943, NCC 2002). In the 1950s just over 3% of the county was built up (1950s HLC). By the mid-1990s over 7.5% of the county had been developed, the greatest growth being around the existing medium to large urban centres, with Northampton, for example, more than quadrupling in size (*see* Fig 3.10).

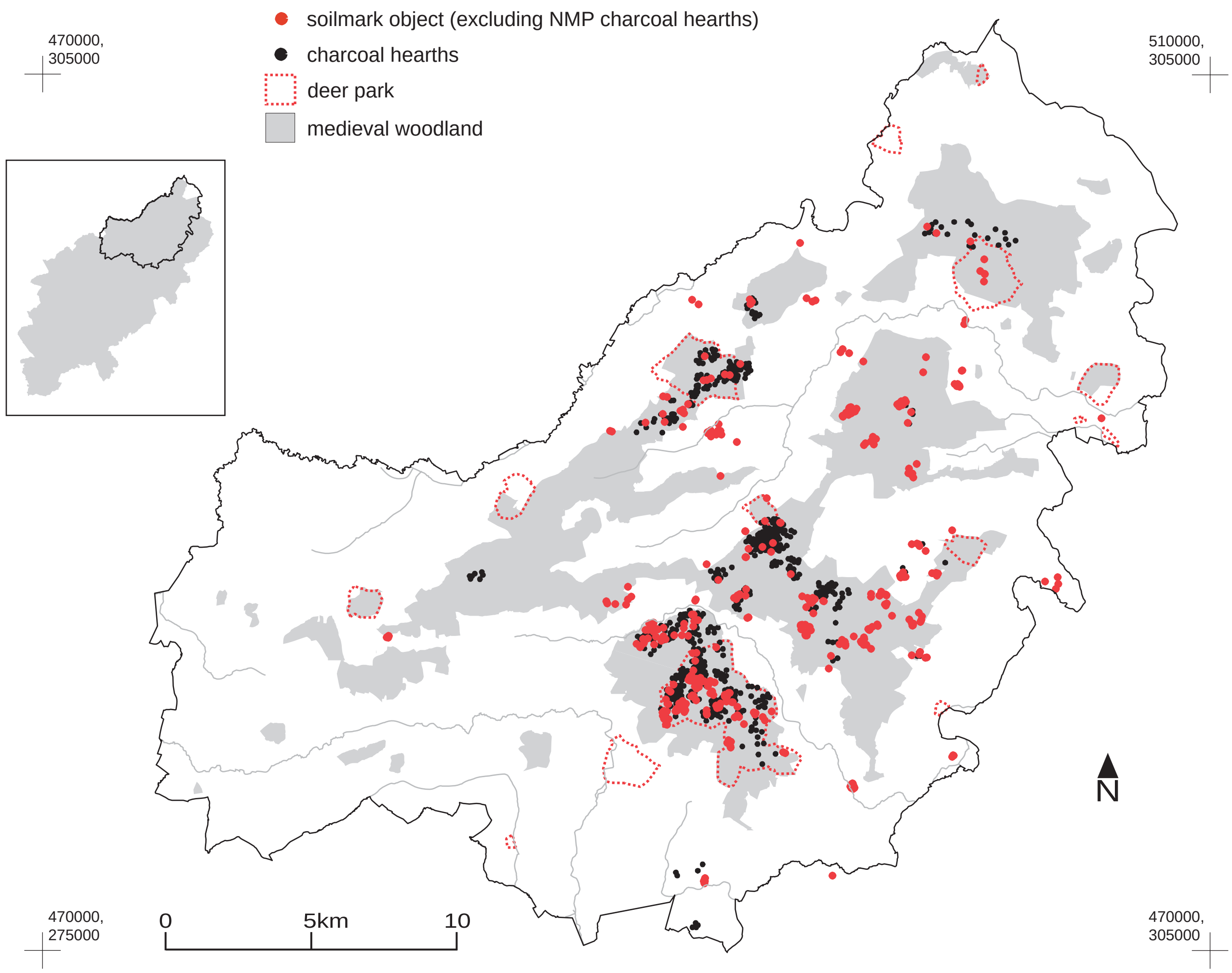

Fig 3.11
The concentration of soilmarks sites in the unploughed zone as defined by surviving medieval woodland (after Foard et al 2004), deer parks (after Foard 2001, fig 6) and the presence of charcoal burning hearths (after Foard 2001, fig 11).

This major urban expansion has encroached equally on the permeable and impermeable geologies, but the number of archaeological sites recorded prior to development is fairly low. Because settlement of the last millennium in the county was highly nucleated, so the smaller-scale infilling and expansion in rural villages has also often destroyed the earthwork remains of more extensive medieval and post-medieval settlement.

Quarrying

In the 1880s there were small-scale ironstone workings at Findon, Gayton and Blisworth and other smaller, dispersed operations (together covering less than 22ha). The Collyweston slate industry was on a much smaller scale, and also had a lesser effect on the landscape because much of the slate was extracted underground rather than from open cast quarries (Ballinger 2001).

The ironstone industry expanded rapidly with the development of mechanised extraction techniques in the late 19th century. The impact of the large open-cast ironstone quarries is substantial. Data from the 1880s and 1950s HLC, the 1928 Land Utilisation map (Field and Holland 1928) and the cropmark, soilmark or earthwork quarry evidence mapped in the project suggest that at least 0.5% of the county had been quarried by the middle of the 20th century. The greatest foci of activity were around Kettering and Corby and between Islip and Cranford St. John. Obviously these quarried areas have produced no evidence of earlier crop mark, soilmark or earthwork remains on air photographs.

In surveys dating variously from 1941 to 1979 the British Geological Survey (BGS) recorded ‘opencast mining’ in extensive swathes around Kettering and Corby, and in a sweeping arc between Finedon, Cranford St John and Islip. Most of this activity absorbed the earlier ironstone quarries. The BGS survey indicates that at least 5243ha, over 2% of the county, had been disturbed by 1979. In the 1960s it was generally deemed uneconomic to continue working low-grade iron sources when higher-grade imports could be processed at coastal steel plants, but British Steel continued extraction around Corby until the late 1970s (Foard 1979b, fig 5; Moore-Colyer 1996, 68).

Since the 1950s, in common with many gravel terraces in England, there has been a growing demand on the resources of the Nene Valley (RCHME 1960). Open cast workings for gravels have had a substantial effect on the landscape, and by 2000 approximately 4098ha of land had been extracted, mainly from the gravel terraces of the Nene between Northampton and Aldwincle. Much of the gravel extraction has occurred during or since the period of intensive NCC reconnaissance. Deliberately targeted flights across threatened areas went some way to mitigate the loss of the archaeological information, providing data supporting the case for recording action through excavation prior to destruction. The project records 287 cropmark objects and 20 soilmark objects that were subsequently destroyed by quarrying.

The combined sources suggest that over 4% of the county has been extracted for ironstone and gravel. Although a proportion of this loss has been on the exposed permeable geologies, deposits masked by boulder clay and alluvium have also been heavily exploited (*see* Fig 3.10).

Reservoirs and water features

There are several reservoirs in the county, mainly in the centre and north-west. The earliest are linked to the London to Birmingham Grand Union Canal, built in 1805, but most are associated with improvements to public utilities, and were in place by the 1880s. The latest, at Pitsford, was created *c* 1950, and it is the only reservoir for which photographs pre-dating the flooding are available. Although together the major reservoirs occupy under 0.4% of the county, individually they obscure areas up to 300ha and their local impact can be significant.

Photography and specialist reconnaissance

It is reasonable to enquire whether the level of specialist and non-specialist air photographic coverage may bias the distribution of cropmarks, soilmarks and earthworks.

The vertical photographs held by the NMR and consulted in the project provided complete coverage for the county, the scale ranging from 1:5 000 to 1:20 000 and the quality also varying. Most of the county was covered by at least one sortie from each decade between 1940 and 1980, while some areas had even greater coverage. With so many sorties, there was usually at least one taken in favourable lighting conditions for earthwork recording, and upstanding remains could be detected stereoscopically on most photographs, providing these were not obscured by vegetation.

However, the occurrence of cropmarks and soilmarks is determined by more complex variables and rarely were the sorties flown when all appropriate conditions were met (*see* Panel 2). Thus, vertical photographs rarely contributed to the recording of levelled sites. When features did show on the verticals there was invariably better coverage from the specialist oblique photographs. Notable exceptions are some of the CUCAP verticals flown specifically for recording archaeological cropmarks, but their coverage is sparse.

The combined results of the NCC reconnaissance programme and photographs from other sources provide extensive and comprehensive specialist cover. Although there were inevitable obstacles to and biases in the data-collection processes, where feasible these were mitigated for by the NCC programme (*see* chapter 2).

The archaeological resource

Variations in the nature of the archaeological resource are reflected in the mapping from the project. Activities that resulted in substantial ditches and banks will be more visible either as earthworks, soilmarks or cropmarks than those that have left more ephemeral traces. Thus, for example, a short-lived or seasonally-occupied unenclosed Bronze Age settlement is less likely to be visible than a long-standing enclosed Romano-British settlement.

The age of archaeological remains is also a factor, with the majority of Anglo-Saxon and earlier sites having been levelled by medieval and later ploughing and settlement. Normally only substantial earthwork monuments, such as the massive ramparts of hill forts, survive from these earlier periods. In addition, the effect of age on the potential of a buried ditch or bank's ability influence crop growth is little studied, and it is not clear whether actions such as soil leaching can, over time, reduce the potential of deposits to produce cropmarks.

Project methodology

Although the project specification includes remains from the Neolithic to 1945, certain monument types were specifically excluded. In particular, upstanding and levelled ridge and furrow was not systematically mapped; only occurances over or underlying other monument types were recorded. Thus, open field systems, including associated features such as boundaries and trackways defined solely by gaps between ridge and furrow, are poorly represented in the NMP data. However, these data are complimented by a comprehensive ongoing survey of the open field systems of the county (Hall 2001b; Foard *et al* 2005). Twentieth-century military remains were also not specifically targeted by NCC reconnaissance, but, although under-represented in the oblique photographic record, these monuments are still well represented on the early vertical photographs. It was the lack of specialist training in the identification of military remains and the low priority given to such remains that has resulted in a relative dearth of these sites (*see* chapter 8).

Conclusion

From the preceding discussion it is clear that certain types of sites are likely to be under-represented in the project data: because of the age and/or nature of their remains; because they lie beyond the scope of the survey or the experience of the interpreter; or because they are under-represented in the photographic record. These issues, which are period-specific will be dealt with the subsequent period chapters. However, the various general influences on cropmark and soilmark distribution discussed above, because relevant to all the succeeding chapters, are synthesised here.

Most importantly it must also be recognised that the distribution of earthwork remains, when taken together with the detailed documentary record, is likely to be far more representative of the original distribution of medieval and later settlement than the cropmark and soilmark records, with all their biases, will ever be for the earlier periods. Ironically, however, the project has a potential to inform analyses of the prehistoric and Roman periods that far exceeds the contribution it can make to the medieval studies.

From 1996 the NCC reconnaissance programme was wound down, and it ceased completely in 2002. However, the trends in land use change suggest that more areas will become more favourable for cropmark and soilmark formation and that a new strategy of aerial reconnaissance in the county should be considered.

Cropmarks

With this understanding of the influences, particularly of geology and land use, on cropmark development, enhanced with reference to influences that may have destroyed or obscured monuments, it is possible to map the different zones of cropmark amenability (Fig 3.12). Thus, land quarried or developed prior to the 1950s, or under enduring woodland, has been inaccessible to photography and has yielded no cropmark data. Archaeology in areas that were developed or quarried from the 1950s to 1970s could has been revealed by cropmarks on the earlier photographs, but, as this predates the period of intensive reconnaissance, the potential was very low, even on permeable geologies, and thus they are mapped here as having low amenability to cropmark formation. The highly permeable and permeable geologies disturbed from the 1980s onward, especially given deliberate targeting of reconnaissance to vulnerable zones, have been classified as medium to low amenability.

The biases resulting from agricultural use are more difficult to quantify. Permanent pasture has persisted over greater areas in the north and west. While boulder clay under arable cultivation in 1928 appears to produce more cropmarks than that converted from pasture in more recent years, this factor cannot be explained and thus all boulder clay has been classified as of low cropmark amenability.

Conditions for cropmark development can be classed as favourable or very favourable in just over a quarter of the county, thus substantially biasing the distribution of aerial data, particularly for Roman and earlier landscapes. Although in some contexts, particular on the boulder clay, there may be broad swathes that are poorly represented, over the greater part of the county conditions change rapidly over relatively small distances, and so at least a limited amount of amenable land should exist in most areas. However, it must be remembered that even in the most favourable conditions not all archaeological sites will have produced cropmarks. Even where they did, those marks will often not have been captured by the reconnaissance programme, especially where the areas of amenable land are fragmented and thus subject to less frequent reconnaissance that the more extensive areas. These biases will have a fundamental influence upon the conclusions that can be drawn in the following chapters. To a limited degree the biases in the cropmark data are mitigated by the distribution of the soilmark evidence, but in most cases one remains dependent upon the field-walking record to correct for the more extreme biases in the cropmark record.

Soilmarks

While small numbers of sparse, ill-defined soilmarks have been revealed on most geologies, clusters of well-defined sites occur in specific areas. The underlying geology appears to have little direct influence: the distinct concentration of soilmarks on boulder clay is a reflection of land use history rather than of soilmark amenability. Only land that had escaped intensive cultivation through the medieval period and into the mid-20th century provides the conditions favourable for soilmark formation (*see* Fig 3.11). Hence soilmarks are clustered in the areas of former woodland in the medieval forests of Rockingham, Salcey and Whittlewood. The importance of this evidence, especially in Rockingham Forest is that it reveals evidence of Iron Age and Roman settlement and land use where cropmarks do not readily form, and reveals some types of monument restricted to the woodland zone – most notably medieval charcoal hearths – that do not produce cropmark evidence.

Ironically the appearance of good soilmarks is also a graphic indication of rapid, ongoing destruction of sites that until recently enjoyed exceptional preservation, and thus this data should be used as a guide to areas requiring urgent conservation action.

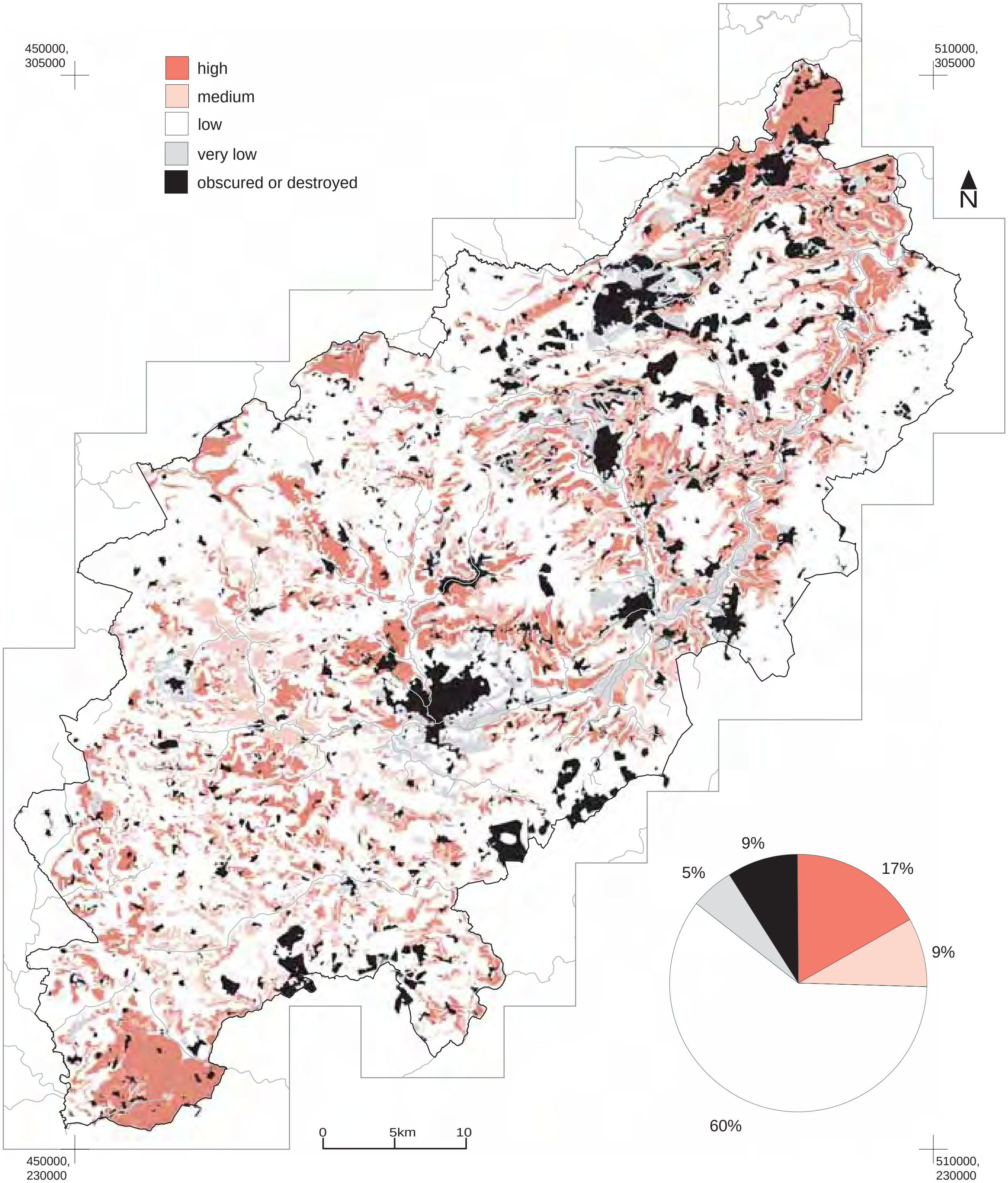

Fig 3.12
The amenability of the land to cropmark formation.

Panel 3.1
An overview of Northamptonshire's geology

Geological uplift and the presence of the more resistant Jurassic formations, particularly the Marlstone Rock Bed, have resulted in higher ground to the west and north-west gently dipping to the south-east. The Oxford Beds, outcropping in the east of the county, are the most recent surviving solid formations, as the Cretaceous and Tertiary deposits were all but removed by later events in this area. In the west and north-west of the county the Upper Jurassic and subsequent deposits were eroded from the higher ground and the Middle and Lower Jurassic strata outcrop.

In the Pleistocene these structures were overlain by glacial and periglacial deposits. Material suspended in the melt-water, dammed by the higher ground, was forced by the approaching ice sheet through the Watford Gap and along the lower ground now occupied by the River Nene. The ice sheets moved and redeposited large quantities of material that had been released from the land surface by periglacial events and glacial erosion; boulder clays of varying composition and depth were laid down by the ice sheets. The nature of these deposits depends on their source, but in Northamptonshire they are predominantly chalky in character. Head deposits of mixed sandstone and limestone rubble, created by solifluction events in periglacial conditions, are found on some slopes and dry valley floors. Sorted sand and gravels were deposited by melt-waters in warmer periods.

Subsequent action by melt-waters and later erosion cut through the glacial and earlier deposits, in parts exposing the various solid strata and re-working the gravels, resulting in a complex geological landscape.

Table 3.2 The stratigraphic sequence of the major geological strata outcropping in Northamptonshire and their attributes (based on Martin and Osborn 1976)

years BP	*geological period*	*geological stratum*	*geological sub-types*	*general attributes*
14,000 approx	HOLOCENE	Alluvium	Alluvial Fan	Generally impermeable but with some reworked gravel
		Terrace		Permeable
1.5M	PLEISTOCENE	Head		Dependent on source material
		boulder clay		Impermeable
		Gravels		Permeable
		Glacial Lake Deposits	Permeable	
65M	TERTIARY			
135M	CRETACEOUS			
		Oxford Clay		Impermeable. Heavy and tenacious clay.
		Kellaways Beds	Kellaways Sand	Permeable
			Kellaways Clay	Impermeable. Heavy and tenacious clay.
		Cornbrash		Permeable. Hard shelly limestone
		Great Oolite Series	Blisworth Clay	Impermeable. Heavy and tenacious clay.
			Blisworth Limestone	Permeable
			Upper Estuarine Series	Impermeable clay inter-leaved with permeable limestone
		Inferior Oolite Series	Lincolnshire Limestone	Permeable
			Lower Estuarine Series	Impermeable
			Northampton Sand and Ironstone	Permeable
		Upper Lias		Impermeable
		Middle Lias	Marlstone Rock Bed	Permeable
			Middle Lias Silts & Clays	Impermeable
195M	JURASSIC	Lower Lias		Impermeable

Table 3.3 The major geological formations and soil types in Northamptonshire (after Soil Survey of England Wales 1983)

geology	*soil association*	*SSEW Unit*	*permeability*
river valley floor	FLADBURY 1	813b	poorly drained
terrace	WATERSTOCK	573a	well drained
	SUTTON 1	571u	well drained
head	various		mixed
boulder clay	RAGDALE	712g	poorly drained
	HANSLOPE	411d	poorly drained
	ASHLEY	572q	poorly drained
	BECCLES 3	711t	poorly drained
gravels	WICK1	541r	well drained
glacial lake deposits	WICK1	541r	well drained
Oxford Clay	OXPASTURE	572h	poorly drained
Kellaways Sand	various		mixed
Kellaways Clay	various		mixed
cornbrash	Moreton	511b	generally well drained
Blisworth Clay	various		mixed
Great Oolitic Limestone			
NE of county	Moreton	511b	generally well drained
S of county	ABERFORD	511A	well drained
Upper Estuarine Series	various		mixed
Lincolnshire Limestone	ELMTON 1	343A	well drained
Lower Estuarine Series	various		mixed
Northampton Sand and Ironstone	BANBURY	544	generally well drained
Upper Lias Clay	WICKHAM 2	711f	poorly drained
	DENCHWORTH	712b	poorly drained
Marlstone Rock Bed	BANBURY	544	generally well drained
Middle Lias Clays and Silts	WICKHAM 2	711f	poorly drained
	DENCHWORTH	712b	poorly drained
	OXPASTURE	572h	poorly drained
Lower Lias Clay	WICKHAM 2	711f	poorly drained
	DENCHWORTH	712b	poorly drained
	OXPASTURE	572h	poorly drained

In more recent times human activity, particularly the massive expansion of arable land in the late Saxon and early medieval periods, has precipitated large-scale soil erosion, resulting in substantial alluvial deposition along the river valleys.

It is the surface geology of today and the recent past that is most pertinent to understanding the archaeological evidence, rather than the deeply stratified structures themselves. It is the character of the exposed formations and the soils developed from them that has influenced human activity and affects the survival and visibility of remains. Tables 3.2 and 3.3 summarise the key characteristics of the major exposed geologies and the soils they bear.

Of the exposed permeable geologies the Northamptonshire Sand deposits are the most common, capping the higher land to the west and exposed in the incised river valleys in central parts. The Marlstone Rock Bed outcrops are limited to the west of the county. Lincolnshire Limestone outcrops in the north-east of the county, particularly around Collyweston and in the Welland Valley. The Great Oolitic Limestone, known locally as Blisworth Limestone, appears in the far south around Brackley and along valley sides in central and eastern Northamptonshire. The Cornbrash is exposed in the Nene Valley, downstream of Irthlingborough, in the east of the county.

Glacial sands and gravels are found in a band arcing from the Watford Gap to the south of Northampton where they peter out and appear only sporadically in the River Tove basin and further down the Nene Valley. Fragmentary terrace gravels are exposed downstream of Towcester on the River Tove and Northampton on the

Nene, while larger expanses survive around the head waters of the rivers Ise and Welland and north-east of Rugby on the River Avon, all in the north of the county.

In general the distribution of impermeable rocks is more extensive. The Lias clays outcrop in a series of bands from the west of the county, predominating on all but the higher ground, where they are capped by Northamptonshire Sand, or where glacial deposits survive. In the east of the county younger Jurassic rocks survive and outcrop along the river valleys. Of note are the particularly heavy and tenacious Kellaways Clay and Oxford Clay.

In all but the far south-west of the county boulder clay blankets the plateaux between tributaries and watersheds between river systems. Alluvial deposits line the valley floors of the rivers and tributaries.

Table 3.3 identifies the soils occurring on the more extensive geological outcrops and shows that these generally reflect the character of the immediate underlying strata. However, the detail and accuracy of the soil survey is generally insufficient to relate the narrow bands of strata exposed in the river valleys to specific soil types.

Panel 3.2

The influences on cropmark, parchmark and soilmark formation and earthwork visibility

Cropmarks

Cropmarks are variations in leaf and stalk colour, and in plant height and vigour. The cropmarks recorded in the county were in the main visible to the naked eye and photographed on (panchromatic) black and white film. Infrared photography can record different variations in vegetation and has made a significant contribution to mapping at Great Harrowden, but for practical reasons and cost effectiveness, this medium has not had widespread use in the county.

Fig 3.13
Cropmarks at Ecton. On the hilltop in the foreground the geology is Northampton Sand and Ironstone and the ditches, pits, medieval open field furrows, and natural fissures are clearly revealed by slower ripening plants against the ripe crop. Towards the far side of the field the ground falls into a valley of Upper Lias Clay and here the crop has yet to ripen and cropmarks cannot be seen – the narrow tongues of the smaller side valleys are also clearly picked out (NCC photograph SP8265/081 20th June 1996 NCC copyright).

Cropmarks occur where there are variations below the ground, such as in-filled hollows, palaeochannels, frost cracks, archaeological pits, ditches, surfaces and banks, or modern disturbances such as land drains. Cropmarks can also be created by variation in the treatment of the topsoil and ground cover – the uneven application of fertilizers, pesticides and herbicides, or physical damage, for example. It is the role of the air photo interpreter to distinguish the archaeologically-significant cropmarks from those that have other explanations.

Cropmarks that delineate buried and levelled archaeological features are the effect of differential growth and ripening between the vegetation on the archaeological deposits and that on surrounding undisturbed ground. Variations in growth and ripening are most visible when there is a significant difference in the water and nutrient availability between the archaeological and natural deposits. Cropmarks can form at any stage from crop germination to ripening, but the optimal conditions are during periods when precipitation is exceeded by transpiration. This results in potential soil moisture deficit (SMD) and water-stressed plants (Jones and Evans 1975).

Prolonged periods of SMD halt plant growth and then cause wilting of the plant leaves, stem and finally root; it is the leaf wilt in particular that is visible from the air. Water-stress is exacerbated by free-draining sub-surface deposits, such as archaeological walls or road surfaces, but mitigated by rich and humic ditch and pit deposits (Fig 3.13). Even after ripening, differences in crop height and bulk can indicate the presence of buried features

Fig 3.14
Cropmarks on Northampton Sand and Ironstone at Boughton. Ditches, pits and even the fine outlines of hut circles as well as numerous natural fissures are clearly visible in this field even though much of the crop is well-ripened. The cropmarks are defined by the bulkier and taller plants, accentuated by the low sunlight (NCC photograph SP7666/025 12th July 1990 NCC copyright).

where there are no tonal differences. The specialist photographer is able to manipulate the available lighting conditions, circling monuments until the optimal balance of light and shadow is achieved; vertical photographs rarely record these cropmarks as effectively unless there is low angle sunlight (Fig 3.14).

Even once all the variables required for cropmark formation are met the appearance of these marks can change by the day; and they can disappear overnight. It takes the skill of the experienced aerial photographer to achieve maximum results from limited air time by exploiting their local knowledge of the developing conditions.

These responses can be seen most clearly in large areas of homogenous, fast-growing plants such as cereal crops and, less frequently, in root crops and grass.

Exaggerated and ill-defined cropmarks caused by differential lodging, usually following heavy rain or wind, can also indicate the presence of underlying archaeological features. Lodging tends to occur when plants experience over-vigourous growth and stand higher than their surroundings, encouraged by nitrate-rich water reserves, such as in archaeological ditch fills (Jones and Evans 1975). Similar effects can be observed among plants on near-levelled ridges, banks and mounds, where their slightly elevated position renders them more susceptible to damage in strong winds. In Northamptonshire this type of cropmark is usually associated with very recently truncated earthworks, which are usually of medieval or later date (Fig 3.15). It is often difficult to distinguish which agency led to the damage – over-vigourous growth or topographic elevation, and thus whether the lodging indicates the presence of an in-filled ditch or a near-levelled bank.

Fig 3.15
Cropmarks at Ravensthorpe. Lodged crop outlines the heavily truncated hollow-way and close boundaries of the shrunken medieval hamlet of Coton. These features still survived as slight earthworks on 1947 RAF photographs (CPE/UK/1994 1370) (NCC photograph SP6771/016 10th August 1979 NCC copyright).

Parchmarks

Parchmarks appear in grass at times of significant moisture stress, usually over buried

Fig 3.16
Parchmarks at Catesby. These parchmarks reveal the buried remains of the Cistercian priory and the Country House that replaced it, some of which do not survive as earthworks (see chapter 8) (NCC photograph SP5159/055 July 1996 NCC copyright).

Fig 3.17 (opposite top) Soilmarks at Bugbrooke. The levelled medieval ploughing is clearly visible as the parallel pale tone ridges and darker tone furrows. An embanked, sub-divided enclosure lies above the ridge and furrow and is clearly outlined by very pale material. The zig-zag effects of the soilmarks are a characteristic caused by the alternating modern plough direction, part of the process which over a number of years will intermix the soil and thus destroy the soilmark (English Heritage (NMR) photograph SP6656/118th June 1980 RCHME copyright).

stone structures or other highly permeable archaeological deposits such as metalled surfaces (Fig 3.16). Aerial photographs of parchmarks have made a valuable contribution to archaeological research in the county, particularly with regard to deserted medieval settlements. On various earthwork sites, parchmarks have revealed buried structures that do not survive as earthworks or, where they do, have added detail. They have also revealed a few Roman stone structures on sites that are under pasture, most notably the massive Cotterstock villa and within the walled area of Irchester Roman town. More often, however, Roman structures have been revealed by negative cropmarks in cereal crops.

The overall distribution of parchmarks is quite different to that of other cropmarks. Although unfortunately parchmarks were not specifically distinguished from other cropmarks in the associated databases, they can be identified by the parchmark mapping convention used by the project and thus may be quantified separately. There are 10,736 cropmark map objects recorded by the NMP, of which approximately 481 are parchmarks in grass or cereal. Cropmarks contributed nearly 72% of all the NMP objects. The average density of cropmark objects (including parchmarks) over the whole county is 4.5 per km^2; there is less than 0.2 parchmark per km^2.

In the absence of supporting evidence it is often difficult to date cropmarked archaeological sites and nearly 40% of the objects mapped by the project are currently recorded as ‘date unknown’. Of those that have been given possible dates, over 85% are attributed to the Roman period or earlier; it is likely that the majority of the undated sites are also of pre-Anglo-Saxon date.

Soilmarks

Soilmarks are the colour and tonal differences between soil above archaeological deposits and the surrounding ploughsoil. Ploughing, which can penetrate the ground to a depth of 450mm, brings to the surface previously buried material, and with its rotation exposes the cut surface uppermost. Where the plough cuts sub-surface banks or in-filled ditches and furrows it brings slices of these deposits to the surface; bank material will often appear lighter than surrounding soil and ditch fill, darker (Fig 3.17). If these slices are sufficiently differentiated from the natural plough or sub-soil, they can be visible from the air. A significant contrast was recognised between the visual definition of soilmarks in different parts of the county and at different times during the 1970s–1990s, something that seems to relate to the initiation of ploughing of permanent pasture, or to phases of deep ploughing.

Soilmarks can be observed in bare ground and occasionally through germinating crop or harvest stubble. Soilmarks are often clearest after ploughing and before harrowing, but can also be enhanced by increased soil moisture. Harrowing breaks down the newly-exposed clods, disperses and mixes material, often, though not always, leading to a softening of visual differences, while weathering and drying will also reduce the clarity of soilmarks. Timing is thus just as critical to the recovery of good soilmark evidence as it is to the recovery of crop mark evidence.

Large-scale topsoil stripping in advance of ground works, most typically where archaeological excavation is underway, also reveals any buried archaeological deposits, but this form of evidence has rarely been photographed in the county, although they have occasionally been captured incidentally on vertical photography.

Just 5% of the objects recorded were revealed primarily as soilmarks. With a total of 777 map objects the average density of soilmarks over the whole county is only 0.3 per km^2, although such marks are particularly common in Rockingham Forest. Two-fifths of the soilmark features are undated, as soilmarks can be more difficult to interpret than cropmarks, because the morphological characteristics are often less well-defined. Of those objects given possible dates, one third of them are attributed to the Roman period or earlier and the rest to the medieval period or later.

Earthworks

Detection and recording of earthworks from the air is determined by their survival and visibility. The survival of earthworks is determined by past and present land use, rarely to natural erosion processes. Occasionally deliberate levelling, but most commonly ploughing, has flattened earthwork sites. Extensive arable cultivation in the medieval period levelled most earlier monuments, with under 2% of the earthworks recorded by the NMP attributed to the Roman period or earlier; most of the latter were revealed in the formerly wooded areas of the county, which escaped medieval cultivation.

Most of the earthworks recorded by this project were revealed by the pattern of sunlight and shadow, but visibility of upstanding features can also be enhanced by differential frost or snow cover, or by the distribution of standing and flood water (Figs 3.18 and 3.19). Even heavily truncated earthworks can be visible in the

Fig 3.18 (below) The earthworks of the moat, fishpond and closes of the medieval monastic grange called Kalendar, near Cottesbrooke, are revealed by long shadows in low angle winter sunlight (NCC photograph SP6974/008 6th January 1984 NCC copyright).

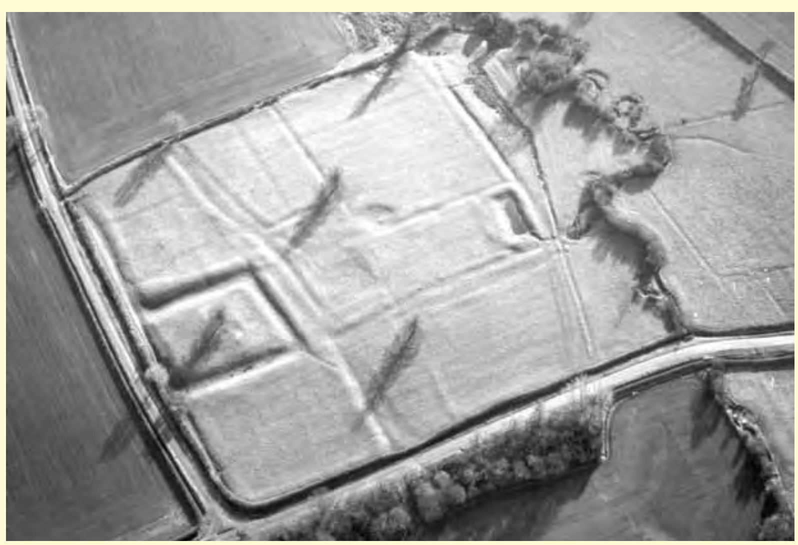

Fig 3.19
Earthworks of part of the shrunken village of Kelmarsh with associated closes, fishpond and ridge and furrow, highlighted by light snow cover (NCC photograph SP7379/052 4th April 1988 NCC copyright).

appropriate conditions, particularly when their appearance is enhanced by changes in vegetation cover or soil tone (as on Fig 3.15). Photographers of specialist oblique views can manipulate the available lighting conditions while in the air, circling monuments until the optimal balance of light and shadow is achieved, something impossible with vertical sorties, where each frame is taken at timed intervals along a predetermined route.

Large and subtle variations in ground relief are further accentuated when viewed stereoscopically. Most stereo images are the vertical photographs taken in long regular sorties, but stereo overlapping can also be achieved from appropriately positioned pairs of oblique views. Stereoscopic photographs are invaluable to the mapping and interpretation of earthworks.

Nearly 23% of all the objects were recorded as earthworks. This is not an indication of current survival of upstanding monuments, as many earthwork features were mapped from early, especially vertical, photographs of sites subsequently levelled. Although this figure suggests that there are far fewer earthworks than there are cropmarks, this is misleading. Most earthwork mapping in the project took the form of complex articulated medieval and post-medieval settlements and associated field system features that were more difficult to resolve into separate graphic objects than the fragmentary, disparate and often less complex elements of cropmarked landscapes. With a total of 3378 objects, the average density of earthworks over the whole county is 1.3 per km^2.

Structures

Most standing structures were excluded from the project specification, with the exception of specialised military and airfield installations. Only 51 objects of this type were recorded, which includes several extant airfield runway surfaces.