Aerial Reconnaissance for Archaeology

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Introduction and History of Research

The first serious application of aerial reconnaissance to archaeology came with the work of OGS Crawford in the 1920s following the rapid development of aircraft in World War I, his first flight in Scotland occurring in June 1930. Aerial reconnaissance was subsequently developed as one of the most important methods of archaeological fieldwork after World War II, particularly in Britain, by JKS St Joseph. Though based with the Cambridge University Committee for Aerial Photography (CUCAP), he undertook reconnaissance in Scotland each summer and maintained a particular interest in Roman military sites. It was not until 1976, however, that the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) set up their own systematic programme, rapidly becoming the primary aerial survey body for Scotland. CUCAP continued to fly regularly in Scotland until the retirement of David Wilson, St Joseph's successor, in 1997, when its proactive programme was brought to an end. For some 20 years from the late 1970s a number of individuals, including the present author, either operating privately or on behalf of their local authorities, undertook reconnaissance on a regional basis, supported financially by RCAHMS. This activity, however, has been much curtailed over the last decade by the tightening of Civil Aviation Authority regulations on the use of light aircraft for aerial photography.

Archaeological sites can be revealed from the air in one of three main ways (Wilson 2000, 38–80). Where sites are extant, even if so little survives above ground level that they are not readily appreciated from the ground, they may be revealed from the air by virtue of the pattern created by the shadows cast in low sunlight, producing what are known as shadow sites (fig. 1). This effect can be enhanced by a light covering of snow resulting in differential drifting or thawing, or can be emphasized by slight differences in texture or vegetation cover (see also the discussion of LiDAR on p. 7). This method of discovery is particularly important in regions with a high proportion of upland which have been less affected by intensive agriculture.
Historically, human settlement has a tendency to

Figure 1. The slight undulations of the rampart and ditch of the prehistoric enclosure at Westside, South Lanarkshire, visible, to either side of the road, as a shadow site in low sunlight.

Figure 2. The wide ditch and inner rampart, with its opposing entrance gaps, of the prehistoric enclosure at Westside, South Lanarkshire, sharply revealed as a cropmark (compare with fig. 1).

concentrate more in lowland regions, a pattern linked directly to the availability of good arable land. In such areas, however, archaeological sites survive less well, often becoming completely invisible above ground because of the destructive impact of the plough over the millennia. Thus, the most important method by which archaeological sites are revealed from the air is by identifying cropmarks (fig. 2). Once growing plants have exhausted the water stored in their rooting zone, they begin to suffer moisture stress and to wilt. Plants growing over buried stone foundations will have a more restricted rooting zone and exhibit signs of moisture stress before other plants in the same field, so that their growth will be less luxuriant and they will ripen more quickly (negative cropmarks). The opposite occurs where plants are growing over buried pits or ditches, producing positive cropmarks – that is areas of relatively enhanced crop growth.

In such lowland areas, where any differential surface topography has been removed by years of ploughing, sites may also be revealed in bare soil primarily through differences in soil colour (fig. 3) or surface concentrations of material. These soil marks are best revealed in shallow soils where there is a strong colour contrast between the subsoil and topsoil, but are generally rare in Scotland.

Methodology, Biases and Limitations

Traditional archaeological aerial reconnaissance involves selective oblique photography of sites identified by observation from light aircraft flying at a height of less than 600m. There is an ongoing debate about the need for more extensive vertical block coverage specifically for archaeological purposes so as to maximize recovery rates and better facilitate the process of producing detailed site plans from the photographs (e.g. Palmer 2007). The vast bulk of aerial photography, however, is not taken to aid the discovery of archaeological sites, but for mapping or landscape monitoring purposes. This is generally vertical photography taken from a much greater height, usually 4500–6000m or more, but it still has the potential to record either shadow sites or cropmarks if it has been taken at the right time of year and in favourable conditions.

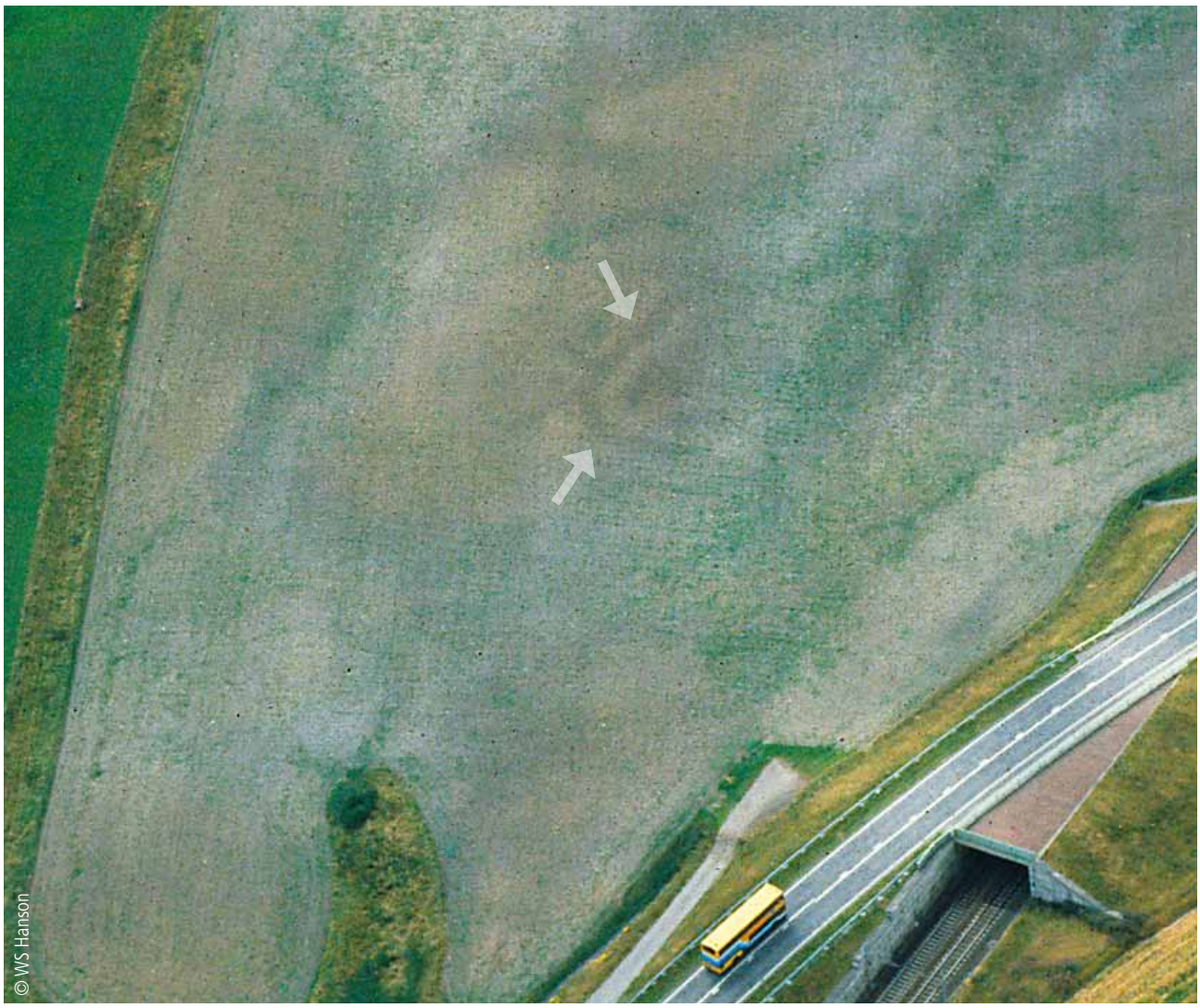

Figure 3. The rampart and ditch around three sides of the small, rectangular Roman fortlet at Wandel, South Lanarkshire, showing as a soil mark.

More sites in Scotland have been discovered through cropmarks than by either of the other two aerial phenomena, but not all areas produce cropmarks with equal facility. Well-draining soils, such as sands and gravels, produce the best results, though even some clay soils can generate cropmarks under the right conditions. However, the combination of factors which best suit cropmark production – well-draining soil types, dry weather patterns and extensive areas of cereal production (Evans and Jones 1977) – tend to generate consistent biases in their distribution towards those areas where these conditions are more often present. Meteorological records clearly indicate that the western half of Lowland Scotland is on average wetter and has marginally cooler summer temperatures than the east (Meteorological Office 1989, figs. 2 and 6), differentials which are compounded by differences in soil type, with a lower percentage of well-drained soils suitable for arable agriculture in the west (Coppock 1976; Brown et al. 1982, 19, 135–40 and map sheet 6). As a result there is a predominance of permanent pasture in the western Lowlands. Thus the already unfavourable factors for the production of cropmarks in terms of soil type and levels of precipitation in the west are reinforced by the emphasis on permanent pasture (fig. 4) (Hanson 2005).

This inherent geographical bias which favours the eastern lowlands is further accentuated by a natural tendency to concentrate reconnaissance in areas where there is the most obvious and immediate return, focusing on what have been referred to as 'honey-pots' (Cowley 2002, 257–62). Historically, this approach has been reinforced by the need to be seen to provide best value for money given the limited finances available for aerial photography (Hanson and Macinnes 1991, 155–7). Thus, the plots of flight paths undertaken by the RCAHMS have shown a consistent heavy concentration in the south and east of the country, especially Lothian, Fife and Angus (e.g. British Academy 2001, fig. 4). Though this picture was slightly offset by the activity of regional fliers, their impact on this overall pattern has at best been marginal because of limited budgets. Even in very dry summers, such as occurred in 1989 or 1992, when results from the less conducive areas in the west were likely to have been better than normal, the bulk of flying still tended to take place in the eastern regions (RCAHMS 1993, 4–5; 1996, 2–6).

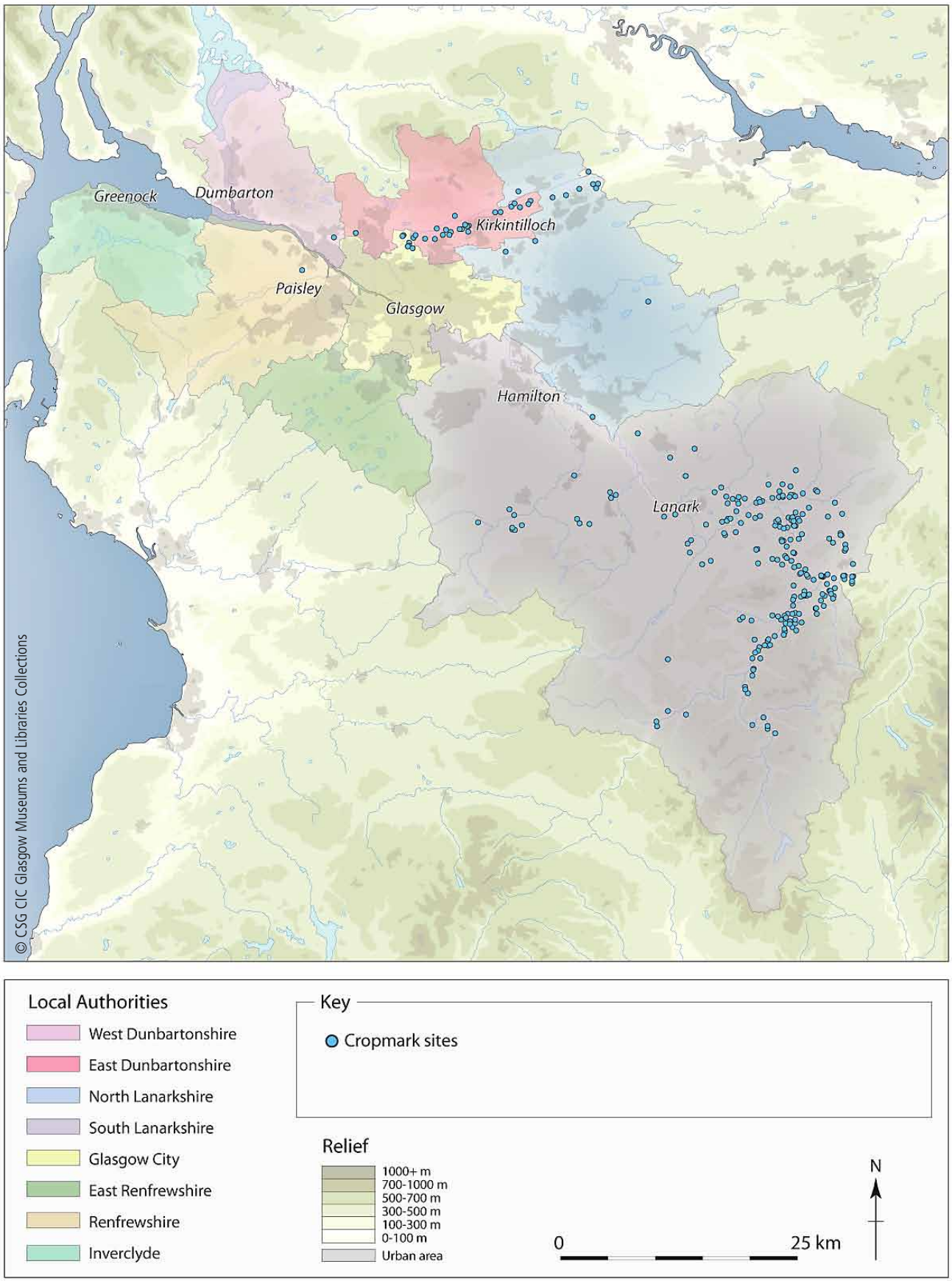

Figure 4. Map of cropmark distribution (based on data provided by RCAHMS), illustrating the bias towards areas of arable cultivation. Produced by the former GUARD (Glasgow University Archaeological Research Division), created by Ingrid Shearer (Northlight Heritage), based on information supplied by the author.

Aerial reconnaissance is good at discovering larger features, such as ditched enclosures (e.g. fig. 2), but much less effective for more ephemeral remains such as shallow gullies or posthole structures. This means that there is a further bias in terms of the types of archaeological sites which tend to be recorded and, accordingly, some archaeological periods are generally ill-represented in the aerial photographic record (see next column). Moreover, even when sites are recorded, the photographic record will be only partial compared to what could be recovered from more detailed work by excavation or possibly by geophysical survey. Finally, because of the way in which the phenomena are revealed, an aerial photograph will not readily distinguish between different phases of human activity on cropmark sites.

Sources of Information

The primary source of archaeological aerial photography for the region is the RCAHMS in Edinburgh, who house the National Monuments Record. The RCAHMS holds not only the oblique photographs from its own reconnaissance, but copies of at least a representative selection of photography from other sources, such as CUCAP and local fliers, including the present author; the RCAHMS regularly seeks to enhance its aerial photographic holdings for Scotland. Increasingly, such material is being made available directly online through Canmore, the RCAHMS's database search engine. RCAHMS is also the repository for historical vertical photography, whether derived from the Ordnance Survey, the RAF in the late 1940s or even the Luftwaffe, though since this imagery was not taken with archaeology in mind it may not necessarily show cropmarks and must be carefully scanned to reveal even extant sites. The date and availability of cover for any particular area can be checked online through AirPhotoFinder, an application hosted by RCAHMS to help locate available vertical aerial photography.

With the advent of the website Google Earth the availability of satellite imagery is becoming increasingly apparent. Low-resolution satellite imagery such as from Landsat is of very limited application for archaeology, though it does provide an overview of current land use. But imagery with a higher ground resolution (1m or less), which is available commercially from satellites such as Ikonos, QuickBird, WorldView and GeoEye, offers the same benefits and limitations as vertical aerial photography. This provides the opportunity for anyone to purchase imagery of a particular area acquired at a particular time, though the costs involved can be quite high.

Free satellite coverage of Scotland, available on the websites of Google Earth or Bing Maps, varies considerably in quality and particularly in resolution. High-resolution imagery, some of which is actually aerial photographic in origin, is currently available on Google Earth for much of the study area except for part of South Lanarkshire, though that available on Bing Maps is slightly less comprehensive. This may change over time since the coverage, particularly on Google Earth, continues to be amended and enhanced as new imagery becomes available. The further limitation of this free imagery, however, is that it may not have been taken when conditions were most suitable for the discovery of archaeological sites.

Impact on Understanding of the Study Area

Aerial reconnaissance is the single most important way of discovering new archaeological sites in Lowland Scotland, though attention has already been drawn to some of the biases involved, which have had a particularly detrimental effect on the recovery of sites in the west. Furthermore, because of the inherent bias in relation to site types referred to above (see previous column), aerial photography provides excellent evidence for Neolithic ritual monuments, for example, but much poorer returns for contemporary settlement, and no assistance to the Mesolithic period. Nonetheless, it has contributed considerably to enhancing knowledge of the density and distribution of sites of all periods from the Neolithic onwards and to demonstrating the time-depth of that landscape. It has made a particular contribution to those periods when site types are morphologically distinct and readily identifiable, such as Neolithic henges (e.g. Harding with Lee 1987), Iron Age hillforts and Roman camps and fortifications (e.g. Jones 2005): approximately half of the Roman forts and fortlets known in the study area and some 75 per cent of the Roman temporary camps are aerial discoveries. Numerous enclosures and linear features have been recorded in the area, but are much more difficult to attribute to particular periods without further investigation.

Aerial photography also facilitates a more landscape-based approach to archaeology, enabling sites to be appreciated within their wider geographical and archaeological context, revealing field systems as well as settlement foci. Finally, it has the potential to make an important contribution to cultural resource management, enabling known sites to be easily recorded and regularly monitored, though this is not an application that has been systematically applied in Scotland in the way that it has elsewhere in the United Kingdom.

Summary and Recommendations for Future Research

The archaeological aerial photographic record for the study area is far less impressive and wide-ranging than for many areas in the eastern lowlands, such as Fife, Angus, West or East Lothian. If we are to redress this balance, there must be more positive discrimination, in terms of both finances and the deployment of personnel, in favour of areas which are less productive in terms of cropmarks, particularly in those rare, very dry years, occurring perhaps only once every decade, which may be the only occasions when some sites in the west become visible. This was called for some years ago (e.g. Hanson and Macinnes 1991, 157) and the need has now been recognized by RCAHMS, who have instigated an explicit, long-term policy of targeting 'less-productive' areas, such as the western lowlands, in an attempt to redress the historical imbalances in coverage (Cowley and Dickson 2007, 50–4).

In terms of information-return, aerial reconnaissance already provides the best value for money in Scottish archaeology on the basis of an annual expenditure which equates broadly with the cost of a single, medium-sized area excavation (British Academy 2001, 44). Though the return, in terms of numbers of new discoveries, might be less in the west than in the east, the value of the archaeological information obtained would be potentially greater by virtue of its comparative scarcity. Systematic vertical coverage of the study area obtained in the right conditions for cropmark recovery might revolutionize our appreciation of the archaeology of the region (Palmer 2007).

Technological developments may provide further enhancement of the aerial archaeological record. The potential of satellite imagery for archaeological aerial reconnaissance has already been alluded to in this paper. The archaeological potential of wavelengths within the electromagnetic spectrum other than the visible light, such as in the near infrared or thermal ranges, is still undergoing assessment, but it has already been demonstrated that such hyperspectral scanning has the potential to address some of the biases in aerial data recovery referred to above (Aqdus et al. 2007), though the cost implications are considerable. Finally, the use of airborne LiDAR (Light Detection and Ranging), which involves directing a pulsed laser beam at the ground and analysing the reflections back, provides a means of recording even very slight variations in surface elevation. This provides the opportunity to exaggerate the surface height differential or change the light direction or angle of view in order to maximize the visibility of archaeological sites that are barely extant. In addition, concentrating on the secondary pulse return from the laser facilitates examination of the ground surface currently masked by vegetation or forest (e.g. Crutchley 2006). Given the high proportion of unimproved upland in large parts of the study area, potential returns from the application of LiDAR are considerable.

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Online resources

- www.airphotofinder.com
  An application to help locate vertical aerial photography in Scotland which is available for purchase from RCAHMS.
- www.bing.com/maps/
  A freely downloadable program providing maps of most of the Earth's land surface with an aerial view which overlays satellite imagery.
- www.google.com/earth/
  A freely downloadable program which displays satellite and/or vertical aerial images of the Earth's surface. Ground resolution of the imagery varies according to availability, but most land surfaces are covered by imagery of at least 15m resolution. It is regularly updated, the newer imagery being layered, allowing users to view changes over time.