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Remote Sensing

Rapid Desktop Reconnaissance: Trial use of lidar for monument recording

S Crutchley & F Small

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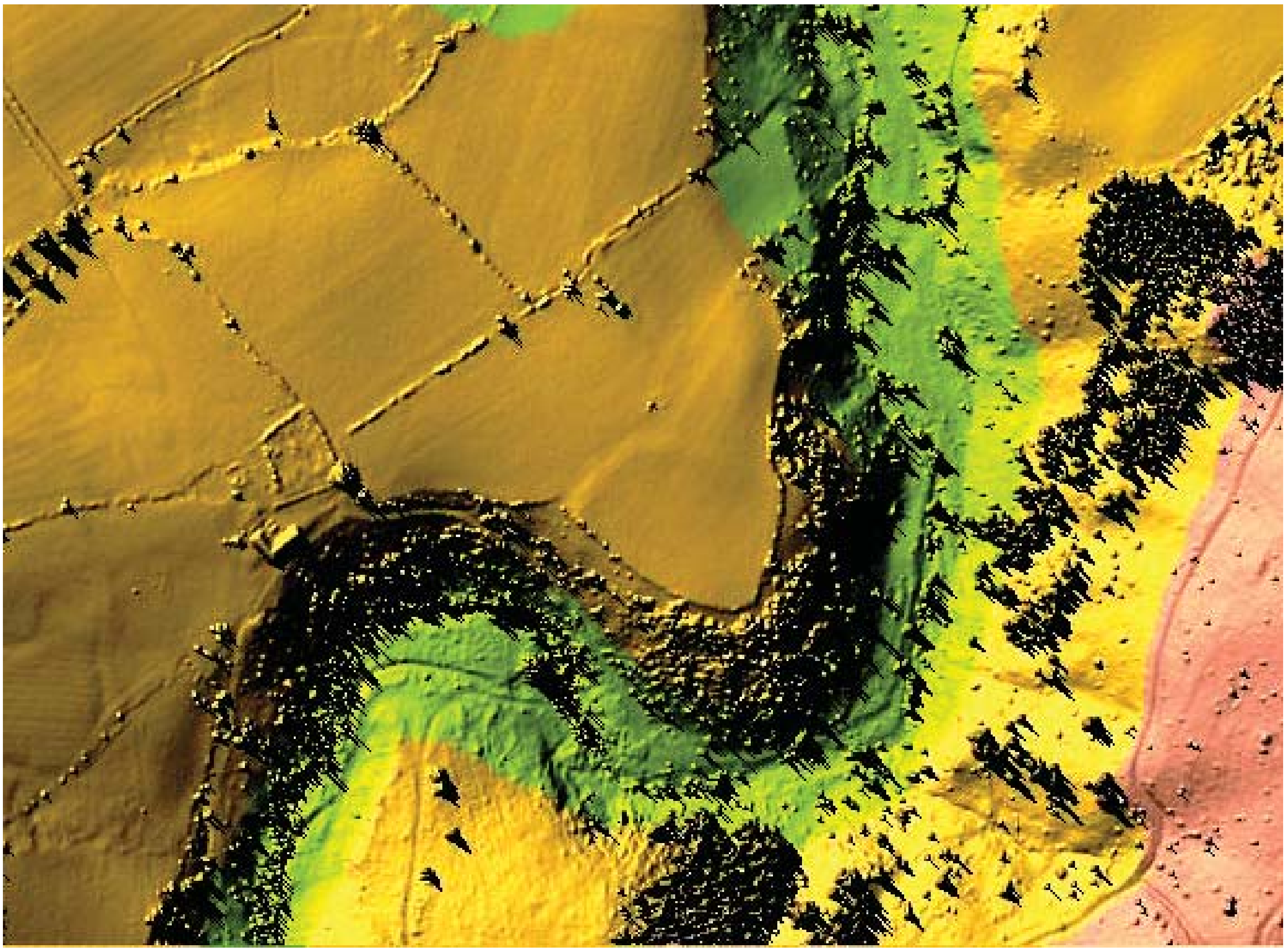

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SUMMARY

This report summarises the results of a project designed to develop methods for rapid identification of heritage assets using the Environment Agency (EA) lidar tiles in a manner similar to that for the existing reconnaissance recording programme. The project was designed to establish whether use of these sources was an effective method for national identification and provides some basic guidance on their potential for future use.

The report covers the methodology used, including looking at some more recent advances that may make some of this redundant. It also examines some of the key archaeological findings and assesses what types of features were recorded, together with some suggestions as to why this occurred. It ends with some conclusions as to the usefulness of the technique and how they might be improved on using new developments in the field.

CONTRIBUTORS

The project was developed and run by Simon Crutchley, Development and Strategy Manager, Remote Sensing. Changes to the visualisation methodology and almost all recording of features was carried out by Fiona Small, Aerial Investigation and Mapping.

ACKNOWLEDGEMENTS

The authors wish to thank the Geomatics Group at the Environment Agency who provided the lidar tiles for analysis.

The cover image shows EA lidar tile SJ4105 DSM 1m 19-MAR-2009 enhanced using Adobe Photoshop.

ARCHIVE LOCATION

There is no archive for this project beyond the Project Proposal, Project Design and this report. All sites identified during the project have had Monument records created in the National Record of the Historic Environment (NRHE).

DATE OF PROJECT

September 2012 - March 2015. Report completed April 2016

CONTACT DETAILS

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BACKGROUND

For several years now lidar data and lidar derived imagery have been used within Historic England (formerly English Heritage) as part of survey projects. Historic England have JPEG image tiles derived from lidar data collected by the Environment Agency (EA) up until June 2014, provided by the EA Geomatics Group . These provide partial, but wide ranging, cover of England and were produced at a variety of scales ranging from 25cm to 2m resolution. They were provided as individual tiles covering 1x1 km or 2x2 km squares; there are also a small number of 0.5x0.5 km squares at 25cm resolution. Each JPEG tile is a composite, made up potentially from a number of separate data tiles captured at different times and at differing resolutions. Each composite JPEG tile at the given resolution includes any data at or above that resolution of data capture. For example, a single 2m resolution tile could contain subsets of data captured at 2m, 1m and 50cm resolution all resampled to create an end result at 2m resolution. The same JPEG tile would also exist at 1m resolution, consisting of the 1m and 50cm data, and at 50cm using only the 50cm data. The JPEG tiles are available as either Digital Surface Model (DSM) or Digital Terrain Model (DTM) versions, the different utility of these is discussed below but see also Crutchley & Crow (2010)

Historic England first began using lidar tiles and data in the early 2000s, but over time they have become an integral part of any project. The EA JPEG tiles are now used on a regular basis and are interrogated as a standard part of any National Mapping Programme (NMP) or site-based project carried by the Aerial Investigation and Mapping team and NMP contractors. In addition, since 2006 HE, and latterly some contractors, have been using the actual data. This usage has increased again in recent years with the advent of certain visualisation tools that will be discussed in more detail below.

In such situations lidar tiles provide complementary information to that derived from the usual archive air photo sources and archaeological reconnaissance material. Based on this it seemed that there was also good potential to use the JPEG tiles on their own as a single resource for the discovery of heritage assets using rapid methods similar to those of the Historic England archaeological reconnaissance recording programme.

The standard EA JPEG tiles are images with height information shown as coloured bands accentuated by hill-shading lit from the NW. They only contain RGB figures, not any actual height data. In this they differ from the ASCII data that is also now readily available from the EA. The JPEG image tiles were assessed as part of this project because the ASCII tiles required significant effort, together with specialist hardware and software, to process to a more user-friendly format.

AIMS AND OBJECTIVES

The aims and objectives as set out in the original Project Design were altered slightly as the project progressed, but it is fair to say that they were met on the whole.

Aim 1 - To develop an effective methodology for the rapid assessment of readily accessible data sources, including lidar and on-line satellite and aerial imagery, for rapid identification of important heritage assets.
Aim 2 – To assess the benefits of this methodology.
Aim 3 - To make recommendations about the potential for rolling out a national programme of such work via targeted regional surveys to complement existing NMP and archaeological aerial reconnaissance programmes.
Objective 1.1 – To develop a flowline for rapid assessment of lidar and on-line sources.
Objective 1.2 – To complete the evaluation of a 100km square to test the methodology and assess the timescale required.
Objective 1.3 – To identify a mechanism for recording the source of any discoveries so as to assess their relative benefits and also to ensure that sources are not examined twice.
Objective 1.4 – To create Historic England National Record of the Historic Environment (NRHE) monument records (in the AMIE database) for any new sites discovered.
Objective 1.5 – To assess the practicality of using Heritage Gateway for concordance with sites previously recorded in the relevant HER, but not in AMIE.
Objective 1.6 – To provide statistics on the effectiveness of the approach.
Objective 1.7 – To provide recommendations on the effectiveness of this approach for identifying heritage assets and how to allocate future resource.
Objective 1.8 – To provide recommendations on how current flowlines should be improved and produce a proposal for a further project where this can be applied nationally.

RESULTS

Methodological results

Using the EA JPEG tiles

The key aim of the project was to develop a methodology for the use of the EA lidar derived imagery for the purpose of the rapid identification of new sites of interest in a similar manner to that already employed using traditional photography. The first step in this process was to ascertain how best to evaluate the imagery. From past experience it was clear that there was more information available in the images than was at first apparent. As is the case with standard aerial photographs a little judicious manipulation in Adobe Photoshop or a similar package enables the user to bring out features that are not as evident in the original image. However, there are a number of different techniques that can be used to enhance an image, and whilst this variety is useful in local research projects, it was evident that for a project with the aim of rapidly identifying the most important new discoveries over a large area, a more structured process was required. To this end the first days of the project were allocated to assessing the various types of manipulation available and their relative values, based on both end results and ease of use.

One key approach used by many when looking at lidar tiles is the simple use of equalising levels, a technique that brings out features with subtle differences. A more subtle development of this technique was the use of a macro developed by P Horne that split the image into its constituent red, green and blue bands and then levelled them. This was quite simple to use, but did require several stages for each image. Initially this appeared to be a good solution until F Small began working on a trial area. Working with D Grady she used the technique applied to modern digital aerial photographs to develop a quicker and even more user friendly approach to enhancing the lidar imagery. They found that, by opening the imagery in Adobe Bridge using Camera Raw and adjusting the sliders for Black and Contrast, they were able to enhance the tile quickly and in an interactive environment. It's true that there was a slightly lesser degree of enhancement than the three part macro, but this was made up for by the speed and ease of use. Because the aim of this project was to create records where appropriate, rather than to map new features there is no need for an enhanced version of the image for importation into GIS or CAD so being able to manipulate and enhance on the fly is a big advantage. The technique of working with Camera RAW images in Adobe Bridge was adopted for the rest of the project with very positive results.

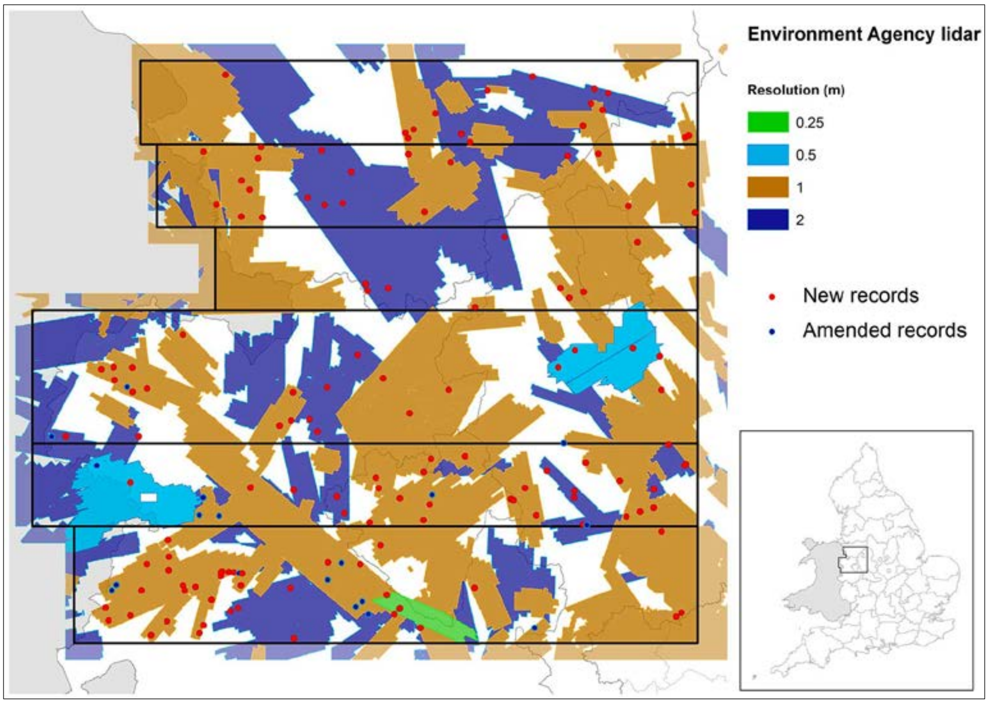

Figure 1: Distribution of EA lidar coverage within the survey area, differentiated by data resolution.

The lidar data were available generally as 1m and 2m tiles. Some areas were also covered with data at 50cm resolution, but these were not utilised because they were duplicated by 1m tiles and did not appear to add any significant benefit in feature recognition. Of the 1m and 2m tiles, the 1m tiles proved more useful, offering adequate clarity for identifying relatively slight earthworks in most terrains, particularly where QT (Quick Terrain) models were produced to clarify selected less clear-cut sites. In contrast, the image quality offered by the 2m lidar tiles was adequate for larger more massive earthworks, but considered to be barely sufficient for detecting subtle sites. Essentially, 2m tiles would not be the preferred scale for aerial survey unless 1m tiles were unavailable.

The specific image processing techniques used for the project were designed for application within Adobe Photoshop, a package available to the project team but that might not be available to a range of potential users. It was planned to examine various Open Source and other readily accessible software packages to replicate what was done in Adobe. As time progressed, however, it became clear that the very nature of Open Source software meant that it is constantly changing with upgrades etc. As such it was considered impractical to provide any structured guidance on the use of alternative packages. Rather the hope is that by describing the techniques used within Adobe those using other packages, and more familiar with their operation, will be able to replicate the results.

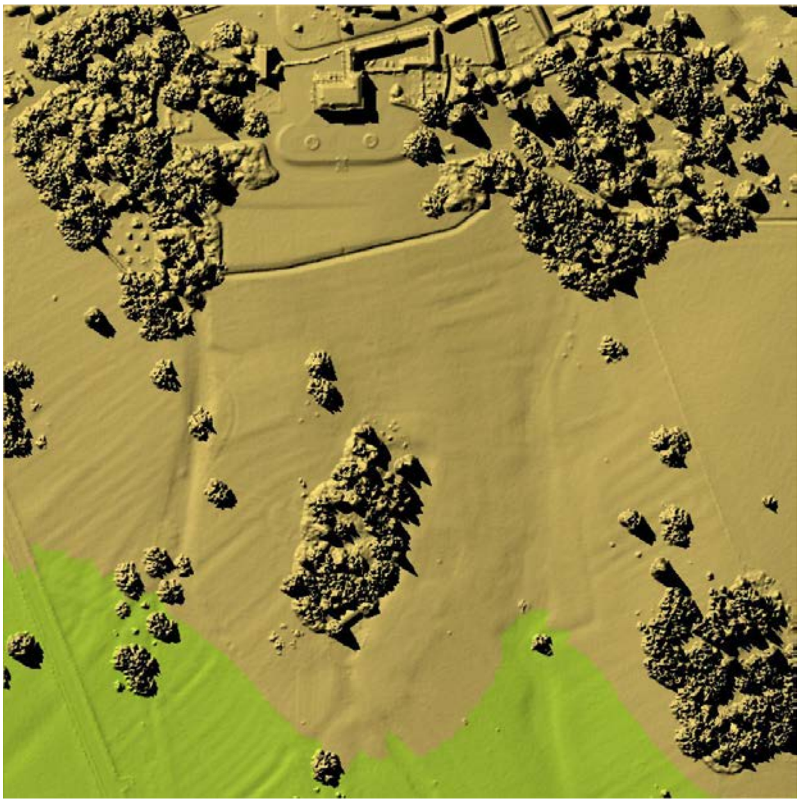

Figure 2 - Original, unprocessed jpeg image as acquired from Environment Agency. LIDAR SJ 8535 DSM 50cm November 2009 – March 2010. Lidar © Environment Agency copyright 2010. All rights reserved.

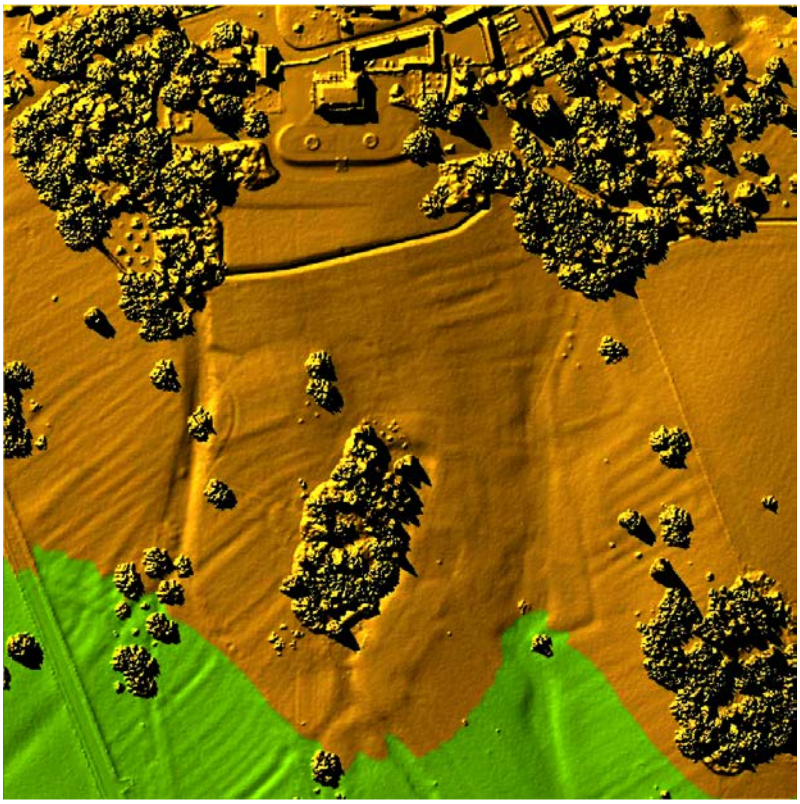

Figure 3 -Processed jpeg image. LIDAR SJ 8535 DSM 50cm November 2009 – March 2010. Lidar © Environment Agency copyright 2010. All rights reserved.

3D/2.5D viewing

The data available from the EA came in both the JPEG tile format and as ASCII grid files. The latter have the advantage of allowing much greater manipulation and visualisation of the data using professional (and often expensive) software (Crutchley & Crow 2010).

Within the project staff had access to the QT Modeller software, an off-the-shelf product that is very effective, but not cheap. On occasion, where there was a degree of uncertainty the ASCII data was quickly processed in QT Modeller to enable it to be viewed in 3D (or rather 2.5D). Although this was not originally envisaged as part of the project, and would not be general practice, it proved useful to clarify the interpretation of some sites, both in positive and negative terms.

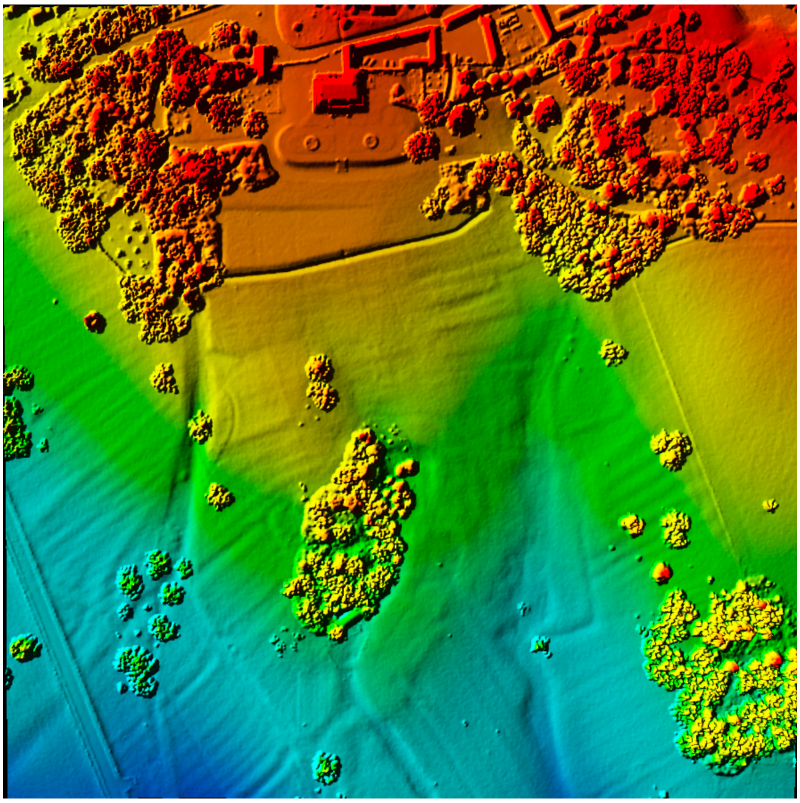

Figure 4 - Image derived from ASCII data in QT Modeller. LIDAR SJ 8535 DSM 50cm November 2009 – March 2010. Lidar source Environment Agency.

Unfortunately at the time of the project, there were very few freely available software packages to view ASCII grid data. The key exception to this is GlobalMapper, a software package that describes itself as "an easy-to-use GIS data processing application that offers access to an unparalleled variety of spatial datasets and provides just the right level of GIS functionality to satisfy both experienced GIS professionals and mapping novices". The main advantage of Global Mapper is that, whilst the full version of the software is relatively cheap, there is a cut down version that is free. This allows you to load ASCII grid data and view it in 2 and 3D with either standard shadings or customised ones including hillshading where the elevation/altitude and azimuth can be controlled along with the vertical exaggeration. It also has a profiling tool that can be useful when assessing whether a feature really is a bank or just a scarp.

In the event that people do not have access to Global Mapper there is a simple tool for converting ASCII grid to xyz available through SourceForge. Once converted the xyz files can then be viewed in several free viewing programmes such as FugroViewer or the on-line viewer Lidarview, but see also the developments described below.

New developments superseding the use of EA JPEG tiles

At the time of the project design the image tiles were readily available to any non-commercial user and therefore guidance on ways of working with them using only basic software was considered to be potentially useful. Since that date there have been a number of developments, some of which are highlighted in the conclusions.

The first major change has been in the availability of EA lidar data to the general public with the creation of a data portal (http://environment.data.gov.uk/ds/survey/index.jsp#/survey). This portal provides access to the actual lidar data as ASCII tiles, which can then be manipulated to produce different visualisations. At the time of the survey it was no longer possible to access the JPEG imagery, but this has now changed. The EA have now released all their tiles on Flickr at https://www.flickr.com/photos/environmentagencyopensurveydata/albums/. These are available in general as 5km x 5km tiles similar to the OS quarter sheets.

However, another development may have a major effect on anyone planning to look at lidar-derived imagery for rapid archaeological analysis and interpretation. It was stated in the Background that the image tiles, rather than the ASCII data, were used because they were readily accessible and could be viewed by large numbers of people without the need for access to complex hardware or software. Over the last few years, however, there have been a number of developments in the creation of various visualisations for lidar data, starting with a major breakthrough that occurred in 2013 with the launch of the LiVT toolbox to allow the creation of the most commonly used lidar visualisations from a single simple toolbox. The toolbox was written to run under various operating systems, but the downside of this was that it meant it had to use BIL format files as both the input and output. This made it difficult to use for those unable to convert files to BIL format. Earlier in 2014, however, a second toolbox was developed (RVT). This one uses Geotiffs for input and output and also includes a conversion tool to convert from ASCII to Geotiff, and indeed x,y,z. This means that it is now very simple for anyone with access to ASCII grid data to create a whole suite of visualisations that should help with the interpretation an analysis of any given landscape. So whilst the freely available JPEG image tiles provide a quick, easy view of the landscape, these new tools provide access to the lidar data in a form more suited for archaeological purposes.

Use of other sources

It should be noted that although the lidar derived image tiles were the primary resource, they were not used entirely in isolation, in the same way that the traditional aerial photographs taken as part of reconnaissance are not used on their own in the reconnaissance recording programme. The key additional resource examined was Google Earth, which was used to help with interpretation and to rule out a recent explanation for features appearing on the lidar derived imagery. The images were also used in conjunction with the Historic England corporate GIS which, provides access to known archaeological features, together with current OS mapping and older mapping such as the OS 1st Edition County Series.

Archaeological results

Overview

As a method of remote survey, lidar provides a rapid means of surveying large areas for archaeological sites surviving as earthworks. Because of the nature of lidar it is possible to detect very slight earthworks that are not visible on aerial photographs, and to confirm the survival of earthwork elements on sites previously believed to have been plough-levelled and known only from cropmarks. Because lidar can only identify earthwork features with some measurable height it should normally only be used as one complementary method of survey alongside conventional aerial photographs and other available data (Crutchley & Crow 2010), but this survey was designed to ascertain the benefits of using lidar largely on its own. Because of the completeness of the evidence they contain, previously unrecorded sites that are well preserved as earthworks are particularly valuable additions to the archaeological record. Similarly sites that are visible primarily as cropmarks, but which have a slight earthwork element, may be better preserved than those plough-levelled sites with no surface indication visible only as cropmarks. Significantly, a shift from a dominance of pasture to an increase in arable cultivation was observed in the Welsh Marches during the Marches Uplands NMP project (Stoertz & Small 2004) comparing aerial photographs taken from the 1970s onwards. It is difficult to ascertain the extent to which this has affected archaeological sites in this area, but it is likely that some remains have been compromised by this change in agricultural practise. However, this shift to more arable cultivation has undoubtedly led to more buried sites being revealed through cropmarks.

The sample transects for this survey covered a 5030km² swathe of countryside extending from the Welsh border between Welshpool and Chester in the west to between Wolverhampton and Macclesfield in the east. The sample area encompassed a range of topographies and different geological landscapes with a range of land uses including various agricultural regimes as well as urban and former industrial areas. The aim of the pilot survey was to ascertain the merits of using lidar for rapid survey across a variety of landscapes and explore the most efficient methods of viewing and analysing the data.

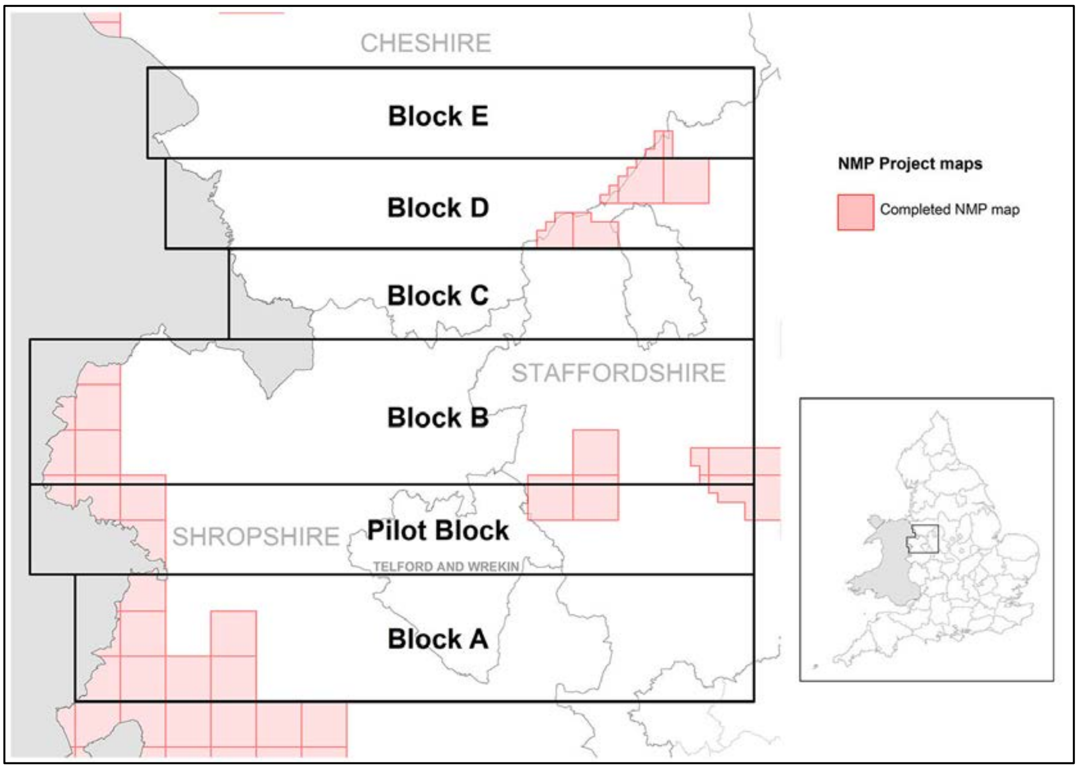

Figure 5: Location of lidar transects. Former NMP mapping project blocks are outlined in red as either complete or partial 25km squares.

What kind of sites were identified?

The survey identified 147 archaeological sites new to the national and County Historic Environment Record (HER) records – the relevant databases for which are readily available on-line through Heritage Gateway. A further twenty existing sites were updated because the lidar survey identified significant additional detail or altered an existing interpretation.

The majority of new sites identified were medieval in date and included such sites as moats, fishponds, settlement remains and ridge and furrow cultivation. The predominance of such sites is largely due to the ease of identification of larger distinctive sites and the reasonable state of preservation of many medieval earthworks.

The second largest group were sites of uncertain date. Many of these were enclosures that could be later prehistoric or medieval in origin, but based solely on the lidar imagery and Google Earth photographs it was not possible to allocate a definite single date. In spite of this uncertainty, 15% of the sites were classified as broadly later prehistoric, being given double or multiple date indexes. A significant number of these were discrete enclosures likely to be Iron Age or Roman farmstead enclosures typical of the Marches together with fragments of field system. Most were seen as very slight earthworks.

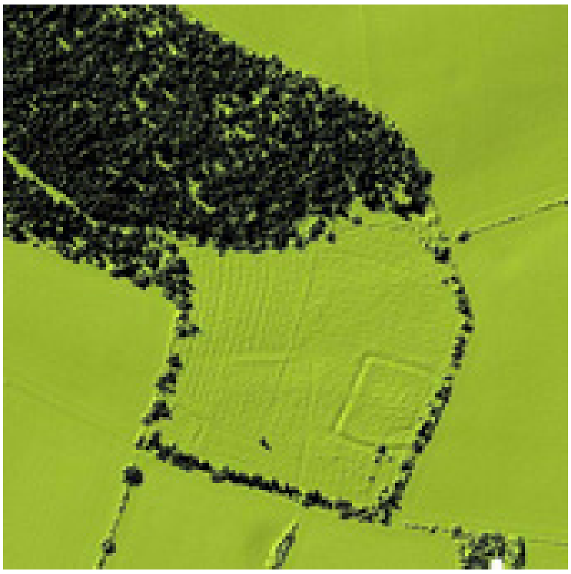

Figure 6: Remains of a medieval moat SW of Penkridge LIDAR SJ 9212 DSM 1m 11-JAN-2007 (left) and a newly discovered enclosure of uncertain date in former woodland to the east of Penkridge LIDAR SJ 9513 DSM 1m 08-APR-2010 (right). Lidar © Environment Agency copyright 2010. All rights reserved.

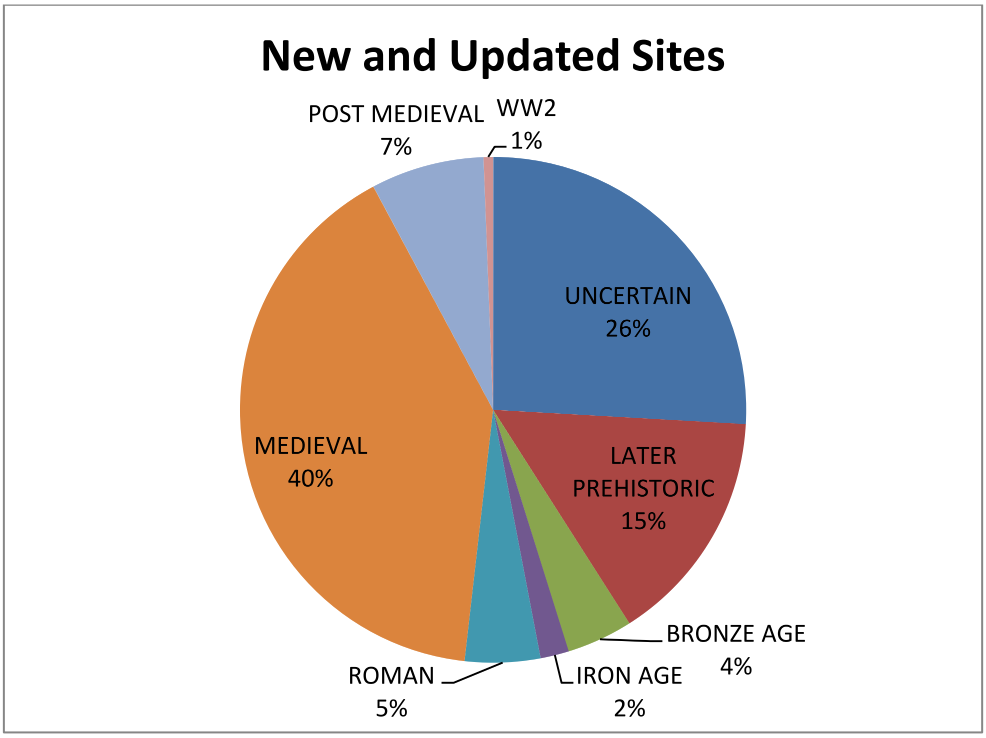

Figure 7: Distribution of new and updated sites identified across all six transects by period.

Only 4% of the new sites were specifically dated as Bronze Age and 2% as Iron Age. These relatively low numbers probably reflect the fact that the majority of earthwork barrows and larger Iron Age enclosures had already been recorded in their relevant county HER or were recorded during the course of the Marches Upland NMP (Stoertz & Small 2004).

Figure 8: Slight earthworks of a possible Iron Age promontory fort at Besfordwood north of Preston Brockhurst, Shropshire. Ploughing has reduced the enclosure bank which now only survives as a very slight earthwork; faint traces of later cultivation ridges are visible. LIDAR SJ5425 DSM 2m 28-FEB-2008 Lidar © Environment Agency copyright 2010. All rights reserved.

However, two previously unrecorded probable Iron Age promontory forts were identified. One on 2m lidar is visible as a single slight earthwork curvilinear bank cutting off the end of a promontory at Besfordwood (see fig5 above), and a second seen on 1m lidar on a small promontory overlooking the Happerley Brook on the eastern side of Pontesbury Hill, Shropshire. In the field to the west of this enclosure are the faint earthwork traces of part of a field system (see fig 6 below).

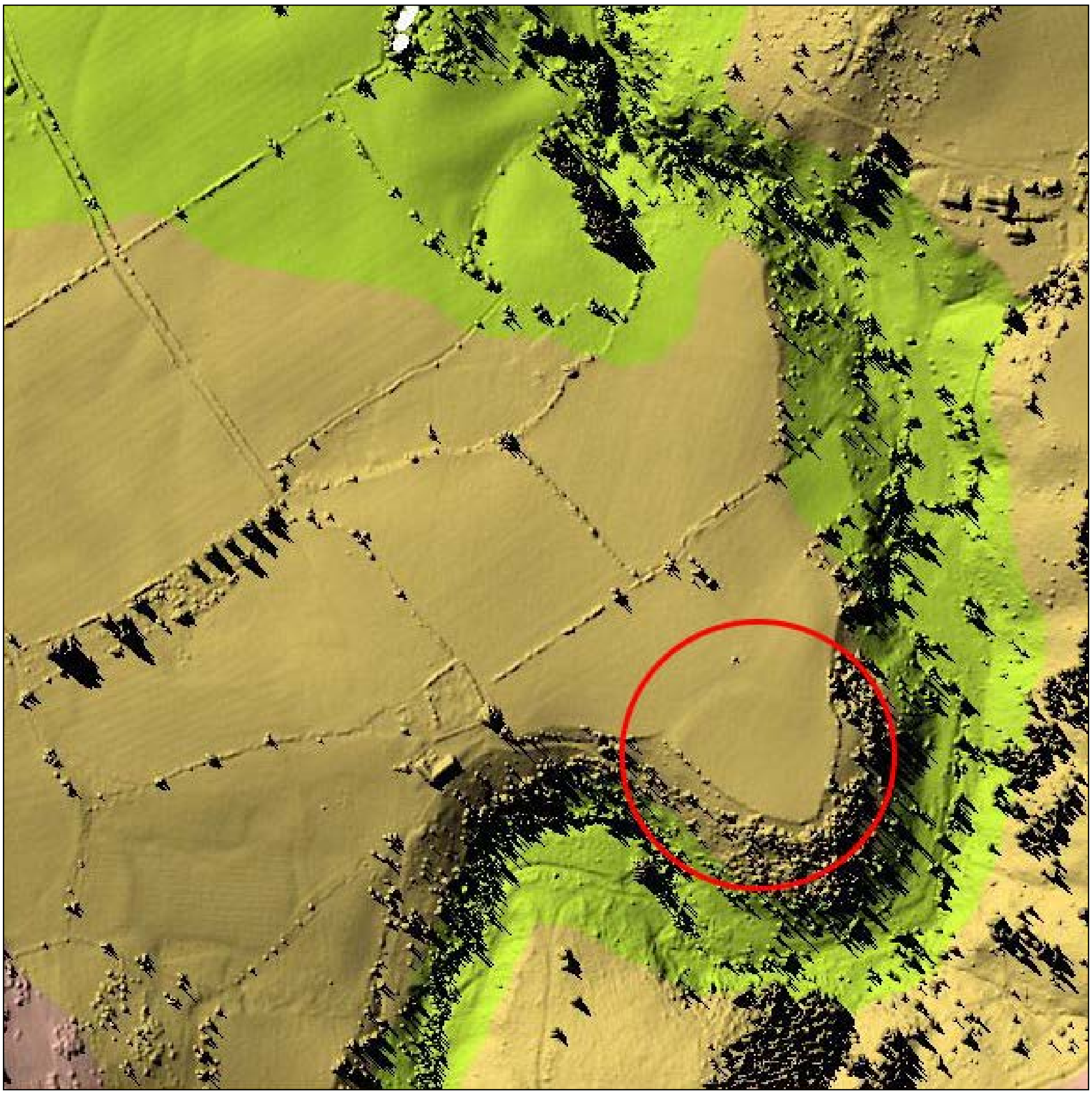

Figure 9: Traces of a previously unrecorded possible small univallate Iron Age promontory fort overlooking the Happerley Brook on the eastern side of Pontesbury Hill, Shropshire. Traces of a field system can be seen in fields to the west of the enclosure. LIDAR SJ4105 DSM 1m 19-MAR-2009. Lidar © Environment Agency copyright 2010. All rights reserved.

Faint traces of numerous smaller rectilinear and curvilinear enclosures with no apparent existing record were seen across all five transects; most are likely to represent the remains of later prehistoric or Roman homestead enclosures.

Not surprisingly, there were concentrations of Roman remains focused on the two important settlements at Wroxeter and Chester and traces of the known and documented sites including multiple camps, forts and roads associated with these two centres were noted on the lidar. However, the lidar did reveal eight potential new Roman sites including a possible camp close to Chester and sections of the Roman road from Wroxeter to the fort at Caersws in

Montgomeryshire with the agger visible as lengths of earthwork visible over 9km in fields between sections still followed by the B4386.

The remains of a number of larger, less well defined features such as large fragmented enclosures and linear features extending across several fields together with platforms and enclosures partially obscured by later features have been revealed. The size and subtlety of the earthworks is the most likely reason why these have not been identified in the past. As with standard photographic reconnaissance recording, dispersed fragments of linear bank and ditch were generally not recorded.

Figure 10: Two examples of possible later prehistoric/Roman settlement enclosures typical to Welsh Marches area. The left-hand site is located near Oswestry (LIDAR SJ3130 DSM 1m 28-MAR-2009) and the right-hand site – a rectilinear ditched enclosure lies to the west of the River Rodan at Lee Brockhurst, Shropshire (LIDAR SJ5526 DSM 2m 28-FEB-2008). A possible castle site is located on a mound in the bend of the river to the east. Lidar © Environment Agency copyright 2010. All rights reserved.

What factors have influenced survival and identification?

Lidar resolution

Unlike conventional reconnaissance recording which is observer led, seeking out and photographing sites visible as cropmarks and earthworks, reconnaissance using existing lidar data relies on a single source of images taken at any time of the year, which will only detect upstanding earthworks. The resolution of the lidar is variable depending on what is available, typically ranging between 0.25m - 2m, with the majority at either 1m or 2m. Where 2m lidar is the only available source all features – earthworks, trees and buildings are less clear and it is noticeably harder to identify smaller and more subtle structures such as pits, mounds, and small building and structures such as pill boxes. The difference in image quality between 2m and 1m lidar is illustrated below:

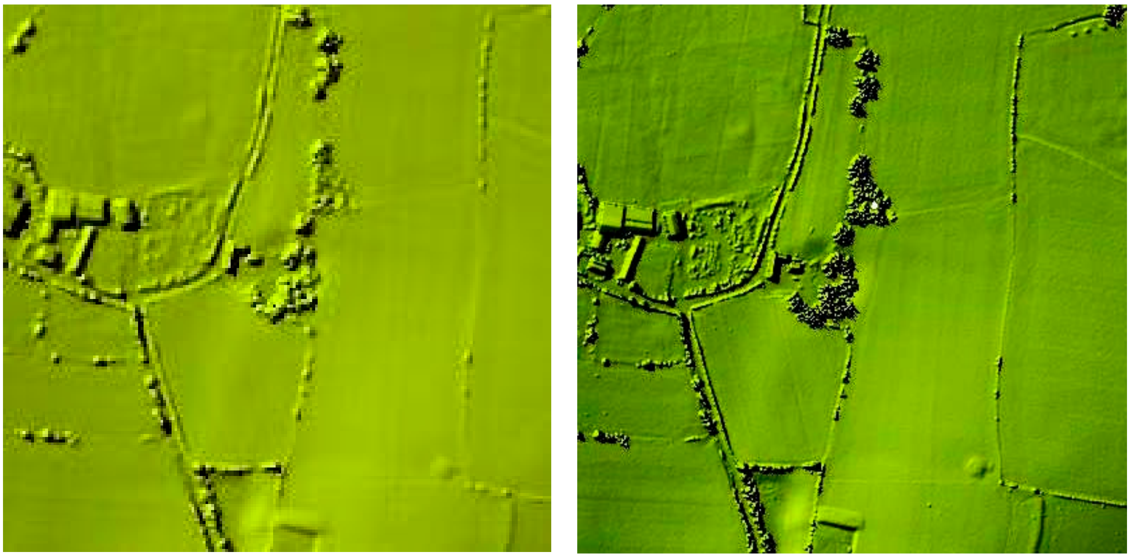

Figure 11: Lidar tile LIDAR SJ9508 DSM 2m resolution 11-JAN-2007 (left) and LIDAR SJ9508 DSM 1m resolution 08-APR-2010 (right) illustrating the difference in image quality between the two resolutions. Lidar © Environment Agency copyright 2010. All rights reserved.

Geology and land use

The area sampled for the project/survey encompassed a range of different topographic and geological areas extending over a variety of zones of land use. With each transect extending through a range of regions it was possible to assess the relative effectiveness of lidar at detecting features in differing conditions.

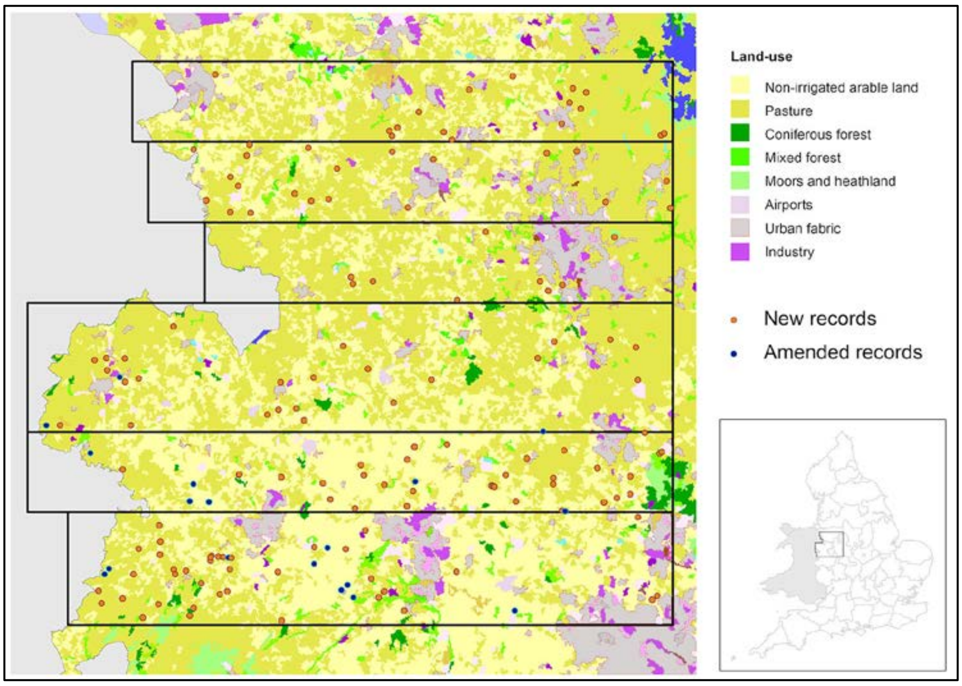

Figure 12: Land use from the Corine Land Classification for the project area.

In practise, lidar proved most effective in the semi-uplands of the English-Welsh border where typically smaller fields are utilized as grazing pasture on the lower hills, interspersed with woodland and semi-improved grassland on the higher slopes. In the valleys there is a greater prevalence of arable cultivation, the intensity of which has increased noticeably since the 1990s when the area was surveyed from aerial photographs for the Marches Uplands NMP project (Stoertz & Small 2004) with widespread drainage and soil improvement over the last few decades. Despite these changes lidar (and aerial photographs) has revealed a number of significant new potential prehistoric sites in areas which are by no means remote. The key factors here are the lack of intensive deep ploughing and low levels of development resulting in the better preservation of earthwork sites. The prevalence of pasture over arable cultivation does mean that fewer sites are detected as cropmarks except in very dry years.

Moving eastwards from the Welsh border the effectiveness of the lidar as a tool for site identification drops across Shropshire because of the increasing intensity of arable cultivation in the Severn Valley resulting in fewer earthwork sites surviving ploughing. However, some new sites were identified. The flip-side of this is the increase in sites which will be detected as cropmarks on aerial photographs.

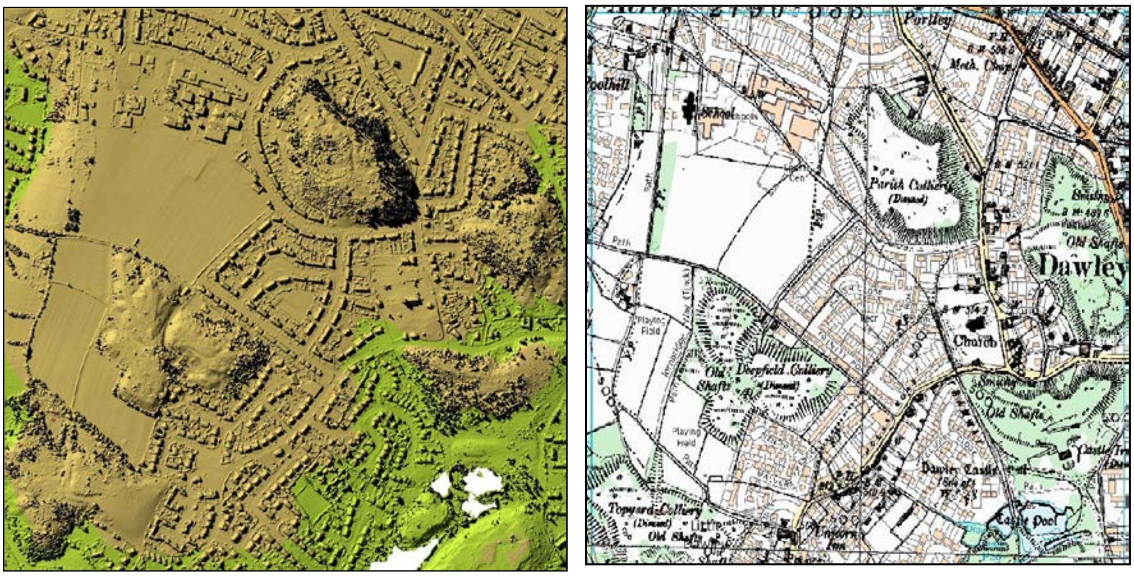

Figure 13: Remains of several coal mines at Dawley, Telford surrounded by modern housing development illustrated by the lidar tile LIDAR SJ6806 DSM 1m JAN-FEB 2011 (left) Lidar © Environment Agency copyright 2010. All rights reserved. and a composite of modern map and 1st edition OS map (right) © Crown Copyright and database right 2015. All rights reserved. Ordnance Survey Licence number 100024900

The former coalfields of the Shropshire/West Midland area proved to be one of the least productive areas for identifying new sites largely due to the extensive re- landscaping and redevelopment of the coalfields undertaken in the 1970s to 1990s with new urban development, the largest being the new town of Telford built over former coal tips. Consequentially, very little of the pre-industrial landscape can be detected, and much of the industrial landscape (with the exception of Ironbridge Gorge and Coalbrookdale), which is present on the 1st edition OS maps of the 1840s has since been lost.

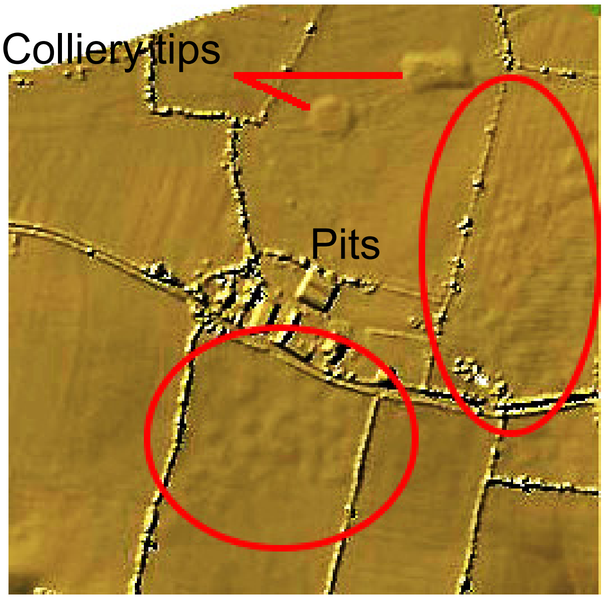

Figure 14: Earthwork traces of former coal tips associated with 19th-early 20th century Newhouse Colliery. Traces of further previously unrecorded pitting from possible earlier extraction can be seen in the fields to the south and east (LIDAR SJ 4303 DSM 2m 28-FEB-2008).

NB. The lidar swathe only covers part of this 1km square and only 2m resolution was available. Lidar © Environment Agency copyright 2010. All rights reserved.

In the rural areas around the new towns the lidar picked up traces of earlier mining activity, mostly 19th – 20th century collieries, many of which are named on the 1st edition OS maps. Shafts have been in-filled and tips grassed over and taken back into agriculture and forgotten. One such example is the 19th-early 20th century Newhouse Colliery at Pulverbatch, Shropshire where several small tips can be seen on the lidar and recorded on the first edition OS maps, but traces of further pitting possibly the traces of older extraction can be seen in the fields to the south and east.

A particular feature of the west midland region is the high number of large houses in parkland. Some are older well-establish estates with their roots in the medieval, but many are more recent or owed their expansion to the sudden increase in wealth generated by the 18th-19th century during the industrial revolution fuelled by the Midlands coal and steel industries.

As seen elsewhere in the country, these large estates took in large tracts of land to make parks which have inadvertently lent themselves to the preservation of pockets of the medieval or earlier pre-emparkment landscapes within the parklands.

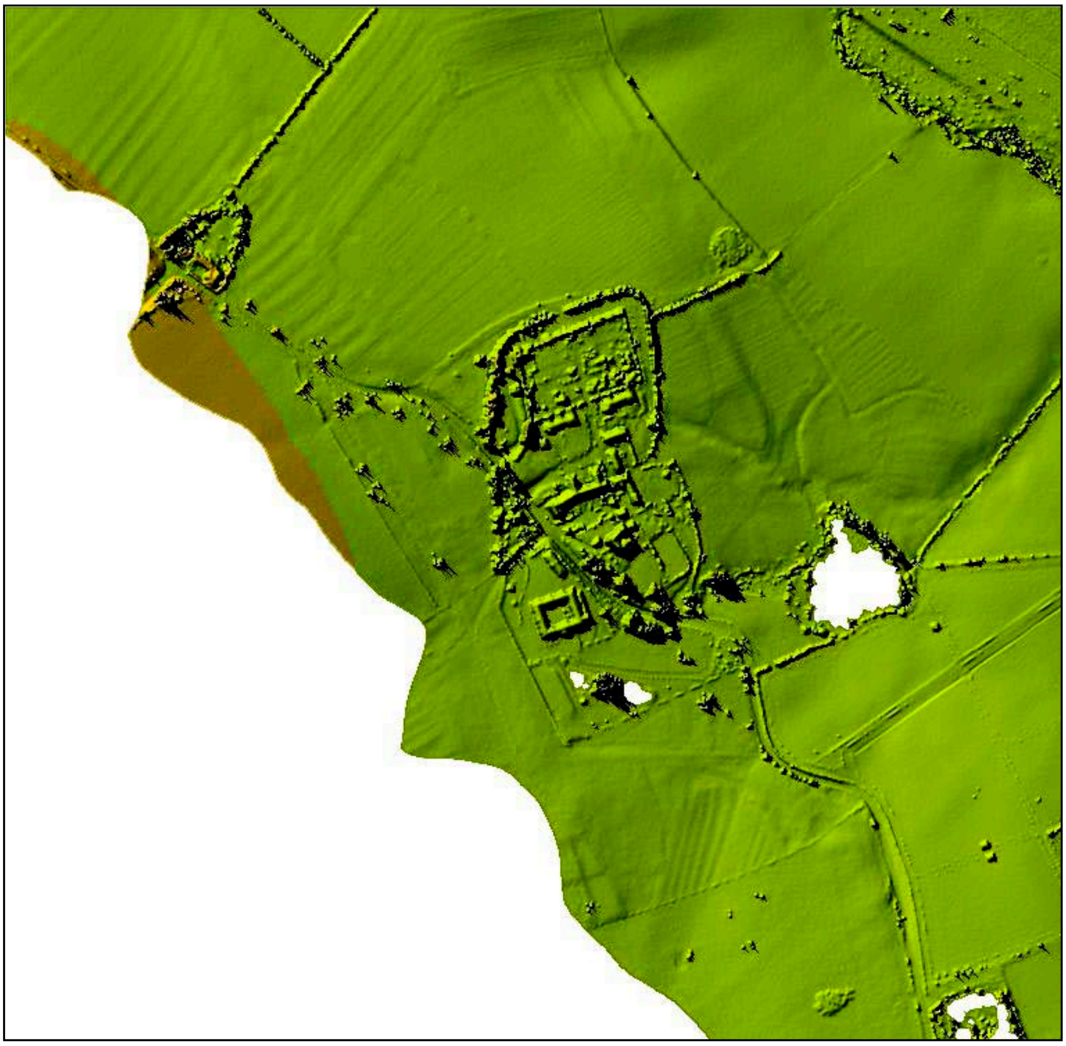

Figure 15: Previously unrecorded earthworks of probable medieval hollow ways, ridge and furrow and possible settlement earthworks visible in the grounds of Butterton Hall, south-west of Newcastle-Under-Lyme. LIDAR SJ8342 DSM 1m 05-APR-2009. Lidar © Environment Agency copyright 2010. All rights reserved.

A second World War searchlight battery lying in parkland was the only recent military feature recorded by the survey. This was identified from 1m lidar immediately to the south of the ruins of Buildwas Abbey just west of the Ironbridge Gorge.

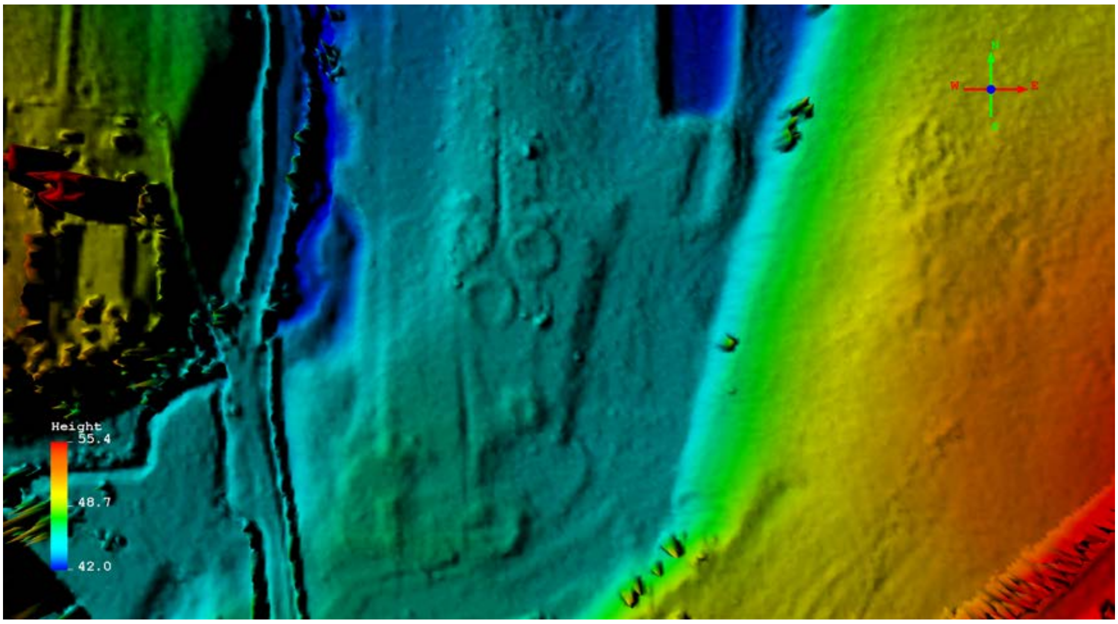

Figure 16: Extract of lidar tile LIDAR SJ6404 DSM 1m 19-MAR-2009 showing the probable remains of a WW2 searchlight battery at Buildwas Abbey near to Ironbridge. Lidar source Environment Agency

Figure 17: The well preserved remains of a searchlight battery south of Buildwas Abbey visible on (left) an RAF vertical aerial photograph (RAF 540/143 5105) taken on 03-JAN-1949 (Historic England RAF photography) and (right) an oblique photograph taken on 01-NOV-2011 (© Historic England). North is to the bottom of the image.

The site appears as two distinct embanked circular features with hints of a third in a characteristic clover leaf formation of searchlight housings. Traces of further earthworks to the south may represent the remains of associated structures and buildings such as the generator and command post. Immediately to the north-east are the remains of one of the rectangular fishponds belonging to Buildwas Abbey.

Discussions with Shropshire HER suggested that this was in fact the site of charcoal burning platforms, but examination of 1940s vertical RAF photography showed conclusively that this was indeed the site of a searchlight battery.

Another area which did not prove productive for the identification of sites from lidar data was the largely low-lying former marsh and peat moss areas of north Shropshire and Cheshire. The peat deposits are geologically more recent developments, which mask earlier Palaeolithic and Mesolithic finds (such as flints and log boats that are well represented in the known records) located at some depth beneath the present ground surface. Some of these areas remained as marsh or peat bog until relatively recently and so are unlikely to reveal archaeological earthworks. These areas are interspersed with meres and exhibit abundant periglacial features from the last ice age such as *pingos* (the remains of collapsed ice lenses in the permafrost forming mounds and hollows) that can be mistaken for man-made enclosures and mounds (Ballantyne and Harris 1994, p65-83).

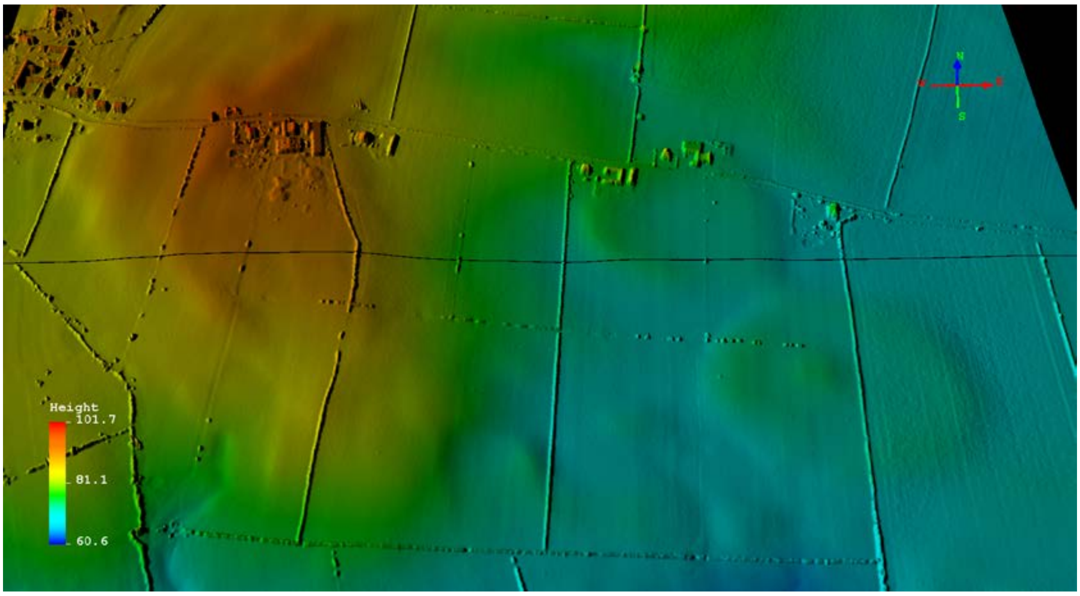

Figure 18: Extract of lidar tile LIDAR SJ4014 DSM 19-MAR-2009 showing periglacial formations on the north bank of the River Severn between Shrawardine and Montford, Shropshire. Lidar source Environment Agency.

One such site at Shrawardine appeared as two adjacent low embanked platforms with the appearance of a denuded motte and bailey. The larger platform has a slight central mound identified as the site of a former house depicted on the 1728 map exploiting a natural platform close to the river. However, clusters of similar features identified in the immediate area give weight to these being natural features.

The better drained and more elevated areas between the former marshy areas in this region were favoured for settlement prevailing into the present day as village and town locations. As a result traces of medieval settlements, ridge and furrow and moated sites have been recorded across this area.

A final area which proved less productive than anticipated was the Millstone Grit area of Staffordshire (located in the far eastern end of Block E). Here the overall impression given by the lidar data is one of an area where few earthworks survive. It is not entirely clear why this should be the case, but it is possible that it is due to the nature of the soils and the result of the prolonged cultivation.

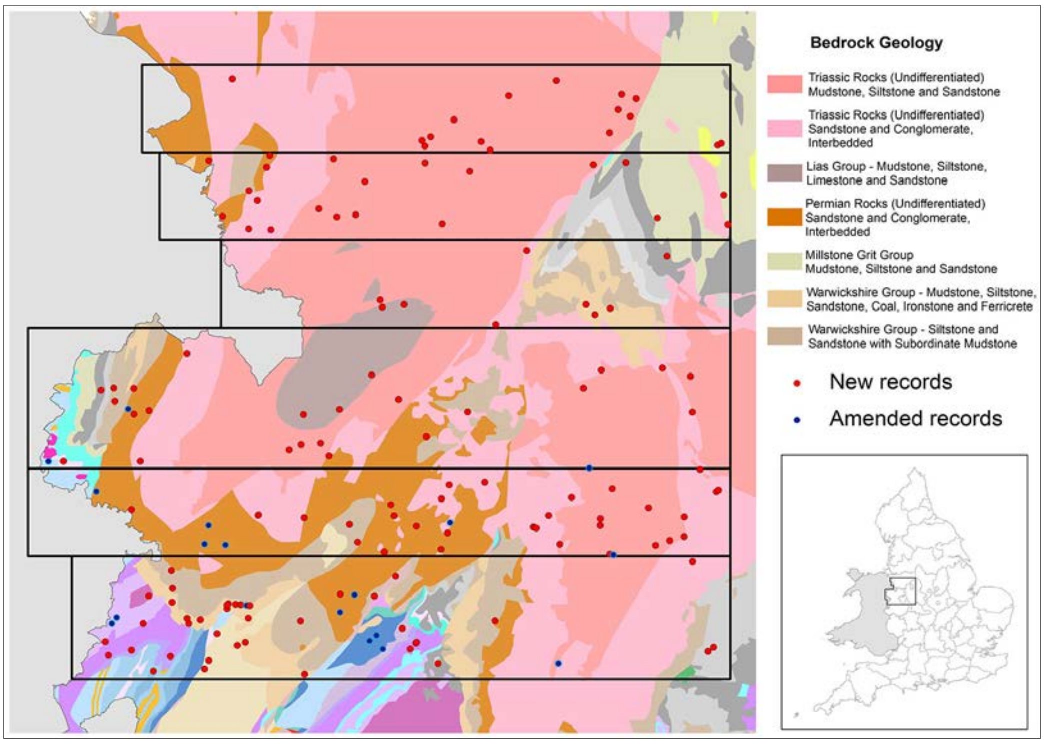

Figure 19: Geology across the project area based on BGS data.

CONCLUSIONS

The project has confirmed the expected usefulness of EA lidar imagery for the recognition and interpretation of a wide range of archaeological features from many periods.

As expected, the higher the resolution of the lidar data, the easier it is to identify earthwork sites. 1m resolution is the optimum scale, but 2m tiles were still adequate though not ideal. This was most noticeable where earthworks are slight or particularly complex as the reduced resolution made it very difficult to work out the details of such features.

Using the various processing techniques it was possible to bring out details in the images that were not immediately obvious in the unprocessed image. This was possible using some very basic tools that are present in most off-the-shelf image processing packages, although they may have subtle differences. As such they should be able to be applied by most people who would access to the imagery.

The question as to where lidar data can be most effectively used is more complex. It is clear from the project that there are a number of factors that affect the success of using lidar data, but these all relate in the end to the fact that lidar only records features that have a surface expression, albeit a slight one.

Lidar survey is likely to be most effective in areas where there has been little or no modern arable cultivation as those areas are likely to have better preserved earthworks. This in turn is often defined by the geology, which determines whether the land is suitable for arable farming or not.

In broad terms we can therefore say that lidar will be cost effective in upland areas where little cultivation has taken place and also in lowland pasture, as long as that pasture is long established and not merely reversion from previous arable.

Using lidar imagery, as with all imagery, is best done in combination with as many other sources as possible. That said, in the same way as there is a place for traditional aerial reconnaissance and recording as a quick way to document exceptional new sites, there is a place for rapid lidar recording. Indeed this has been shown by those tracing Roman Roads etc using lidar alongside other online sources such as GoogleEarth and Bing Maps

http://www.dailymail.co.uk/news/article-3381432/Long-lost-Roman-roads-discovered-flood-maps-Hi-tech-Lidar-data-reveals-route-2-000-year-old-highways-Britain.html http://metro.co.uk/2016/01/02/flood-maps-reveal-long-lost-roman-roads-across-england-5596264/

What is less certain is whether a series of rapid regional surveys using lidar as their main source would be the most effective use of resources in comparison with other methodologies such as the National Mapping Programme and that used by the more recent National Archaeological Identification Survey Pilot projects (Oakey et al 2015). However, it is certainly an option that should be considered in evaluating the appropriate survey technique for any extensive area project.

The advances in visualisation techniques discussed above, together with the greater difficulty in obtaining the standard jpeg imagery means that any future rapid survey would almost certainly use the new toolbox and ASCII generated imagery rather than the colour tiles. There are likely to be some advantages to this in terms of recognising features, but the creation of multiple visualisations also has the potential to increase the time required to look at each site, reducing the efficiency of the process.

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APPENDIX 1 - GUIDANCE

Preliminaries

- Ensure you are fully conversant with what lidar can and cannot do by reading relevant publications i.e. Crutchley & Crow 2010 https://www.historicengland.org.uk/images-books/publications/light-fantastic/.
- Lidar data will only record features with a surface expression. The surface expression, however, can be very slight and just because a landscape has been under arable cultivation for decades, does not necessarily mean that there will be no visible features as has been proven at numerous sites across the UK.
- Understand the differences between DSM and DTM datasets and the pros and cons of each.
- If possible use DTM data for areas with extensive woodland and DSM data for open landscapes. In mixed landscapes both will be useful, but be aware of the smoothing effect of DTMs
- Use data with a resolution of at least 2m and preferably 1m or better.

Sources of data

- The primary resource is the Environment Agency lidar data covering large areas of England at a variety of resolutions.
- The EA data is freely available from the Survey Open Data website http://environment.data.gov.uk/ds/survey/#/survey
- Currently this provides direct access to the ASCII gridded data and also some point cloud data for most recent years.
- These are produced from the last return data for any survey and are available as either the unfiltered DSM or the filtered DTM. Because the last return is used even the DSM may have a degree of canopy penetration depending on when the survey was carried out.
- The easiest and most readily accessible data, or rather the derived imagery, are JPEG images that have already been prepared for viewing. The EA makes DSM and DTM JPEG images freely available online via Flickr at https://www.flickr.com/photos/environmentagencyopensurveydata/albums

Using pre-processed JPEG lidar visualisations

- Be aware that a JPEG image contains less information than the original data.
- Image tiles usually contain much more information that can be easily seen by the human eye. Increase your chance of identifying less obvious features by using simple tools within image processing software such as Adobe Photoshop to adjust the contrast range etc.
- If possible import tiles into a GIS type package so that a seamless view of the landscape can be viewed. This will help interpretation of features that appear close to the edge of individual tiles.

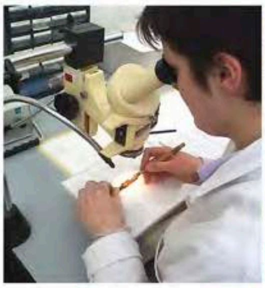
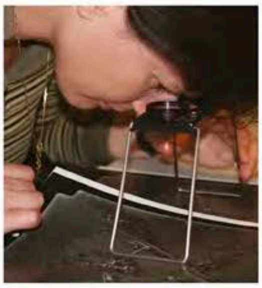
Using ASCII gridded lidar data

- The ASCII gridded data needs to be viewed using a specialist package such as a GIS.
- Using GIS type packages, both commercial and Open Source, the data can be manipulated in a number of ways to highlight features
- Alternatively data can be processed using a specialist toolbox to create image files. The Relief Visualisation Toolbox (RVT) http://iaps.zrc-sazu.si/en/rvt#v is freely available and generates some of the most common visualisations currently used by archaeologists for interpreting lidar data
- The resulting GEOTIFFS can be imported into GIS packages or the RGB/8 bit versions can be viewed and manipulated within image processing software.

Other resources

As with any type of survey it is important to use as many resources as possible so as to avoid misinterpretations. GoogleEarth, Bing Maps and similar sites should be used whenever possible as they provide easy access to recent aerial imagery that can help to ensure accurate interpretation of features seen on lidar..

The Heritage Gateway provides easy access to records relating to the Historic Environment. It is always worth checking what is already recorded on both the Local Historic Environment Record as well as the National Record of the Historic Environment (HE PastScape).
http://www.heritagegateway.org.uk/gateway/

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