Flying High!

Combining Old with New Methods for Enhanced Airborne Prospection and Characterisation

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Introduction

Reference to aerial photographs and lidar imagery by trained specialists provides a well-established means of rapidly identifying and mapping archaeological monuments over large areas. In this paper we make reference to a project focused on the volcanic Cheviot Hills in Northumberland, Great Britain, (Holgate 2019) that was undertaken to Historic England (HE) standards and was funded by HE through the National Heritage Protection Commissions Programme (NHPCP).

The aim of the project is to increase understanding and protection of Northumberland's historic environment by providing a comprehensive dataset of mapped archaeological features from aerial sources to the Northumberland HER in order to inform the planning process. This was achieved by mapping and recording all archaeological features (earthworks, cropmarks, soilmarks, parchmarks and structures) visible on aerial photographs, satellite imagery and lidar imagery where available. The study involved the systematic study of all aerial imagery covering an extensive project area of 10,400ha in northern England.

Data sources

Sources consulted as part of the project include all readily available aerial photographs, together with 16-direction hill-shaded lidar (where coverage was available). The HE Archive was the primary source of vertical and oblique aerial photography in both digital and print formats. The vertical photographic coverage from the archive was comprehensive across the project area, ranging in date from 1945 to 2014. The photographic source consisted of 383 vertical photographs and 1558 oblique. Other sources of vertical photography included orthophotography supplied to HE by Next Perspectives™ through Aerial Photography for Great Britain (APGB), Google Earth™ imagery and Bing Map™ imagery. Oblique photography was provided by the HE Archive and oblique photography

from the Northumberland Historic Environment Record was also consulted. Unfortunately, the Cambridge University Collection of Aerial Photography (CUCAP) was not operational and could not be consulted. CUCAP contains 52 oblique and 235 vertical photographs within the project area, of which 383 oblique and 1558 vertical photographs are held by the HE Archive and were consulted as part of their loan. Reference to the CUCAP catalogue shows that obliques within the collection focus on known sites and it is therefore unlikely that sites have been missed by this project as a result of lack of access to that collection. Lidar data provided by the Environment Agency at 1 and 2 metre resolutions was consulted and covers c.95% of the project area, 80% of which is at 1m resolution. The National Record of the Historic Environment (NRHE) database and the Historic Environment Record (HER) and Scheduled Monument data were consulted regularly during the interpretation, mapping and recording programme. The nature of underlying bedrock and surface drift geology, as well as soil types, were used to inform interpretation, with online maps available from the British Geological Survey's 'Geology of Britain viewer' and 'The Coal Authority Interactive Map viewer', and the Cranfield Soil and Agrifood Institute (NRSI) 'Soilscapes Viewer'.

The datasets outlined above were scrutinised while adhering to the Aerial Imagery and Mapping (A&IM) guidance standards and methodology as recommended by Historic England (Winton 2019). Vertical and oblique aerial images were analysed under magnification and stereoscopically, where possible, to identify archaeological features in the landscape. Frames in which features were identified were scanned at a resolution of between 400-600dpi and rectified using the specialist AERIAL 5.36 software, with control derived from Ordnance Survey MasterMap® 1:2,500 scale digital maps or 25cm resolution APGB orthophotography. Lidar data was supplied by the Environment Agency in the form of 1km² ASCII files that were processed in Relief Visualisation Toolbox 1.1 to produce 16-direction hill-shaded images.

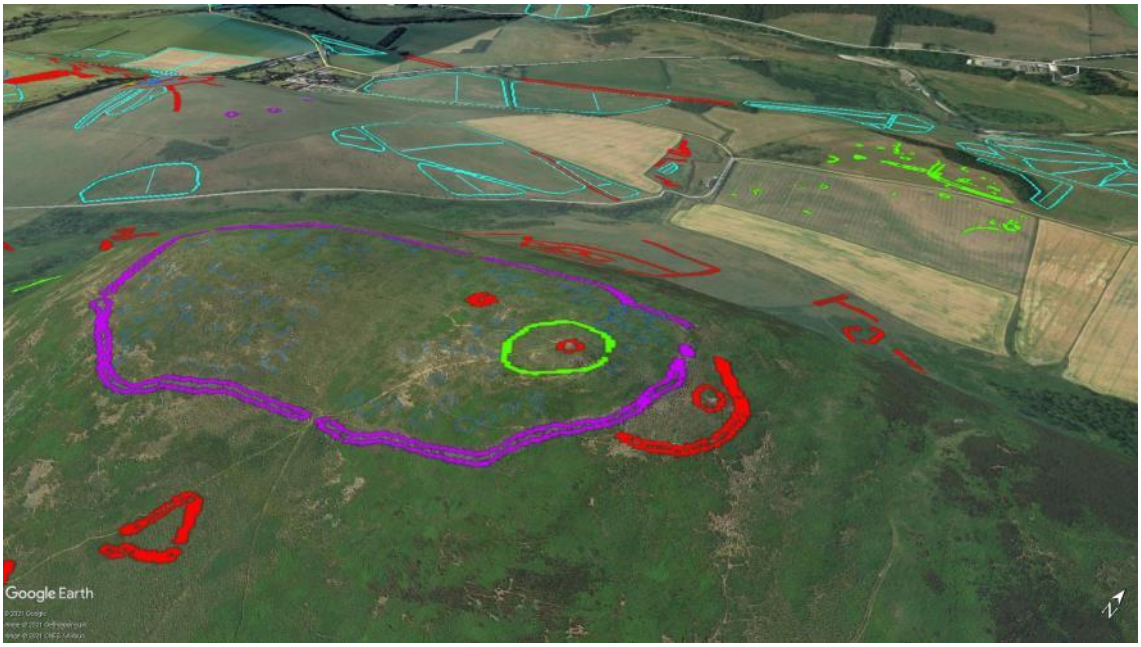

Fig. 1. Probable burial cairn (UID) identified at the eastern summit of Yeavering Bell. This is visible in Lidar imagery as a mound with a diameter of 10m. A second newly-identified burial cairn (UID) is visible in Lidar imagery within the eastern enclosure at Yeavering Bell with a diameter of 13m. Excavated examples of pit alignments in the nearby Milfield Basin have been shown to range in date from the Neolithic (Micket 1981) to the early post-Roman period (Passmore and Waddington, 2012).

Rectified images, georeferenced orthophotography, and Lidar imagery were inserted into AutoCAD Map 3D where they were analysed and features mapped. Details of each feature were recorded as monument data in an object data table attached to each .shp file, along with an Historic England Research Records number allowing each feature to be identified in the national and local historic environment records.

Archaeological features were also recorded in WARDEN, the Historic England Research Records database maintained by Historic England. Records consist of an interpretation, assignation to a period, the location, a description and sources from which a given feature was identified. New records were created for previously unrecorded sites and those with existing records were updated.

APGB orthophotography was used to record the latest monument condition for earthworks and structural elements, unless more recent lidar imagery or photography was available. In addition, the corresponding HER number for a feature (where existing) was included in the attached mapping data to aid concordance between local and national records.

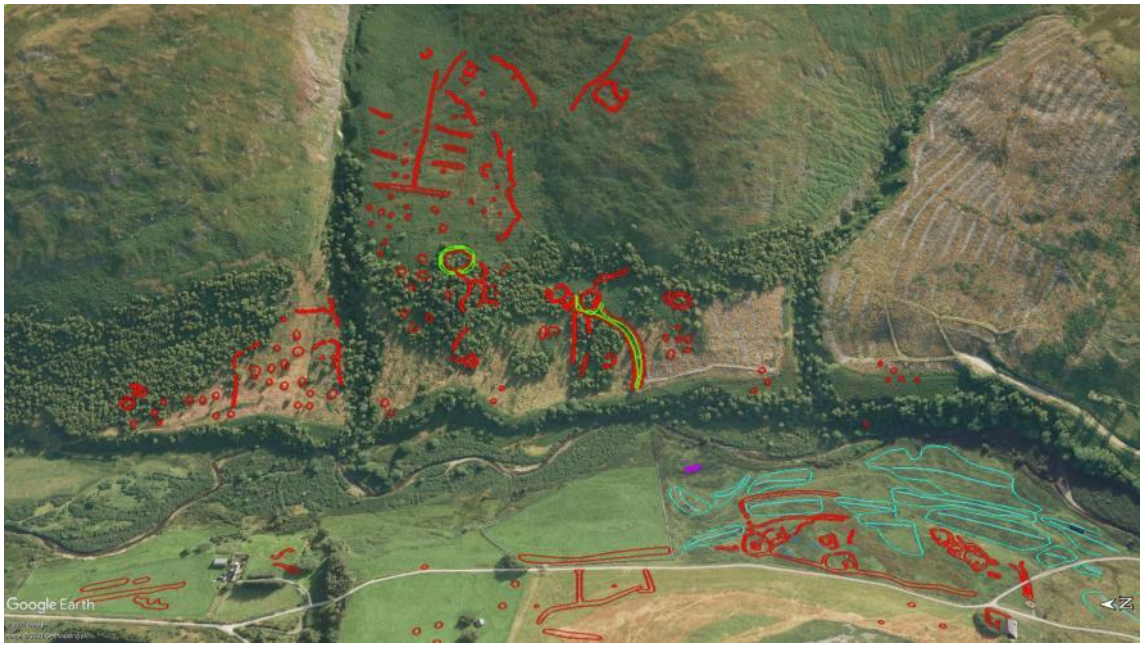

Fig. 2. Newly identified agricultural terraces (UIDs) are visible as earthworks in Lidar imagery on the southern hillside of Yeavering Bell. These are represented by discrete embanked earthworks.

The extent and availability of existing datasets is good, with their analysis being able to produce both meaningful and valuable results that directly address the project aims and assist considerably in the current and future management of archaeology in the region. While there is coverage of historic vertical photography for the entire project area, much of it is covered only by a single run of photography often captured in poor weather condition at too high an altitude to allow for the identification of subtle earthworks, thereby reducing the chance of identifying visible archaeology as cropmarks or earthworks from this source. While the number of vertical photographs held by the archive was found to be relatively small, oblique photograph coverage is exceptionally good as a result many years of aerial reconnaissance across the area. This photography proved invaluable for the mapping and interpretation of sites, particularly when viewed alongside lidar images. There is excellent coverage of 1m resolution lidar across the majority of the project area. This proved key to the successful completion of the project, reducing what would have been an almost complete reliance on oblique

photography that would have severely limited the project's capacity to identify previously unknown sites. High resolution lidar also allowed for earthwork sites, that make up the majority of those identified by the project area, to be mapped quickly and remotely, without the need for access to HE's offices which were periodically closed as a result of the Covid-19 pandemic.

The study has successfully utilised 1m resolution to map extensive tracts of Bronze Age and Iron Age upland settlement visible as subtle earthworks in this imagery. Despite covering an upland landscape that has been intensively studied and photographed, the project has made a significant contribution to the Historic Environment Record. A total of 79 new records were created in the Historic England Research Records and a further 99 existing records were updated and enhanced. As a result, 44.4% of the records produced comprised new monuments in the Historic England Research Records. In addition, 54 records were new to the HER (30.3% of the total therefore being new to the HER) representing a 5.6% contribution of new records to the HER within the project area.

Conclusions

The results of this project represent a significant contribution to an already well-studied landscape and a substantial increase in the number and extent of known sites in the area. It highlights the value of such work, the potential for 'known' landscapes to continue to yield new insights and understandings, as well as the significant potential contribution of aerial survey to previously under-studied upland landscapes. The project highlights the impressive contribution current methods of aerial survey can make effectively evaluating the archaeological resource of regions where development pressures require a good understanding of their character and extent. It also provides a useful benchmark by which the utility of novel techniques of remote sensing and prospection can be measured.

With the reliance on archive and legacy data in mind, Archaeological Research Services Ltd has invested in state-of-the-art drone-based technology to extend the range of imagery available for the region and to appraise its utility for identifying features beyond those that can be discerned from existing datasets. The availability of high-quality multispectral image and lidar sensors that can be conveniently mounted to UAVs (Drones) means that the capture of additional datasets is now achievable. The possibility of capturing such data readily means that existing datasets can be augmented by imagery captured at higher resolution (RGB, Lidar) or by taking advantage of seasonal variation in vegetation (multispectral imagery). When used in a targeted manner to better resolve existing datasets the combined method offers a much enhanced and efficient means to improve landscape survey at an extensive scale and to improve the management of these valuable heritage assets. The paper concludes by discussing these innovative developments and considers the current and future direction and potential limits to these technologies.

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Conflict of Interests Disclosure

There are no conflicts of interests apparent to the authors.

Author Contributions

Please list the contributions of the project participants here, according to the CRediT system. See specific descriptions of the role here: (http://credit.niso.org/). You can omit non-applicable roles.

Conceptualization: Waddington and Holgate
Data curation: Waddington, Holgate and Goodchild
Formal Analysis: Goodchild, Waddington and Holgate
Funding acquisition: Waddington and Holgate
Supervision: Waddington and Holgate
Writing – original draft: Doonan, Goodchild, Waddington and Holgate
Writing – review & editing: Goodchild, Doonan, Waddington and Holgate

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