9. THE ATLAS OF HILLFORTS OF BRITAIN AND IRELAND ONLINE

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Abstract

The Atlas of Hillforts of Britain and Ireland was a collaborative research project funded by the Arts and Humanities Research Council and carried out by the Universities of Oxford and Edinburgh, together with colleagues from University College Cork, Ireland. Building on a strong tradition of mapping dating back to the nineteenth century, the Atlas of Hillforts for the first time draws together evidence relating to all known hillforts – an iconic class of monument which forms the dominant component of settlement record in the first millennia BC and AD - on both sides of the Irish Sea. The digital version of the Atlas of Hillforts of Britain and Ireland was created using the ArcGIS platform, with the underlying data hosted on an ArcGIS Enterprise server and an accessible user interface created using Web AppBuilder for ArcGIS. It was launched at the end-of-project conference in June 2017 and has attracted over 275,000 visitors from 198 countries since then, with an average visit of over 6 minutes and more than 45 page views per visitor. The digital atlas has been used to promote National Parks, museums and public archives and has been highlighted as an invaluable research tool and educational resource for schools and universities.

Keywords: GIS; JavaScript; Web Mapping Application

Introduction

The Atlas of Hillforts of Britain and Ireland was produced as part of an Arts and Humanities Research Council (AHRC) funded project, run by Professor Gary Lock at the University of Oxford and Professor Ian Ralston at the University of Edinburgh. Working with colleagues from University College Cork and partners from local and national government, the project team collated and harmonized records relating to 4,147 hillforts in England, Scotland, Wales, the Isle of Man, Northern Ireland and the Republic of Ireland. The different traditions of research in each of these countries presented challenges, not least in terms of defining what constitutes a hillfort from one country to the next. Three criteria were ultimately used to define hillforts for the purposes of the Atlas:

(1) topographic position – sites that occupy a prominent/focal position in the landscape;
(2) scale of enclosing works – sites with enclosing works that were designed to impress;

(3) size of enclosed area – sites with enclosing works that enclose an area >0.2 hectares.

In addition to professional archaeologists, the project benefited from the input of many citizen scientists to document hillforts in their local communities and, when possible within resource limitations, provided volunteers with training in earthwork survey and archaeological recording (Lock this volume). Results from the volunteer surveys have been incorporated into the Atlas of Hillforts, together with the analysis of historic maps, aerial photographs and LiDAR data, and information obtained from accessible archives in both National Monuments Records and local authority and other Historic Environment Records, publications and other records. The Atlas of Hillforts of Britain and Ireland was intended to be published in two formats, namely a digital atlas (Lock and Ralston 2017) and a traditional paper-based atlas (Lock and Ralston forthcoming).

Open access publication has now become a standard condition of projects funded by the research councils and researchers are increasingly required to demonstrate the impact of their work beyond the academic community. From the outset of the project, the intention was to publish the atlas data online, although initially, the digital atlas was conceived as a standard web interface to the project database that incorporated aerial imagery from Google Earth. As the project developed, however, so did the requirements for publishing the data online – ultimately, the digital atlas was published as a web mapping application. The Atlas of Hillforts of Britain and Ireland web mapping application (https://hillforts.arch.ox.ac.uk) was created using the ArcGIS platform. It can be accessed from any device, including smartphones and tablets, with a web browser which supports JavaScript and was published under a Creative Commons Attribution-ShareAlike 4.0 International License.

The web mapping application started life as a FileMaker Pro 11 database comprising a table with information about the hillforts and supplementary tables with information about related entrances, investigations and dating evidence. A table with information on the principal related references was added later to improve the display of citations. The FileMaker database was exported as a series of CSV files and imported into a file geodatabase using ArcGIS Desktop 10.5.1. Point features were created for the hillforts and relationship classes were defined between the hillforts feature class and the related tables. The data was cleaned, restructured and published as a mapping service[1] comprising a feature layer (hillforts) and four related tables (references, investigations, entrances and dating evidence), using ArcGIS Enterprise 10.5.1. This exercise accounts for the fact that there are some minor changes in the counts of individual features from those published in interim articles or given during project presentations, where data was derived from the FileMaker Pro database.

A user interface was created for the mapping service using the Web AppBuilder for ArcGIS (Developer Edition) Version 2.5 Software Development Kit – a what-you-see-is-what-you-get (WYSISYG) application which allows web mapping applications to be built without writing a single line of code. The user interface was built using out-of-the-box functionality, with the exception of a custom widget displaying an HTML table containing a summary of the other widgets available in the web mapping application,

[1] https://maps.arch.ox.ac.uk/server/rest/services/hillforts/Atlas_of_Hillforts/MapServer

which was devised in order to demonstrate the ease with which web mapping applications can be created to colleagues at Oxford. Whilst this made some aspects of the creation of the web mapping application more time-consuming and made some of the functionality less stream-lined than it could have been, all of the functionality required by the project team could be added using standard widgets. The web mapping application was deployed on a Microsoft IIS web server hosted at the School of Archaeology, University of Oxford.

The digital version of the Atlas of Hillforts of Britain and Ireland was built using proprietary software rather than open source software. Although an Open Layers, Leaflet and GeoServer stack could have been used, the ArcGIS platform was considered to be a better fit with the project for several reasons, but primarily because it is simple to set up and maintain, with a robust architecture that is scalable and resilient, and supports spatial analysis in a web browser. Locally, within Oxford, this has the advantage that it allows better integration with postgraduate taught courses which are based on ArcGIS. The former consideration was critical both in terms of the high level of demand when the web mapping application was first launched and in terms of the plans for future development of the web mapping application to allow users to perform spatial analysis, with the goal of not just providing a mechanism to share the data from the project but also furnishing tools that allow the data to be used without the need for specialist software.

User Interface

A detailed overview of the functionality of the web mapping application can be found in the online user guide accompanying the Atlas. This can be accessed through the links on the title bar and downloaded as a PDF file[2]. The user interface for the digital Atlas of Hillforts of Britain and Ireland is deceptively simple, belying the wider power and utility of the web mapping application. Common tasks such as searching for hillforts and querying attribute data can be performed using the widgets found in the title bar at the top of the web app, the navigation tools either in the top right or bottom left corner of the web app or the anchor bar at the bottom of the web app (Figure 9.1 and explained below). The web mapping application has a responsive design – the positions of the elements of the user interface and the number of widgets displayed in the anchor bar will differ from one device to the next. On devices with smaller screens, additional widgets can be accessed by clicking the icon farthest to the right of the anchor bar.

INSERT FIGURE 9.1 HERE

Title bar

The title bar contains a search box which allows users to search the Atlas of Hillforts of Britain and Ireland by hillfort name and/or place name. A list of results (limited to the

[2] https://maps.arch.ox.ac.uk/assets/help.html

first 10 results) will be displayed for the search term. Search results can be selected to zoom to a hillfort or place and open an HTML popup containing summary data on the particular site. A search radius can be applied to a place name using the Near Me widget in the anchor bar. This Near Me widget was added in response to feedback on the web mapping application. Search results identified in the Near Me widget are sorted by distance and can be selected to display a summary of the hillfort and related tables. Both the search box in the title bar and the Near Me widget in the anchor bar support the use of postcodes. The link icon to the right of the search box on the title bar can be used to access help topics for the web app as well as information about other aspects of the project, notably in relation to the way the data collected is structured.

Navigation tools

The navigation tools can be used to zoom in/out, to zoom to the full extent of the map, to zoom to the current location and to navigate to the previous/next extent of the map. A scale bar and a co-ordinates widget (not visible on all screens dependent on size) are displayed in the bottom left corner of the web mapping application. By default, the co-ordinates widget will display the longitude and latitude for the centre of the current map view. The default co-ordinate system (EPSG 3857: WGS 1984 Web Mercator Auxiliary Sphere) for the map can be changed to either OSGB 1936 British National Grid (EPSG 27700) or IRENET95 Irish Transverse Mercator (EPSG 2157) by clicking on the up arrow to the right of the displayed numbers. British National Grid and Irish Transverse Mercator coordinates can be displayed by selecting the crosshairs on the co-ordinates widget and clicking on a location on the map.

Anchor bar

The anchor bar contains a series of eleven widgets that replicate standard GIS functions and can be used to open/close the attribute table (Attribute Table), select features by rectangle/polygon/circle (Select), query layers by attribute and location (Query), display a list of layers in the current map (Layer List), select a different basemap (Basemap Gallery), add a new layer from a file (Add Data), share a link to/embed the current map (Share), search for nearby features by location (Near Me) and create a PDF from the current map (Print). This bar also contains widgets that summarise the key functions of the web mapping application (Widgets) and provide a brief introduction to the Atlas of Hillforts project (About). The widgets open in panels and can be opened and closed by clicking on the corresponding icons in the anchor bar. Option menus for widgets and HTML pop-ups can be accessed by clicking on ellipses (small dotted lines).

Atlas Data

Two design constraints were placed on the web mapping application for the Atlas of Hillforts of Britain and Ireland, namely that all points would be visible on the map and that all fields of information collected for the project should be included in the attribute table. Both of these constraints have implications for accessing the web mapping application on smaller devices. First, the size of the symbols needed to be reduced to minimise the overlap between points at small scales, thus making it harder to select point features on a device with a touch screen. Secondly, the attribute table for the hillforts feature class includes a number of text fields which contain long comments or detailed descriptions, unavoidably resulting in large amounts of white space in the

Attribute Table widget. While these constraints could have been overcome by using clustered points and thinning out the attribute table, compromises in regard to user experience were thought preferable to the loss of data. Data can be accessed at multiple levels in the web mapping application, including through HTML pop-ups, the Attribute Table widget and static HTML webpages.

HTML pop-ups

HTML pop-ups, displaying a summary of each of the hillforts and the corresponding entries in related tables, (Figure 9.2), can be accessed by selecting either a point feature on the map or a result from the search box in the title bar. The following information is displayed in the HTML pop-ups:

a title based on the country code, the unique Atlas number attributed to the site, site name and alternative name(s);

buttons to share a link to the hillforts via email, Facebook, Twitter and Google+ (now deprecated);

status and location data, including Historic Environment Record, National Monument Record and Scheduled Monument numbers, a grid reference and the confidence in the record;

hyperlinks to the static HTML webpage and the WikiData entry for the hillfort;

a descriptive summary of the hillfort;

expandable lists of the records related to the hillfort in the references, investigations, entrances and dating evidence tables.

INSERT FIGURE 9.2 HERE

Attribute table

The Attribute Table widget in the anchor bar can be used to view records in the hillforts feature class and related records in the references, investigations, entrances and dating evidence tables. On launch, only the attribute tables for the investigations, entrances and dating evidence tables are displayed in the Attribute Table widget. The attribute table for the hillforts feature class can be opened from the options menus on the Layers, Select and Query widgets by clicking on the ellipsis to the right of the corresponding layer or query result. Records from the attribute table can be exported as a comma separated values (CSV) file using the dropdown menu in Attribute Table widget. Simple queries, with preconfigured searches grouped by subject or theme, can however be performed using the Query widget. Query results can be removed prior to running a new query using the options menu on the Results tab of the Query widget. More complex queries, with user defined expressions, can be performed using the Filter option on the dropdown menu in the Attribute Table widget (Figure 9.3). Only records which match the filter expression are shown on the map and in the attribute table. The resultant map can be exported as a PDF file or image using the Print widget.

INSERT FIGURE 9.3 HERE

HTML files

One of the most substantive changes made since the launch of the web mapping application has been the creation of static HTML webpages displaying the full records for each of the hillforts and the related records in the references, investigations, entrances and dating evidence tables. URLs for the static HTML webpages have a constant prefix and a variable suffix based on the country code and Atlas number for the hillfort, e.g. http://hillforts.arch.ox.ac.uk/records/EN3598.html for Maiden Castle, Wimborne St. Martin, Dorset (EN3598). The static HTML webpages were created in order to make the records for individual hillforts easier to access and to counteract the misconception that the summary of the hillforts displayed in the HTML pop-ups represented the sum totality of the data collated during the course of the project. PDF files can be created from the static HTML webpages using the print to PDF function available in most web browsers (Firefox works particularly well in this regard).

Impact

The web mapping application for the Atlas of Hillforts of Britain and Ireland was launched in June 2017 at the conference to mark the end of the project hosted at the University of Edinburgh. Although the launch was accompanied by a national press release and was widely covered in the print media, the level of demand for the web mapping application was far higher than anticipated and required the handling of over 250,000 transactions per hour on the day of the launch. It is perhaps not surprising that there were therefore teething problems on the morning of the launch with many users experiencing difficulty accessing the web mapping application, requiring it to be rebuilt using an image service rather than a feature service. Since it was launched (to 21st March 2019) the web mapping application has received over 41 million hits and 13 million page views, with over 275,000 visitors from 198 different countries (Table 9.1).

Table 9.1. Cumulative user statistics for the Atlas of Hillforts of Britain and Ireland web mapping application.

Hits	**Day 1**	**Week 1**	**Month 1**	**Year 1**	**Lifetime**
Total Hits	2,889,423	12,215,618	16,867,299	36,006,219	41,981,252
Average Hits per Day	2,889,423	1,745,088	562,243	98,647	65,801
Average Hits per Visitor	181.77	203.64	200.86	164.12	150.31
Page Views	**Day 1**	**Week 1**	**Month 1**	**Year 1**	**Lifetime**
Total Page Views	669,113	3,825,006	5,355,342	11,568,124	13,390,182
Average Page Views per Day	669,113	546,429	178,511	31,693	20,987
Average Page Views per Visitor	42.1	63.79	63.81	52.95	48.4
Visitors	**Day 1**	**Week 1**	**Month 1**	**Year 1**	**Lifetime**
Total Visitors	15,892	59,967	83,931	218,462	276,673
Average Visitors per Day	15,892	8,566	2,797	598	433
Total Unique IPs	13,403	46,152	60,982	141,512	170,474
Countries	115	160	166	185	196

Average Visit Length	08:06	05:36	05:32	05:33	06:10

Lifetime is here defined as 22nd June 2017 to 21st March 2019

Although the digital Atlas has a limited geographic scope (i.e. it pertains solely to Britain and Ireland), the Atlas has had global appeal with large numbers of visitors not just from the United Kingdom and the Republic of Ireland but from around the world (Figure 9.4). Countries such as the United States, Canada and Australia, with large communities that have British or Irish ancestry, unsurprisingly feature prominently in the list of top 10 countries by visitor (Table 9.2) emphasising the shared nature of our heritage. Some of the other countries which figure strongly have cognate monuments, France and Germany are cases in point. The most pleasing aspect of the user statistics for the web mapping application, however, is the number of page views per visitor and the mean length of visit which, almost two years on, average 48 page views per visitor and 6 minutes and 10 seconds spent per visit (Table 9.1). Both of these statistics indicate that users are not just visiting the site but are engaging with the information it contains.

INSERT FIGURE 9.4 HERE

Table 9.2. Top 10 countries by visitor for the Atlas of Hillforts of Britain and Ireland web mapping application

Rank	Country	Hits	Visitors	% Visitors
1	United Kingdom	29,701,972	151,316	54.69%
2	United States	3,000,644	40,343	14.58%
3	Ireland	3,863,212	20,488	7.41%
4	China	79,294	6,117	2.21%
5	Russian Federation	46,517	4,898	1.77%
6	Germany	359,197	4,192	1.52%
7	Canada	655,720	4,192	1.52%
8	France	293,786	4,100	1.48%
9	Australia	575,733	3,677	1.33%
10	Brazil	40,168	2,535	0.92%

Feedback on the web mapping application has been overwhelmingly positive, with critical comments mostly relating to difficulties in accessing the digital Atlas on the day of the launch and the decision to use proprietary rather than open source software. Several changes have been made to the web mapping application since it was launched based on user feedback. Some of these modifications are small, such as adding a new way to search for hillforts using the Near Me widget, while others are more substantive, such as creating static HTML pages to display the full Atlas project records for each hillfort. Additional widgets will be added to the web mapping application in the future to allow users to perform spatial analysis on the Atlas data. The level of demand for the digital Atlas was far higher than was anticipated at the onset of the project and further funding is likely to be required to deliver this functionality in a sustainable way.

Despite initial teething problems in its online delivery, the Atlas of Hillforts of Britain and Ireland has been recognised as an overwhelming success by funding bodies. The project was selected as one of two projects to represent the Arts and Humanities Research Council at the BEIS Market Place Fair, a showcase to highlight thought provoking projects funded by the Research Councils and Innovate UK to the Department of Business, Energy and Industry Strategy, in September 2017. It was also selected as one of three projects to represent UK Research and Innovation at the American Association for the Advancement of Science (AAAS) Annual Meeting in Austin, Texas in February 2018, Figure 9.5. The AASS Annual Meeting was co-sponsored by Great Britain and Northern Ireland to promote the strength and depth of research in the UK and the project was selected by the AHRC as an excellent example of the best of UK multidisciplinary research.

INSERT FIGURE 9.5 HERE

The Atlas of Hillforts of Britain and Ireland has also received industry recognition. The web mapping application is featured on the Web AppBuilder for ArcGIS – Live Sites Showcase on ArcGIS Online as an effective example of a different use for Web AppBuilder for ArcGIS[3]. It won the Esri UK & Ireland Customer Success Award for Community Engagement awarded at the Esri UK Annual Conference in London in 2018[4]. The Esri UK & Ireland Customer Success Awards showcase innovative uses of GIS and world-leading GIS best-practice, and the web mapping application of the digital atlas was highlighted as a great leading example of how to make research output accessible beyond the academic world.

Discussion

When the web mapping application for the Atlas of Hillforts of Britain and Ireland was launched there were no preconceptions as to what information would be of interest to users or how they would use that information. The information available in the digital Atlas represents all the data collected on individual sites that were accepted as hillforts during the project and is thus identical to that being used to prepare the paper-based Atlas. Moreover, the web mapping application is being used in the preparation of the paper-based Atlas, allowing the authors to interrogate the Atlas database and produce distribution maps themselves. This eliminates the bottleneck of having to rely upon a GIS specialist to produce preliminary distribution maps for the purposes of planning and writing the final publication, a problem that is more acute in the latter stages of a project when the principal investigators are often the only people working on its final products. From my perspective as a GIS practitioner, this is not something to be feared

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[3] https://pm.maps.arcgis.com/home/group.html?id=76eb5528ceb64750923d8b07a42723b9#overview

[4] https://www.esriuk.com/en-gb/about/events/ac/presentations/2018 (Closing Plenary video)

but a potential to be embraced – technology advances and if those advances enable more people to work with spatial data that can only be a positive development.

Whilst a large part of the success of the web mapping application lies in the parity of access to the data created during the course of the project, that is only half of the story – the success of the digital Atlas lies in providing tools that enable all users to interact with and use the data. Had this been an episode of the well-loved television series *Yes Minister*, the decision to publish the digital Atlas before work on the paper-based Atlas was much advanced would perhaps have been described by Sir Humphrey Appleby as 'brave' or 'courageous'. On the one hand, in the cut and thrust of academia, it could seem foolish to release the data long before the printed volume that traditionally marks the end of a research project is published allowing colleagues to steal a march on the authors of the paper Atlas. On the other hand, the data is already serving its purpose and is being actively used, not just in academic research but in a wide range of use cases – some of which were anticipated, others of which were not.

The Atlas of Hillforts of Britain and Ireland web mapping application has been used to encourage people to visit National Parks and has been used to promote datasets that are freely available from government agencies and heritage bodies. It has been highlighted as a valuable teaching resource – not just for teaching prehistory and local history as part of the National Curriculum but for teaching GIS and the basics of working with maps and aerial photographs in Geography. Mentions on social media also indicate that people are using the digital Atlas to plan their free time, including days out on weekends and in school holidays. It is this impact upon daily lives that highlights the value of academic research into subjects like archaeology which may be perceived as esoteric – impact which can only be achieved by opening up academic research to the public. Many of the hillforts included in the Atlas lie at the heart of our communities and in the places where they go for recreation. They are just as important today as they were in the past.

Acknowledgements

Derek Law (Esri) and Addy Pope (Esri UK & Ireland) are thanked for championing the Atlas of Hillforts of Britain and Ireland, Mike Collins (AHRC), Julie Venis (AHRC) and Terry O'Connor (UKRI) for helping to promote the digital Atlas on both sides of the Atlantic, Julia Lee-Thorp (Head of the School of Archaeology, University of Oxford) for giving the author latitude to explore the potential of web GIS for collaborative research, and Jeremy Worth (School of Archaeology, University of Oxford) for his support and advice on setting up the server that powers the web mapping application. I am also grateful to Emma Gowans and Chris Green for their comments on drafts of this paper which have improved it immensely. Lastly, thanks are due to Ian Ralston and Gary Lock, and the rest of the Atlas of Hillforts of Britain and Ireland team (Stratford Halliday, Paula Levick, Ian Brown, Johnny Horn, Jessica Murray, William O'Brien, James O'Driscoll and Alan Hawkes) for allowing me to release their data into the wild – I'm not sure they realised fully what they were letting themselves in for.

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Figure captions

Figure 9.1. The user interface for the Atlas of Hillforts of Britain and Ireland web mapping application

Figure 9.2. Maximised HTML pop-up for Maiden Castle, Wimborne St. Martin, Dorset (Atlas ref: EN3598).

Figure 9.3. Filter expression to show all confirmed hillforts on the Isle of Man.

Figure 9.4. Geographic footprint of the Atlas of Hillforts of Britain and Ireland web mapping application, showing the number of visitors per country since launch (from 22nd June 2017 to 21st March 2019). The symbology is binned at intervals of 500 visitors and is clipped at 6,000 visitors.

Figure 9.5. Gary Lock, John Pouncett and Ian Ralston (left to right) and the Atlas of Hillforts of Britain and Ireland at the American Association for the Advancement of Science (AAAS) meeting, Austin, Texas, 2018.