

# Archaeological Measured Survey on Scotland's national forest estate









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# A window onto the past

From Mesolithic flint scatters to the coastal defences of the Second World War, the archaeology on Scotland's national forest estate spans thousands of years of history. Discover how Forestry Commission Scotland's archaeological measured surveys support our vital conservation work.

Forestry Commission Scotland's historic environment programme includes a wide range of sustainable conservation management, from path repair on ancient duns and hillforts to masonry consolidation of 18<sup>th</sup> century military bridges.

In order to protect the many archaeological sites, historic structures and cultural landscapes across Scotland's national forest estate, we must identify and assess their surviving remains to inform conservation and management.

This publication presents a number of recent archaeological measured surveys undertaken to support the programme. It explores and illustrates the wide range of conservation work that we undertake.

Ranging from plane table survey using alidade and tape to laser scans located using GPS satellite technology, our surveys are united in their efforts to present the results in an attractive and coherent manner.

*Like a jigsaw, the larger picture must be painstakingly built up from these small pieces of evidence.*

## Helping understand the past

Archaeological sites rarely remain the same from construction to abandonment. Disentangling the sequence of damage and repair, demolition and rebuilding, expansion and contraction is critical to our understanding of the past.

Like a jigsaw, the larger picture must be painstakingly built up from these small pieces of evidence. The individual fragments are fragile and easily disturbed and once lost they are gone forever. While protection and conservation often simply involves the avoidance of damage or the removal of scrub vegetation, positive action can also include the creation of a baseline record by targeted survey.



< LEFT:  
A surveyor recording  
one of the pillboxes  
in Lossie forest.



The process of interpreting the results of archaeological measured survey is akin to the process of archaeological excavation; first we gather the evidence and then we analyse the results.

### Informing conservation management

The importance of archaeological measured survey for sustainable historic environment conservation should not be underestimated. Benefits include:

- an enhanced historic environment record;
- an assessment of the cultural significance of a site within the wider regional context;
- baseline information that can inform conservation management and allow detailed condition monitoring over time; and
- visibly and effectively demonstrating and confirming the importance of significant sites.

Historic environment conservation management requires a baseline knowledge of the resource – such as an overall estate register, thematic and site-based surveys, individual site-based records and an appreciation of the wider context.

#### ▼ BELOW:

**Traditional measured survey by EDM total station at the site of Carn Mor dun on the Black Isle.**

It also requires an understanding of the differing objectives and requirements of protection, conservation and presentation. And it requires a framework for achieving the priorities and opportunities that such conservation entails. Sustainable conservation management balances environmental, social and economic objectives by seeking to deliver best practice in regard to:

- historic environment priorities;
- best value use of resources;
- additional benefits for the historic environment (such as encouraging the development of new techniques, the enhancement of the Historic Environment Record and the identification of Continuing Professional Development or training opportunities); and
- additional benefits for local (and wider) communities.

### Institute for Archaeologists workshop

This publication also supports an *Institute for Archaeologists* workshop showcasing archaeological measured survey illustration, collecting a number of contemporary Scottish case studies for discussion.

The workshop will highlight the purpose and practice of landscape-based and site-based archaeological measured survey by focussing upon the management objectives, the wider strategic framework (particularly the research context) and presentational methodology.





# Na Clachan Aoraidh

Situated in Forestry Commission Scotland's Allean Forest, the Na Clachan Aoraidh 'four poster' stone circle is an early Bronze Age ceremonial site on the limestone ridge of Cnoc na Craoibhe above Loch Tummel.

## The site

Na Clachan Aoraidh translates as 'Stones of Worship'. The site above Loch Tummel (NN 838 620) is considered to be a 'four poster' stone circle - a quadrilateral arrangement formed by four large orthostats, generally dating to the early Bronze Age (early 2<sup>nd</sup> millennium BC).

Although likely to be ceremonial, the few excavated examples often also display activities associated with funeral pyres and cremation burials. There is a particularly dense concentration of such sites in northern Perthshire, with examples scattered through the Tay, Earn and Tummel valleys.

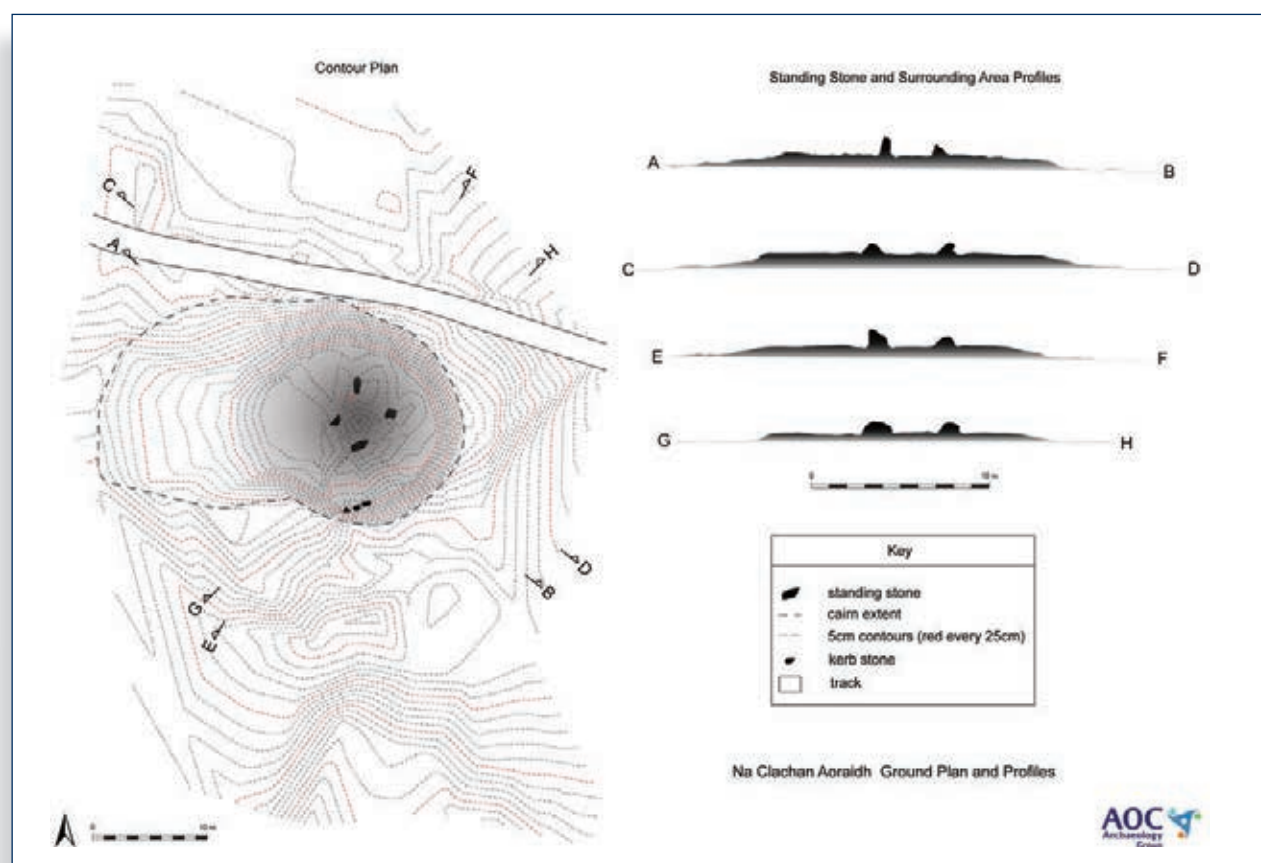
▼ **BELOW:** Traditional topographic plan and profiles of Na Clachan Aoraidh 'four poster' stone circle.

## The survey

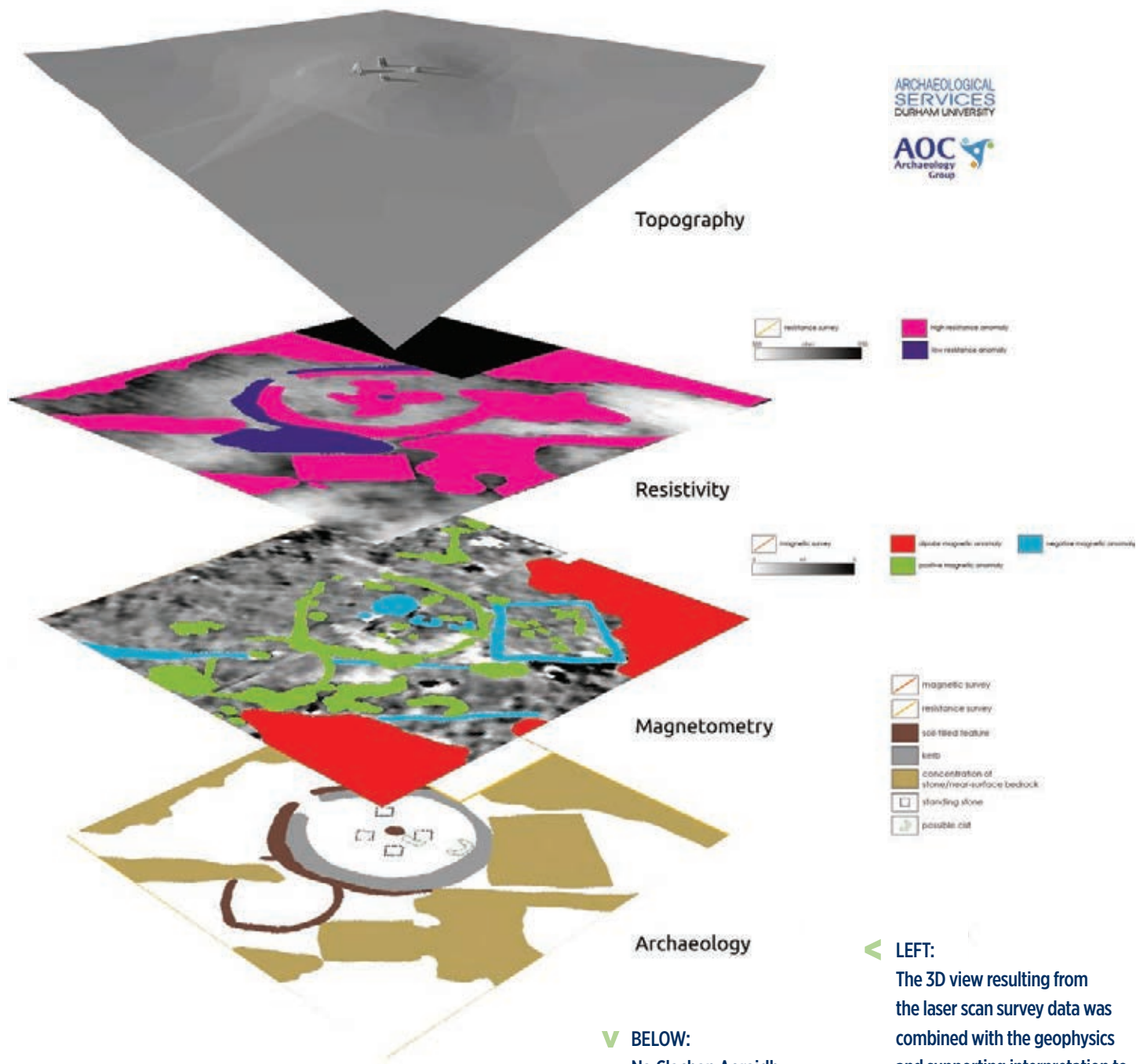
The site was the subject of a topographic and geophysical survey by AOC Archaeology. The 3D view resulting from the laser scan survey data was combined with the geophysics to produce an unusual isometric view.

## The results

The laser scan survey will help inform conservation management and enhance the historic environment record. It's the first modern record of this important site since Coles (1908) and Watson (1915). The survey products included a traditional contour survey and sections, as well as an unusual isometric view that combines the results of measured survey with geophysical survey.







BELOW:  
Na Clachan Aoraidh  
'four poster' stone circle  
(view facing west).

LEFT:  
The 3D view resulting from  
the laser scan survey data was  
combined with the geophysics  
and supporting interpretation to  
produce this unusual isometric  
view (facing north).





# Ord Hill

Ord Hill above Lairg boasts a complex prehistoric landscape that includes Neolithic funerary monuments and Bronze Age settlement and field systems.

## The site

Ord Hill (NC 574 055) displays the remains of many different periods of human use, including two Neolithic chambered tombs, several Bronze Age burial cairns, a large number of prehistoric hut circles and associated field systems, and a number of likely post-medieval enclosures.

Ord Hill forms the basis of an interpreted archaeological trail. However, the current all-access path is only partially complete. It currently suddenly stops on the lower flanks of the summit and an informal and unplanned path has developed.

The correct route should circumvent the hill, allowing access to the summit - both for the views and the most spectacular archaeology - while avoiding unnecessary damage.

## The survey

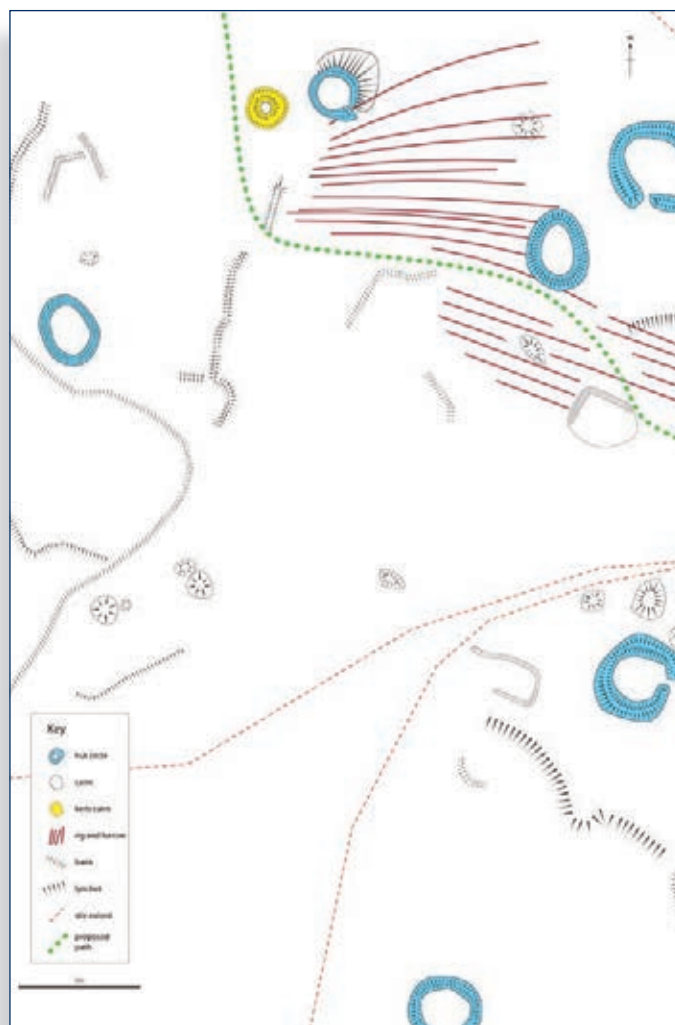
A detailed topographic archaeological landscape survey was required in order to inform both future conservation management and the route of the proposed path extension.

Headland Archaeology surveyed the complex landscape in great detail - and the resulting landscape-scale measured survey will be used to inform access and ongoing conservation management.

The traditional landscape survey used EDM and photography to record the surviving features.

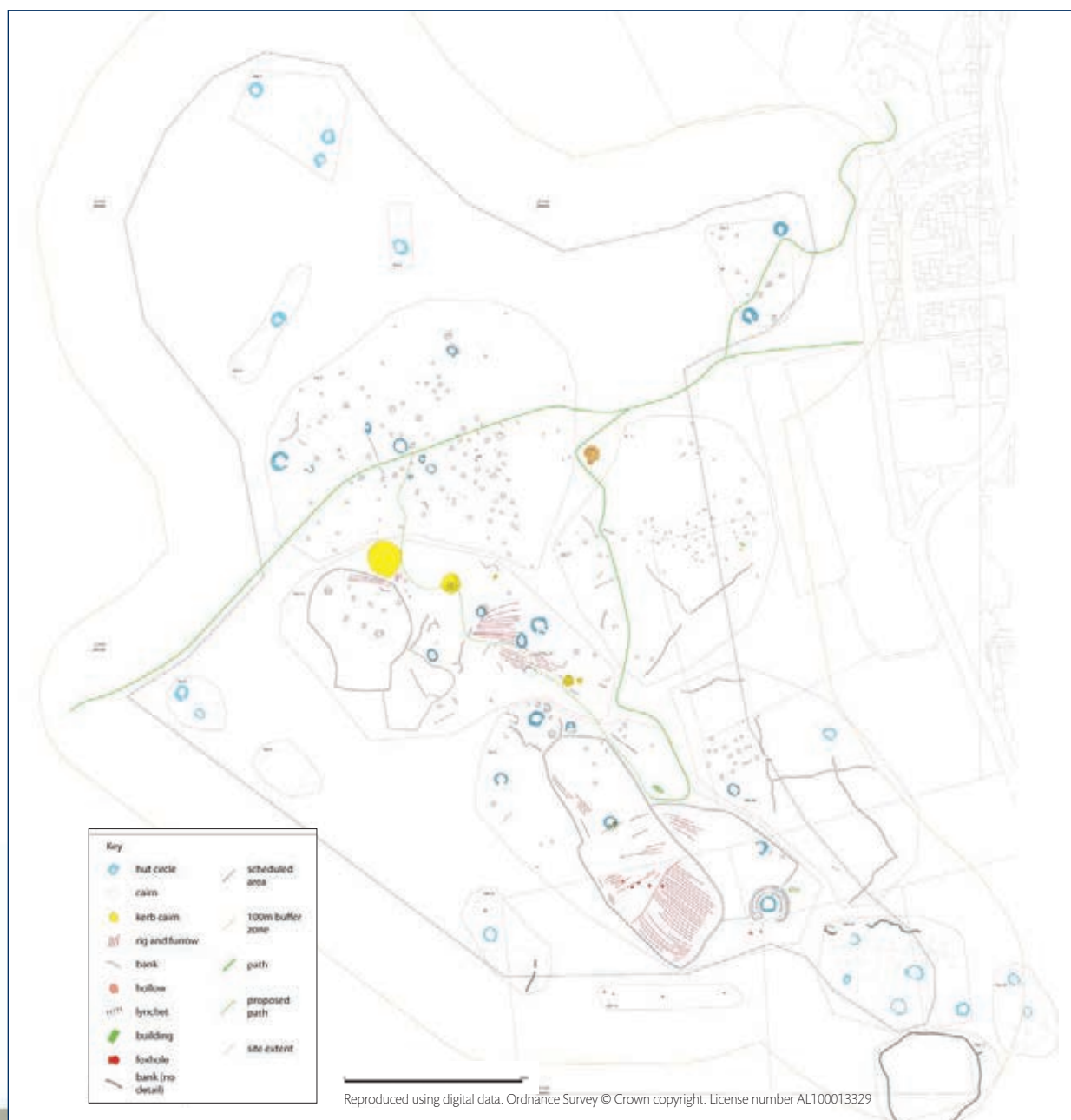
## The results

The great attention paid to the final plan (using bold colours to differentiate archaeological features) enabled the complex landscape to be clearly presented and readily understood. In total over 450 individual archaeological features were recorded - including chambered tombs, ring cairns, a burnt mound, hut circles, subrectangular buildings and over 300 clearance cairns.



- ▲ ABOVE:  
A detailed extract from the  
Ord Hill landscape survey.
- RIGHT:  
The Ord Hill landscape survey.
- BELOW RIGHT:  
The northernmost  
chambered tomb on Ord Hill  
is an impressive landmark,  
visible for miles around.







# Dun Deardail

Dun Deardail is a well-preserved example of an Iron Age vitrified fort in an impressive and evocative location above Glen Nevis.

## The site

Dun Deardail (NN 127 701) is pear-shaped on plan and defined by a well-preserved grass-covered vitrified wall some 4m in thickness and up to 2.5m in height internally. There are several impressive exposures of vitrification within the wall.

It has great archaeological potential, both in terms of buried archaeological deposits and structural detail and as a monument in its own right within the wider landscape. Visitor access is assured and encouraged by the construction of a well-built 'link' path leading from the popular West Highland Way.

## The survey

Headland Archaeology surveyed the fort in advance of a small programme of erosion repair and path work undertaken by Forestry Commission Scotland in October 2008.

The Dun Deardail topographic survey was one of a series of ten fort surveys on the national forest estate. It used a traditional means of archaeological measured survey

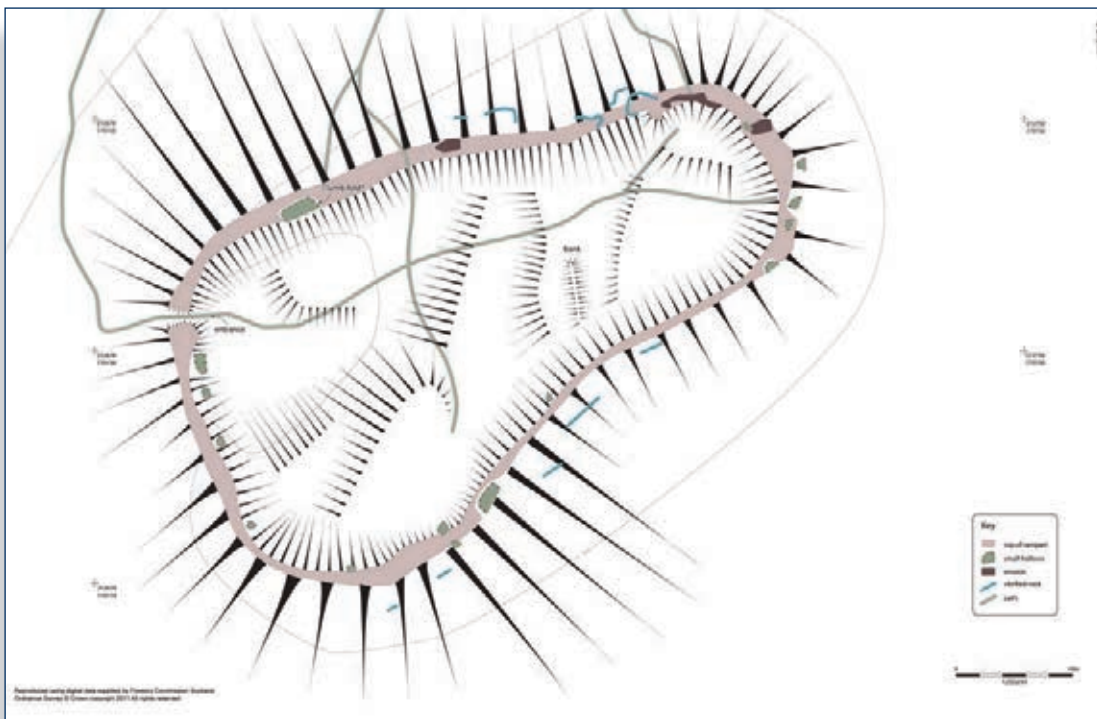
to enhance the historic environment record and provide information for conservation management.

Attention was paid to presentation for public use, including using bold colours and shading the 'line of rampart'. Supporting plans included conservation issues such as the extent of bracken or existing path routes for Forest District use.

## The results

Forestry Commission Scotland repaired the erosion caused by visitor pressure on the north flank of the fort and crossing its rampart by cutting turves from outwith the scheduled area and carefully placing them in the exposed ruts and hollows. The access path was then realigned around the north-west flank of the fort, following the line of the original approach (visible within the aerial photography).

The survey will also enable ongoing condition monitoring of this popular and well-visited fort.



LEFT: Traditional measured survey of Dun Deardail with enhanced interpretative detail (showing the extent of the spread ramparts) and detail for ongoing condition monitoring (highlighting the exposed vitrification and paths).

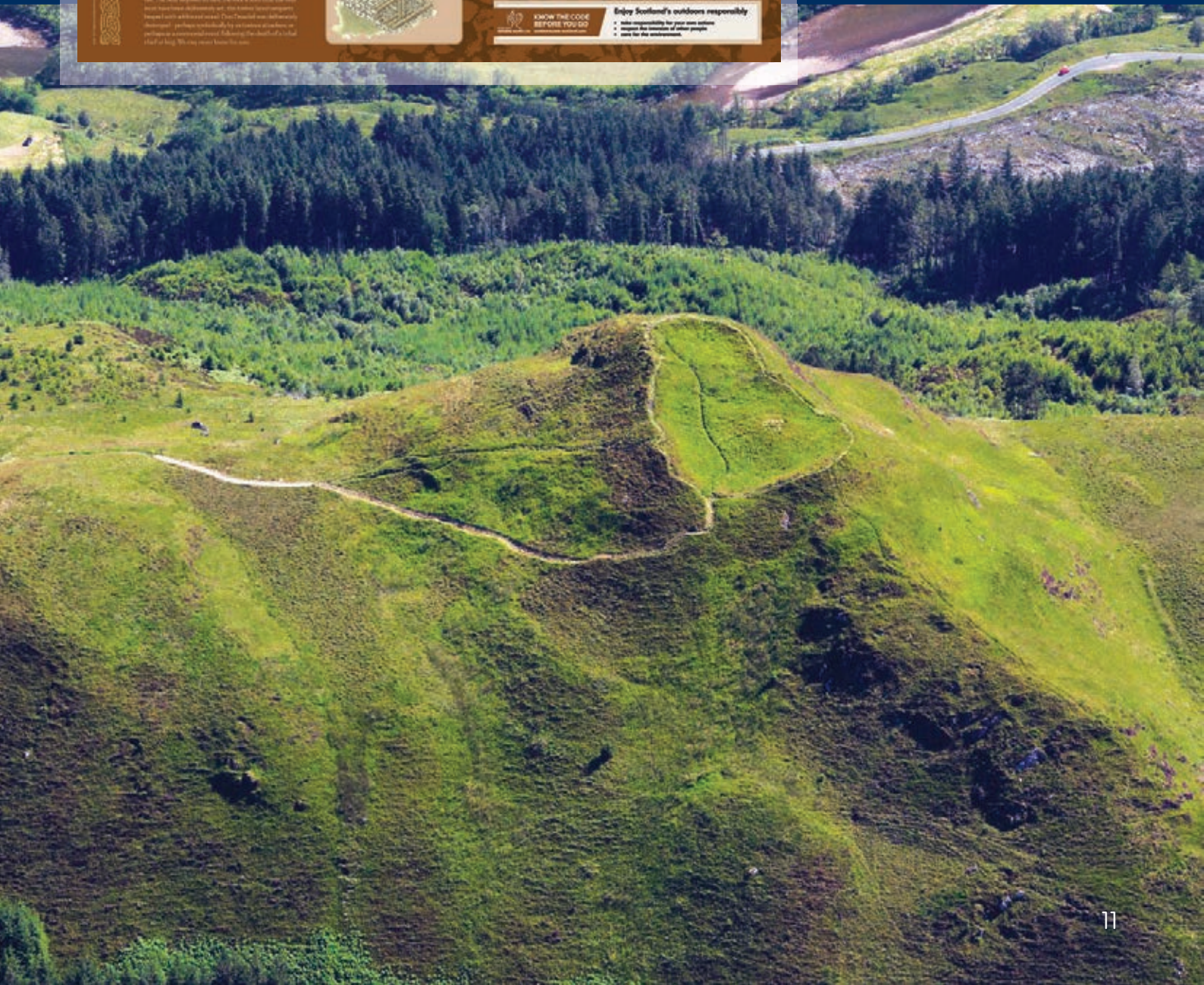
RIGHT: Dun Deardail, Glen Nevis (view facing east north-east).





**< LEFT:**

The interpretation panel focuses on the one thing we know for sure about Dun Deardail: that it was destroyed by fire. The vitrification of the rampart must have been the result of a deliberate destruction event – whether as an act of vanquish after the capture of the fort or as a ceremonial burning, perhaps following the death of a tribal chief or king. There were also several important behavioural messages that we needed to highlight, particularly that visitors should respect the site and use the new path.





# Caisteal Grugaig

The Iron Age broch of Caisteal Grugaig stands on a rocky knoll on the headland of Totaig, overlooking the junction of three sea lochs.

## The site

Caisteal Grugaig (NG 866 250) sits on a steeply sloping hill called Faire-an-Dun, the 'Watching place of the tower'. The impressive nature of the broch tower is increased by the huge triangular lintel over the low entrance passage. When in use, further chambers, stairways and passages constructed within the thickness of the double skinned wall would have provided access to upper floor levels. As the ground surface is rocky and unlevel, these may have been the main living spaces, with the ground floor possibly being used for storage or to house animals over the cold winter months.

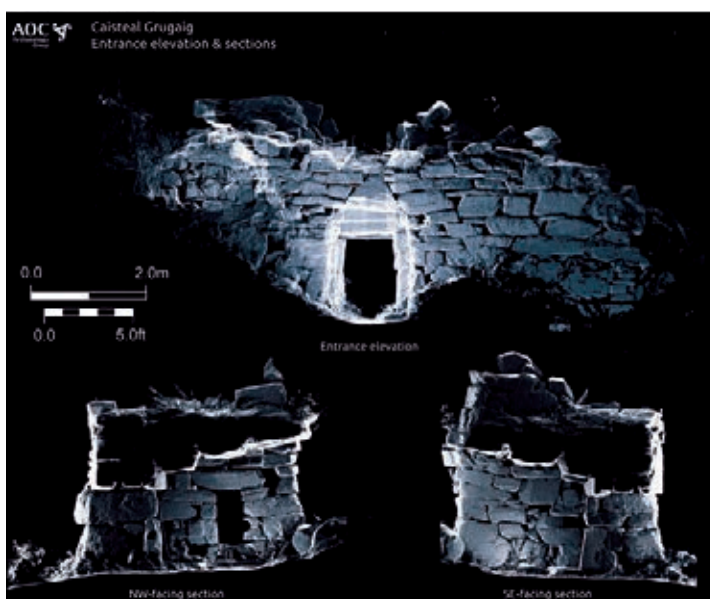
## The survey

The broch was the subject of an archaeological measured survey by AOC Archaeology. It was scanned by laser and the results – illustrating wall courses that survive up to 3m in height in places and architectural details such as scarcement, staircases and intramural galleries – are displayed as an orthoimage by elevation. The baseline measured survey was supported by a detailed condition statement, providing an enhanced historic environment record.



## The results

The survey will enable future condition monitoring and was used to inform a suite of reconstruction images and an online video ([www.forestry.gov.uk/forestheritagescotland](http://www.forestry.gov.uk/forestheritagescotland)).



### ▲ ABOVE:

Aerial photography can also enable enhanced condition monitoring.

### ➤ TOP RIGHT:

Modern laser scan techniques were used to undertake the standing masonry recording, displayed as an unusual but effective orthographic view. This pioneering presentational device is also used in conjunction with online animated fly-through.

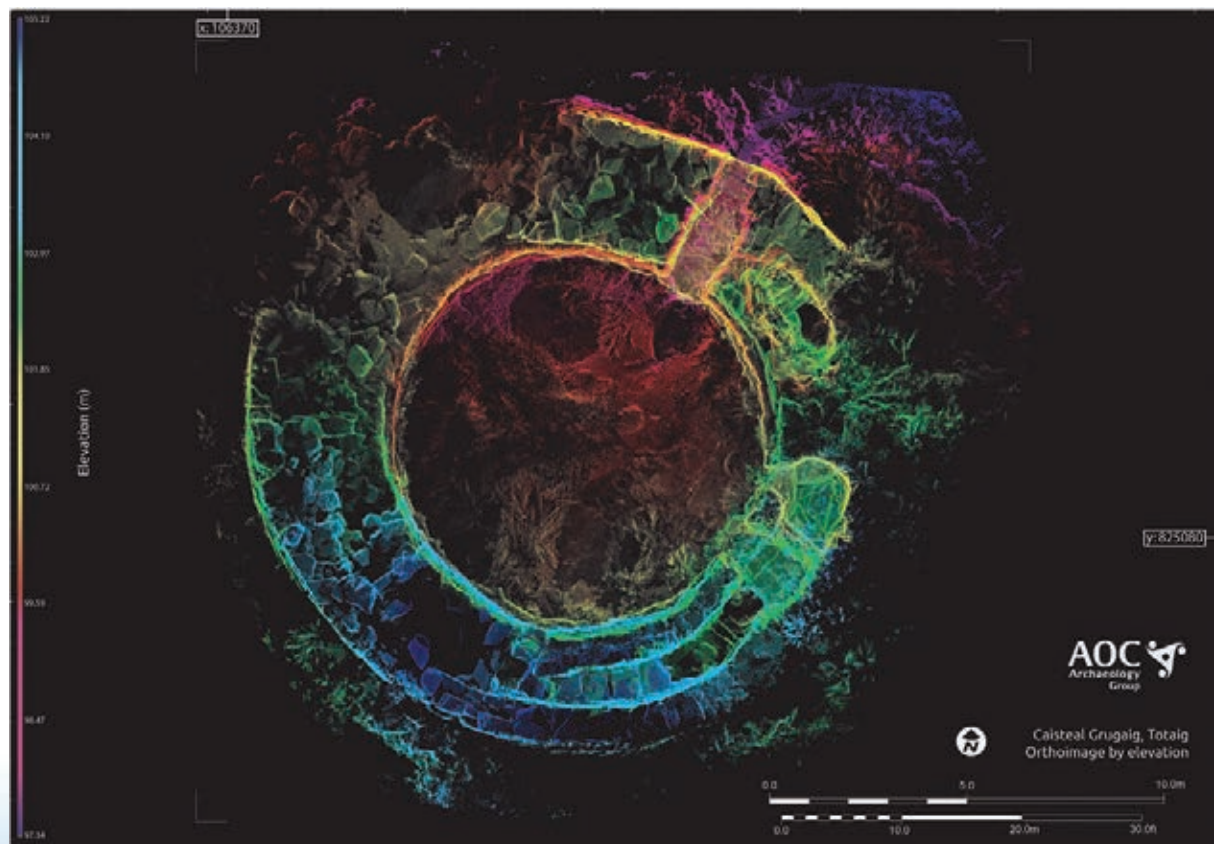
### ➤ BELOW RIGHT:

Caisteal Grugaig broch (view facing north from the rear, overlooking the interior).

### ◀ LEFT:

Caisteal Grugaig broch entrance elevation and sections.







# Skelbo

The remains of a 2,000-year-old broch sit on a slight knoll in Skelbo Wood, Sutherland.

## The site

Skelbo broch (NH 782 944) is situated on a slight knoll and comprises a massive circular spread rubble mound with an overall diameter of around 18m. An outer wall encloses the central mound and there are no visible wall faces.

## The survey

The site was surveyed by Ross & Cromarty Archaeological Services to enable better conservation management, particularly in terms of site monitoring for conservation management. The traditional survey approach was simple and affordable. It recorded the detail of the ruinous broch and its outworks, showing the spread and condition of the walls and the location of paths across the site.

## The results

The survey has enhanced the historic environment record and will inform ongoing conservation management. Recording the camera point detail has created an excellent baseline for simple ongoing condition monitoring.

### > ABOVE RIGHT:

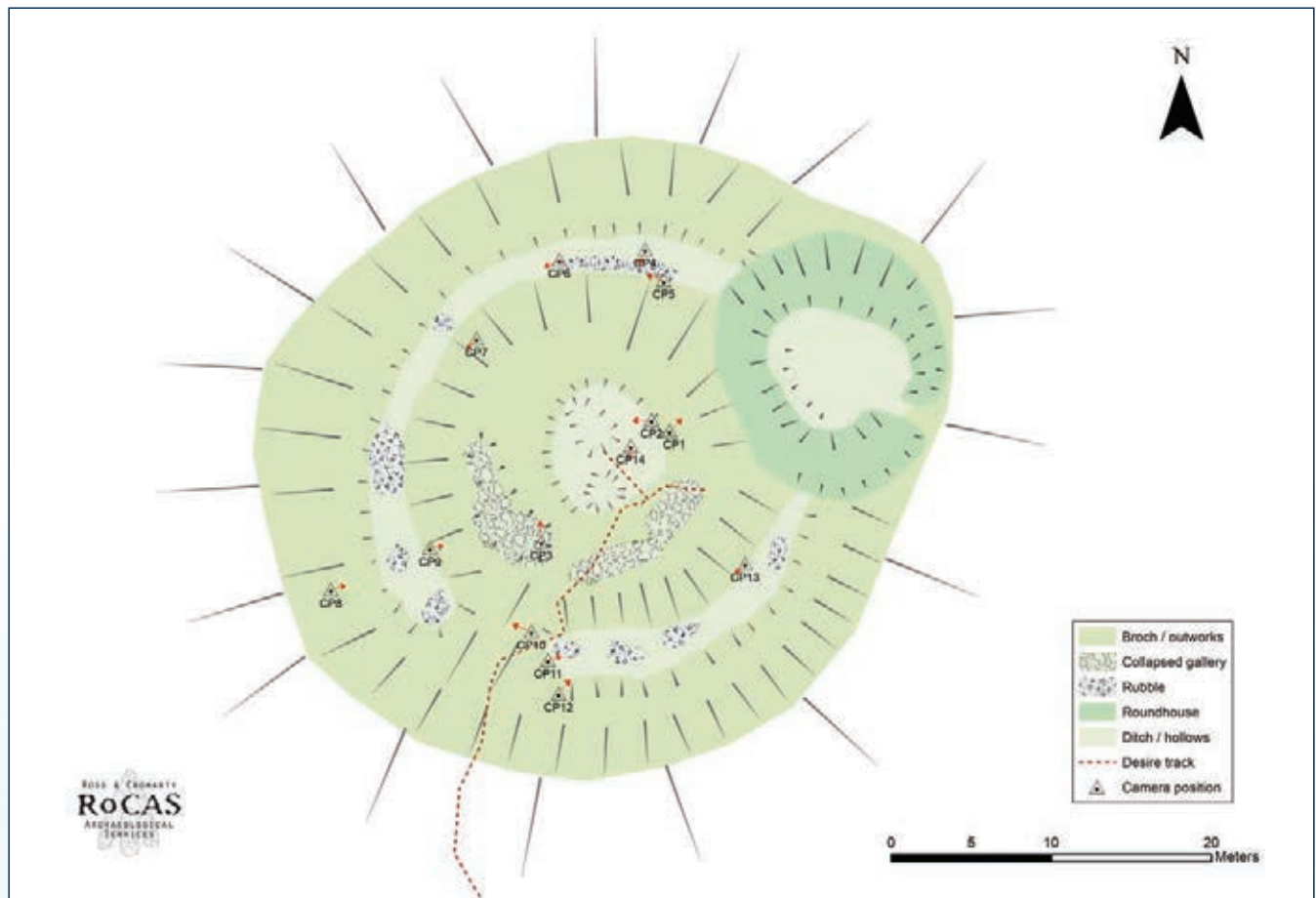
Traditional measured survey of Skelbo broch with camera point detail (including catalogue number and direction of view) for condition monitoring.

### v BELOW:

The spread outer wall, causeway and central mound of Skelbo broch (south-west side, view facing north-west).









# Cracknie

The remote Iron Age souterrain at Cracknie in Borgie Forest in Sutherland is a well-preserved example of these enigmatic underground passages.

## The site

At 13.2m long, 1.3m high and 0.8m wide, the Iron Age souterrain at Cracknie in Borgie Forest in Sutherland (NC 665 509) is almost intact with no modern consolidation. The entrance is marked by a hollow and a number of large stones, including one fallen cap stone. No above ground structure survives. The souterrain is curved on plan - as is usual for such sites - and has a distinct sub-circular chamber at its end. The walls are carefully built without mortar and it is roofed with large slabs overlapping each other.

## The survey

The site was the subject of an archaeological measured survey by AOC Archaeology. The souterrain was scanned by laser and the results, which illustrate the well-preserved walls and roof lintels, are displayed as orthographic views. The baseline measured survey was supported by a detailed condition statement and an assessment of cultural significance, providing an

enhanced historic environment record and placing the site within its regional context (particularly comparing the condition of the site with other examples).

The survey used modern laser scan techniques to undertake standing masonry recording and to create a stone-by-stone architectural record. The presentational response was similar to recent surveys of similar sites, allowing a continuity of record, particularly aiding any future academic publication and research.

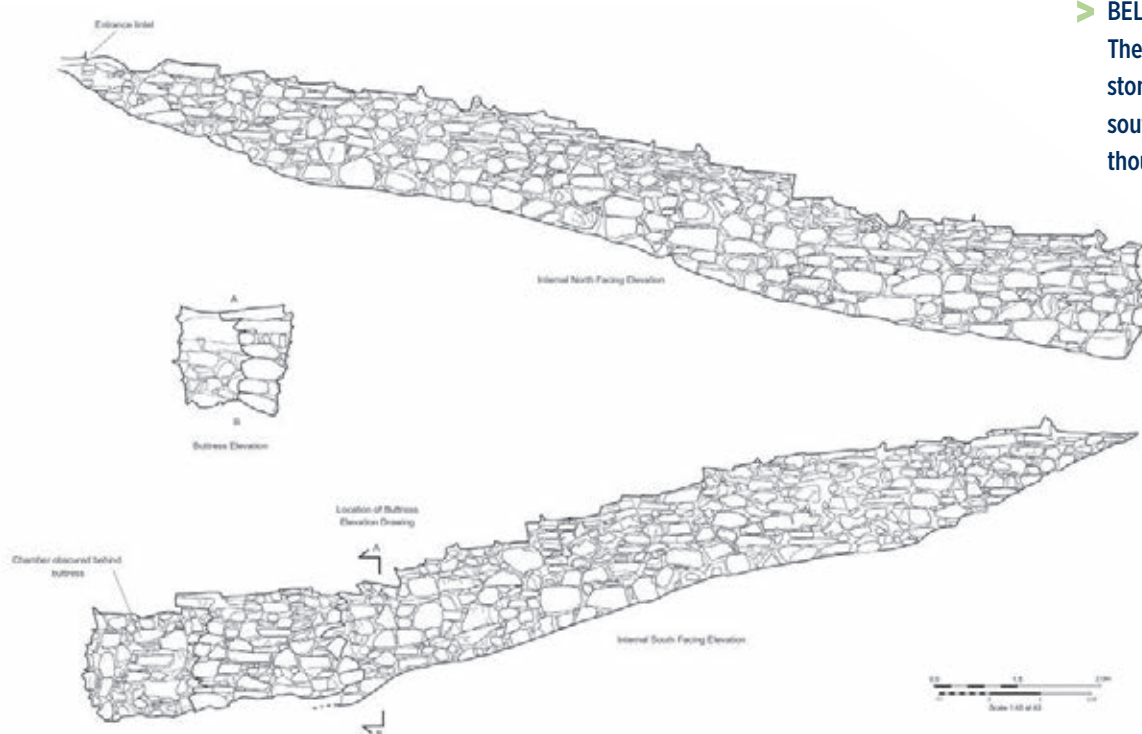
## The results

The survey has allowed this complicated structure to be readily understood on plan and in elevation. As site is difficult to get to, an online 3D flythrough enables a level of remote access.

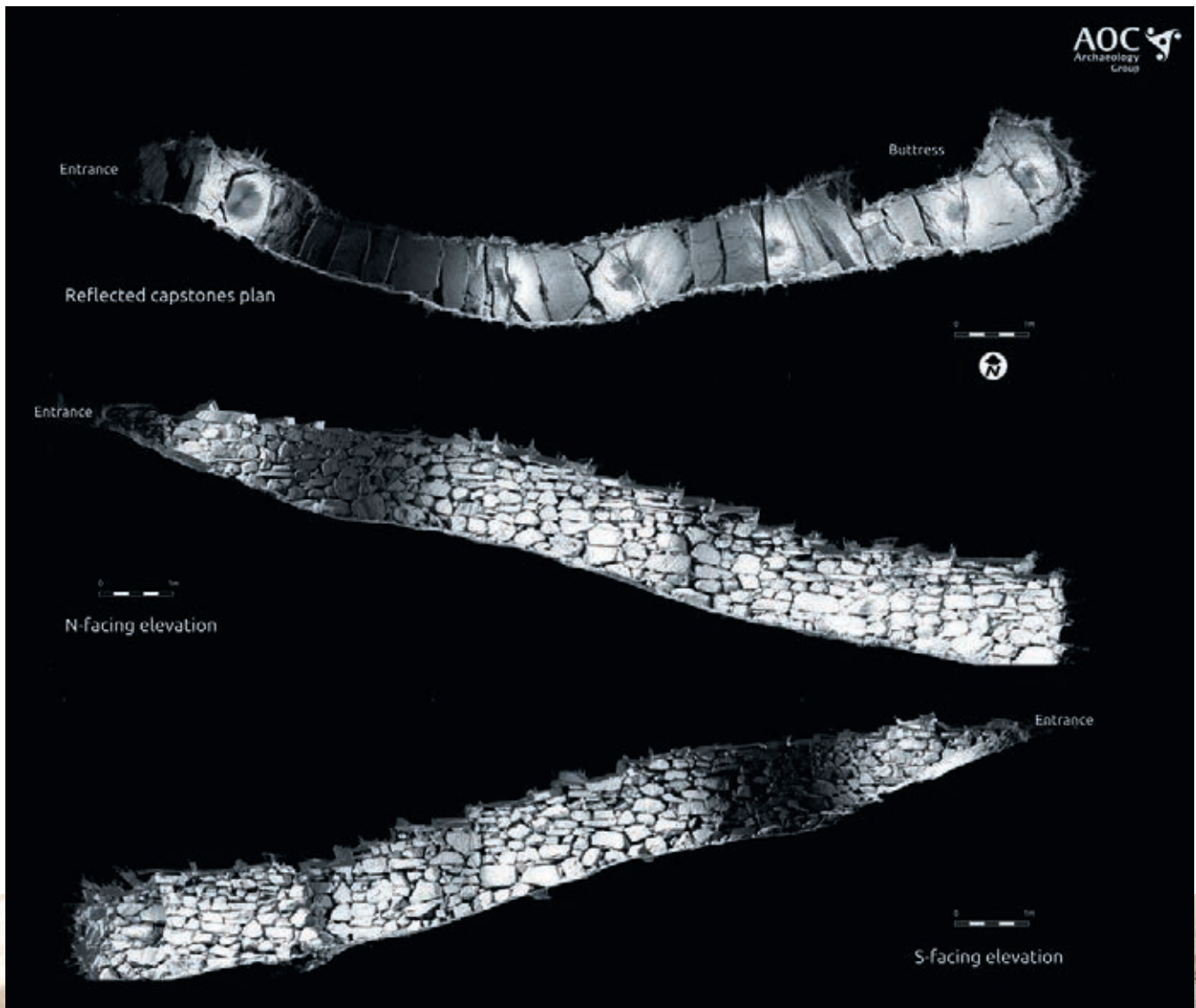
▼ **BELOW:**  
Cracknie souterrain  
elevations.

➤ **RIGHT:**  
Cracknie souterrain  
orthographic views.

➤ **BELOW RIGHT:**  
The drystone walls and  
stone lintels of the Cracknie  
souterrain are over two  
thousand years old.









# Dun Boredale

Dun Boredale is an excellent example of an Iron Age galleried dun in an impressive and evocative location on the Isle of Raasay.

## The site

The well-preserved dun (NG 554 364) measures about 12.5m in diameter within a massive drystone wall around 3.8m in thickness and in parts at least 2m in height. It is situated on a distinct knoll on the southeast facing slopes of Boredale Wood, above the fertile slopes to either side of the Inverarish Burn. Several stretches of wall courses are visible both externally and internally, and a scarcement ledge is visible around the interior on the south side. This would have supported an upper floor level.

The entrance was deliberately placed at the lowest point on the knoll - an architectural detail similar to the nearby broch of Caisteal Grugaig. This acts to accentuate the impression of height (the wall elevation may have stood 9m above the entrance passage). The site has much archaeological potential, both in terms of buried occupation deposits and of structural evidence.

## The survey

AOC Archaeology surveyed the dun using a laser scanner, and interpreted detail and topographic features were recorded using an EDM total station.

Without much in the way of internal structural detail, unlike Caisteal Grugaig, it was felt that a traditional plan of the site would suffice, setting the site within a landscape contour survey. The survey also forms part of a suite of similar recent laser scan surveys of the major brochs and duns on the national forest estate, allowing a continuity of record and understanding.

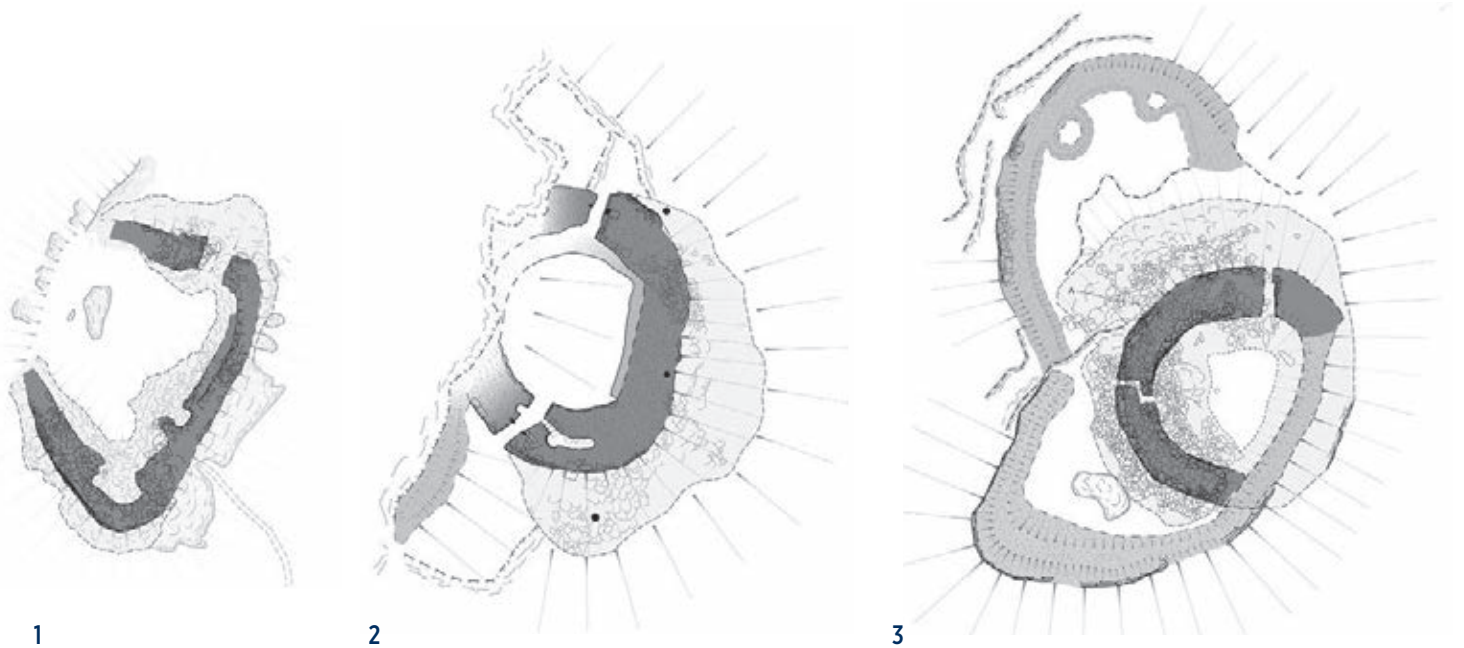
## The results

The detailed plans were all drawn to a similar standard, which enhances their potential for publication, and will help to inform ongoing conservation management and enhance the historic environment record.



➤ **RIGHT:**  
Traditional contour  
survey of Dun Boredale.





**▲ ABOVE:**  
Comparative surveys of (1) Castle Dounie (NR 767 932); (2) Druim an Duin (NR 781 913); and (3) Dun a Choin Duibh (NR 804 640).

**◀ LEFT:**  
A detail of the interior scarcement ledge at Dun Boredale (view facing SE).



**▼ BELOW:**  
The triangular lintel over the entrance of Dun a Choin Duibh.





# Carn Mor

Carn Mor dun is an Iron Age dun set within woodland on the Black Isle.

## The site

The site of Carn Mor dun (NH 603 585) on the Black Isle is situated on a slight knoll. A circular dun with an internal diameter of around 16.2m, it comprises three concentric ramparts with an entrance in the south-west. The north-west quadrant of the site is best preserved, where the wall height of the second (central) rampart remains around 1.8m in height. There are no visible wall faces. The innermost rampart is spread up to 8.3m in width; the central and outer ramparts, where preserved, are spread up to 5m in width. The central and outer ramparts are only visible as breaks of slope in the southeast quadrant of the site. It is possible that the walling for the second and third ramparts was not continuous on all sides.

## The survey

The dun was surveyed by Ross & Cromarty Archaeological Services to enable better conservation management, particularly in terms of site monitoring for potential visitor erosion. The purpose of the fieldwork was to record the detail of the dun ramparts and to show the spread of the walls, the contours of the surrounding landscape and location of paths.

## The results

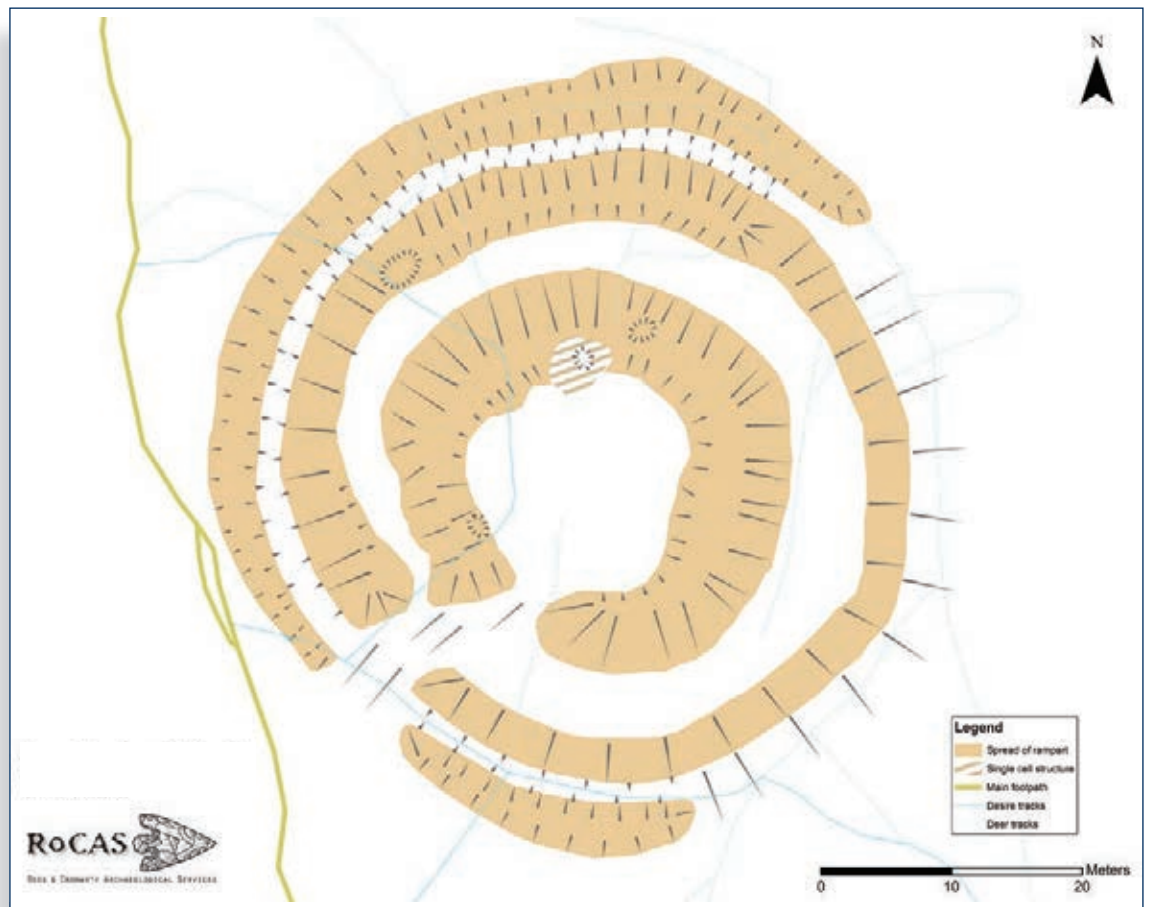
The traditional survey will inform ongoing conservation management. It was supported by high pole photography, allowing an excellent appreciation of the site from an elevated viewpoint.





➤ LEFT:  
Traditional  
measured survey  
of Carn Mor dun  
with enhanced  
interpretative  
detail (showing  
the extent of the  
spread ramparts)  
and detail  
for condition  
monitoring  
(showing the path  
and tracks).

◀ RIGHT:  
Carn Mor dun  
(south-east  
quadrant, view  
facing east).



▼ BELOW:  
The dun comprises three concentric ramparts. The northwest quadrant of the site  
is best preserved; this view looks over the central rampart (view facing ENE).





# Rubha an Fhaing Dhuibh

Rubha an Fhaing Dhuibh is a simple dun on Loch Shiel likely dating to the later half of the 1<sup>st</sup> millennium BC or the first half of the 1<sup>st</sup> millennium AD.

## The site

The later prehistoric site of Rubha an Fhaing Dhuibh on Loch Shiel (NM 813 718) was first recorded by Jim Kirby (then the local Forestry Commission forester) in 1983. The monument comprises a low sub circular enclosure set upon a level stone built platform. The platform occupies the whole of the promontory of the headland known as Rubha an Fhaing Dhuibh on the south shore of Loch Shiel.

The enclosure measures around 15m in diameter internally and survives as a low stone wall that measures about 1.1m in thickness and around 0.2m in height. Although now spread and ruinous, well-defined facing stones are visible on both the interior and exterior face. There is much rubble from the wall under the waterline around the edge of the platform.

The interior of the enclosure is flat and featureless. On the landward side and built into the wall there are two stone-built structures, with that to the west likely contemporary with the dun enclosure and perhaps indicating a form of block house (now much reduced). These structures are robbed and ruinous and have a higher ground surface than the interior of the island. Traces of a stone dyke run out to the south-west of the site. This complex site lends itself to rectified photography, with low drystone walls but much architectural detail.

## The survey

A photogrammetric archaeological survey was carried out by WA Heritage in order to record the site. The survey comprised over 2,000 digital photographs that were successfully combined with a traditional topographic survey to generate a suite of plans and images. The photogrammetric plan contains over 40 million points.



## The results

The survey has helped to inform conservation management and has greatly enhanced the historic environment record. The pioneering survey has also provided an assessment of the methodology of photogrammetric survey in terms of its capabilities, accuracy and constraints when used to record an archaeological site of this nature.

### < LEFT:

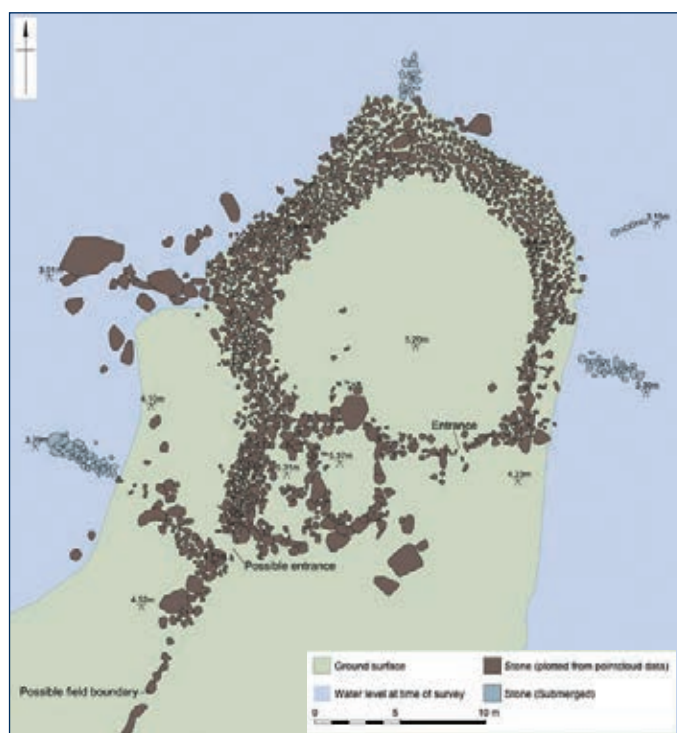
A detail of the wall on the north-west side of Rubha an Fhaing Dhuibh (view facing NE).

### > BELOW:

The archaeological measured survey of Rubha an Fhaing Dhuibh.

### > BELOW RIGHT:

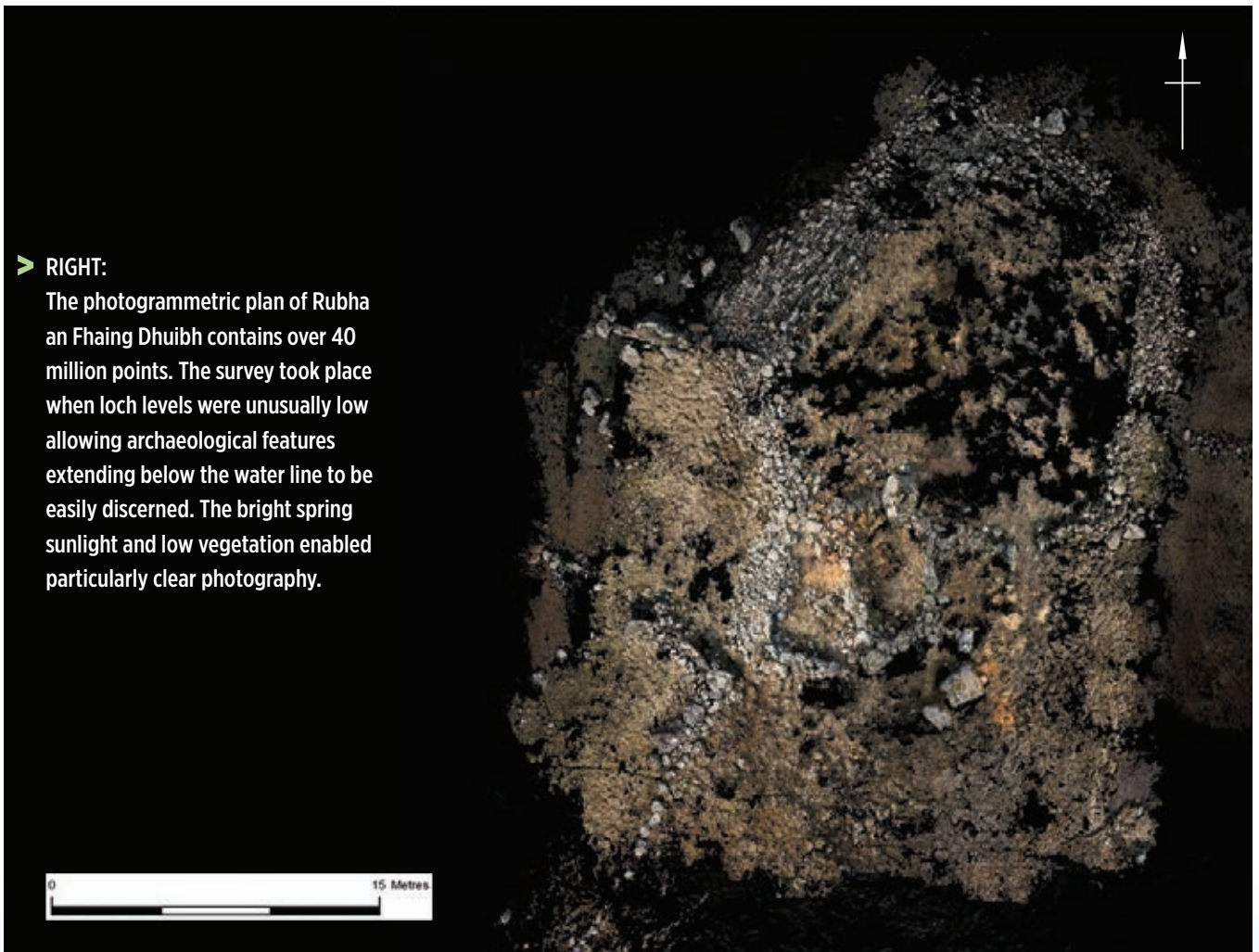
Rubha an Fhaing Dhuibh dun after clearance in early 2012.





➤ RIGHT:

The photogrammetric plan of Rubha an Fhaing Dhuibh contains over 40 million points. The survey took place when loch levels were unusually low allowing archaeological features extending below the water line to be easily discerned. The bright spring sunlight and low vegetation enabled particularly clear photography.





# Moat Park

The 12<sup>th</sup> century motte of Moat Park is set within the policies of Cally House, near Gatehouse of Fleet in Galloway.

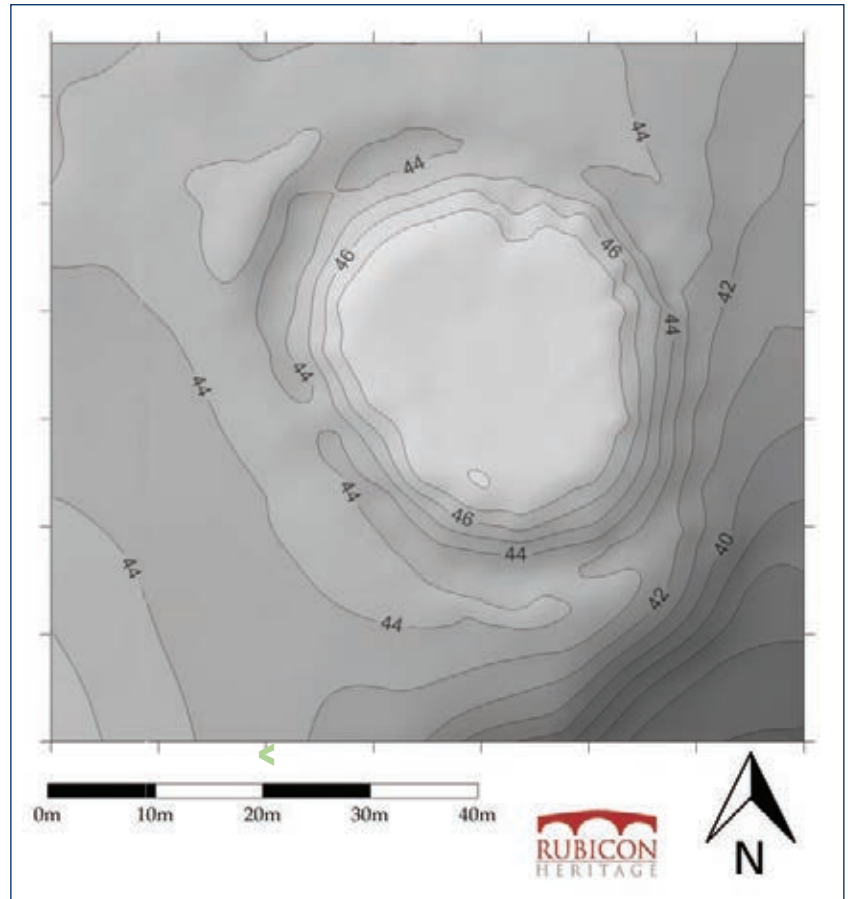
## The site

The combination of contour survey and geophysical survey of Moat Park motte (NX 606 556) provides an evocative image with an interesting story. The site was constructed by cutting a substantial ditch around the summit of a low ridge that supplied a strategic position in the landscape. Defensive earthworks such as the counter-scarp on the southern and western sides may have carried other defensive features such as a wooden palisade. The absence of this counter-scarp on the north side of the motte may indicate the position of a wooden causeway.

## The survey

The motte was the subject of a challenging topographical survey conducted by Rubicon Heritage, who also hosted a visit from the local community conservation group during the fieldwork. A series of geophysical surveys were also conducted on the summit of the mound to identify possible buried features at the site and further enhance the historic environment record.

Fluxgate magnetometry and electrical resistivity geophysical surveys were conducted on the summit of the mound. The electrical resistivity survey did not reveal evidence for substantial ditches or walling on the summit of the mound. However, given that mottes were most commonly constructed of earth and timber, this is perhaps not surprising. The results of the fluxgate magnetometry survey identified subsurface magnetic anomalies that may represent an episode of burning at this location. The irregular form and substantial size of the area suggests that this magnetic response does not represent a simple hearth – and may perhaps be associated with the destruction by fire of a timber superstructure on the summit of the motte.



## The results

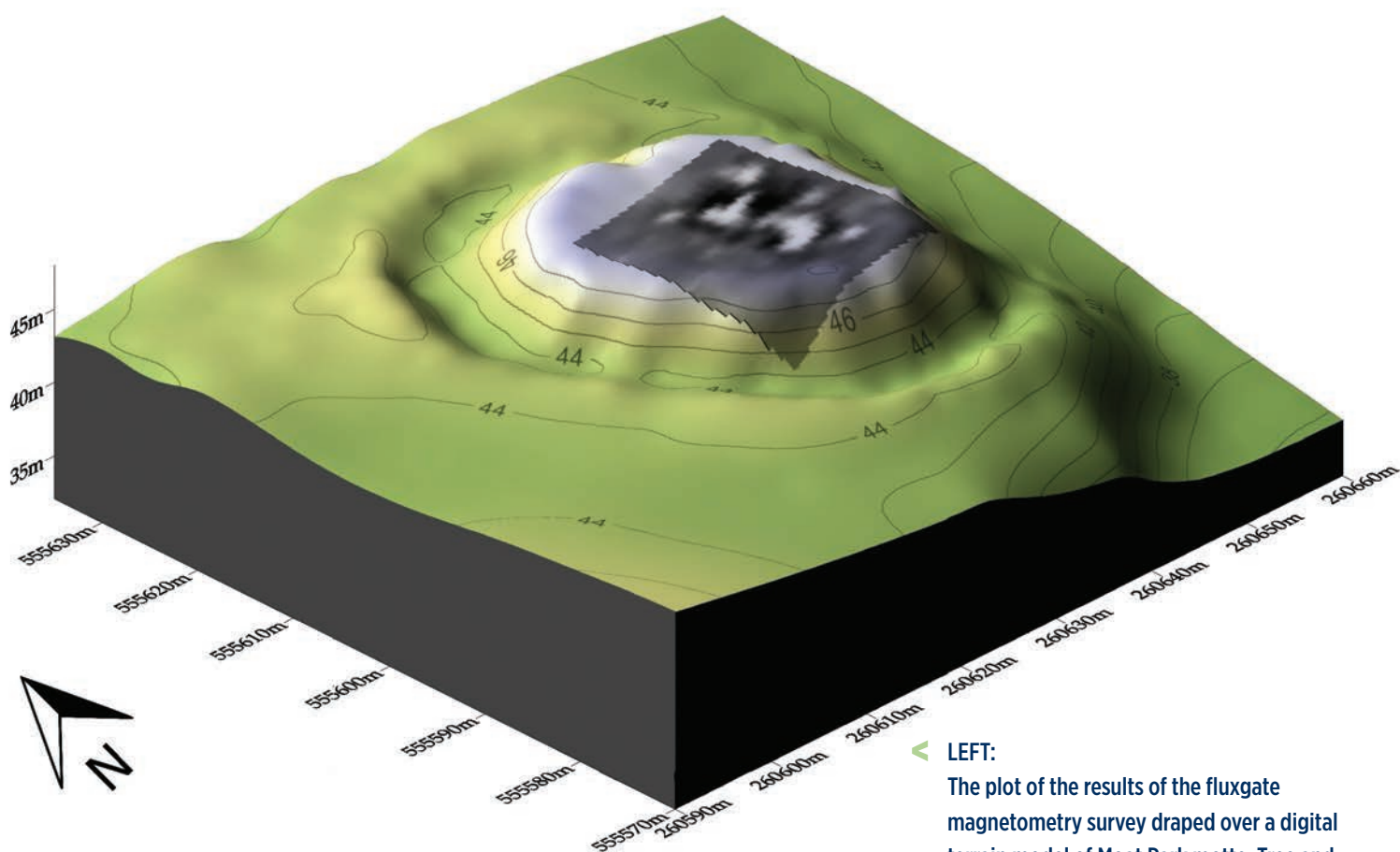
The survey will inform future conservation management and has provided an enhanced record of this important site prior to major tree clearance.

### ▲ ABOVE:

This grey-scale contour plan of Moat Park motte will be used to mark trees to be felled and define access routes for the Harvester during conservation management works.

➤ Surveying in a woodland environment can be very challenging.





◀ LEFT:  
The plot of the results of the fluxgate magnetometry survey draped over a digital terrain model of Moat Park motte. Tree and vegetation cover on the northern edge of the summit prevented inspection in this area.





# Nether Horsburgh

The 16<sup>th</sup> century tower house of Nether Horsburgh in the Scottish Borders is an archaeological site without modern consolidation or intervention.

## The site

Nether Horsburgh Tower in the Scottish Borders (NT 304 397) is a fine example of a small 16<sup>th</sup> century tower house. Such tower houses were usually built by local lairds who were keen to be accommodated within houses displaying the accepted towered symbolism of moderate defensibility, but who could only afford to construct on a limited scale. In Peeblesshire alone there were more than 80 towers, of which only five remain more or less intact and a further twenty survive in a ruinous condition.

However, although some have continued in use within domestic complexes (such as stately Traquair House), few examples of the traditional late medieval tower house survive in the Scottish Borders that have not been reduced to ruin or converted and reused from the 17<sup>th</sup> century onwards. Nether Horsburgh Tower survives as an unconsolidated standing ruin with earthwork evidence of external ranges and an enclosing barmkin wall. The tower once rose to four storeys in height, with a vaulted ground floor and stairs built within the walls. The whole of the east wall has collapsed.

As an unconsolidated ruin without later consolidation or intervention, Nether Horsburgh tower retains a much greater degree of authenticity and integrity (key concepts in many international conservation charters) than comparable sites.

## The survey

The site was the subject of a measured historic building survey by AOC Archaeology and considered as part of a wider assessment of cultural significance of similar sites on the national forest estate in the Borders.

## The results

The baseline architectural record has enhanced the historic environment record and allows a conservation programme of managed decay. Saplings and scrub vegetation will be removed (with the stumps treated as roots can regenerate), prolonging the life of the structure. While buried archaeological deposits remain protected, the unconsolidated ruin will be allowed to decay without consolidation. Although the consequences of this approach are clear - the interior of the tower will remain closed to public view and the structure itself will remain at risk of localised collapse - there are significant benefits in terms of authenticity and integrity by keeping the site as true 'ruins as archaeology'.

➤ **RIGHT:**  
Nether Horsburgh Tower during survey.

▼ **BELOW:**  
Nether Horsburgh Tower: (1) the north interior elevation, (2) ground floor plan and (3) first floor plan.









# Leitir Fura

Leitir Fura is a deserted township situated in a clearing amongst native woodland on the south-east coast of Sleat on the Isle of Skye.

## The site

Leitir Fura township has been interpreted and presented to the public as a good example of the archaeology of the Highland Clearances. Believed to have been inhabited up to the early 19<sup>th</sup> century, the remains of houses and other buildings lie either side of what was a cattle drive road.

## The survey

An archaeological re-evaluation of the township of Leitir Fura (NG 731 158) was undertaken by West Coast Archaeological Services in 2010, fourteen years after its original survey.

The original survey included a walkover of the general area, an assessment of the condition of archaeological sites recorded and an assessment of the woodland and vegetation cover both on and around the remains of the settlement of Leitir Fura. The re-evaluation was designed to assess the effects on both the archaeological remains and the immediate woodland environment of over a decade of conservation management and public access.

The entire area covered in the 1996 survey was re-walked to check for sites overlooked because of forest cover or simply missed during the initial survey. This was followed by a re-assessment of the condition of each individual element recorded in 1996. This included the structural condition, re-growth of vegetation and tree cover, encroachment of casual pathways on archaeological remains and the suitability of current interpretation.

A stone-built promontory fort of irregular plan was also recorded, lying at the neck of a small peninsular on the coast below Leitir Fura. At the landward end of the peninsular the walls stand to almost 2m in height with the remains of an intramural passage visible.



The walls measure around 3m in thickness, except on the west side where they are formed from a volcanic dyke that has been encased internally with walling. At the seaward end, the wall appears to be considerably narrower, with the remains of an entrance just visible in the centre. A spur wall and massive entrance is attached to the east end of the seaward wall.

With likely late prehistoric origins, it is possible, considering the style of the entrance and internal courtyards, that this site was re-fortified in the 17<sup>th</sup> century.

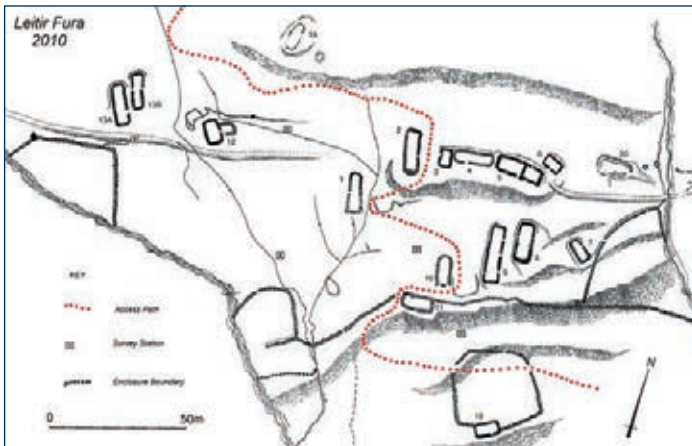
## The results

The re-evaluation of the Leitir Fura settlement has demonstrated that, with careful management, unconsolidated sites such as this can be presented to the general public without fear of damage and disturbance.

▲ ABOVE:  
Leitir Fura township.

➤ RIGHT:  
Leitir Fura township: building no. 10.





▲ ABOVE:

The topographic survey of  
Leitir Fura township.

➤ RIGHT:

The fine archaeological plan of the  
promontory fort, recorded using  
traditional survey techniques with  
interpretative detail highlighted in bold.





# Loch Arklet

An 18<sup>th</sup> century military road runs above the north shore of Loch Arklet in Loch Lomond and The Trossachs National Park.

## The site

A thematic archaeological survey was undertaken of the 18<sup>th</sup> century military road network on the national forest estate in the Highlands. This was undertaken in order to identify and record extant remains, evaluating and categorising their importance and providing baseline condition monitoring information. Two main sets of features were evaluated: well-preserved stretches of original road; and built features such as culverts and bridges. Further measured survey recorded well-preserved features in advance of improvement and consolidation. One such stretch of road runs past Loch Arklet to reach the now ruined army barracks of Inversnaid.

The road is being improved as part of a community-driven recreational long-distance path upgrade, linking Loch Katrine to Loch Lomond.

## The survey

Archaeological measured survey was undertaken by Headland Archaeology in advance of the path upgrade. The two phases of construction were recorded: an earlier route (hugging the contours) and a later route (cut and embanked on a straighter line), alongside the positions of built features such as culverts.

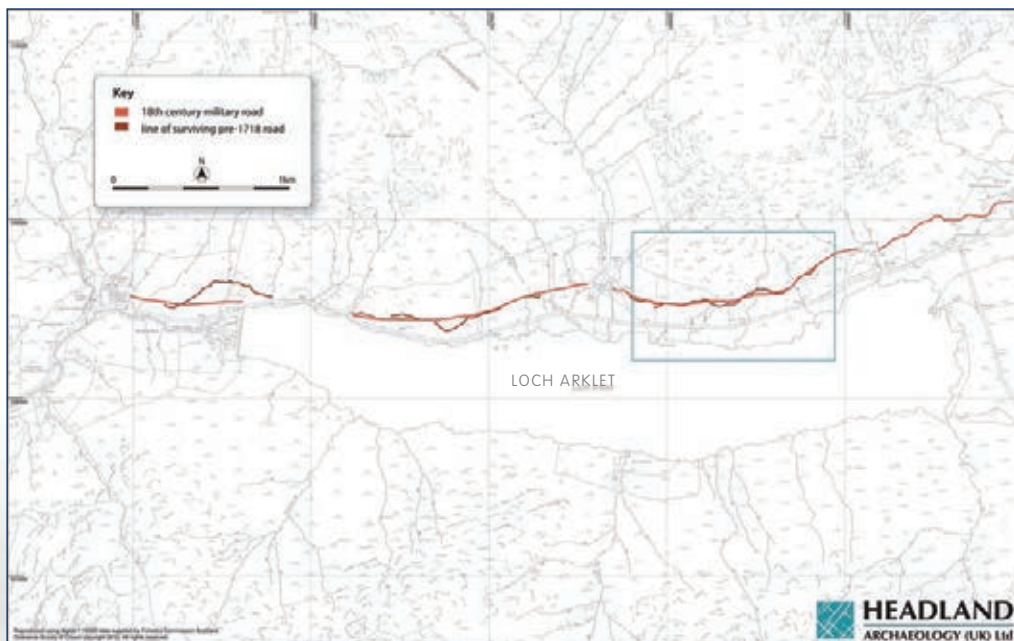
## The results

The Loch Arklet survey provided excellent preservation by record of the surviving route in advance of the construction of the recreational long-distance path upgrade. Inspired by guidance from the *Institute for Archaeologists*, the associated excavation (determining the nature of the surviving structural evidence) and final whole project publication was undertaken as a Continuing Professional Development opportunity within Forestry Commission Scotland's historic environment programme.



- ▲ ABOVE RIGHT:  
The two phases of construction can clearly be seen in this detail - the earlier route hugging the contours and the later route cut and embanked on a straighter line. The positions of culverts are also clearly marked.
- CENTRE:  
The well-preserved stretch of road at Loch Arklet was surveyed at a landscape scale and in sections with greater detail.
- RIGHT:  
Two phases of construction can clearly be seen along this stretch of road above Loch Arklet.
- ◀ LEFT:  
Excavation of an exemplar culvert in advance of the long-distance path upgrade.







# Wester Drumclair

Wester Drumclair farm is a mid-18<sup>th</sup> century farmstead in Limerigg Wood near Slamannan.

## The site

Occupation of Wester Drumclair farm in Limerigg Wood (NS 860 711) can be traced back to the mid-18<sup>th</sup> century by map evidence, but the upstanding remains appear to be 19<sup>th</sup> century in date. They survive as exposed wall footings, with some larger stretches of upstanding masonry present. These lie within an area of ornamental tree-planting, again of 19<sup>th</sup> century origin, with the remains of a disused railway cutting lying to the east.

## The survey

A programme of archaeological assessment and survey works was undertaken by Rathmell Archaeology in order to inform both the management and the interpretation of the farmstead.

The survey covered the farm buildings and plantation features and included the adjacent railway cutting. More detailed recording of the farm buildings was also undertaken. During survey and recording, a site visit was organised for local primary school children.

## The results

The historic building recording involved extensive historical research, photography and the creation of detailed traditional elevation drawings.

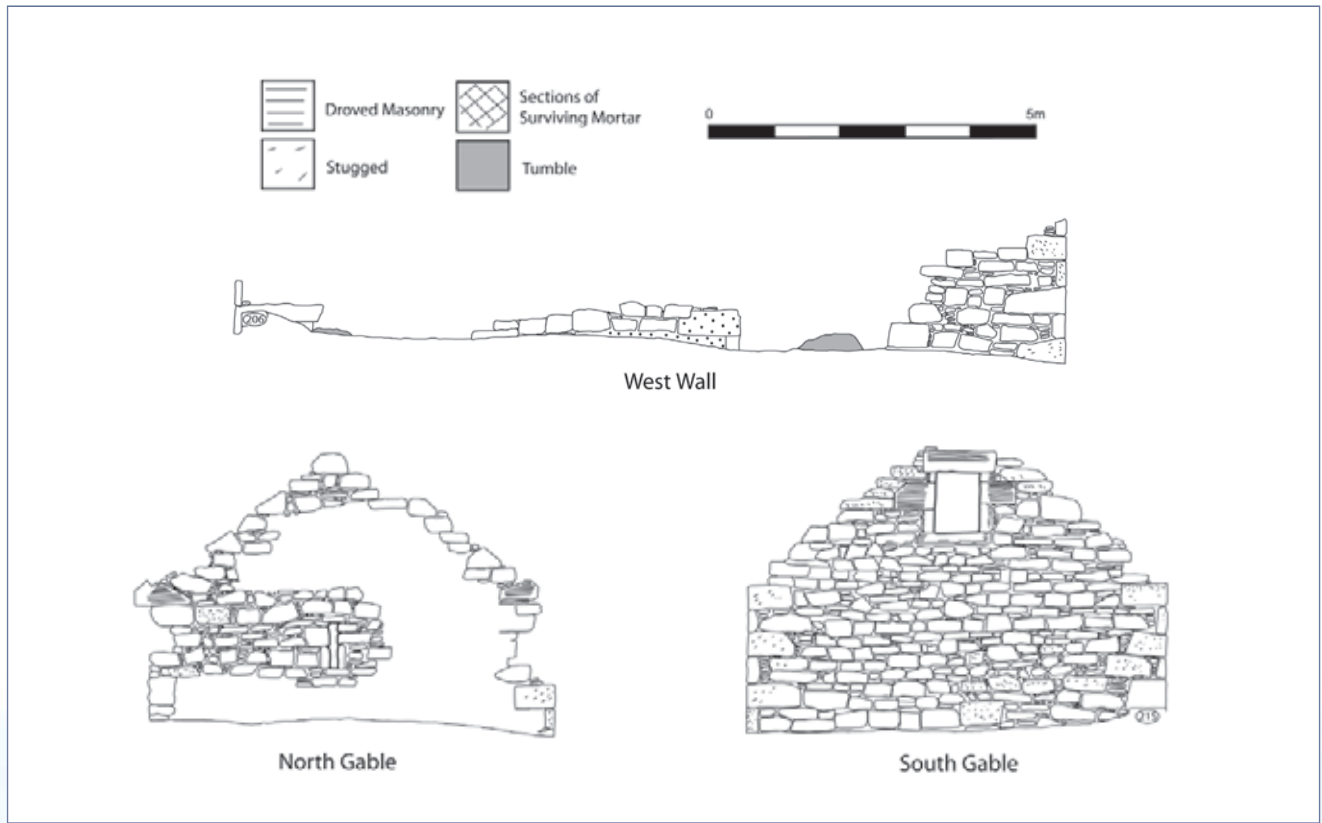
➤ **ABOVE RIGHT:**  
Traditional detailed exterior elevations of Wester Drumclair barn.



◀ **LEFT:**  
A site visit to Wester Drumclair barn by Limerigg Primary School during the archaeological survey.

➤ **RIGHT**  
Wester Drumclair barn.







# Culbin Sands

Timber posts in the tidal lagoon at Culbin in Moray were used to create anti-glider defences during WWII.

## The site

The tidal lagoon at Culbin (NH 967 623) is dotted with regular lines of poles, erected in buried herring barrels and packed in with stones. The lines were built in 1940 in order to deter enemy gliders from landing.

Hundreds of poles remain standing within a tidal lagoon, protected by sand dunes and forest. However, many have been reduced to little more than stumps.

## The surveys

Two significant large-scale archaeological sites on the national forest estate were recently flown for LiDAR survey by Forest Research, an agency of the Forestry Commission: Culbin and Wilsontown.

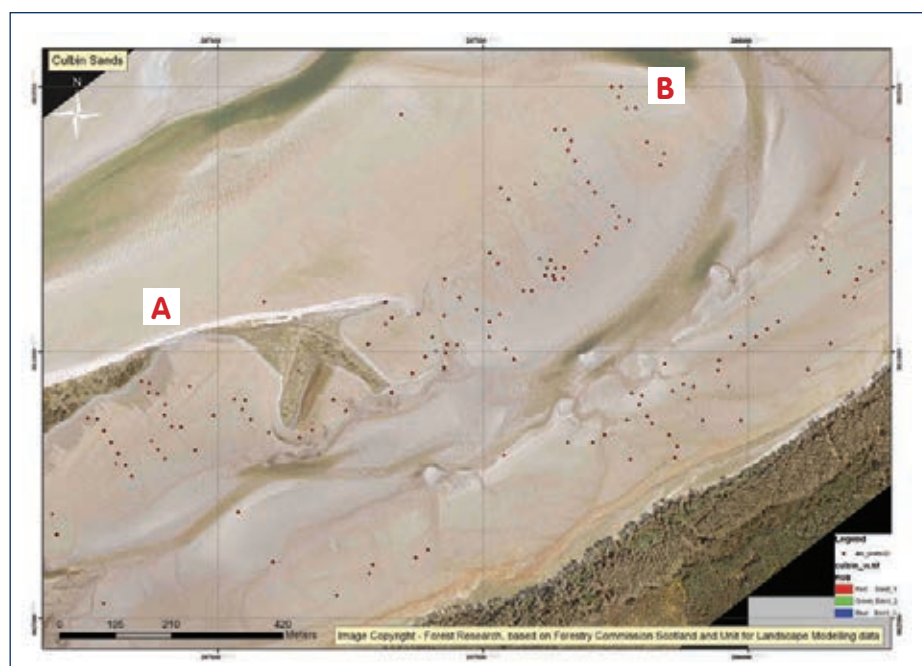
The two surveys are interesting examples of the use of LiDAR to capture detailed information regarding extensive landscape-scale archaeological sites. While prospective LiDAR will always require follow-up walk over archaeological survey, targeted LiDAR for measured survey is a cost-effective and attractive option.

At Culbin, the data was manipulated by cropping the LiDAR models to remove the surrounding forest before subtracting the Terrain Model from the Surface Model to produce a new model of height difference between the two. Features with a height range between 0.2m and 4m were selected, selecting by hand those features likely to be posts - discrete points away from obvious patches of tall vegetation. Posts shorter than 0.2m were not plotted as it would be difficult to distinguish them from any vegetation present.

The points depicting the location of the posts have not been checked on the ground - they represent features detected by LiDAR standing 0.2m or higher within a flat tidal environment (and the LiDAR survey was flown at low tide).

## The results

Using a blend of LiDAR survey and traditional vertical photography, the data gathered provides a detailed record of the surviving remains. The general surviving layout of the anti-glider defences can now be appreciated - particularly the ranked lines intended to dissuade gliders from landing along the beach.



- ▲ TOP RIGHT:  
'The Gut' at Culbin Sands is dotted with regular lines of poles. The poles were erected by digging a hole, inserting an old herring barrel, dropping in the pole and securing it using stones and sand.
- RIGHT:  
Oblique aerial views of areas A (upper) and B (lower).
- ◀ LEFT:  
The results of the LiDAR survey combined with vertical aerial photography.





## What is LiDAR?

Light Detection and Ranging (LiDAR) is an aircraft-mounted survey system that can fire a laser in very rapid pulses - thousands of times a second - towards the earth below. When the laser strikes a solid object, such as a building, it is reflected back to a detector on the aircraft. Because light travels at a known speed, differences in the reflected signal time to the aircraft flown at a constant altitude directly relate to changes in the height of the ground below, or objects on it. Sophisticated navigational and flight sensors onboard continuously measure the pitch, roll and location of the aircraft. When combined with the times collected for the reflected laser pulse, the data allows 3D co-ordinates to be calculated for the reflected surfaces below. Millions of these co-ordinates can be joined together to form 3D models of the landscape.

When LiDAR is used over a light-porous surface, such as woodland, some of the laser energy is reflected back from the canopy and used to create a Surface Model. Some of the energy also passes through, creating reflections from the forest floor below.

The LiDAR detector onboard the aircraft records the series of reflected signals from every single laser pulse emitted, and the combined data can be analysed to filter out the tall vegetation and other above-ground points to create a 3D model of the forest floor - known as a Terrain Model. At high resolution, archaeological features previously hidden from aerial reconnaissance can be revealed.

The technique can also be used to accurately plot large archaeological features, such as hillforts, and even investigate wider landscapes. The results can highlight archaeological structures and earthworks, and can be displayed as interpretative images or animation alongside historical map evidence and aerial photographs. Such surveys, and their terrestrial counterparts, also inform future conservation management.



# Wilsontown

Founded in 1779, Wilsontown Ironworks on the banks of the Mousewater in Lanarkshire was the first Ironworks in Lanarkshire.

## The site

Wilsontown Ironworks (NS 951 550) was the second of the lowland coke-fired ironworks to be built in Scotland (after Carron Ironworks in 1759) and the first ironworks in Lanarkshire.

It is reputed to be the location for the discovery of the 'hot blast' process, patented by J B Neilson in 1828, and was also where John Condie developed the 'Scotch Twyre' in 1831 – two innovations that revolutionised the iron industry.

The foundation of Wilsontown in 1779 can be set into the wider context of the Industrial Revolution by comparison with the initial expansion of coke-fuelled ironmaking at Coalbrookdale, Shropshire in 1754, and the foundation of the great Welsh ironworks of Cyfarthfa in 1765 and Dowlais in 1759.

The works developed over the following three decades and the community around it rapidly grew to nearly 2,000 by 1812, when the company employed 521 men. Poor transport links, managerial failures and costly legal disputes between the owners led to the collapse of the company in 1812 and the Ironworks finally closed in 1842. The much-ruined remains of most of the buildings were demolished in 1974. However, many of the early features of the ironworks remain visible, including the blast furnace, coke and calcining kilns and an extensive area of bell pitting.

## The survey

The area was surveyed using LiDAR in 2009. There are many survey variables that can alter the ability of LiDAR to capture the desired aspects of a landscape, and different parameters were used to meet the needs and objectives of the Wilsontown and Culbin Sands surveys.



For example, the Wilsontown survey required a high-resolution survey, which involves an average of four laser hits per square metre of ground, to allow the detail of the landscape to be modelled and ensure we would see all the subtle detail on site. This was flown at a lower altitude of 1000m, resulting in a small – approximately 25cm – footprint of the laser on the ground. However, this smaller footprint meant it is possible that not every patch of ground was hit.

The aim of the Culbin Sands survey was to map every extant defence post surviving

within the coastal zone. The posts were known to be several metres apart, so a resolution of several hits per metre was not necessary. In order to maximise the chances of them all being captured, the plane flew from a greater height, resulting in a larger footprint on the ground. With a medium resolution survey, there would still have been a good overlap on footprints, ensuring that every square centimetre would be hit and all posts captured. The laser beam was set to a greater diameter of 90cm. This meant that, with a minimum survey resolution of two laser hits per square metre, there would be little chance of not detecting a post with the diameter of 10cm or greater.

## The results

A simple Surface Model – coloured to show changes in height – and a semi-transparent hillshaded image to show the surface detail were combined to produce a spectacular image. The image can be used in both public presentation of the site – and as a baseline record prior to the construction of an all-abilities recreational path circuiting the site.



◀ LEFT:

Traditional measured landscape survey by RCAHMS (Forts, Farms and Furnaces 1998). Crown Copyright: RCAHMS (Derived from information compiled by and/or copyright of Ordnance Survey) [100021242]

➤ RIGHT:

The LiDAR survey of Wilsontown Ironworks: this image combines a simple Surface Model, coloured to show changes in height, and a semi-transparent hillshaded image to show the surface detail.

▼ BELOW:

One of the larger bellpits on the east side of the site.





# Woodmuir

The coke ovens associated with the nearby Woodmuir Colliery were a vital component of coal mining and associated industries in 19<sup>th</sup> and 20<sup>th</sup> century Britain.

## The site

The Woodmuir coke ovens near Woodmuir Farm in West Lothian (NS 968 598) are a scheduled monument and amongst the best preserved examples in the region. The bank of ten ovens, set back to back in rows of five, are likely to have been built some time after the Woodmuir Colliery was established in 1896. They may have been used into the early 1960s; the colliery itself closed down in 1963.

Coke ovens were crucial components of coal mining and associated industries in 19<sup>th</sup> and 20<sup>th</sup> century Britain. Coke can be used as fuel through slow controlled burning, and in the 19<sup>th</sup> century it was often used as fuel for the larger blast furnaces in ironworks and steelworks.

The process of making coke was relatively simple but required precise timing. Coal would have been shovelled into either the top or the front of the ovens as soon as the previous load had been removed in order to retain the heat and reignite the new batch of coal. Working day and night, the air supply would then have been removed from the ovens by means of either bricking up the access hole or by means of an iron gate with holes that could be covered to control the air supply. This control was considered a very important post and the role of the 'coke burner' was a skilled one.

As their use became even more widespread, beehive coke ovens began to be built in batteries. The ovens were continuously improved to retain heat better and increase the efficiency of the procedure.

## The survey

AOC Archaeology undertook an historic buildings survey of the coke ovens to enhance the historic environment record and inform any future conservation management or consolidation works.

The ovens are simple structures that lend themselves well to 3D fly-through animation, including the readily visible bricks.



## The results

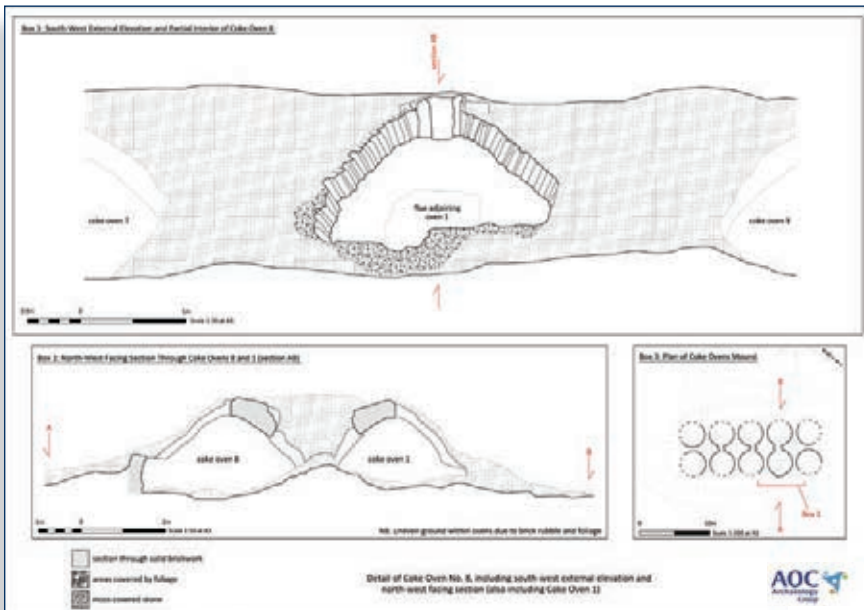
In commissioning the historic building survey Forestry Commission Scotland has ensured a baseline architectural record of the surviving structural features of the Woodmuir coke ovens. The survey has enhanced the historic environment record and will be used to inform condition monitoring.

View the results on the FCS website at [www.forestry.gov.uk/forestheritagescotland](http://www.forestry.gov.uk/forestheritagescotland).

### ▲ ABOVE:

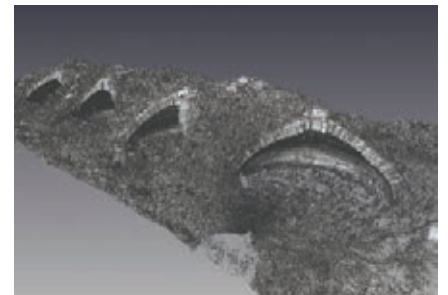
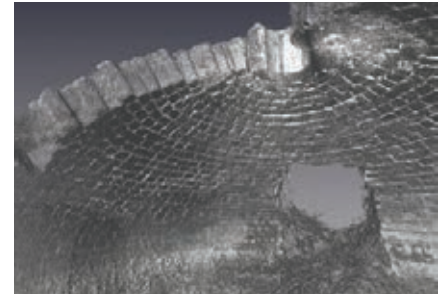
**Detail of Coke Oven No. 9.** The ovens are all brick-built and survive in varying conditions ranging from only a small area of the back wall to more substantial structures with at least half of the oven intact. The ovens are identical and form a bell shape with a distinct flue in the top of the oven. A space at the rear appears to 'connect' to the oven behind.





▲ ABOVE:  
The survey of Coke Oven No. 8: south-west external elevation;  
north-west-facing section; and basic plan of the bank of ovens.

▼ BELOW:  
Woodmuir coke ovens (views facing north).



▲ ABOVE:  
The data from the laser scan survey  
can be manipulated to produce any  
number of viewpoints.





# Lossie

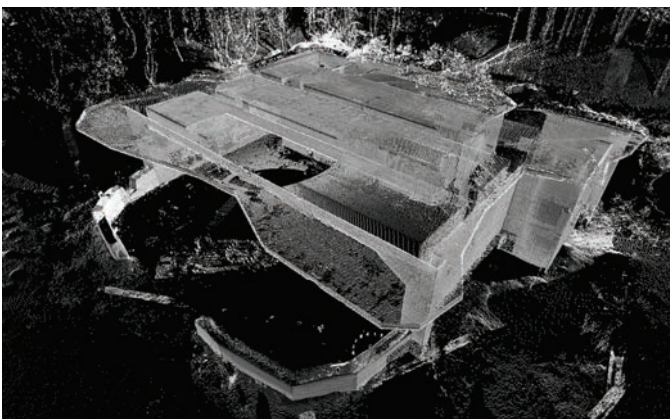
An unbroken line of WWII coastal defences survives within Lossie Forest along the Moray coastline.

## The site

In the autumn of 1940, a line of defences was constructed along the Moray coastline, aiming to slow down a possible German invasion from Norway. In Lossie Forest, an unbroken line of anti-tank cubes (interspersed with pillboxes) survives today, alongside a coastal gun battery at Innes Links. The defences include an observation post, magazine, generator houses, searchlights and the concrete foundations of the barrack blocks.

During wartime, the front of the Innes Links Emergency Coastal Gun Battery contained two gun emplacements, each armed with a large 6" Mark II gun. A large magazine housed the shells, which were brought forward and prepared in the forward magazine. The battery went out of operation in April 1945, followed by the removal of the guns two months later, although the circular iron fixtures are still visible.

The Battery Observation Post is hidden on a knoll overlooking the beach. As command control, this was where the calculations for aiming and firing the big guns were made. Two searchlight stations provided light to see an enemy attack at night, and machine gun emplacements would provide firepower to defend the beach if enemy troops landed. To prevent detection from enemy planes the buildings were painted and hidden with web netting. They also have irregular roofs to disguise their shape and several of the buildings still boast painted camouflage designs.



## ▲ ABOVE:

**The Innes Links Emergency Gun Battery was built in 1940 and forms part of the defensive coastal crust surviving in Lossie Forest.**

## The survey

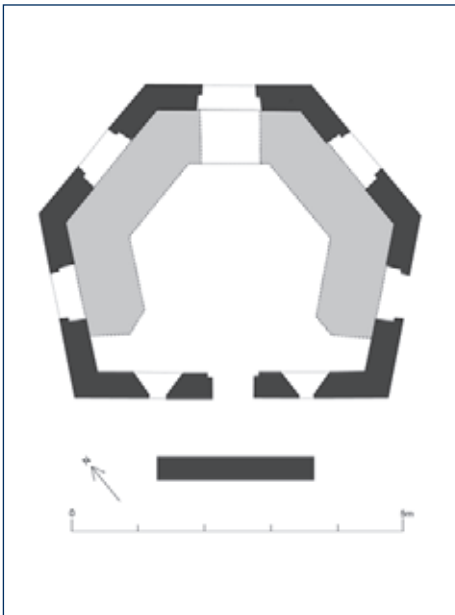
In 2009, AOC Archaeology undertook an archaeological survey of the defences, including an archaeological measured survey of the second gun emplacement using a laser scanner.

## The results

The various surveys demonstrate a range of techniques, with the common objectives of record, conservation management and presentation. Dr Gordon Barclay returned in 2012 and used the plans to inform drawings uniformly presented for a national study.

View an online 3D fly-through animation of the gun emplacement at [www.forestry.gov.uk/forestheritagescotland](http://www.forestry.gov.uk/forestheritagescotland). The powerful laser scanner has even picked up the modern graffiti!





▲ ABOVE:

A national survey has recently been undertaken by Dr Gordon Barclay. He included the measured survey of several sites on the national forest estate and reinterpreted the laser scan plans to follow the presentational protocol of the national publication. Traditional survey techniques enabled the swift and comprehensive record of standardised sites such as this Type 24 pillbox (left); and allowed the results to be incorporated into illustrative area surveys such as this road block arrangement (right).

➤ RIGHT:

The WWII defensive coastal crust at Lossie Forest comprises an unbroken line of several thousand anti-tank cubes, interspersed with pillboxes and an impressive coastal gun battery.

◀ LEFT:

The gun emplacement was surveyed by laser scanning in 2009, the results informing conservation management, a suite of artistic reconstruction drawings and later standardised national survey.









Forestry Commission Scotland's historic environment programme includes a wide range of sustainable conservation management, from path repair on ancient duns and hillforts to masonry consolidation of 18<sup>th</sup> century military bridges.

In order to protect the many archaeological sites, historic structures and cultural landscapes across Scotland's national forest estate, we must identify and assess their surviving remains to inform conservation and management.

This publication presents a number of recent archaeological measured surveys undertaken to support the programme. It explores and illustrates the wide range of conservation work that we undertake.

Ranging from plane table survey using alidade and tape to laser scans located using GPS technology, our surveys are united in their efforts to present the results in an attractive and coherent manner.

#### **FRONT COVER:**

**The spectacular view looking north over the Iron Age dun of Castle Dounie and the Sound of Jura. The dun was surveyed in advance of a path upgrade, rerouting the existing desire line away from crossing the wall (and causing erosion) and approaching the site via the original entrance.**

#### **INSIDE FRONT COVER:**

**The huge triangular lintel over the low entrance passage at Caisteal Grugaig broch.**

#### **LEFT:**

**Survey in progress at Moat Park.**

### **Acknowledgements**

Thanks are due to all those archaeological surveyors whose hard work and dedication have made this publication and workshop possible - including (in no particular order) staff from AOC Archaeology, Caledonian Air Surveys, Headland Archaeology, Rathmell Archaeology, RCAHMS, Ross and Cromarty Archaeological Services, Rubicon Heritage, WA Heritage and West Coast Archaeological Services. Thanks also to Dr Gordon Barclay, Peter Crow from Forest Research and to Colin Shepherd. A final big thank you to the many Forestry Commission Scotland staff who helped to facilitate the surveys and who organise the ongoing conservation management.





Forestry Commission Scotland serves as the forestry directorate of the Scottish Government and is responsible to Scottish Ministers

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