Ellie Evans

Monitoring Cumbrian Heritage Sites:
Case Studies at Castlerigg Stone Circle and Long Meg & Her Daughters Stone Circle

Greeting / introduction

- From Grange-Over-Sands in south Cumbria, north west England.
- Here are a handful of photographs taken in Grange, just on my phone. A moon rise, some photos of the aurora borealis this year (11 May and 10 October), and the Summer Triangle in the night sky above my house. (Altair, Deneb and Vega).
- Although my presentation is not about Grange, taking photos like these is relevant and I will come back to that.
- How did I get into surveying outdoor heritage sites:
- I studied BA Egyptology at the University of Liverpool as my undergraduate degree which brought me into the world of museums and heritage.
    - I saw this article and, although it isn't something I have studied in depth, thought it would be of interest here. (An article showing how the ancient Egyptian deity Nut may represent the Milky Way in ancient Egyptian art).
    - https://news.artnet.com/art-world/ancient-egyptians-nut-milky-way-2469051
    - The photograph on this slide is one I took on a family holiday to Egypt in December 2010, showing a replica of the circular zodiac in Dendera Temple (the original is now in the Louvre, Paris). Again, this is not something I have ever studied, but may be of interest to people here today.
- I later went on to study, the two-year course, MSc Conservation Practice at Cardiff University where I got hand-on conservation experience working on archaeological finds. (This MSc was interrupted by the Covid-19 pandemic, so half of my final year was spent in lockdown, unable to work in the labs).
    - As part of this MSc I completed work placements at Bolton Museum (including the historic houses Hall I'Th Wood and Smithills Hall), at Cardiff University labs and at an Archaeology Field School in Ireland.

Hawkshead Grammar School Museum

- After my MSc and the worst of the pandemic, I got a job at Hawkshead Grammar School Museum, where I researched the collection and curated exhibitions. This is how I met Mike and Gerrard, through my research about William Pearson, who was a student at the grammar school at the same time as William Wordsworth. I am sure you all know about William Pearson so I won't expand at this time.
- Other job / s.

Introduction

- In 2021, I started my PhD journey at the University of Cumbria (based at the Ambleside campus).

- I wanted to work with heritage, but was worried that access to museums would not be possible with the pandemic, so I decided to focus on outdoor heritage sites and in Cumbria so that I would not need to travel far.
- A key outcome of my research will be a toolkit for heritage organisations to use to help them monitor their heritage sites (in a cost-effective manner). This will be especially useful for small heritage organisations. I have designed the toolkit and used it for my fieldwork in my PhD work and it has very recently been tested by a small heritage organisation who run Nenthead Mines in Cumbria (and their feedback has been really positive).
- I wanted to design a method which would be easy to use and as low cost as possible whilst getting useful data. The photos from my phone I mentioned earlier fit with this idea, as many people have powerful technology with them (a smartphone) and the application of photography can have amazing and useful results.
- I am part of the Centre for National Parks and Protected Areas (CNPPA) within the Cultural Landscapes research theme.

Types of Heritage

- There are two main types of heritage, Natural heritage and Cultural Heritage.
    - Natural heritage is a natural landscape with values such as scientific value (e.g. due to the wildlife and flora there) and/or has aesthetic values and more. But it is not based on man-made structures.
    - Cultural heritage can be sub divided into tangible and intangible heritage.
    - Tangible heritage includes heritage assets you can touch, see, etc.
    - Intangible heritage includes things such as traditions, oral histories, languages, dances, etc.
        - An example of protected intangible heritage is the Welsh Language.
- I mentioned heritage assets, these are things whether they are tangible or intangible which have a heritage value and are often considered in protection and planning processes.

Heritage Values

- This diagram shows the different types of ‘values’ heritage assets can have. Some can have all of these, others only one or two.

Heritage Sites and Monuments

- The focus of my research is outdoor heritage sites.
- A monument is a built structure, this (usually) sits inside a heritage site, which is located within the cultural landscape. There can be multiple heritage sites within a cultural landscape.
- Why do we need conservation? We need conservation and protection of these sites because of a variety of threats and to preserve the heritage for future generations of people.

Threats to Heritage Sites

- Natural disasters / extreme weather
- Environmental change (e.g. climate change)

    - See Trevor Pearson's 2013 English Heritage document on flood risk at English Heritage inland sites.
- Visitor presence:
    - Erosion from footfall
    - Graffiti
    - Littering
    - Pollution from nearby vehicles
- Livestock:
    - Erosion
- Wildlife:
    - Burrowing rabbits – the photograph on the left is of Kendal Castle hill and there are lots of rabbits burrowing in the hill. This can cause the loss of subterranean remains (archaeology) and can impact the structures above ground.
    - Acidity in bird mess, lichens and moss can cause erosion of stone surfaces
    - Microorganisms = micro erosion
    - Plants – growing around and into heritage assets

However:

- It should be noted that threats may also have benefits to other aspects of the site
    - E.g. grazing animals owned by local farmer will be contributing to the local economy
    - Lichens and mosses have ecological benefits- biodiversity
    - Visitors enjoy going to sites and their presence helps to local economy, the education of the wider community and being in outdoor spaces can benefit health and wellbeing.
    - This is why these sites are preserved.

Carrying Capacity:

- A site's carrying capacity is how much the site can undergo without destroying its assets.
- A balance needs to be found between the visitors wants and needs and the site's conservation needs.

To Manage the Carrying Capacity:

- Heritage sites/organisations put in place different controls.
- Regulatory controls & manipulative Controls
    - Regulatory controls are things like open hours, set routes to walk and 'no entry' areas, legal acts to protect heritage.
    - Manipulative controls are subtle ways of persuading visitors to behave in a certain way at a site, e.g. by placing interpretation panels at certain places, or mowing a path into the grass to suggest that people walk there
- Here are some examples of sites with different managements:
    - Visitor Centres
        - Stonehenge (EH)
        - Carlisle Castle (EH)
        - Hill Top (Beatrix Potter's House, National Trust)
        - Vindolanda (Vindolanda Charitable Trust)

        - Cardiff Castle (Cardiff Castle)
    - Free-to-enter sites
        - Kendal Castle
        - Mayburgh Henge
        - King Arthur's Round Table (Eamont Bridge)
        - Avebury Stone Circle
- Here are some examples of different controls at sites.

Heritage Management:

- Historic England's 'Heritage At Risk' form
- English Heritage's Flood Assessment
- Regular checks & condition reports

'Valuing culture and heritage capital: a framework towards informing decision making' (Sagger, Philips & Haque, 2021 (DCMS))

- Identified a need to monitor the loss of heritage assets.
- Heritage assets change over time.
- Deterioration cannot be stopped, only slowed.
- Visitor behaviours.

Questions I wanted to answer:

- How do you monitor loss of heritage assets at outdoor heritage sites in a cost-effective way?
- How do you monitor visitors if it is an unstaffed, free-to-enter site?
- In order to protect and maintain heritage assets, they should be monitored to assess the loss of value, as recommended by DCMS (Sagger, Philips & Haque, 2021).

AIMS:

- To design and critically evaluate a method to monitor visitor behaviour and the physical condition of free-to-enter outdoor heritage sites and monuments in Cumbria.
- Produce a cost-effective toolkit for heritage organisations to use.

OBJECTIVES:

- To critically evaluate existing literature and research in order to select and design a method for surveying sites.
- Using a set of criteria, select a number of sites to monitor and the most appropriate method for monitoring these sites.
- Carry out study x number of times at each site
- Interpret, compare/ contrast results.
- Identify vulnerable areas at the site evidenced by the studies and suggest appropriate conservation strategies or measures to implement.

Research and Review Methods:

- I researched different methods for monitoring visitors heritage sites
- Looking into surveying sites, it became apparent that you could ‘cover more ground’ (or capture more data) using aerial surveys.
- And then I researched different platforms and sensors for site surveys.
    - Platforms are items which are used to mount the sensor (e.g. a tripod, a balloon, a plante). The sensor is the piece of equipment used to record data (e.g. a camera, a laser scanner).
    - One of my favourite methods was the use of pigeons with cameras to take aerial photographs.
    - From previous experience I had carried out site measurements and surveys on the ground.
    - I researched a range of sensors.

Chosen Methods

- From my research, I chose a combinaton of methods for site monitoring.
- Recording heritage sites:
    - Record sites with aerial photography (using a UAV) **repeatedly**.
    - Use the aerial photographs to produce digital 3D models of sites (**photogrammetry**).
    - Compare the 3D models (visually and using software – CloudCompare).
- Visitor route recording:
    - Record number of visitors to a site and their **routes** around the site
    - Paper-and-pencil method (to draw routes visitors have walked onto a paper map)
- Compare:
    - Compare visitor surveys with the site surveys

Equipment & Software

- UAV (unmanned aerial vehicle, aka a drone): DJI Mini2. (photographed here)
- Software: **DroneLink** (used to plan flight routes for the UAV)
    - (DroneLink has various pricing options, the one appropriate for the needs of this project costs a one off payment of £119.99)
    - When planning a site survey to capture images for photogrammetry:
    - Grid pattern
    - Overlap
    - Camera angle
    - Need to consider time constraints (battery life)
- Photogrammetry software: **Agisoft Metashape**
    - Easy to use, the standard version costs around £150 (you can also get a 30 day free trial). Professional costs over £2690!
- Comparison software: **CloudCompare** (a free software, but requires some getting used to!)

Equipment & Software (continued)

- Paper and pencil
- Digitise (scan to jpeg or pdf)
- Trace (PowerPoint or Adobe Illustrator)
- Overlay onto aerial view of 3D model

I had to also consider how to select appropriate sites for my study:

- Site Selection

Access
Permissions
Size of site
Monuments on site
Visitor numbers

- Requirements for sites:

Selected Method
Financial Cost
Practicality for outdoor sites
Portable equipment
Ethical approval and permitted at heritage sites
Easily repeatable, achieves accurate & fast results

Chosen Sites:

- Ambleside Roman Fort
- Castlerigg Stone Circle
- Kendal Castle
- Long Meg & Her Daughters Stone Circle
- Shap Abbey

Obviously, in this presentation I will be focussing on Castlerigg and Long Meg.

Cumbrian Stone Circles

- Cumbria is home to a quarter of the stone circles in the UK and Republic of Ireland
- These include a range of different type of stone circle, spanning from the earlier stone circles (~3200 BCE) to the later ones (~1600 BCE).

Cumbrian Stone Circles Astronomy

- Most alignments relate to the rising & setting of the sun, the moon (small number) and brighter stars
- Used to aid mark solar observations and build a form of calendar
- Marking solstices & equinoxes
- Used to locate the points on the horizon of the rising and setting of the sun on equinoxes. Then stone structures built.
    - Alexander Thom's work
        - 'most of them (stone circles) have no astronomical significance'
        - However, Castlerigg is an exception to this, which has solar alignments (and lunar alignments)!

Pilot Study

- I carried out a pilot study to test and refine the methods of the survey techniques
- I tested out mapping visitor routes
- I compare different UAV altitudes to see how this impacted on the results and the processing time:
    - 40m, 35m, 30m, 25m, 20m
- Quality of 3D model

- Image overlap
- Number of photos
- Flight time

Castlerigg Stone Circle

- Stone Circle close to Keswick.
- Scheduled Monument.
- 38 standing stones.
- (Waterhouse, 1985) (English Heritage 2022a)

Today:

- Located inside LD
- Tourists.
- Locals.
- Rituals & Ceremonies.
- Some sheep grazing.

Background

- Built around 3000 BCE (late Neolithic Period) (Nixon, 2009)
- Site owned by NT and managed by English Heritage.
- A corn field in 1769 (Watson, 2015)
- Skiddaw slate, 38 stones, two (possibly three) cairns (marking burials), Castlerigg as a location for the ”trade in stone axes”.
- In 1883, Castlerigg was scheduled (”one of the first national monuments in England to be scheduled… protected”)(Watson, 2015)
- One formal archaeological dig in 1882

Background continued

- In 1856, evidence of 3 cairns, however, 1985 ‘no trace of them’.
- Artefacts found: 3 stone axes
- 1882, excavation inside the rectangle of stones - nothing found
- ‘*There is nothing quite like the rectangle in any other stone circle in the British Isles*.’ John Waterhouse, 1985
- Alexander Thom considered this site to have great astronomical significance: megalithic geometry and astronomy

Astronomy at Castlerigg Stone Circle

Alexander Thom

- Yellow:
- Aligns S-E marking the position of the rising sun over High Rigg
- And the opposite way marks the point of the summer solstice sun-set
- Red:
- Mid-winter sun-rise from centre of the circle to stone 15.

Anderson

- Orange:
- Sun-rise on the summer solstice
- ‘Celtic Kalendar’ – feast days
- Alignment from centre to a (now missing) outlier stone aligned with sun-rise on May Day and this alignment goes through the middle of Long Meg & Her Daughters.

Flight Plan

- This is the pilot study flight plan used to survey Castlerigg with a UAV
- The photograph overlap was 65% forward 65% side
- The camera was facing 90o (vertically straight downwards)

First 3D model
3D model (colour removed)

First 3D model

- This is the resulting 3D model from the first aerial UAV survey
- As you can see there is a loss of detail around the shapes of the standing stones
- This model is useful as it has recorded areas of standing water on the site
- As well as showing the visible plough lines which run through the site

Visitor Routes

- Here are the pilot study recorded visitor routes on paper maps
- It appears to show that visitors tend to walk around the circular structure

Visitor Routes on 3D Model

- This slide shows the first visitor route map overlaid onto the first 3D model

Second 3D model

- I adjusted the flight plan so that there was more overlap between the photographs taken, 80% forward, 70% sideways
- I also added extra photos to be taken with the camera at a 70 degrees angle after the 90 degrees angle, so that more images of the stones' shapes could be gathered

Second 3D model – animated

Comparison (1)

- Pilot study models Nov 22 and Feb 23.

Comparison (2)

- You can see here how adjusting the flight plan has improved the 3D model, especially the details of the shapes of the stones

Comparison (3)

- Annotated images of the 3D models, showing areas of soil erosion, standing water, mounds, and a central ditch

April 2023

- 3D model from April 2023

(Animation)

Comparison

- The three pilot models compared and annotated

Castlerigg Stone Circle – Visitor Routes

- Visitor routes overlaid onto the 3D model

Pilot Study Conclusions

Visitor Surveys:

- Paper & pencil method (with tally count of visitors)
- Record places where people linger/ meet

Site Mapping:

- Use **25m altitude** for most sites
- Use forward overlap of **80%** and side overlap of **70%**
- Use extra mapping with camera at -70^{o} angle to capture more detail

An interesting feature:

- The 3D models show two circular raised features within the stone circle
- This page from Waterhouse's book shows one of these features
- A ploughed out barrow or remains of a burial mound?

Castlerigg Surveys Continued Beyond Pilot Study

- 3 more aerial surveys took place after the pilot study
- Weather conditions and heavy site visitation during the summer made it difficult to carry out more surveys

Photogrammetry

- Using the UAV, approx.. 160 photos are used to build a 3D model for Castlerigg.

Set of Results

- This slide shows all the aerial views of the Castlerigg 3D models, annotated, and at the bottom is an example of a CloudCompare model and some maps with visitor routes overlaid onto them.

Aerial photo

- What I found is that different weather conditions change the quality and colouring of the 3D models, making some features clearer at certain times.

Long Meg & Her Daughters Stone Circle

- Third largest in England
- Close to Little Salkeld
- Long Meg standing stone is red sandstone
- Her Daughters are a type of granite (rhyolite) & quartz crystal
- Witches turned to stone
- Today:
- Located outside of LD
- Tourists
- Locals
- Rituals & Ceremonies
- Cows grazing over summer

Aerial Photographs

- This slide has two aerial photos, on the left is the stone circle (which I missed Long Meg off) and on the right is Long Meg standing at the ‘entrance’ of the stone circle

Background – image and book page

Background
- Entrance way and direction indicator
- Carvings on the Long Meg stone
- Nearby small stone circle, Little Meg
- Long Meg and Little Meg are linked by an alignment through the centre of Long Meg SC and Little Meg to Fiend’s Fell, marking the point of sun-rise around the day mid way between the spring equinox and summer solstice and summer solstice and the autumn equinox.

Carvings
- One of the more special features at Long Meg are the carvings on the Long Meg stone.
- These are similar to the carvings at Little Meg

The Monument – William Wordsworth

‘*A weight of awe, not easy to be borne,*
Fell suddenly upon my spirit,—cast
From the dread bosom of the unknown past,
When first I saw that family forlorn.
Speak thou, whose massy strength and stature scorn
The power of years,—pre-eminent, and placed
Apart, to overlook the circle vast,—
Speak, giant-mother! tell it to the Morn
While she dispels the cumbrous shades of night;
Let the Moon hear, emerging from a cloud;
At whose behest uprose on British ground
That sisterhood, in hieroglyphic round
Forth-shadowing, some have deemed, the infinite,
The inviolable God, that tames the proud!’

Surveys
- Due to the size of the site, this study only surveyed part of the site, with a focus on Long Meg
- Due to the presence of cows on the site from May to October, UAV surveys could only take place outside of this window.
    - November 2022
    - January 2023
    - April 2023
    - November 2023

First Try (Pilot)
- November 2022
- The first try did not use a flight planning software
- Here is the resulting model!

- (Not so good!)

January 2023
- Pilot study period – same problem as Castlerigg, loss of detail
- Long Meg has all but disappeared!

January 2023 (continued)
- On the image on the left I've annotated where more clear soil erosion was visible
- Animation on the right

April 2023
- This model worked better, more of Long Meg is visible (with a slight chunk missing).
- The image on the right is annotated where there's more wear. You can also see tracks left by a farm vehicle on this aerial view.

April 2023 (continued) – animation

November 2023
- On the left is the aerial view, annotated where visible areas of erosion were.
- On the right is an angled view, the Long Meg stone looks good in the model, and around its base you can see the erosion.

November 2023 (continued) – animation

Visitor Routes at Long Meg
- Here you can see all of the visitor routes tracked at Long Meg from Nov 22 to Nov 23
- There is a dense area around the Long Meg stone, and having visited the site may times, I have seen people leave offerings of flowers, incense and shells at her base.

Combination of Results
- On the left the visitor routes are overlaid onto the aerial view of the 3D model.
- On the right is a Cloud Compare model with visitor routes on top of it.
- Here it is not clear that the Cloud Compare model is showing clear changes at the site

Conclusions
- Benefit of using photogrammetry at a large site is you can fly lower and record a large area in detail
- The use of a small cheaper UAV is cost effective for small heritage organisations
- The visitor survey method is easy to learn and inexpensive
- The development of the toolkit will benefit people/groups who take care of heritage sites