Section A

Institution: University of St Andrews

Unit of Assessment: UoA 07: Earth Systems and Environmental Sciences

Title of case study: Heritage Protection and Preservation using Remotely Sensed Data

Period when the underpinning research was undertaken: 2010 - 2019

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
C. Richard Bates	Reader	01 August 1996 - present

Period when the claimed impact occurred: 01 August 2013 - 31 December 2020

Is this case study continued from a case study submitted in 2014? N

Section B

1. Summary of the impact


Discovery of the oldest human footprints out of Africa

The preservation of heritage to understand humankind's past requires reconstructing fragmentary records to accurately portray past landscapes and cultures. Multidisciplinary research on geophysical remote sensing techniques for mapping, including land and marine palaeo-landscape reconstructions developed by Dr C. Richard Bates, has addressed that challenge by pioneering novel combinations of those techniques. This research has:

(1) **informed UK and Scottish Government policy for the management and conservation of heritage** (UK Offshore Energy SEA 2016) which, for the first time, resulted in a site, Scapa Flow SPA, gaining protected status based entirely on its submerged heritage;

(2) **through digital techniques, preserved archaeological and UNESCO heritage sites** ranging from 800,000-year-old human footprints in the UK to World Heritage Sites in Syria, Tanzania, Croatia, UK, Italy, France and Nepal, including some, such as Palmyra and Durbar Square, lost due to wilful and natural disaster destruction, respectively;

(3) **in Tanzania and Malawi led to government intervention in preserving and managing heritage** such as the UNESCO World Heritage sites at Kilwa Kisiwani (Tanzania) and Chongoni Rock-Art (Malawi);

(4) **provided means for local economic growth** for two community-based heritage enterprises owned by local women's groups and a community heritage museum at Kilwa, Tanzania, thus providing income for local families;

(5) **since August 2013, contributed to wider public understanding**, regionally and globally, through sustained multi-media initiatives, including the British Science Festival (2014) and Royal Society Summer Science Festival (2015) and eight documentaries for the BBC, Discovery Channel and the Travel Channel; and

(6) **through citizen science, engaged the local community** to investigate their local heritage at the Callanish standing stone site on the Isle of Lewis.

2. Underpinning research

Natural decay, climate-change-enhanced weathering, general neglect and deliberate destruction, are threatening the preservation of heritage worldwide. However, preserving 'tangible heritage', the physical features of cultural sites, buildings and monuments, is not always possible and new methods are being developed for creating 3-D virtual reconstructions. Heritage preservation also

requires embracing 'intangible heritage', the oral traditions, arts, rituals and festive events that generate the basis for constructing tangible heritage. Thus, preservation and protection of heritage requires multidiscipline integration across archaeology, anthropology, computer science, geology and sociology, as well the promotion, at local to international levels, about the importance of heritage and its protection.

In 2011, Bates initiated a multi-disciplinary research programme underpinned by his expertise in the use of remote (geophysical) sensing techniques for mapping marine systems (**R1**). To expand into land-based studies, he modified onshore electromagnetic and electrical geophysical surveying methods to be applicable at the scale of valley landscapes (tens of km^2) and undertook detailed characterisation of World Heritage sites at Stonehenge and the Heart of Neolithic Orkney. Because of his ability to develop geophysical techniques to meet the needs of archaeologists and anthropologists, he was invited by the British Museum to participate in the Happisburgh study of ancient human occupation of Britain. His geophysical work reconstructed an 800,000-year-old landscape and led to the remarkable discovery of the oldest known human footprints outside of Africa (**R2**).

Bates recognised that comprehensive reconstruction of heritage and its contemporaneous landscapes and environmental conditions required better integration of land, airborne, marine and non-marine geophysics for building geo-archaeological datasets. Consequently, he focused research on the application of techniques using previously untried combinations of geophysical techniques. For example, in 2016-17, together with a team from Bradford University, new discoveries at Stonehenge revealed a hitherto hidden scale to Durrington Walls super-henge (**R3**) and in 2017-18 led to the discovery of ancient lightning strikes at the centre of the iconic Callanish standing stone circle (**R4**).

He has adopted his skillset to be applicable worldwide. His work has led to new insights and documentation of UNESCO World Heritage sites of Kilwa Kisiwani (**R5**) in Tanzania. In 2015, to address malicious heritage destruction in the Middle East, Bates co-established the multi-institute, multi-disciplinary AHRC-funded digital project for heritage reconstruction, *Curious Travellers: Visualising Heritage*. This required novel remote sensing, multiple-geophysical sensors and imagery methods to digitally record and recreate using photogrammetry tangible heritage (**R6**).

3. References to the research (indicative maximum of six references)

R1-R5 are publication which were peer-reviewed and published in high-ranking journals; R6 is a book chapter published by a multinational academic publisher. These publications are representative of a more extensive body of research.

R1. Bates, C.R., Lawrence, M., Dean, M. & Robertson, P. 2011. Geophysical Methods for Wreck-Site Monitoring: The Rapid Archaeological Site Surveying and Evaluation (RASSE) programme. International Journal of Nautical Archaeology. v 40.2: 404–416 DOI: 10.1111/j.1095-9270.2010.00298.x.

R2. Ashton, A., Lewis, S.G, Parfitt, S., De Groote, I., Duffy, S., Bates, M., **Bates, C.R.,** Hoare P., Lewis, S., Peglar, S., Williams, C. & Stringer, C. 2014. Hominin footprints from Early Pleistocene deposits at Happisburgh, UK. PLOSone, 9(2): e88329, DOI: 10.1371/journal.pone.0088329.

R3. Gaffney, V., Neubauer, W., Garwood, P., Gaffney, C., Löcker, K., **Bates, R.**, De Smedt, P., Baldwin, E., Chapman, H., Hinterleitner, A., Wallner, M., Nau, E., Filzwieser, R., Kainz, J., Trausmuth, T., Schneidhofer, P., Zotti, G., Lugmayer, A., Trinks, I. & Corkum, A. 2018, 'Durrington Walls and the Stonehenge Hidden Landscape Project 2010-2016' Archaeological Prospection, vol. 25(3) pp. 255-269. DOI: 10.1002/arp.1707.

R4. Bates, C.R., Bates, M., Gaffney, C., Gaffney, C., Gaffney, V and Raub,T. D.2019. Geophysical investigation of the Neolithic Calanais Landscape. Remote Sensing, v., 11, 24, 2975. DOI: 10.3390/rs11242975

R5. Pollard, E., **Bates, C.R.**, Ichumbaki, E. & Bita, C. 2016. Shipwreck evidence from Kilwa, Tanzania. International Journal of Nautical Archaeology 45(2), p.352-369. DOI: 10.1111/1095-9270.12185.

R6. Wilson A.S, Gaffney V.L, Gaffney C.F., Ch'ng, E., **Bates, C.R.**, Sears, G., Sparrow, T., Murgatroyd, A., Faber, E. & Coningham, R. 2019. Curious Travellers: Repurposing imagery to manage and interpret threatened monuments, sites and landscapes. In: Dawson, M., James, E. & Nevell, M. (Eds) Heritage Under Pressure - Threats and Solutions. Studies of Agency and Soft Power in the Historic Environment. Oxford: Oxbow. 107-122. hdl.handle.net/10454/17623: ISBN: 9781789252460

4. Details of the impact

Bates' digital heritage preservation research underpinned by geophysical remote sensing techniques, as described in section 2, has:

(1) changed UK and Scottish Government policy (UK Offshore Energy SEA 2016) resulting in a new heritage-based SPA, Scapa Flow;

(2) helped to develop geophysical techniques which have digitally preserved the oldest human footprints outside Africa and UNESCO World Heritage Sites in more than 7 countries, including the destroyed sites of Palmyra, Syria and Durbar Square, Nepal;

(3) safeguarded, through government intervention, additional World Heritage sites in Tanzania and Malawi, such as Kilwa Kisiwani, the Leaky Lateoli (out of Africa) footprints and Chongoni Rock-Art Malawi;

(4) provided new means for economic growth through two woman-owned enterprise companies in Tanzania;

(5) contributed to wider public understanding by conducting a sustained programme of multi-media public engagement on heritage issues stemming from the research. These included two UK science festivals and eight documentaries for the BBC, Discovery Channel and the Travel Channel, which reached a world-wide audience; and,

(6) engaged the local community on the Isle of Lewis, Scotland, with their heritage through citizen science to investigate the wider Neolithic landscape of Callanish.

(1) Informed UK and Scottish Government policy for the management and conservation of heritage. Bates' research providing geophysical background, fundamental geophysical development (**R1**) and landscape modelling on drowned archaeological landscapes for Historic Environment Scotland has been central in making policy for marine Special Protection Areas (SPA) and led to the first ever SPA based on heritage, Scapa Flow: "…*work of St Andrews University has had a direct bearing on the advice and documentation we have provided to the Scottish Government…to designate the Scapa Flow Historic Marine Protected Area*" (**S1**). This was as a result of production of Marine Guidance Notes for Historic England on offshore survey, which the UK Government adopted as policy for the development and exploration of the North Sea in its Offshore Energy Strategic Environmental Assessment (OESEA) programme; this mandates directly protection of areas with high archaeological potential, many identified by Bates and colleagues (**R1** is representative of a body of work which goes back to 2001). In March 2016, Seafloor modelling by Bates was directly used in OESEA3 (**R2**, **S2**).

(2) Digital cultural preservation of archaeological and World Heritage sites. This includes the discovery, virtual documentation and preservation of the 800,000-year-old landscape off Norfolk and the discovery of the oldest human footprints outside of Africa (**R2,** Dec. 2020 Altmetric score of more than 959). A Senior Curator at the British Museum writes that the discovery received "*widespread coverage by all UK television and radio networks… with over 250 newspaper reports around the world*" and though *"news is short-lived, so it is more gratifying to see how the footprints have endured in other, sometimes unexpected, ways*" (**S3**). The discovery was also part of three exhibitions, including a fundamental role in the Natural History Museum (NHM) special exhibit, First Britons (Britain: One Million years of Human Story). In total, the NHM exhibits received over 108,000 people (visitors) and featured in at least four popular books, including "The Road to Little Dribbling: More notes from a Small Island" written by Bill Bryson after he visited the research site in 2015. *"The story of the Happisburgh footprints has left a mark on an astonishingly wide array of audiences, but this has only been through detailed research of the archaeology, biology and geology at the site and the relationships of those studies brought together through the geophysics*" (**S3**).

The *Curious Travellers* project (**R6**) pioneered the combination of academic and public-sourced photos and images using an international crowd-participation platform, thereby promoting widespread public, academic and government engagement with research. Its global call for donation of photographs of World Heritage Sites in Syria, Tanzania, Croatia, UK, Italy, France and Nepal resulted in gathering over 16,000,000 images from over 165 countries and regions (**S4, pp. 1&2**). As a result, since 2016, full digital reconstructions of key historical sites, including Palmyra, Kilwa Kisiwani, Split, Fountains Abbey, Basilica of St Benedict, Notre Dame and Durbar Square, were created for the preservation of these iconic sites, including ones which had been destroyed (Palmyra and Durbar Square) for future generations (**S4, pp. 3-6**). The project was initiated by Bates who contributed geophysical data to the development of the methodology while Bradford University contributed digital model building.

(3) In ODA settings, Government interventions in preserving and managing World Heritage sites. Research on marine sites in Tanzania (**R5**) led to the development in 2019 of the first National Digital Heritage Databases for Tanzania and Malawi. These databases consist of over 300 sites not collectively recorded previously and include World Heritage Sites such as Kilwa Kisiwan (Tanzania) and Chongoni Rock-Art Area (Malawi) (**S5**). In 2020, in response to a request for help to preserve the world's oldest footprints at Lateoli, the Government of Tanzania adopted the database to preserve, manage and market its rich cultural past and meet national strategic development goals. The Permanent Secretary, Ministry of Natural Resources and Tourism, Tanzania, stated that the National Data Base *"...has been fully adopted by the Government of Tanzania as it represents a step-change in how tangible and intangible heritage will be recorded in the future. We view this as not only paramount to helping but also that it fits directly in line with our regional and national goals for increased prosperity under Africa Agenda 2063, and the desire to raise the number of tourists in Tanzania…."* (**S5, p. 6**). For the Tanzanian work, Bates led on background heritage research with University of Dar es Salaam providing archaeological context.

(4) Delivered new means for local economic growth in Tanzania through two women-owned businesses. An outcome of Bates' research that has helped define new governmental policy and protocols for heritage management in Tanzania (**R6**) is an increased sense of heritage ownership by local communities. This has generated a spirit of entrepreneurism and led to creation of two new businesses at Kilwa and Bagamoyo that are run by local women's groups for heritage tourism, a service which wasn't available before. These are part of the Sustainable Preservation Initiative and both are now completely self-sustaining, supporting local women and their families and providing not only income in impoverished areas of Tanzania but helping to establish the beginnings of gender equality as well as the building in 2020 of a new community heritage museum at Kilwa Kisiwani (**S6**).

(5) Contributed to wider public understanding through sustained media engagement. Since Aug. 2013, Bates has undertaken a deliberate and sustained programme of social engagement of the research through public events and other media. Examples include:

- The Stonehenge World Heritage site work that discovered over 120 new monuments (**R3**) stimulated international interest when presented at the British Science Festival 2014 and Royal Society Summer Science Festival 2015 - over 13,000 people (public; children to adults) in attendance and over 50,000 people online (**S7**). The ensuing global media coverage (Guardian Science and Naked Scientists podcasts with more than 10,000 people (listeners) and the Royal Society's YouTube channel with more than 22,000 views), resulted in the research team winning the prestigious public-voted Current Archaeology Awards' Research Project of the Year 2017 (**S8, pp. 1&2**).
- The application of geophysical research to the eroding coastlines of Norfolk led to the discovery of the first (800,000yr old) hominin footprints in Europe at Happisburgh in 2015 (**R2**). This discovery was extensively covered by international news (reported by 68 global news outlets worldwide and is included in 5 Wikipedia pages) (**S8, pp. 3-5**) and led to the public voting it Current Archaeology Awards' Rescue Dig of the Year 2015 for "First Impressions: discovering the earliest footprints in Europe" (**S8, pp. 6&7**).
- Since 2014, Bates has regularly communicated his research with public audiences through media outlets. Between 2017 and 2019, Bates' research findings on the use of geophysics in

reconstructing past landscapes and human endeavours has featured in eight documentaries for the BBC, Discovery Channel and the Travel Channel (**S9**). Operation Orkney, a BBC 3-part series based on his work led to an additional 3 programmes by the US Travel Channel which used Bates' work in Scotland, India and Namibia (e.g. **R6**) for a series of heritage programmes. In 2020, a BBC Landward episode about the Callanish research, which was undertaken by Bates and community volunteers (**R4**), achieved an increase of approximately 3.5 times the typical viewing numbers to 835,000 people (**S9, p. 2**).

- A novel way of engaging audiences with issues facing the World Heritage Kilwa Kisiwani site in Tanzania where the research findings (**R5**) were woven together with indigenous Swahili song and modern (Bongo Flava – rap) music in the form of musical videos. The result, 'Kilwa, Our Heritage' engaged local communities and hard to reach audiences with the research and further made international audiences aware of the site. A commissioned video for UNESCO based on country-wide African heritage research ('Africa, Our Heritage', over 81,000 views as of Dec. 2020) was launched at their headquarters in Paris on 23rd May 2018 (**S10**) and a musical video, 'Bahati Yeti' (Our Ocean), that addresses the issues for local communities around indigenous boat building and fishing, was released in December 2020 and achieved over 10,000 views in the first week of viewing.

(6) Engaging the local community on the Isle of Lewis, Scotland with their heritage through citizen science

In 2018, to encourage more community-level public participation in recording heritage at risk, two projects were initiated on the Isle of Lewis with the Comunn Eachdraidh Nis (a historical society that collects and preserves local history) and the Callanish Visitor Centres: Digital Landscapes and What Lies Beneath the Peat, respectively. According to the Project Delivery Director at Calanais Standing Stones Trust, Bates' "*research at the Calanais sites has also been inspirational for the design of our expanded visitor centre with its focus on digital content and delivery*" and in 2018 "*saw 70 local residents attend [a] session to learn more about the work…into this historic landscape"* (**S11**). Part of the research team's engagement included the development of new online material for the Visitor Centre at Callanish (Calanais), which streamed from the lightning strike discovery (**R4**), as short films and broadcast on social media. These posts "…*outperformed our usual posts with an average reach of 7,000 per post which is 7 times our usual"*. This led directly to the community organising and successfully winning GBP40,000 from Historic Environmental Scotland to fund a community-led project investigating the wider Neolithic landscape of Callanish (**S11**). Bates was the Principal Investigator for the geophysical investigation, digital reconstruction and archaeological interpretation of the data.

5. Sources to corroborate the impact

S1. Letter from Historic Environment Scotland on Marine SPA for Scapa Flow

S2. Offshore Energy Strategic Environmental Assessments OESEA3

S3. Letter of support from the Senior Curator Palaeolithic Archaeology, British Museum.

S4. Data analysis of Curious Travellers project

S5. National Data Base Tanzania, letter from the Permanent Secretary, Government of Tanzania

S6. Letter of support from Kilwa/Bagamoya women group

S7. Attendance numbers provided by the Royal Society

S8. Current Archaeology: Research Project of the Year Awards & Footprint media coverage

S9. Television documentaries and programmes

S10. UNESCO Africa Heritage video and views

S11. Letter from the Project Delivery Director at Calanais Standing Stones Trust (Callanish Visitor Centre)