

## Impact case study (REF3)

<b>Institution:</b> Bournemouth University		
<b>Unit of Assessment:</b> 14		
<b>Title of case study:</b> Discovering and preserving human fossil footprints at White Sands National Park, United States		
<b>Period when the underpinning research was undertaken:</b> 2009 – 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Professor Matthew Bennett	Professor in Environmental and Geographical Sciences	2002-current
Professor Marcin Budka	Professor in Data Science	2005-current
Dr Sally Reynolds	Principal Academic, Hominin Palaeoecology	2015-current
<b>Period when the claimed impact occurred:</b> 2018 – 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<b>1. Summary of the impact</b> (indicative maximum 100 words)		
<p>Researchers at Bournemouth University (BU) used digital analysis to confirm the presence of human fossil footprints at White Sands National Park, New Mexico. This discovery, and the ensuing media attention:</p> <ul style="list-style-type: none"> <li>• Led to stronger site conservation and management, using bespoke freeware developed by BU to digitally preserve the footprints.</li> <li>• Contributed to the upgrading of the US National Monument to National Park in December 2019, with the crucial inclusion of 'palaeontology' and 'archaeology' in its founding legislation.</li> <li>• Contributed to, via re-designation, an additional USD6,000,000 (an increase of 16%) for the local economy.</li> <li>• Helped increase visitor numbers – by 18% in February 2020 and by 12% in September/October 2020 – despite the impact of Covid-19.</li> </ul>		
<b>2. Underpinning research</b> (indicative maximum 500 words)		
<p>Fossil footprints are an important, but neglected, part of the palaeontological and archaeological record. Bennett is a recognised authority on human footprints, having published widely on the subject and authored the only research text on the subject [R1], a reputation built on his work on the second oldest footprints in the world published in <i>Science</i> 2009 [R2]. His work was supported by a GBP316,599 Natural Environment Research Council (NERC) grant (2010-13), which developed analytical approaches for the capture and analysis of human footprints. This work was translated into the freeware DigTrace, via a GBP97,487 NERC Innovation grant [R3]. DigTrace and similar 'Structure from Motion' photogrammetry approaches have revolutionised vertebrate ichnology, providing data for advanced biomechanical analysis, enhanced visualisation, and the preservation of fragile fossil footprints.</p> <p>DigTrace was essential to this research and to track preservation. One of the key publications [R4] was 35<sup>th</sup> out of the top 200 palaeontological papers in 2018, and casts of the fossil tracks described are on display in the Peabody Museum at Harvard University. In December 2020,</p>		

PLOS SciComm listed the findings as number one in its 'Top 9 discoveries in human evolution, 2020 edition'.

The research is ongoing including the discovery and analysis of the longest known human trackway so far reported [R5]. Significantly the team have also pioneered the geo-prospection of human tracks using geophysical methods [R6, R7]. Three popular articles linked to this research in *The Conversation* have a combined number of reads in excess of 410,000, and the work has featured in: *National Geographic*, *New York Times*, *Daily Telegraph*, *The Times*, *Atlantic*, *BBC Radio*, *Gizmodo*, *Live Science*, *New Scientist* and many more. The team exhibited at the Royal Society Summer Exhibition in 2018 and New Scientist Live in 2019. A Leverhulme Research grant was awarded in 2020 to one of the team at the Royal Veterinary College for ongoing work at WHSA.

### 3. References to the research (indicative maximum 6 references)

All references were subject to rigorous peer review; R4 was ranked 35<sup>th</sup> out of 200 palaeontological papers in 2018.

**R1:** Bennett, M.R., Morse, S.A. (2014). "Human footprints: fossilised locomotion?" Springer International. <https://www.springer.com/gp/book/9783319085715>. (Book available on request.)

**R2:** Bennett, M.R., et al. (2009). "Early Hominin Foot Morphology Based on 1.5-Million-Year-Old Footprints from Ileret, Kenya," *Science* 323, pp. 1197-1201. DOI: [10.1126/science.1168132](https://doi.org/10.1126/science.1168132).

**R3:** Bennett, M.R., Budka, M. (2018). "Digital technology for forensic footwear analysis and vertebrate ichnology," Springer International. <https://link.springer.com/book/10.1007/978-3-319-93689-5>. (Book available on request.)

**R4:** Bustos, D., Jakeway, J., Urban, T.M., Holliday, V.T., Bennett, M.R. (2018). "Footprints preserve terminal Pleistocene hunt? Human-sloth interactions in North America," *Science Advances*, 4. DOI: [10.1126/sciadv.aar7621](https://doi.org/10.1126/sciadv.aar7621).

**R5:** Bennett, M.R., et al. (2020). "Walking in mud: Remarkable Pleistocene human trackways from White Sands National Park (New Mexico)," *Quaternary Science Reviews*, 249, 106610. DOI: [10.1016/j.quascirev.2020.106610](https://doi.org/10.1016/j.quascirev.2020.106610).

**R6:** Urban, T.M., Bustos, D., Jakeway, J., Manning, S. W., Bennett, M.R. (2018). "Use of magnetometry for detecting and documenting multi-species Pleistocene megafauna tracks at White Sands National Monument, New Mexico, USA," *Quaternary Science Reviews*, 199, pp. 206-213. DOI: [10.1016/j.quascirev.2018.07.012](https://doi.org/10.1016/j.quascirev.2018.07.012).

**R7:** Urban, T.M., Bennett, M.R., Bustos, D., Manning, S.W., Reynolds, S.C., Belvedere, M., Odess, D. and Santucci, V.L. (2019). "3-D radar imaging unlocks the untapped behavioural and biomechanical archive of Pleistocene ghost tracks," *Scientific Reports* 9, pp. 1-10. DOI: [10.1038/s41598-019-52996-8](https://doi.org/10.1038/s41598-019-52996-8).

### 4. Details of the impact (indicative maximum 750 words)

In January 2017, the US National Park Service (NPS) was not sure how to proceed: they knew they had tracks of Ice Age animals at WHSA such as giant ground sloth and mammoth, but did they have human tracks? If they did, how old were they, what stories could they tell that would inspire visitors, and how should they be conserved? The last point was critical since the NPS has a legal responsibility to preserve natural heritage in designated areas. The problem is the tracks are located on an eroding gypsum lake-bed in co-use with the US Military. The White Sands Missile Range surrounds the WHSA. The Missile Range is famous as the site of the first nuclear test (Trinity Site), the historical home of NASA, numerous missile tests and now the landing site for the NASA/Boeing Starliner.

The tracks, known locally as 'ghost tracks', only appear under certain moisture conditions, making the management of this resource difficult. The NPS had no protocol for managing this resource; moreover, they had no money to do so. Federal funding within the NPS is dependent on the founding legislation for each Monument/Park and funds are only awarded for designated conservation interests. In this case, the only identified interest was the 'largest gypsum dunes in the world'. Added to which, they had just started to negotiate a land swap with their military neighbours and, at the instigation of the local US Senator (Martin Heinrich), begun to explore a switch from Monument to Park. The NPS reached out to Bennett in June 2016 for advice based on [R1]. Bennett attended White Sands National Monument (WHSA) for the first time in January 2017. He has visited a further 10 times both for fieldwork and to help NPS staff revise their visitor experience.

Research collaboration ensued between Bennett and David Bustos, Resource Manager at WHSA, with the support of the Park's Superintendent Marie Sauter and the head office in Washington DC. Human footprints were quickly confirmed and their interaction with Ice Age animals explored. Through this research [R4, R5], and the use of DigTrace, Bennett helped the NPS develop conservation management methods and approaches, enabling them to conserve digitally this eroding resource. Methods for mapping hidden tracks using geophysics were developed [R6, R7]. As a consequence, NPS staff had the tools to map the tracks and interact with their military neighbours from a position of knowledge for the first time.

The first big publication [R4], which was led, written, and co-ordinated by Bennett as corresponding author, not only confirmed the presence of fossil human tracks, but described how those humans were actively hunting giant ground sloth. This work attracted a significant media profile, including a feature in a French/German documentary in 2019 (*Terra X*). It is also due to feature in an episode of *Ancient Mysteries Decoded* (*Discovery*, 2021) and a *Nova Documentary* for PBS America in 2021. NPS statistics indicate that the Advertising Value Equivalency (AVE) of the media coverage was USD762,923, with the story covered in 136 US news publications. Trending themes were words such as: "footprints", "Bennett", and "Ice Age", with "White Sands National Monument" mentioned 121 times.

This platform of public interest was used in May 2018 by Heinrich and US Representative Xochitl Torres Small to launch draft legislation to re-designate the Monument as a Park and include the words palaeontology and archaeology in the founding legislation [E1]. Independent research undertaken by the non-profit research group Headwaters Economics at the time suggested that the economic impact to the local economy of Alamogordo (Otero County) was likely to be worth USD6,000,000 per annum due to an enhanced number of visitors [E2].

The legislative process was slow, with a number of false starts. A letter from Heinrich to Bustos (4 June 2018) shows awareness of the research [E3], however, the influence became clearer when, in June 2019, Heinrich appeared before a crucial Senate Sub-Committee (19 June 2019). In this he describes the hunting scene from the key paper [R4; E4]. In fact, it is the *only* evidence that he provides at this hearing for how important this site is.

In December 2019 President Trump signed the name change, new founding legislation, and associated land swap into law, and White Sands became the 62<sup>nd</sup> National Park in America.

On the 23 December 2019 Bustos wrote to Bennett [E5], confirming the importance of the track research to the legislative success, a fact acknowledged further by the NPS's Chief of Science and Research, and Senior Palaeontologist [E6, E7]. A letter from the Sant [sic] Director of the Smithsonian National Museum confirms just how important the site is within the Americas [E8].

Due to Covid-19, evidencing the increase in visitor numbers, and therefore direct economic benefit, following re-designation is difficult at the time of writing since the Park was closed for much of 2020. However, visitor numbers in February 2020 were up by approximately 18%, by

15% in September 2020 and 12% in October 2020, with resulting benefits to the local economy [E9].

The role of DigTrace in helping the NPS develop its conservation management and visitor plans at WHSA is evidenced in a letter from the Chief of Science and Research at NPS [E10]. Research into the tracks at White Sands continues, with enhanced federal funding due in the 2020/21 fiscal year and a re-design of their visitor experience underway.

#### 5. Sources to corroborate the impact (indicative maximum of 10 references)

##### E1:

E1a. US Senator Martin Heinrich, (2018). *Heinrich introduces White Sands National Park Establishment Act*. [online] Available at: <https://www.heinrich.senate.gov/press-releases/heinrich-introduces-white-sands-national-park-establishment-act> [Accessed 8 February 2021].

E1b. A Bill to establish the White Sands National Park in the State of New Mexico as a unit of the National Park System, and for other purposes, S.1582, 116<sup>th</sup> Cong. (2019).

E1c. Heinrich.senate.gov. (2018). *U.S. Senator Martin Heinrich of New Mexico*. [online] Available at: <https://www.heinrich.senate.gov/download/white-sands-national-park-establishment-act-fact-sheet> [Accessed 8 February 2021].

##### E2:

E2a. US Senate Energy and Natural Resources Committee, (2019). *Statement of P. Daniel Smith, Deputy Director, National Park Service, US Department of the Interior*.

E2b. Las Cruces Sun-News. (2018). *Path to national park? U.S. Senator unveils bill to upgrade White Sands monument*. [online] Available at: <https://eu.lcsun-news.com/story/news/local/2018/05/04/senator-martin-heinrich-unveils-bill-upgrade-white-sands-monument/582628002/> [Accessed 8 February 2021].

E3: US Senator Martin Heinrich. (2018). Letter, 4 June.

E4: US Senate. (2019). *Archived webcast*. [video] Available at: <https://www.energy.senate.gov/hearings/2019/6/subcommittee-on-national-parks-legislative-hearing> [Accessed 8 February 2021].

E5: National Park Service. (2019). Letter, 23 December.

E6: National Park Service. (2020). Letter, 30 August.

E7: Office of Senator Heinrich. (2020). Email, 14 October.

E8: Smithsonian National Museum. (2020). Letter, 14 September 2020.

##### E9:

E9a. White Sands National Park. (2020). Email, 15 October.

E9b. Integrated Resource Management Applications (2020) *National Park Service Visitor Use Statistics, Recreation Visits by Month: White Sands NP*, Available at: <https://bit.ly/3qlfz5X> [Accessed 15/01/2021].

E10: National Park Service. (2019). Letter, 12 April.