Institution: University of Bristol		
Unit of Assessment: 5) Biological Sciences		
Title of case study: Translating evidence into conservation policy and practice for bats		
Period when the underpinning research was undertaken: 2009 - 2020		
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:**
Gareth Jones	Professor of Biological Sciences	02/1985 - present
Period when the claimed impact occurred: 1st August 2013 - 2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact

Biodiversity faces anthropogenic threats including habitat loss and disturbance. University of Bristol research into the effect of these threats has informed guidance and policy for bat conservation nationally and internationally, especially in the EU: new UK licensing procedures now require compulsory training of consultants in the methods established by our research. Changes to policy and practice have ensured the conservation of threatened bat roosts, including historic and culturally significant buildings. Consensus between historic building and wildlife conservation groups has improved the public perception of bats, especially important given increased negative perceptions during the COVID-19 pandemic. Collaborative research with ecological consultancies has also informed the development of acoustic deterrents for bat mitigation at large infrastructure projects.

2. Underpinning research

The International Union for the Conservation of Nature (IUCN) lists a third of bat species globally as threatened or data deficient. Loss of roost and foraging sites is the greatest threat to bat species worldwide, and many bat populations are in decline. Evidence-based research is fundamental for informing national and international conservation policy and practice for the management of bat populations. Bat species play crucial ecological roles as pollinators, seed dispersers and suppressors of pests in many ecosystems yet are among the most under-studied mammals. University of Bristol (UoB) research [1-6] led by Prof Gareth Jones has been used to inform conservation decisions to mitigate negative impacts and manage protected bat species with a particular focus on historic buildings and artificial light at night.

Churches are important features of the historic landscape of England. Damage to historical artefacts from bat urine and droppings is a widespread problem. Bats are legally protected because of historic population declines, hence developing mutually beneficial solutions for both bats and church conservation is important. In collaboration with the Bat Conservation Trust, Natural England and the Church of England, and with funding from Defra, SITA Trust and English Heritage [i-iii], UoB research assessed the impact of management actions for bat populations. Radio-tracking data and population modelling showed that excluding bats from churches is likely to have a negative impact on their welfare and conservation status, but that novel solutions such as judicious use of deterrents, especially high intensity ultrasound, and construction of bespoke roost spaces can mitigate problems [1]. Acoustic deterrents have also been implemented in novel ways to potentially deter bats from tunnels along proposed high-profile railway developments [iv, v], following evidence-based research [2]. Novel methodologies were evaluated by using thermal

imaging cameras to monitor how bats responded to broadcast ultrasound via a BBSRC Impact Acceleration award [vi].

Large roosts of bats can cause problems in domestic dwellings. Radio tracking was employed to investigate the impact of exclusion from dwellings on survival, roosting and foraging behaviour. Following exclusion, soprano pipistrelles found alternative roosts and no difference in roosting or foraging behaviour before and after exclusion was found. Population modelling showed that any reduction in survival following exclusion could have a negative impact on population growth, whereas a reduction in productivity would have less effect. While the number of soprano pipistrelle exclusions currently licensed each year is likely to have little effect on local populations, the cumulative impacts of licensing the destruction of large numbers of roosts would be of concern [3].

NERC-funded UoB research [vii, viii] has also investigated the impact of artificial street lighting for bat behaviours crucial for survival, including foraging and reproduction. Bats are almost exclusively nocturnal and therefore highly vulnerable to artificial lighting at night. The research revealed negative effects of street lighting on bats, including changes in the use of established flight routes and commuting behaviour [4]; it has also identified consequences of switching to novel LED and metal halide lighting [5], which reduce carbon dioxide emissions. This research highlighted the complexities of simultaneously meeting targets for reduction in greenhouse gas emissions and biodiversity loss, and the need to carefully test new technologies. The research also identified potential mitigation methods such as dimming or spectral change to minimise the detrimental effects of lighting on bats [6].

3. References to the research

1) Zeale MRK, Bennitt E, Newson SE, Packman C, Browne WJ, Harris S, **Jones G** & Stone E. (2016). Mitigating the impact of bats in historic churches: the response of Natterer's bats *Myotis nattereri* to artificial roosts and deterrence. *PLoS ONE* 11: E0146782. DOI:10.1371/journal.pone.0146782

2) Gilmour LGV, Holderied MW, Pickering SPC & **Jones G.** (2020). Comparing acoustic and radar deterrence methods as mitigation measures to reduce human-bat impacts and conservation conflicts. *PLoS ONE* 15: E0228668. DOI:10.1371/journal.pone.0228668

3) Stone E, Zeale MRK, Newson SE, Browne WJ, Harris S & **Jones G.** (2015). Managing conflict between bats and humans: the response of soprano pipistrelles (*Pipistrellus pygmaeus*) to exclusion from roosts in houses. *PLoS ONE* 10: E013182. DOI:10.1371/journal.pone.0131825

4) Stone EL, **Jones G** & Harris S. (2009). Street lighting disturbs commuting bats. *Current Biology,* 19, 1123–1127. DOI:10.1016/j.cub.2009.05.058

5) Stone EL, Wakefield A, Harris S & **Jones G.** (2015). The impacts of new street light technologies: experimentally testing the effects on bats of changing from low pressure sodium to white metal halide. *Philosophical Transactions of the Royal Society London, B*. 370: 2014012S. DOI:10.1098/rstb.2014.0127

6) Zeale MRK, Stone EL, Zeale E, Browne WJ, Harris S & **Jones G.** (2018). Experimentally manipulating light spectra reveals the importance of dark corridors for commuting bats. *Global Change Biology* **24**: 5909-5918. DOI:10.1111/gcb.14462

Grant Information:

i) **Jones G**. Improving mitigation success where bats occupy houses and historic buildings, particularly churches, Defra, 2011-2014, GBP602,430

ii) **Jones G.** Bats, churches and the landscape: sustainable conservation of bats in the East of England, SITA Trust, 2011-2014, GBP96,000

iii) **Jones G**. Management of bats in churches, English Heritage, 2014-2015, GBP100,000

iv) **Jones G**. Deterring bats from tunnels, Ecology Consultancy, 2016-2018, GBP34,000

v) **Jones, G**. Evaluating methods to deter bats from approaching wind turbines, NERC-funded CASE studentship (with Ecotricity) 2014-2019, GBP78,445

vi) **Jones, G**. Implementing 3D thermal imaging tracking to minimise bat fatalities at wind farms. BBSRC IAA, 2015-2016, GBP10,538

vii) **Jones G.** Experimental approaches to determine the impacts of light pollution: field studies on bats and insects. NERC, 2012-2015, GBP559,705

viii) **Jones G**. The effects of new street lighting technologies on British bat species. NERC, 2013-2019, GBP80,000

4. Details of the impact

Informed conservation guidance and policy nationally and internationally

UoB research led by Prof Jones is cited in European guidance for the conservation and management of bats, including the 2018 European Commission's 'Action Plan for the Conservation of All Bat Species in the European Union (2018-2024)' [A]. Research outlined here on artificial lighting [4, 5] resulted in authorship of the Eurobats publication 'Guidelines for consideration of bats in lighting project' [B]. The guidelines were developed in pursuance of Resolution 7.13 on Implementation of the Conservation and Management Plan established under the EU Convention on the Conservation of Migratory Species of Wild Animals, commissioned by the United Nations Environment Programme (UNEP)/EUROBATS Secretariat (Bonn). Artificial light at night is increasing globally in quantity, especially through street lighting, and the spectral quality of lighting is changing due to the transition to LEDs. Our research [4, 5, 6] has informed recommendations to limit the impacts of artificial light on: i) feeding areas and commuting routes (Table 5.1 p.39.), and ii) on roosts (Table 5.3 p.43.) [B]. For example, the recommendation *'conserve dark areas'* was informed by [4], and *'adapt lamp spectra'* by [5] and [6].

Concurrently in 2018, updated UK guidance covering 'Bats and artificial lighting' produced by the Bat Conservation Trust (BCT) and Institute for Lighting Professionals (ILP) [C], incorporated the body of work led by Jones [e.g. 4-6], which *'significantly increased [our] knowledge about the impact of artificial lighting'* [H] and recommended measures for mitigating impacts of artificial lighting. The lighting research [4, 5] also informed Defra's Biodiversity 2020 report [D], which cites this work to highlight the vulnerability of bats to light pollution (p.67).

Informed new licensing procedures and changing practice in ecological consultancies

Protection by law requires that anyone surveying bats must have a licence to prevent disturbance of roosts. UoB research has resulted in the introduction of new licensing procedures for training bat conservation consultants to implement mitigation in churches [E]. The English Statutory Nature Conservation Organisation, Natural England, brought in new licensing arrangements in 2015 to train consultants in our methods proposed and developed in [1], such as installing bespoke bat boxes [E]. The team at Natural England responsible for developing the 'Bats in Churches Class Licence' note that studies led by Prof Jones *'have informed the content of the licence itself (e.g. licensed activities, conditions) and guidance'* [F]. To date 27 ecologists from commercial and public bodies carrying out ecological surveys have been successfully trained in these new methodologies and are currently registered to use the licence [H] and bat mitigation systems have been installed in seven churches despite limitations on implementation caused by COVID-19 in 2020 [Jiii].

The Bat Conservation Trust (BCT) runs training courses for professional ecologists and cites Prof

Jones' work extensively to inform practice guidance, including acoustic surveys, radio tracking including 20 papers cited in 'Bat Surveys for Professional Ecologists' [H]. These guidelines are *'the authoritative reference for bat surveys by Natural England, Scottish Natural Heritage, Natural Resource Wales and Northern Ireland Environment Agency licensing'* [I].

Our work on acoustic deterrence [2] evolved into developing methods for deterring bats from tunnels along the proposed HS2 route. The research involved collaboration with the Ecology Consultancy, linking academics with practitioners, proved effective in deterring bats, and won two awards from the Acoustics & Noise Consultants (2019) [I].

Conserved roosts of threatened bat species and aided conservation of historic and culturally significant buildings

Since 2017, GBP5,000,000 of funding from the Heritage Lottery Fund has been secured for mitigation actions, bringing together church and wildlife conservation groups [H]. This funding is being used to deliver a five-year partnership project, bringing together wildlife, heritage conservation and church organisations to save bats and protect churches so that future generations can enjoy and benefit from both. The project is supporting 102 of the most severely impacted church communities across 26 counties in England, to reduce the negative consequences of bats on the church, without harming the bats. The churches supported are *'home to locally and even nationally important roosts'* [H].

The project is also creating a new network of fully trained volunteers who can undertake bat surveys and support congregations who have bat roosts at their church. The network also provides training for professional ecologists and historic building specialists in new techniques, enhancing knowledge and improve their advice to congregations. In 2016, a one-day conference was attended by national and local representatives from the church, built heritage and conservation sectors [H]. Natural England is working in partnership with the Church of England, Historic England, Bat Conservation Trust, and the Churches Conservation Trust to deliver this ambitious and innovative project. Key outcomes to date include:

i) Created consensus between historic building and wildlife conservation groups

Prior to our work, considerable conflict existed between church conservation groups and bat conservationists. St Nicholas' Church in Stanford on Avon is a Grade 1 listed building that contains monuments dating from the 16th-19th century. Many of these monuments were damaged by bat droppings and urine, with >GBP60,000 spent on restoring them. Underpinning research [1] led to exclusion of the bats from the roost, whilst providing suitable alternative roosts located nearby, verified through radio tracking. In effect, artificial roosts have been created on the outside and the inside of the church, and there are signs that these are beginning to be used. The congregation at St Nicholas' are delighted with the results and are beginning further restoration of the church artefacts.

ii) Changed public perception of bats

Work on the ceiling at a church in Braunston-in-Rutland has stopped droppings and urine entering the church, and church services can now proceed without clearing of bat droppings [H, Ji]. The church has engaged with bat conservation and held a 'beer and bats evening' on International Bat Night. The success was documented via the BBC News website [Jii], and in the Daily Telegraph, and the work was implemented after the local MP raised the situation with the Church Commissioner in Parliament.

Feedback from the Bats in Churches project has highlighted the change in attitudes and enthusiasm of congregations and local communities [H]:
"We all learnt a lot about bats and what the Bats in Churches project is endeavouring to achieve … we all felt more positive about all the problems we have been enduring over the past years" (Church warden, St Edmund's, Egleton).

"Explaining and showing the children how this issue is a local one and how they can help really motivated them to think about how we can help make sure bats are looked after without damaging our local churches." (Teacher, Rissington School).

5. Sources to corroborate the impact

A) European Commission & EUROBATS (2018). Action plan for the conservation of all bat species in the European Union (2018-2024)

B) United Nations Environment Programme (UNEP) and EUROBATS. Voigt *et al.* (2018). Guidelines for consideration of bats in lighting projects,

C) Bat Conservation Trust (BCT) and Institute for Lighting Professionals (ILP) (2018). Bats and artificial lighting in the UK

D) Defra (2019). Biodiversity 2020: A strategy for England's wildlife and ecosystem services

E) Natural England (2019). Bat licenses for mitigation, surveys, research, possession and sale.

F) Natural England (2020). Corroborating statement - Project manager

G) Bat Conservation Trust (2016). Bat Surveys for Professional Ecologists – Good Practice Guidelines

H) Bat Conservation Trust (2020). Corroborating statement – Head of Conservation Services

I i) ANC Acoustics & Noise Consultants (2019). Awards 2019: Environmental Infrastructure (joint winner)
ii) The Ecological Consultancy (2019). News Acoustic deterrents as a bat mitigation strategy research brings home two Noise Awards!

J) i) Church Times (2019). Why time could be up for bats in the belfry
ii) BBC News (2019). Bat faeces no longer interrupting Rutland church services
iii) Bats in Churches (2020). December 2020 Update: Looking back and planning ahead