Institution: University of York		
Unit of Assessment: 5 - Biological Sciences		
Title of Case Study: Improving effectiveness of conservation areas in Africa		
Period when underpinning research was undertaken: 2012 - 2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (eg job title):**	**Period(s) employed by the submitting HEI:**
Dr Colin Beale	Reader	Apr 2012 - present
Dr Andy Marshall	Reader	Jan 2007 - present
Dr Rob Critchlow	PDRA	Jan 2014 - present
Dr Colin Courtney-Mustaphi	PDRA	Jan 2013 – Nov 2016
Period when the claimed impact occurred: 2015 – 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact (indicative maximum 100 words)

York research into African ecology and the management of protected areas has led to improvements in the effectiveness of management of >30,000km^2 of conservation areas across Africa. Through partnerships with governments and NGOs, our research has increased the effectiveness of ranger patrols detecting and preventing poaching, contributing to stabilisation of elephant populations in Tanzania and increased detection rates of illegal activities more widely. York's research informs fire management activities in key conservation areas and has led directly to the establishment of a new protected area in a key biodiversity hotspot.

2. Underpinning research (indicative maximum 500 words)

York's research informs conservation policy in Africa's iconic protected areas, identifying the key conservation challenges in these areas and researching methods to improve conservation actions.

Our work started by identifying the ten greatest management challenges that threaten biodiversity in African protected areas (**3.1**). These ten challenges have informed conservation policy in savannah ecosystems globally. Of the ten challenges identified, we have focussed subsequent research on three: (i) identification of the best boundaries for protected areas (where our research has led to the designation of new protected areas), (ii) improving law enforcement (through identification of ways to increase the effectiveness of ranger patrols) and (iii) management that maintains and promotes functional heterogeneity (through identifying how the variety within fire regimes (pyrodiversity) increases biodiversity and the fire management practices required to promote it).

Identifying the best boundaries for protected areas requires knowledge of priority species, their distributions and movements. York's research has documented the distribution of key species (e.g. **3.2**), the increased reliance on protected areas by birds responding to climate change and landscape degradation and the threats from land use along key migration corridors.

Law enforcement within protected areas is largely undertaken by ranger patrols, payment for which represents the main expenditure of many protected areas in Africa. More effective use of rangers could improve law enforcement with no additional expenditure. York research has developed methods for using biased and messy data gathered by rangers to identify spatial hotspots and long-term trends in poaching activity. We have used this understanding to direct ranger activities to where they will be most successful at locating illegal activities, resulting in an improvement in efficiency at detecting all types of law-breaking by up to 300% (**3.3**). With support from York, these methods are now driving development of the SMART conservation software used in hundreds of protected areas globally. Focussing specifically on elephant poaching, we pioneered the use of spatial analyses of aerial survey data to identify local elephant poaching hotspots within the ecosystem where the vast majority of the continent's elephants were being poached at the time (**3.4**). Building on our detailed understanding at this

single site, we expanded our research to identify how much poaching is occurring across the continent and the factors that facilitate this, concluding that corruption is a key enabling process, and showing where and how law enforcement needed to act to control elephant poaching (**3.5**).

Alongside law enforcement, the main practical management within conservation areas in East Africa has traditionally been focussed on fire management, with simplistic application of fire treatments potentially leading to a loss of functional heterogeneity (**3.1**). Our research has focussed on identifying the variety within fire regimes (pyrodiversity) and the role of pyrodiversity on maintaining and promoting biodiversity within protected areas, demonstrating that maintaining high pyrodiversity can increase biodiversity by 20-30% (**3.6**).

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

3.1. **Beale, C.M**., van Rensberg, S, *et al.* 2013a. Ten lessons for the conservation of African savannah ecosystems. *Biological Conservation*. 167: 224-234. DOI: 10.1016/j.biocon.2013.08.025
3.2. Menegon, M., Tolley, K. A., Jones, T., Rovero, F., **Marshall, A. R.,** & Tilbury, C. R. (2009). A new species of chameleon (Sanria: Chamaeleonidae: Kinyongia) from the Magombera forest and the Udzungwa Mountains National Park, Tanzania. *African Journal of Herpetology*. DOI: 10.1080/21564574.2009.9650026
3.3. **Critchlow, R.**, Plumptre, A. J., Alidria, B., Nsubuga, M., Driciru, M., Rwetsiba, A., & **Beale, C.M.** 2016 Improving Law-Enforcement Effectiveness and Efficiency in Protected Areas Using Ranger-collected Monitoring Data. *Conservation Letters*. DOI: doi.org/10.1111/conl.12288
3.4. **Beale, C.M.**, Hauenstein, S., Mduma, S., Frederick, H., Jones, T., Bracebridge, C., Maliti, H., Kija, H., Kohi, E.M. (2018a) Spatial analysis of aerial survey data reveals correlates of elephant carcasses within a heavily poached ecosystem. *Biological Conservation.* DOI: 10.1016/j.biocon.2017.11.016
3.5. Hauenstein, S., Kshatriya, M., Blanc, J., Dormann, C. F., & **Beale, C. M.** (2019). African elephant poaching rates correlate with local poverty, national corruption and global ivory price. *Nature Communications*, DOI: 10.1038/s41467-019-09993-2
3.6. **Beale, C.M.**, **Courtney Mustaphi, C.J.,** Morrison, T. A., Archibald, S., Anderson, T. M., Dobson, A. P., Parr, C. L. (2018b). Pyrodiversity interacts with rainfall to increase bird and mammal richness in African savannas. *Ecology Letters*. DOI: 10.1111/ele.12921

Indicators of quality:
All references **3.1 - 3.6** are published in international peer-reviewed journals.
References **3.5** & **3.6** are from peer-reviewed NERC and Leverhulme funded research.
References **3.5** & **3.6** are being submitted as part of the outputs portfolio to REF2021.

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

Impact on practice. As a direct consequence of our work on law enforcement in our experimental sites at Queen Elizabeth National Park, Uganda, rangers detected three to five times more illegal activities when following our optimisation regimes, with no extra financial cost. Uganda Wildlife Authority have adapted ranger patrol routes and are working to use these methods to improve ranger effectiveness across wildlife areas, and our partners document how our work has led to '*extremely helpful improvement in our ability to fulfil our law enforcement objectives*' (**5.1**). More widely, the most common method for rangers to record and monitor their field activities is a programme called SMART. This conservation software is rapidly becoming the globally preferred database for managing rangers (implemented at >900 sites in >70 countries), and our research has informed a collaboration with the SMART partnership to deliver a 'predictive patrolling' module giving simple access to our methods ultimately to all SMART users. Since 2018, this programme has already been rolled out, "*though a preliminary 10 sites across Zimbabwe, South Africa and Zambia amongst other countries where more efficient patrols are already improving the conservation outcomes*" (**5.2**).

Fire management is also changing in Africa's protected areas as a result of our research: Grumeti Game Reserve's fire management plan was developed in consultation with University of

York and now underpins the burning of c. 5,000km^2 each year, improving the conservation outcomes at of one of the richest savannahs in Africa (the filming location of BBC Earth's *Serengeti*) (**5.3**).

Impact on policy. Our identification of the ten key challenges for conservation of savannahs has helped nature reserves develop management plans across the globe. It shapes policy at both the site level (it is cited in management plans for many key conservation areas e.g. **5.3**) and at the international level (e.g. the Grasslands section of the Convention for Biodiversity's Global Biodiversity Outlook 4 is shaped around several of the key challenges and cites the research (**5.4**)).

Publicity surrounding York research on elephant poaching in Tanzania's Ruaha-Rungwa ecosystem (which led the ITV News at 10 in the UK on 18/12/17) led to the creation of a Tanzanian Government task-force on poaching, with the Tanzanian Government noting "*it is our view the presence of an unusually high number of carcasses around these posts is an issue for further investigation*" (**5.5**). The findings of this task force are not public but resulted directly in a change in focus of national law enforcement policy towards combating corruption; our partners note "*a combination of the publicity and the collaborative approach taken by Dr Beale to work with Tanzanian government colleagues has contributed to this addressing of corruption*" (**5.6**). They further note that "*Dr Beale's work with TAWIRI [Tanzania Wildlife Research Institute]… and his support for individuals there ... has strengthened the analytic capabilities of TAWIRI and, therefore, their ability to fulfil mandatory advisory roles within Tanzania"* (**5.6**) strengthening Tanzanian government institutions.

York research underpins recent improvements to the analysis presented in statutory reports that inform global policy on ivory trade (**5.7**). The primary intergovernmental convention tackling trade in wildlife species is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The 182 governmental signatories to CITES asked the secretariat to establish an independent programme called Monitoring the Illegal Killing of Elephants (MIKE) to provide independent information on elephant poaching to inform discussions. Our research now forms the basis for MIKE reports to CITES conventions (**5.7**, **5.8**), and the MIKE programme managers notes that "*the work also contributed to the development of an improved information base that support Parties' decision-making on elephant management and conservation*", that led to continuation of the international trade ban on ivory, despite proposals to the contrary (**5.8**).

Increases in ranger effectiveness through use of SMART and the potential for expanding use of our methods for increasing effectiveness of ranger patrols through this software means implementing SMART conservation software is now national policy for the management of national parks in 12 countries across the world, from Uganda and DRC, to Peru, Pakistan and the Philippines. (**5.2**)

York research and activities also underpinned the recent gazettement of the Magombera Nature Reserve, ensuring the long term protection of this biodiversity hotspot. (**5.9, 5.10**)

Impact on biodiversity As a consequence of changes in policy and practice, biodiversity has been positively impacted in many locations. Concrete impacts are most clearly documented in the reduction in the number of illegally killed elephants across Ruaha-Rungwa and Tanzania more generally as a consequence of increased focus on anti-corruption interventions: our partners note "*It is fair to say that the original reports and subsequent publication had direct impacts on conservation in Southern Tanzania… the collaborative approach taken by Dr Beale … has contributed to this addressing of corruption, which is a factor in the current significantly lower levels of elephant poaching.*" (**5.6**). At its peak, poaching was killing c.10,000 elephants per year in the ecosystem, this is now greatly reduced (latest estimates are of stable elephant populations across the ecosystem and Tanzania more generally) (**5.6**). Similar biodiversity improvements are likely across Ugandan National Parks (our partners note "*although it is currently impossible to quantify the exact impact of improved efficiency of patrols on actual wildlife numbers, the ability to significantly increase detection of illegal activities without*

increased costs is a major advance" **5.1**) and in the other ten sites where our methods for designing more efficient ranger patrol routes are being rolled out and "*are already improving the conservation outcomes of these protected areas*" (**5.2**), but are harder to quantify exactly.

Quantifying the biodiversity benefits from improved fire management is tricky: from our research we know that in wet savannahs, vertebrate biodiversity can be increased by 20-30% through appropriate fire management. With 5,000km^2 of the highest diversity sites being managed more effectively we can infer significant biodiversity benefits.

Biodiversity benefits from the new Magombera Nature Reserve will be significant, preventing habitat loss at this site and associated loss of extremely rare and localised species (**5.9, 5.10**).

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

5.1. Letter from Ugandan field collaborators confirming impact of York research on Ugandan law enforcement efforts and an increase in ranger efficiency within protected areas.
5.2. Letter from SMART partnership confirming (i) the size of SMART programme, (ii) the size of existing rollout of predictive ranger-monitoring, coming from York research, (iii) the importance of our predictive work on the future growth of SMART and in establishing national policy.
5.3. Grumeti Fund Fire Management plan containing numerous references and citations to York research and the Leverhulme funded Serengeti Fire Project (led from York), and with explicit acknowledgements of Dr Beale's input.
5.4. Convention on Biological Diversity - Global Biodiversity Outlook 4 (GBO-4) The Grasslands section (beginning page 97) is shaped around several of our '10 lessons' research, and the paper is cited in the main report.
5.5. Transcript of ITV News at 10 bulletin on corruption in poaching in Tanzania, reporting on Dr Beale's research with Tanzanian Government responses.
5.6. Letter from Non-Governmental partners (STEP) in Tanzania confirming (i) a change in policy towards tackling corruption following York research in Ruaha-Rungwa, and (ii) that this has led to the decline in elephant poaching in Tanzania.
5.7. Official CITES/MIKE papers from the 18th Conference of the Parties. Official papers contain citations to and replications of our published analyses (pages 10 & 11 and compare with 3.5)
5.8. Letter from CITES confirming details of the discussions behind the scenes at CITES Conference of the Parties (CoP) 18 and political implications of the CITES reports and York work during the CoP.
5.9. Management Plan for Magombera Nature Reserve, by the Tanzania Forest Services Agency and signed by the Minister for Natural Resources and Tourism [York / Marshall references: lower right inset of map, p5; main text p11,12,13,16; appendix 4];
5.10. Data and reports showing: (i) Magombera Forest threats then conservation: (ii) IUCN Red List species assessments; (iii) village agreement indicating community support/benefit; (iiii) press article showing the importance of Magombera Nature Reserve.