

<b>Institution:</b> University of York		
<b>Unit of Assessment:</b> 7 - Earth Systems and Environmental Sciences		
<b>Title of case study:</b> Improving Environmental Conservation in East Africa and Beyond		
<b>Period when the underpinning research was undertaken:</b> 2000 - 2019		
<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>
Dr Andrew Marshall Prof Robert Marchant Dr Colin Beale Dr Philip Platts	Reader Professor Senior Lecturer Research Fellow	Jan 2007 - present Sep 2005 - present Apr 2012 - present May 2005 - Aug 2009; Nov 2009 - Jan 2010; Apr 2012 - present
<b>Period when the claimed impact occurred:</b> Aug 2013 - Dec 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<p><b>1. Summary of the impact</b> (indicative maximum 100 words)                  Our research has improved the management of threatened environments through evaluation of biological change, socioeconomic drivers and policy implementation. Our work has enabled 3-5 times more effective ranger patrols in Queen Elizabeth National Park, Uganda, and improved governance of protected areas, including the creation of the globally significant Magombera Nature Reserve, Tanzania. This has reduced threats (tree-cutting); improved species populations (increased tree density and size); and enabled local communities to benefit economically and gain improved knowledge of forest management. Our work has stimulated policy-scale impacts: joint Government–NGO landscape strategies across large, biodiversity rich regions in Africa; creation of Reforest Africa as a new charity; and revision of UK Government zoo standards</p>		
<p><b>2. Underpinning research</b> (indicative maximum 500 words)                  Our environmental research strategy aims to investigate direct, indirect and <i>ex situ</i> tiers of environmental conservation (Figure 1), maximising impact potential. Our work is truly interdisciplinary, involving a number of different researchers rather than a single individual. Collectively, the four researchers in this case study have published more than 300 articles and professional reports in this research area, including Nature, Science and PNAS; multiple outputs have led to the stated impacts, besides those referenced in Section 3.</p>		
		<p>Figure 1. Three tiers of environmental conservation that influence the long-term prospects of threatened ecosystems and species, either directly (inner ring), indirectly (central ring) or <i>ex situ</i> (outer ring).</p> <p>This diagram originates from University of York published research from 2014.</p>

### 2.1. Conservation management

York research has directly investigated the management of threatened ecosystems. Since 1997, Dr Marshall's and Prof Marchant's teams have worked with multiple university partners, museums, herbaria, non-governmental organisations (NGOs), local communities and Governments to assess the impacts of tropical forest damage on plant and animal biodiversity, abundance and biomass, demonstrating **negative effects of inadequate protection** on forests, animals and plants. In particular, Dr Marshall's long-term work in the Udzungwa Mountains of Tanzania, a globally significant region for species diversity, has revealed extensive impacts of forest disturbance and clearance, highlighting critical geographic priorities for conservation intervention [3.1, also involved Dr Platts]. This work then inspired Dr Marshall's Australian Research Council-funded FoRCE experiment, which began in 2015, which is **testing new methods for forest restoration** in Australia, Africa and beyond, partnering with multiple universities, herbaria and land managers. Aside from his core research, Dr Marshall has personally discovered several species new to science, including trees, amphibians and the Magombera chameleon, *Kinyongia magomberae*.

In tropical savannas, Dr Beale works with university and Government partners, including the Tanzania Wildlife Research Institute and National Parks Authority, to study the fundamental drivers of ecological function and is undertaking **applied research to reduce illegal activities in protected areas**, integrating his research findings into a tool which is part of a conservation programme called SMART. This has included an assessment of ranger patrols, which found law enforcement was inadequate and suggested ways to optimise patrols without increased costs [3.2].

### 2.2. Conservation drivers

York research has investigated the indirect impacts on conservation, i.e. the major drivers of ecosystem decline, recovery and preservation. Dr Marshall's work since 2007 has demonstrated the **ineffectiveness of protected areas for supporting local people**, including ecosystem services, conservation awareness and wellbeing [example 3.3]. Research under the Leverhulme Trust Valuing the Arc Project (VTA; 2005-2009) has also addressed the importance of carbon and carbon management in tropical forests, both in East Africa and in global collaborations. Inspired by this, Dr Marshall's FoRCE project also investigates **forest landscape restoration planning** in East Africa and the broader tropics.

Multiple projects involving Prof Marchant and Dr Platts assessed the wider ecosystem services of Tanzania and Kenya, measuring nature's contributions to people in national and international assessments (e.g. Kenya Natural Capital Atlas; IPBES Africa Assessment) and measuring/modelling carbon across ecosystem, degradation and management gradients. Inspired by this work, Prof Marchant's team uses archaeological and ecological data to understand the impact of past events on present-day tropical vegetation and uses this to develop models to assess potential futures. This prompted his team to develop and apply a **land-use scenario modelling tool, "Kesho"**, combining participatory narratives, environmental and social data and empirical modelling. Kesho has revealed interactions between water, biodiversity and carbon, facilitating **landscape-level assessment of drivers of landcover change** across East Africa, at national and local scales [3.4].

Dr Platts has also published widely on species distributions, climate change ecology, ecosystem services and protected area effectiveness. He specialises in data analytics and produced the **first comprehensive high-resolution ensemble of future climate projections for Africa, AFRICLIM** [3.5].

### 2.3. Ex situ conservation

Dr Marshall's expertise led him to be selected as an expert advisor on conservation on the Zoos Expert Committee, led by the UK Department for Environment, Food and Rural Affairs (DEFRA), and be Vice Chair of the British and Irish Association of Zoos Field Program Committee.

Through these roles, Dr Marshall assessed conservation challenges for securing **Government, institutional and public support for conservation**, including assessment of the effectiveness of the world's zoos in funding conservation [3.6]. For the first time this work collated financial information on how conservation funds are allocated by zoos, which was previously not shared between organisations. Thus, with focus on one of the world's oldest and most respected zoo associations, the cited report [3.6] was a world-leading output, despite being unpublished. The report was the most direct research link to the stated impacts [4.3], while several peer-reviewed

publications also contributed, including assessment of zoo effectiveness at breeding of threatened species and educating the general public.

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

**3.1. Marshall, A.R.**, Jørgensbye, H.I.O., Rovero, F., **Platts, P.J.**, White, P.C.L., Lovett, J.C. (2010) The species-area relationship and confounding variables in a threatened monkey community. *American Journal of Primatology* 72 325-336. <https://doi.org/10.1002/ajp.20787> \*

**3.2. 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* 10, 572-580. <https://doi.org/10.1111/conl.12288> \* \*\*

**3.3. Latham, J.E.**, Sallu, S.M., Loveridge, R., **Marshall, A.R.** (2017) Examining the impact of forest protection status on firewood sufficiency in rural Africa. *Environmental Conservation* 44(3), 221-233. <https://doi.org/10.1017/S0376892917000066> \*

**3.4. Capitani, C.**, Mukama, K., Mbilinyi, B., Malugu, I.O., Munishi, P.K., Burgess, N.D., **Platts, P.J.**, Sallu, S.M. and **Marchant, R.** (2016) From local scenarios to national maps: a participatory framework for envisioning the future of Tanzania. *Ecology and Society*, 21(3). <https://doi.org/10.5751/ES-08565-210304> \* \*\*\*

**3.5. Platts, P.J.**, Omeny, P.A., **Marchant, R.** (2015) AFRICLIM: high-resolution climate projections for ecological applications in Africa. *African Journal of Ecology* 53(1), 103-108. <https://doi.org/10.1111/aje.12180> \* \*\*\*\*

**3.6. Marshall, A.R.**, Needham, N., Wilson, S., Darling, M., Deere, N.J., Hindle, B.J., Bowkett, A.E., Dangerfield, J., et al. (2015) Quantifying Conservation Effort by Zoos: a pilot study of BIAZA members. CIRCLE, York and BIAZA, London. CONFIDENTIAL. \*\*\*\*\*

\* Peer reviewed; \*\* Top 5% of all research articles scored by Altmetric; \*\*\* Submitted output to REF2021; \*\*\*\* Top ten most highly cited articles in this journal; \*\*\*\*\* Unpublished due to confidentiality, but world-leading [see section 2.3]

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

#### 4.1. Conservation management

York research has informed the *in situ* management of threatened ecosystems and species.

Our research led directly to the **establishment of a Tanzanian not-for-profit company (2016)**, **UK charity (2019)** and **Tanzanian Non-governmental Organisation (NGO, 2019)**, all under the name of Reforest Africa [5.1], run by Dr Marshall and guided by UK Trustees and a Tanzanian Board of Directors. Creating Reforest Africa followed years of gathering evidence on the negative impact of inadequate forest conservation on habitat fragmentation and animals [3.1] and on people [3.3], and poor knowledge of forest restoration techniques [2.1]. Thus, Reforest Africa's mission is "To develop and implement techniques for ecological restoration, conservation and monitoring of African forests for wildlife and people".

Through Reforest Africa, Dr Marshall led a successful 2019 campaign and fundraising drive, partnering with the Government of Tanzania, Rainforest Trust, World Land Trust, Reforest Africa and another local NGO, to gazette the **new, globally unique, Magombera Nature Reserve** [5.2]. This stemmed directly from Dr Marshall's work identifying Magombera as a very important conservation priority for habitat connectivity and species conservation, and placed in the context of regional forest connectivity in [3.1]. In a consultancy report for WWF, Dr Marshall's data showed extreme levels of illegal tree-cutting in Magombera that would have cleared all regenerating trees from the forest by 2018 if left to continue [5.3a]. This forest has a plant community found nowhere else, with many globally threatened species including a flagship species, the Magombera chameleon, discovered by Dr Marshall in the jaws of a snake. As Director of Reforest Africa, Dr Marshall now directs the management of this protected area through his team of 13 staff in Tanzania. The outline management plan for the reserve developed by the Ministry of Natural Resources and Tourism specifically cites our research and states that it will be used in the management of the reserve [5.2], including forest restoration techniques [2.1] and direct revenue generation for local villages [3.3]. Creation of the new Nature Reserve received widespread media attention, e.g. Steve Lemaq's BBC Radio 6 Music show dedicated to trees and forests, and numerous press articles. A Chief Scientist at UNEP-WCMC (UN Environment Programme World Conservation Monitoring Centre) stated: "*The creation of this new Reserve demonstrates just how powerful bottom-up, inclusive conservation can be. By working with local communities, charities, academics and private organisations, we were all able*

*to establish a Reserve that protects people's livelihoods as well as providing a home to a range of endangered species."* [5.3c]

Preceding Reforest Africa, and inspired by the same research [3.1, 3.3, 2.1, 2.2], Dr Marshall's forest protection and community engagement work in Magombera, since 2013 (Udzungwa Forest Project), has stimulated **improvements in habitat quality, species conservation, community knowledge and support** including (a) increasing tree density (c. 100 stems/ha in 2007 to c. 450 by 2018-20) and size (mean DBH increase from c. 32 cm in 2013 to c. 38 cm in 2016), (b) reduced illegal firewood collection (from c. 5 down to 0 observations per km between 2013 and 2016), (c) 10-100% improvement in villager knowledge regarding different aspects of forest conservation, from 2015 to 2017, (d) formal community agreement for forest conservation with economic benefits for the communities, and (e) downgrading of a monkey species on the International Union for the Conservation of Nature (IUCN) Red List of threatened species [5.3a,b,d,e]. Dr Marshall's associated species discoveries and field surveys have led to at least five complete and/or ongoing **species reclassifications on the IUCN Red List** (including three reliant on Magombera Nature Reserve [5.3e]). Successive agreements on forest conservation have led to four nearby villages receiving in excess of TSh 27 million (GBP9,000) in combined revenue from tourism and partnership with Reforest Africa, between 2013 and 2020, and in excess of GBP250,000 through in-kind support. These funds have provided **employment, school, tree seedlings, education and training**, and the support has given the community a voice in forest management decisions [5.3d]. In 2020, the Reforest Africa team **trained more than 2,200 people** in the construction of fuel-efficient stoves, resulting in more than 1,300 new households using these in their homes. This has reduced demand for firewood from the forest and was also a direct result of York work [5.3d].

The SMART tool [2.1; 3.2] led to **more effective protected area management**, through implementation of new methods which assist in planning 'predictive patrolling' for rangers, and these have been rolled out at 10 preliminary sites across countries such as Zimbabwe, South Africa and Zambia. The programme manager of SMART, which is in use at 900 sites across 70 countries, stated, "*Dr Beale's work using data collected by rangers using SMART...has highlighted the importance of effective analysis of ranger-based data to further improve the efficiency of ranger patrols, a key conservation activity in each site where SMART is implemented.*" [5.4a] Dr Beale's work on law enforcement at Queen Elizabeth National Park, Uganda, resulted in rangers detecting 3-5 times more illegal activities when following optimisation regimes, with no additional financial cost. Uganda Wildlife Authority have adapted ranger patrol routes and are continuing to use York's methods to improve ranger effectiveness across wildlife areas. The Key Biodiversity Areas programme stated, "*Without effective ranger patrols it is likely that we would see rampant poaching for the bushmeat and commercial trade...the ability to significantly increase detection of illegal activities without increased costs is a major advance*" [5.4b].

#### 4.2. Conservation drivers

York research into human, infrastructure and environmental considerations for successful conservation has led to some significant progress in managing these drivers. Forest ecology and human livelihood research [2.1, 2.2, 3.1] and the establishment of Reforest Africa, led directly to a Forest Landscape Restoration Plan for a 40,000km<sup>2</sup> region of major importance for biodiversity conservation, the greater Udzungwa-Kilombero Ecosystem [5.5a]. Crucially, this plan stimulated a workshop attended by tens of expert delegates, and village representatives from across the region, who universally agreed to a **Declaration on Forest Landscape Restoration**, with quantifiable commitments by 2030 [5.5a, p18; 5.5b]. To act as a hub for implementation of this plan, in 2019-20 Dr Marshall fundraised ~GBP20,000 to **found a new botanic garden**, on the edge of the Udzungwa Mountains National Park in Tanzania, that will act as the first seed reservoir, plus a training and method-testing site, for implementation of the Declaration. Thirteen acres of land has been purchased for the garden and letters of support written by Missouri and Edinburgh Botanic Gardens, Rainforest Trust, Tanzania Forest Service Agency and the Tanzania Forest Conservation Group [5.6a-c].

Data from the Valuing the Arc Project [2.2] is used by the National Carbon Monitoring Centre in Tanzania and contributes to Tanzania's assessment of carbon budgets. The results are used to inform the country on carbon changes, forest management policy, and feed into national commitments and international agreements, e.g. UN Framework Convention on Climate Change

[5.7a]. The associated Kesho landcover scenario tool [2.2; 3.4] has been employed for land-use planning at different scales in Ethiopia, Tanzania and Kenya during the REF period. For example, the African Wildlife Foundation used Kesho to inform the development of the Kilombero Cluster Development Framework in the Southern Agricultural Growth Corridor of Tanzania, and Frankfurt Zoological Society used Kesho to enable local communities to input their pastoral knowledge into future rangeland management in Loliondo (Tanzania). [5.7b]. This **informed planning decisions and led to greater awareness among practitioners and local communities** of land use transitions and the interactions of agricultural, infrastructure, conservation and pastoral demands on future land use [5.7b].

Regarding climatic drivers of forest conservation [2.2; 3.5], our **AFRICLIM tool has been accessed by more than 50,000 people**, averaging more than 500 people daily in 2018-19 [5.8a]. AFRICLIM has been cited by non-academic organisations including Biodiversity International, Critical Ecosystem Partnership Fund, International Relief and Development, World Conservation Monitoring Centre, IUCN, and World Agroforestry Centre [5.8b].

Through membership of the IUCN Species Survival Commission's (SSC) Climate Change Specialist Group, AFRICLIM [3.5] and other climate change modelling research [2.2], Dr Platts' work has been a major influence towards the **IUCN SSC Guidelines for Assessing Species' Vulnerability to Climate Change**. Dr Platts co-authored two chapters in the Guidelines and was lead author of a Guidelines case study [5.9a]. The Guidelines have been downloaded more than 12,000 times since 2016, leading to impacts such as improved watershed health for people and amphibians (Columbia), improved assessment of threats to biodiversity from hurricanes (Mexico), and improved protected area management for climate change (South Africa) [5.9b]. The Guidelines are being translated into training modules for IUCN Red List assessments, to help 160+ IUCN SSC specialist groups better account for climate change in their Red List assessments of extinction risk [5.9b].

#### 4.3. Ex situ conservation

In his DEFRA advisory role on the Zoo Expert Committee (ZEC), Dr Marshall and other committee members used York research findings [2.3; 3.6], to **propose updates to the UK Secretary of State Standards for Modern Zoo Practice**. The Director of Animal and Plant Health and Welfare at DEFRA stated that Dr Marshall "*...played an important role in ZEC activities, in particular through encouraging zoos to undertake conservation activities and by ensuring that clear requirements on conservation are included in the proposed updates to the Secretary of State's Standards for Modern Zoo Practice.*" [5.10]

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

- 5.1. Reforest Africa UK Registered Charity certificate; b) "Memorandum and Articles of Association" for non-for-profit company; c) Constitution for non-governmental organisation
- 5.2. Management Plan for Magombera Nature Reserve (York/Marshall references: lower right inset of map, p5; main text p11,12,13,16; appendix 4)
- 5.3. a) Ecological Report on Magombera Forest and observed results of conservation; b) Data from Udzungwa Forest Project demonstrating conservation success; c) Press releases about Magombera Nature Reserve; d) Village agreement indicating community support/benefit (in Swahili) and Reforest Africa letter confirming economic/social benefits; e) IUCN Red List species assessments
- 5.4. a) Letter from Programme Manager at SMART (ranger patrol improvements); b) Letter from Head Key Biodiversity Areas Secretariat (ranger patrol improvements, Uganda)
- 5.5. a) Forest Restoration Plan for the greater Udzungwa-Kilombero Ecosystem; b) Minutes from the Workshop for Developing a Restoration Plan
- 5.6. a) Land sales agreements for botanic garden; b) Seed funding partnership agreement with Rainforest Trust; c) Letters of support for phase 2 funding
- 5.7. a) Letter from National Carbon Monitoring Centre; b) Letters from conservation organisations demonstrating use of the Kesho scenario tool
- 5.8. a) AFRICLIM access data; b) WoS citations, showing global interest/non-academic use
- 5.9. a) IUCN SSC Guidelines for Assessing Species' Vulnerability to Climate Change; b) Letter from IUCN
- 5.10. Letter from Director of Animal and Plant Health and Welfare at DEFRA