Institution: University of Gloucestershire

Unit of Assessment: 14

Title of case study: Stopping the poachers: technological solutions for rhino conservation

Period when the underpinning research was undertaken: 2015-2018

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:**
Professor Anne Goodenough	Professor of Applied Ecology	September 2006 to date
Professor Adam Hart	Professor of Science Communication	July 2005 to date

Period when the claimed impact occurred: 2016 to date

Is this case study continued from a case study submitted in 2014? No

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

Between 2008 and 2018 at least 9,151 white rhinoceros and black rhinoceros were illegally killed across Africa for their horn, which is valued highly on transcontinental black markets. Because of this poaching, ~5% of the total population of these species is currently being lost annually, driving them towards extinction. Since 2015, we have instigated and led collaborations to develop low-cost thermal imaging (TI) approaches for anti-poaching operations with front-line rangers in three countries that together support >85% of rhino in Africa.

Our research showed that low-cost TI was highly effective in detecting potential poachers, increasing detection distance by >50% compared to spotlighting. As a direct result of our research, National Parks, wildlife reserves, and national anti-poaching NGOs in South Africa, Namibia and Botswana and now use TI as an anti-poaching tool. The adoption of TI by these organisations has decreased or eliminated rhino poaching in areas under their protection. Our research and its subsequent impacts was recognised by a Green Gown sustainability award, winning the Research with Impact category in 2019.

2. Underpinning research (indicative maximum 500 words)

Rhino are killed illegally (poached) for their horn by organised international criminal syndicates supplying lucrative transboundary black markets, where a single kilo of horn is worth an estimated £42,000 and horn from a single animal can be worth as much as £168,000. Rhino horn is ultimately destined for use in traditional medicine: illegal trade in animal parts for this purpose is valued as >$6 billon US (2019 figures). Since 2013, in South Africa alone, 892-1,349 rhino have been lost to poaching per year. These rhino die of traumatic injuries when their horn is literally hacked from their face **(Fig 1a)**; pregnant females are often cut open so poachers can remove horns from unborn offspring. Poaching has dramatically increased from 13 individual animals lost in 2007 **(Fig 1b)** and ultimately threatens the long-term survival of the species. Moreover, rhino poaching is a violent activity involving heavily-armed individuals and poses a considerable threat to front-line rangers.

Most rhino poaching occurs at night and it can be impossible to detect poachers using conventional torch spotlighting. We identified low-cost thermal imaging (TI) as a potential tool for anti-poaching operations. However, its effectiveness in detecting people in realistic field conditions was untested, and deployment optimisation undetermined. We worked with front-line rangers in South Africa in 2015 to conduct the first robust empirical tests of low-cost TI for detecting humans in the African bush. After developing an optimisation protocol for detecting concealed human targets **(Fig 1c)**, we used a fully randomised double-blind procedure to assess the effectiveness of low-cost TI units (£1,200 in 2015) in comparison with conventional spotlighting and high-cost TI units (£13,100 in 2015) using a repeated measures framework.

Our research showed: (1) low-cost TI increased the distance at which human subjects could be detected relative to conventional spotlight searches by >50%; (2) low-cost TI had a low false detection rate; and (3) there was no significant difference in detection rate or accuracy between low- and high-cost TI. This research was published as Hart et al. (2015).

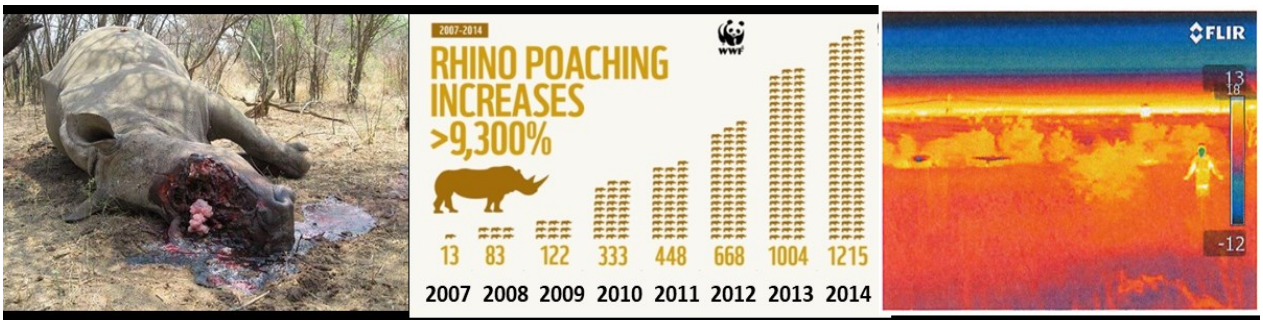

Figure 1: (a) Rhino killed by poachers in 2014 at the South Africa Wildlife Reserve where the research reported in Hart et al. (2015) was undertaken; (b) WWF graph of rhino poaching increase in South Africa, (c) heat signature of a man in the SA bush using TI

Use of TI equipment on nocturnal anti-poaching patrols indicated that TI could also be used to detect animals that were otherwise very difficult to locate. We realised that if animals could be identified accurately and reliably, TI could make an important contribution to ecological surveying. We undertook two further research projects on the effectiveness of TI for species identification using thermal images and video (Goodenough et al., 2018a, 2018b). We showed that species with characteristic features were identifiable using TI images with ~80% accuracy, and this increased to 100% for expert observers using TI videos for distinctive species such as wildebeest.

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

1. **Hart, AG**., Rolfe, RN., Dandy, S., Stubbs, H., MacTavish, D., MacTavish, L. & **Goodenough, AE.** (2015). Can handheld thermal imaging technology improve detection of poachers in African bushveldt? *PLoS One*, 10, e0131584.

2. **Goodenough, AE.,** Carpenter, WS., MacTavish, L., MacTavish, D., Theron, C. & **Hart, AG.** (2018a). Empirically testing the effectiveness of thermal imaging as a tool for identification of large mammals in the African bush. *African Journal of Ecology*, 56, 51-62.

3. **Goodenough, AE.**, Carpenter, WS., MacTavish, L., Theron, C., Delbridge, M. & **Hart, AG.** (2018b). Identification of African antelope species: Using thermographic videos to test the efficacy of real-time thermography. *African Journal of Ecology*, 56, 898-907.

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

Our research has provided crucial benefits to people combatting rhino poaching on the ground. We have worked in South Africa, Namibia and Botswana to facilitate deployment of low-cost TI units for anti-poaching operations. These countries together support >85% of rhino in Africa (96% of white rhino and 76% of black rhino). We have collaborated with rangers in National Parks and wildlife reserves, as well as anti-poaching operatives in national NGOs. The adoption of TI by these organisations has decreased or eliminated rhino poaching in areas in their protection[1,2,3,4,5].

Reducing and eliminating rhino poaching

The impact of our research first benefited the wildlife reserve in South Africa where the original research (Hart et al., 2015) was conducted and built on practitioner links we developed as part of this research with co-author L. MacTavish. This reserve had previously been hit by poachers in 2014 (Fig 1a), during which it had lost one third of its rhino population[1]. Following publication we worked with this reserve to implement thermal imaging (TI) to combat poaching. This involved training rangers on optimisation and use of low-cost units in line with our research findings but, crucially, using units that were ultra low-cost (£400) launched since the original research was published. Since adopting TI in their day-to-day anti-poaching operations, this reserve has seen a complete cessation of rhino poaching within the REF impact census period (to 31 December 2020)[1] and the rhino population has grown by 50%.

Building on this success, in 2018 we worked with additional white rhino reserves in South Africa to use TI to protect >300 rhino. The new reserves collectively cover 37,000 contiguous hectares and this scale, coupled with diverse landscapes and thick bush, made conventional anti-poaching operations logistically challenging. TI is now integrated as part of a combined approach involving 60 security staff and other partners including IBM through their Connected Wildlife Solution Initiative[2]. TI is now a much-valued tool in their war on poaching and to date these reserves have not lost any rhino to poachers[2].

In the same year, we trained an anti-poaching NGO operating in reserves across South Africa in the use of TI. As a consequence of this experience, this NGO changed their practice to ensure that all anti-poaching patrols now utilise TI and have not lost any rhino since its adoption[3]. In 2018 we also established a training centre in South Africa for teaching the use of TI in anti-poaching and nocturnal wildlife surveying using techniques developed through our research **(Fig 2)**. This centre provides advanced TI training that reaches >400 people per year[6].

Figure 2: Field training session with an Anti-Poaching Unit in South Africa in November 2018 using ultra low-cost thermal imaging units

In 2019, we expanded the impact of our research into Namibia and Botswana. In Namibia we trained government-supported anti-poaching operatives in the Wildlife Protection Service (WPS).

The WPS now uses low-cost TI as part of their "boots on the ground" strategy to protecting the world's largest population of black rhino in Etosha National Park[4]. In Botswana we worked with Rhino Conversion Botswana (RCB), a publicly-funded anti-poaching charity supported by TUSK, the International Rhino Foundation, the Save African Rhino Foundation and the Botswana Defence Force. Our work has increased the security of the biggest population of rhino in Botswana, which is located within the Okavango Delta[5]. With a total area of 44,000 sq km and ~2000 km of boundary, areas under the protection of WPS and RCB not only support important numbers of white rhino but, crucially, almost half of the global population of black rhino[4,5].

Economic impact

Reserves frequently spend up to 60% of their total conservation budget each year on rhino anti-poaching initiatives. The Rhino Owners' Association estimates the minimum cost of poaching protection is £6,200 per rhino per year (2019 figures). This includes funding anti-poaching staff, vehicular patrols, fuel, foot patrols, training of dogs, fence maintenance, firearms, and ammunition. Scaled up, this is nearly £2 million per annum for the rhino population of reserves with which we collaborated in 2018 alone. Costs now frequently exceed revenue: this is simply unsustainable. TI-based anti-poaching is thus an affordable approach that is viable for adoption within the economic context of Africa and using TI as part of a wider anti-poaching operation could lead to a 10% saving in current APU costs[7]. For a reserve with 100 rhino, this is a saving of £62,000 per year for a one-off cost of £2,000 for five units: a 10% annual saving for a 0.3% initial cost.

Reduction in poaching of other species

The illegal hunting of wild animals, such as antelope and warthog, for "bushmeat" is a problem for most wildlife reserves in southern Africa. Since using TI, bushmeat poaching has decreased by 80% for one reserve that records all poaching incursions[1], saving that reserve around £5000 per year. This decrease is due both to the use of TI and the deterrent effect of poachers believing reserve staff can "see in the dark"[1,8].

Safeguarding rangers

Facing armed incursions and potential ambush situations is highly dangerous and stressful for front-line rangers. Using low-cost TI as part of routine patrols, and in all emergency responses, allows rangers to proceed with confidence at night, relatively safe in the knowledge that they are not entering an ambush where they could be wounded or killed[1,9]. This has substantially enhanced ranger wellbeing and morale[1,9].

Enhanced ecological surveying

Effective ecological management depends on robust data from ecological surveying. Our research demonstrated the effectiveness of using TI to survey species at night. Some reserves that have adopted TI for anti-poaching have also integrated TI into mammal censusing, and have consequently benefited from more robust data to inform habitat management practice. For example, one reserve found that wildlife counts using aerial censusing by helicopter underestimated the populations of some species (such as impala and kudu) by up to half compared to mammal population estimates that incorporated TI[7].

Summary

The combined impacts of our research won the Research with Impact award in the Green Gown sustainability awards in 2019, which are open to all Higher Education Institutions and all disciplines. The judging panel highlighted the immediate and lasting impact of our work in

reducing rhino poaching, ensuring reserves are economically sustainable, and protecting front-line rangers. We are committed to building on this by increasing the reach and impact of our work in key sites across South Africa, Botswana and Namibia, as well as new reserves in Zambia and Zimbabwe. Our work is even more vital due to the increased poaching threat as international borders open following COVID-19 restrictions.

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

1. Video testimony from Dr Lynne MacTavish, Wildlife Reserve, South Africa
2. Written testimony from Dr Jonathan Swart, Wildlife Reserve, South Africa
3. Written testimony from Brett Gottscho, rhino anti-poaching NGO, South Africa
4. Written testimony from Vincent Guillemin, Wildlife Protection Services, Namibia
5. Written testimony from Map Ives, Rhino Conservation Botswana, Botswana
6. Video Testimony from Luke Levitt and Melissa Dawson, Training Centre, South Africa
7. Written testimony from Chloe Garrigues, Wildlife Reserve, South Africa
8. Video testimony from Brendan Schimmal, Wildlife Reserve, South Africa
9. Written testimony Richie Fourie, Wildlife Reserve, South Africa

For rhino security reasons, locations relating to named reserves have been omitted here but are fully disclosed in the testimonial evidence.