Analysing the use of remote sensing & geospatial technology to combat wildlife crime in East and Southern Africa

Isla Duporge
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Analyzing the use of remote sensing and geospatial technology to combat wildlife crime in East and Southern Africa

ISLA CAMILLE DUPORGE

Duporge, I., 2016: Analysing the use of remote sensing and geospatial technology to combat wildlife crime in East and Southern Africa. Master thesis in Sustainable Development at Uppsala University, 51 pp, 30 ECTS/hp.

Abstract:

There has been a marked increase in the use of remote sensing and geospatial technologies to prevent wildlife crime in the last decade. Conservationists are engaging with this technology in-order to better locate poaching incidents and combat the rapid decline of species. This thesis focuses on the use of these technologies in the context of East and Southern Africa to combat rhino and elephant poaching. The methodology used comprises three parts, firstly companies and organisations working on the development of remote sensing technology used for anti-poaching efforts, in the study region, are identified through the creation of a database. The social impacts and risks involved in using these technologies are then outlined by analysing the responses to a research survey from those in the conservation community and thirdly there is a literature review to contextualize the findings within the commentary found in the academic literature on this subject. Three key research questions are addressed: Which remote sensing technologies are in use and what kinds of companies and organisations are mainly working on their development? What are the main risks of using remote sensing technology to specifically target wildlife crime in the region? And can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation? The last question is discussed in relation to existing research on this topic. Considering the findings from this paper, recommendations for further research are then made.

Keywords: sustainable development, poaching, illegal hunting, environmental crime, remote sensing, green surveillance

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Summary:

This thesis analyses the use of remote sensing technologies in efforts that seek to combat wildlife crime in East and Southern Africa. Companies and organisations working on the development of remote sensing technology used for anti-poaching efforts, in the study region, are identified through the creation of a database. The social impacts and risks involved in using these technologies are then outlined by analysing the responses to a research survey from those in the conservation community working with wildlife crime. The species focus is on rhino and elephant poaching, thus, the thesis begins with a background on the legislation surrounding both the hunting and trade of these species. Stockpiling of rhino horn and elephant tusk will be discussed as well as other anti-poaching strategies that do not use remote sensing technology. Three key research questions are then answered: Which remote sensing technologies are in use and what kinds of companies and organisations are mainly working on their development? What are the main risks of using remote sensing technology to specifically target wildlife crime in this region? And can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation? The last question is discussed in relation to existing research on this topic. Considering the findings from this paper, recommendations for further research are then made.

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### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>CITES</td>
<td>Convention on International Trade in Endangered Species of Wild Fauna and Flora</td>
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<td>ESA</td>
<td>European Space Agency</td>
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<td>GIS</td>
<td>Geographical Information Systems</td>
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<td>GP</td>
<td>Global Programme for Combating Wildlife and Forest Crime</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>MIKE</td>
<td>Monitor the Illegal Killing of Elephants</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organisation</td>
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<td>RS</td>
<td>Remote Sensing</td>
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<td>SADC</td>
<td>Southern African Development Community</td>
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<td>SDGs</td>
<td>Sustainable Development Goals</td>
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<td>SMART</td>
<td>Spatial Monitoring and Reporting Tool</td>
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<td>TRAFFIC</td>
<td>The Wildlife Trade Monitoring Network</td>
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<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<tr>
<td>UMIACS</td>
<td>University of Maryland, Institute for Advanced Computer Studies</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<td>UNOOSA</td>
<td>United Nations Office for Outer Space Affairs</td>
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<td>UNODC</td>
<td>United Nations Office of Drugs and Crime</td>
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<td>WWCR</td>
<td>World Wildlife Crime Report by the UNODC</td>
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1. Introduction

The rate of biodiversity loss and the extinction of animal species is occurring at an unprecedented rate. The loss of the world’s largest herbivores negatively alters ecosystems by disrupting ecological interactions which causes subsequent detrimental impacts on other species and environments (Ripple et al, 2015). Since the 1960s the numbers of black rhinos has fallen 95% from approximately 100,000 to under 5,000 in 2010 (TRAFFIC, 2012) and in just two years between 2010 and 2012, 30,000 elephants were slaughtered for their tusks (UNODC, 2016). Transnational trafficking of illicit wildlife products is the fourth largest illegal market with market turnover estimated to be between $8-$10 billion per annum, ranking just behind the trafficking in drugs, arms and humans (CITES, 2013). Whilst wildlife crime is not defined in any treaty, it is generally understood as referring to any crime related to the environment that involves the poaching, capture, collection or processing of animals taken in contravention of national and international laws. As this illicit trade begins to accrue more market dominance and generate higher proceeds for criminal syndicates, the attention of many transnational criminal law enforcement agencies have turned toward this issue and the topic has become increasingly securitized. This is evident in the formation of the United Nations Office on Drugs and Crime (UNODC) Global Programme for Combating Wildlife and Forest Crime (GP) launched in 2012 and the International Police (INTERPOL) environmental crime projects including Project Wisdom in 2008, Predator in 2010, and Scale in 2012. These programmes seek to prevent the trade in ivory, Asian cats and fish, respectively. In 2013, the US Presidential Task Force on Wildlife Trafficking was established which has employed many representatives previously working with anti-terror activities (Welz, 2015).

The trade in prohibited wildlife specimens is interlinked with other transnational organised crime, and is thus increasingly being viewed as a security concern by the international community (UNODC, 2016, p.3). Criminals involved in the trafficking of wildlife also support other illegal activities, such as money laundering, corruption, piracy, document, tax and customs fraud and human trafficking. The latter is most notable in the case of fisheries crime – an umbrella term for transnational organized criminal activities that take place in the context of the fisheries sector (OECD, 2016, p.111).

Although no species makes up more than 6% of illegal wildlife seizures (World Wildlife Crime Report (WWCR, 2016, p.13) the trade in elephant tusk and rhino horn has received heightened international attention due to the profitability and magnitude of these markets plus the iconic status and tourist status of these animals (Humphreys & Smith, 2014). The preservation of species has traditionally fallen under the remit of the work of conservationists while securing and defending conservation lands and high value species has in the past often included law enforcement agents and military groups (Duffy et al, 2016). Many conservation areas on the African continent were demarcated in the colonial era, and the responsibility of guarding these lands was given to military elements of the colonial powers (Jasanoff, 2016; Cavanagh et al, 2015; Neumann, 2004).
In modern times due to the profitability of many animal products, poaching groups are becoming increasingly well-armed. A recent example of this is in the case of an anti-poaching pilot, Captain Gower, who was shot down by poachers in Tanzania in January 2016 while conducting an anti-poaching flight in collaboration with the Tanzanian Wildlife Authority (Kideghesho, 2016). These kinds of anti-poaching flights are a response to ‘industrial-scale poaching’ from poachers who are ‘heavily armed with sophisticated military weaponry’ (Parveen, 2016). In defence of vulnerable species, a few aggressive conservation strategies adopted have been cited by some as a ‘new war for biodiversity’ (Duffy, 2014, Cavanagh, 2015, Neumann, 2004). This ‘war’ is against a crime that subverts the rule of law, compromises economic development, fosters instability, debilitates development assistance efforts and underpins weak governance in countries that are in early stages of state building. It also robs the global community of rare species of flora and fauna.

While there are numerous strategies currently being used to combat wildlife crime in different regions of the world, the focus of this thesis is on one aspect of this effort, namely the use of remote sensing (RS) technologies to monitor animals, rangers and poachers. Multidisciplinary partnerships are integrating conservation aims with cutting-edge technologies; these technological advances are being used to protect a wide variety of flora and fauna (Benson, 2010) and conservation practitioners have proven highly capable of incorporating sophisticated technologies into their work (Marvin, et al. 2016). This thesis is specifically focused on the use of remote sensing technologies used to detect and deter rhino and elephant poaching in East and Southern Africa. It must be noted that some of the technologies referred to are not strictly RS technologies; they are rather geo-spatial technologies that rely on data from RS technologies, for the purpose of consistency reference is always made to remote sensing (RS) technology. The regional focus of East and Southern Africa has been chosen due to the high rates of poaching and the high concentration of remotes sensing initiatives used to combat poaching in these areas. Remote sensing is defined as a way of collecting and analysing data to get information about an object of interest without the instrument used to collect the data being in direct contact with the object (European Space Agency, 2016). For the purposes of this thesis the use of standard closed-circuit television (CCTV) cameras has been excluded.

While this thesis acknowledges that the issue of wildlife crime has been securitized e.g. cited as a security threat with increasing involvement of transnational crime agencies, it seeks to investigate whether the issue has been militarised e.g. whether responses have adopted a military character. This militarised development, often cited within the academic literature as ‘green militarisation’, refers to conservation efforts that have adopted a military character. However, the characteristics that militarisation entails is often unclear, as different or a lack of definition is provided (Duffy 2014; Humphreys and Smith 2014; Lunstrum 2014; Büscher and Ramutsindela 2016, Neumann 2004). The criteria of what constitutes a military character lacks consensus in the literature when the label of ‘green militarisation’ is applied. Therefore, this thesis will analyse what ‘green militarisation’ means in the context of anti-poaching activities using RS technologies. It is important to focus on the militarisation aspect in the use of RS technology for anti-poaching efforts, as many of the systems in use were originally
created for military purposes e.g. UAVs, Global Positioning System (GPS) trackers, military grade ground sensors and advanced camera traps etc. In light of the increase in the use of RS technology in anti-poaching efforts over the past ten years, this paper seeks to investigate whether this can, in fact, be regarded as a militarised approach toward conservation.

1.1 Research aim

While there has been a marked increase in the use of RS technologies to combat poaching in East and Southern Africa there has been little analysis on the kinds of companies involved in their development. This thesis aims to begin filling the knowledge void by providing both an overview of the systems in use and an analysis on the risks and social impacts involved in using these technologies, particularly in resource poor areas. This is done through a literature review, presentation of a database of remote sensing projects in East and Southern Africa and a research survey. This thesis acknowledges that wildlife crime has become securitized and as such has generated concern in the conservation community over the militarisation of conservation efforts. Concern over militarisation is identified as a key concern in both the literature review and in the answers to the research survey; therefore this thesis goes on to investigate to what extent this concern is justified and a comprehensive picture of the situation will be provided.

Three central research questions will be addressed in this thesis.

1.2. Research questions

Given the purpose stated above the research questions are as follows:

**Research Question 1:** Which remote sensing technologies are in use and what kinds of companies and organisations are mainly working on their development?

**Research Question 2:** What are the main risks identified within the conservation community in relation to using remote sensing technology to specifically target wildlife crime?

**Research Question 3:** Can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation?

1.3 Delimitations

This thesis is concerned with RS technologies that are used in the physical conservation area where the species concerned reside; as such the analysis is limited in its exclusion of the use of non-RS technologies. Technologies that have been designed to combat wildlife crime but are not used in the conservation site for the purpose of detection and deterrence before the
poaching occurs are not included in this analysis e.g. big data mining, environmental DNA analysis and various wildlife crime apps, these will be briefly described.

Two winners of the Wildlife Crime Tech Challenge, a competition to design tools that assist in stopping wildlife crime, use big data analysis. One project employs a computational model that mines data from law enforcement agents to detect commercial sites for the fauna listed under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This information is used to detect enforcement gaps where illicit specimens are most likely to be trafficked. The second project running under The Global Database of Events, Language and Tone (GDELT) employs data mining in multiple languages to find news reports of wildlife crime events. These are then profiled and applied to a map to see where most events are taking place. Environmental DNA analysis can help in locating where seized elephant tusks and rhino horns were poached and conducting species identification for carcasses. This allows for the creation of biodiversity inventories that can be used by other remote sensing technologies mentioned in this thesis. In terms of crowd sourcing information, various identification apps and awareness raising games have been designed. These technologies, while valuable in combating wildlife crime, are not included in this thesis as they are not remote sensing technologies and may never affect the conservation sites where the animals in question reside.

The use of remote sensing technology is by no means restricted to East and Southern Africa and the decision to focus on these regions, as previously mentioned, is due to the high rates of poaching and the high number of remote sensing conservation technology projects in operation in these regions. In the case of elephants, they range over 37 African countries while 60% are known to exist in Botswana, Tanzania and Zimbabwe. Eastern Africa experiences the highest rate of elephant poaching, with Tanzania being the worst affected. In the case of rhino horn, 94% of global poaching incidents in 2014 took place in South Africa, 68% of which took place in Kruger National Park alone (World Wildlife Crime Report, 2016, p42 & p.70). In terms of the analysis used in this thesis, the regions chosen make it appear that the use of remote sensing technology used for conservation purposes maintains a species bias toward elephant and rhino. However, this is simply a reflection of the regions chosen and the international preference for the preservation of these large iconic mammals in these countries. As the United Nations World Wildlife Crime Report (WWCR) shows, different illicit species flows are associated with different regions e.g. birds with Central and South America, mammals with Africa and Asia, reptiles with Europe and North America and corals with Oceania (2016, p.14). Any of these regions could equally have been chosen as the focus of analysis in this thesis. It is not possible to say whether the technologies reviewed in this thesis and the associated impacts on local communities are applicable to regions outside of the study area.

2 Background

In East and Southern Africa, the vast majority of technologies have been designed to target the poaching of elephants and rhinos, therefore, the legislation and attempts at market
legalisation will be covered specifically for these two species. This background is provided so that the reader can understand the broader context in which remote sensing technologies are being used. It is important to understand the wider legislative context in which poaching is taking place and the dynamics of the illicit markets. The background on trophy hunting and the trade in rhino horn will first be outlined before looking at the trade in elephant ivory. This will then be followed by a description on the stockpiling of these wildlife products and a description of how the issue of poaching has been securitized; other non-remote sensing strategies used to deter poachers will then be discussed.

Scholars from different disciplinary backgrounds have written on the topic of poaching and illegal hunting is covered in journals in Applied Ecology, Criminal Justice, Conservation Biology, International Relations, Political Geography, and Remote Sensing among others. This thesis is written under the subject ‘Sustainable Development’. The recent recognition of this subject as an academic discipline is reflective of the need to analyse phenomena from a multi-disciplinary perspective, drawing on insight from a range of academic subject areas. Sustainable development is a broad field of research which takes its definition from the 1987 Brundtland report which first used the term sustainable development to refer to the need to meet human development goals while sustaining the natural systems that provide the resources on which the economy and society depend. Sustainable development is also used as an organising principle for the new UN sustainable development goals (SDGs). Illegal poaching in East and Southern Africa is both an economic, ecological, social, and political issue.

### 2.1 Legislation & Legalisation

The horn and tusk of these animals is highly sought after by criminal syndicates for their lucrative market value. Rhino horn is regarded as containing high medicinal value in several countries in Asia, e.g. China, Thailand and Vietnam, and is used to treat fever and cardiovascular disease, and more recently cancer and hangovers. The horn is made from the same substance as the human finger nails, keratin, and contains no scientifically proven medicinal value. The horn is also consumed as a status symbol as it is rare and hard to purchase. The biggest market is currently in Vietnam where rising incomes are fuelling demand (WWCR, 2016, p.70).

Elephant tusk is regarded as highly precious and has historically been used as a prestige symbol to display ones cultural credentials, e.g., used as piano keys, hair pins, carvings, etc. In modern day China, where the biggest market demand for ivory is found, possession indicates the political connectedness of the owner precisely because it is so difficult to obtain (WWCR, 2016, p.41 & 45).

The dominant piece of international legislation prohibiting the trade in these products is the International Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), originally signed in 1973. 173 states are party to this convention agreeing to protect over 30,000 species of flora and fauna. CITES is an international trade agreement and
as such it regulates the flow of illicit goods between countries – it does not possess jurisdiction within states, only over flora and fauna in transit. Nations can decide in their own national legislation to regulate domestic behaviour toward different species, this they can adjust as they see fit (CITES, 2016).

2.1.1 Trophy hunting and the trade in Rhino horn

Two species of rhino, black and white, exist in four African countries, including Kenya, Namibia, South Africa and Zimbabwe. Trophy hunting is legal in both Namibia and South Africa and is used as a conservation strategy to prevent the habitat loss for these species. The cost involved in preserving the habitat of rhino can be offset by the income gained from selling hunting permits. This is necessary to stop landowners switching to other more lucrative forms of land-use. While this measure has proven successful in conserving rhino’s ranging lands in South Africa it also provides a loophole for ‘pseudo hunts’; practices whereby individuals who possess no hunting skills purchase permits and hire a professional to make the kill. This practice is illegal in South Africa. Trophy hunters are entitled to one permit per year and in case of black rhinos the kill must be directed toward male (bulls) that are no longer fertile. Hunting of white rhinos is less regulated because of their higher population. The rules stipulate that after the kill the rhino horn must be micro chipped and mounted by a taxidermist. Official government documents then accompany the horn in order to legally exit South Africa. However, legal flows of horn cause confusion in consumer markets about what is legal. In some cases legal streams of horn can inadvertently boost illegal markets by endorsing acceptance of consumption and providing criminal syndicates with an opportunity to falsely present illicit horn as legal (IUCN, 2016, p.10).

Between 2007 and 2010 annual averages of 116 rhinos were hunted in South Africa. This is almost double that of the previous three years (CITES, 2013). The WWCR explains that Vietnamese nationals, who are the largest consumers of rhino horn, submitted large numbers of applications. Thus, in order to prevent pseudo hunts, the South African government banned applications from Vietnamese nationals in 2012 (2016, p.73). Authorities in the Czech Republic then became aware of a huge increase in national applications for hunting licenses. During the investigation that followed, Vietnamese traders were found to be recruiting Czech citizens to participate in pseudo hunts. Twenty-four horns were discovered and sixteen people in the Czech Republic were prosecuted (WWCR, 2016, p.73). The high price rhino horn fetches on the black market outweighs the price of an average trophy hunt. Hence professional criminals who previously had no association with rhino hunting are being attracted into this trade.

In South Africa there are several cases where game owners have been convicted of racketeering, implicated in schemes with Asian criminal networks for violating trophy-hunting regulations. The US Presidential Task Force for Wildlife Trafficking has convicted 30 individuals under “Operation Crash” an initiative that specifically targets the trafficking of rhino horn and elephant tusk (US Department of State, 2016). One notable conviction involves South Africa brothers –The Groenewals, owners of ‘Out of Africa Adventurous
Safaris’ who were extradited to the US and convicted for defrauding nine US tourists under the Lacey Act – the nation’s oldest criminal statute addressing illegal poaching and wildlife trafficking (US, Department of Justice, 2014). The pair travelled to ‘gun shows’ throughout the US where they sold illegal hunts. Professional American hunters were deceived and told that the rhinos had to be killed because they were “problem rhinos” thus the horn could not be legally exported, instead the hunters could pose for a photo with the dead animal and the brothers would subsequently sell the horn on the black market – capitalising twice on this venture. Considering that the majority of conservation land in South Africa is privately owned and it holds the highest number of rhinos, it would be impractical to ban trophy hunting which acts as a much needed income source for their conservation (IUCN, 2016, p.2).

However, there is an alternative to trophy hunting that is being trialled in some parks in South Africa labelled “green hunting” which involves shooting rhinos with a tranquilising dart rather than a bullet, allowing the hunter to take photos, moulds of the horn etc., before a vet administers an antidote. Legalising the trade in rhino horn is a highly contentious topic. Some game owners foresee a legalisation of the trade in the near future and have begun stockpiling. One ranch in North West South Africa holds 1,261 rhinos – 4% of the global population. The owner maintains a permanent veterinary team who are tasked with trimming the horn every 19-24 months; this is stockpiled in the hope that it can be sold legally in the near future (Bale, 2016). Despite the lack of evidence that selling horn legally will curb the market demand or decrease poaching rates, the owner of this ranch is fighting a court battle with the government of South Africa to legalise the trade (Laing, 2016). Other instances of farmed rhino can be found in China where white rhinos have been imported from South Africa and are being bred in captivity – permits are currently only provided for pharmaceutical research purposes (Al Jazeera, 2013).

2.1.2 Elephant hunting and the Ivory trade

Elephants were placed on Appendix 1 of the CITES convention in 1989 which effectively put a ban on the international trade in ivory. Since the ban, elephant poaching has declined in some countries and changed little or even increased in others (Lemieux & Clarke, 2009). In 1997 and again in 2000, elephants ranging in Botswana, Namibia, South Africa, and Zimbabwe were down-listed to Appendix II and one-off sales of ivory stockpiles were permitted – to Japan in 1999 and to Japan and China in 2008. These sales are cited as causing confusion in consumer markets with buyers unclear about whether the sale of elephant ivory is legal or not. The decision to allow the sale of ivory stockpiles was initiated under the condition that funds would be exclusively used for elephant conservation and development programmes within or adjacent to the elephant range. Whether this happened remains a contentious topic (Cruise, 2016). It is expected that at the CITES Conference of Parties (CoP17) taking place in South Africa this year (November, 2016) several Southern African Development Community (SADC) countries, including Namibia, South Africa and Zimbabwe, will seek permission to operate a controlled market for trade.
2.2 Stockpiling

Conservationists argue that any attempt to decrease the price of these wildlife products through legalisation will simply trigger crime syndicates to stockpile in order to regulate the price, as is done with other products e.g. oil, tuna and is suspected to be the case with elephant tusk. The data available on the amount of elephant tusk found on the market is not reflective of the poaching rates recorded. The WWCR (2016, p.45) claims that it is difficult to see where the tens of thousands of ivory shipments are going. The incongruity in market demand and poached quantities has led some to hypothesize that criminal syndicates are stockpiling the tusk, using it as an object of speculation and an investment-grade product. If this is found to be true then it undermines government led initiatives to destroy stockpiles, as these actions further limit the supply to the market, consequently enriching the very groups these actions seek to deter.

Since the ban on ivory trading in 1989, several politically backed campaigns across the continent have organised stockpile-burning events to raise awareness of the scale and impact of the illicit trade. One recent awareness-raising event was held in Nairobi National Park, Kenya, where President Kenyatta set ablaze 105 tons of elephant ivory and 1.35 tons of rhino horn – the largest government stockpile in history. This event was widely covered in the continent’s media outlets and attended by a number of international state dignitaries. On visiting this site several months later I could not help thinking of the cost of this performance. There is a melancholic irony to over a hundred tons of ivory and horn worth more than its weight in gold and diamonds being set ablaze, with the smoke wafting over to the adjacent settlements in Kibera, the largest slum on the continent.

![Fig. 1. Burnt Ivory Stockpile in Nairobi National Park (2016)](image)

2.3. Securitization and militarised responses to poaching

It is widely acknowledged that the issue of illegal poaching has been securitized and the ‘war on poaching’ is often framed within a greater ‘war’ on biodiversity protection – this has been termed ‘green militarization’ (Lundstrom, 2014). However, it is necessary to differentiate between securitization and militarisation. The theory of securitization derives from the
Copenhagen School of Security Studies; the theory regards threats as emerging from a collective inter-subjective construction. In the securitizing process there is a move by a securitizing actor, typically a speech act which verbally consigns the referent object to the realm of a security threat. This is then either accepted or rejected by the audience on the grounds put forward. The response, if accepted, is then an extra ordinary military orientated move by the securitizing actor (Buzan & Wæver, 1988). This response can amount to militarisation depending on the definition used. The use of ‘militarisation’ or ‘green militarisation’ terminology should be approached cautiously as the term is loosely defined. The Oxford Dictionary (2016) defines militarisation as to “give (something, especially an organisation) a military character”.

References to “green militarisation” rather relate to securitization, i.e. speech acts that relegate conservation concerns to that of a security threat. Several scholars have reflected on the value and use of the term green militarisation and called for a refinement of the concept. Shaw & Rademeyer have claimed “current explanations of ‘green militarisation’ at least as they apply to Kruger often obscure as much as they explain, drawing as they do selectively on the available evidence.” (2016, p.11) “There is not an “easy fit between ‘militarisation’ and events in Kruger as a reading of the literature suggested, we found a troubling incongruence between the emerging academic consensus and what we viewed as the reality. The evidence suggests that the ‘green militarisation’ arguments may have been overplayed, with important implications for refining how the phenomenon should in fact be analysed” (Shaw & Rademeyer, 2016, p4). According to these authors, the role of the security forces in South African conservation affairs does not amount to militarisation, framing it as such would be a case of further securitization. Others have raised this view in terms of the broader discourse of a ‘war on biodiversity stating that these “discourses that ‘securitise’ climate change are actually part and parcel of these markets, and thus play a part in bringing about the very insecurities that they might purport to address” (Dunlap & Fairhead, 2014, p.938).

While the issue of poaching has certainly been securitised, shown in the fact the many law enforcement agents are now focused on this issue and the profuse use of war terminology employed when the issue is discussed, militarisation does not always necessarily follow. That is not to say that in some cases militarisation by all definitions has taken place, but this must be assessed on a site-specific basis. In the case of Kruger there have been some large donations of military equipment, including UAVs and helicopters, by the Ichikowitz Family Foundation and founder of the Paramount Group, the largest defence company on the continent. However, whether these donations translate to militarisation on a national level is debatable. There are a vast number of conservation parks in East and Southern Africa, each managed in a different style, with different techniques and types of equipment employed. While it can broadly be claimed that the issue of poaching has been securitized, it cannot simultaneously be claimed that the issue is militarised, as this depends on the definition of militarisation used and the site-specific conditions.
2.4. Other strategies used to deter poachers

Beside the use of remote sensing & geospatial technology, other strategies have been trialled, unsuccessfully, to deter poachers. Some of the more prominent ones will be described here. One involves infusing rhino horn with a combination of chemical compounds that can make those consuming the horn sick. However, the effectiveness of this strategy is still unknown. As Ferreira et al (2014, p.55) show, even when the infusions contain indelible dye the poachers may not see this due to the blood, mud and other substances covering the horn during poaching events. The idea that demand will be curtailed by poisoning the horns should also not be taken for granted. As in the case of puffer fish, a delicacy in China and Japan, the poisonous neurotoxins it contains and the death of several consumers each year has not decreased demand (Bingbin, 2012, cited in Ferreira et al, 2014, p.52). Maintaining the effectiveness of the infusion is challenging and the cost of administering it is high. This deterrence strategy is feasible in small and relatively isolated populations; however, it is impractical in larger widely dispersed populations. Another strategy has been removing the rhino horn entirely, however, this is also not a sustainable solution as the horn grows at 5-6cm a year and poachers have been known to poach for just the stump of the horn.

In the case of elephants, removing the tusk is often proposed as a possible solution to poaching, but this is a highly impractical strategy. Firstly, it is very expensive to hire the large teams of veterinarians and rangers needed to take down the world’s largest animals, weighing up to six tons. The effective sedatives are very costly and difficult to obtain and there are far too many elephants to make it realistic to capture all of them – an estimated 470,000 African elephants (WWF, 2016, p.42). Most elephants live in remote areas that can make darting extremely laborious. The elephants also require their tusks for digging grasses, roots, defending themselves and their young and excavating water etc.

Another strategy put in motion last year is 3D printing of rhino horn. Pembient, the company who launched this initiative, claims that it will provide a cheap alternative to consumers in the same way faux fur does. The CEO of the company asks “Why not try to satisfy their needs instead of telling them their needs are wrong?” (Osborne, 2015). The synthetic printed horn is largely made of keratin and retains the same spectrographic signature as rhino horn. Conservationists have claimed that the company has missed the point as many consumers use the horn as a status symbol that a 3D print won’t substitute. The demand the imitation product may stimulate could act as a smokescreen for illegal horn to enter the market. By approving a similar product the value and demand for horn is endorsed. The director of TRAFFIC, the largest NGO dedicated to wildlife trafficking responded to this company by saying “The road to hell is paved with good intentions. My hat’s off to these guys for sticking their necks out and trying to do something but they should sit down with the people in the country who are experts on consumers and talk these things through, because this could really backfire.” (Nuwer, 2015). The failure of these efforts increases optimism toward the use of remote sensing conservation technology initiatives, an advantage of which is that they make very limited impact on the day-to-day welfare of the animals – the only technology that causes a minor disturbance is the use of GPS tags or collars.
3. Methodology

The research for this thesis was conducted during a visiting research scholar placement at the UNODC Policy Analysis and Public Affairs section at the United Nations in Vienna, Austria. The questions posed in this thesis were identified as important and unexplored ones that resounded in conversations and policy discussions during this placement.

There are a number of UN agencies working with the topic of illegal poaching, The Global Programme for Combating Wildlife and Forest Crime working under the Policy Analysis and Public Affairs division of the United Nations Office on Crime and Drugs (UNODC). The United Nations Environment Programme (UNEP), headquartered in Nairobi, and the United Nations Office for Outer Space Affairs (UNOOSA) who held a conference at the request of the Kenyan government and in collaboration with ESA, on the subject of Space Technology and Applications for Wildlife Management and Protecting Biodiversity, in June 2016. Each agency has different mandates to fulfil in relation to protecting bio-diversity and preventing wildlife trafficking and as yet there is the lack of a clear vision on how any of these agencies will engage with RS technology to prevent wildlife crime.

The methods that were used to answer the research questions of this thesis entailed three stages of research.

The first was the creation of a database of projects working with RS technologies for anti-poaching purposes, in Appendix 2. This method was used to answer the Research Question 1: Which remote sensing technologies are in use and which organisations are mainly working on their development? I was sponsored by UNOOSA to attend the conference on Space Technology and Applications for Wildlife Management and Protecting Biodiversity in Nairobi, 2016. This conference revealed that to date there had been no systematic study on the different remote sensing technologies in use to combat wildlife crime. In order to begin exploring this subject a systematic ‘database’ was created in-order to empirically show the kinds of initiatives being undertaken, the actors involved and the aims of each project.

The second method used was a research survey to answer Research Question 2: What are the main risks identified within the conservation community in relation to using remote sensing technology to specifically target wildlife crime? As Oberg and Sollenberg (2011) argue, surveys are a good method to ascertain the soft issues of a subject. As Hoglund and Oberg (2011) explain, “surveys are an important tool for establishing what people in general or in particular sub-groups actually think and feel about conflict-related issues.” The method of using a research survey was opted for over interviews, as I wanted the answers to be reflective of a range of people rather than detailed opinions of just a few individuals. It proved more practical to ask people in high positions with busy work schedules to dedicate five minutes to filling in a research survey rather than arranging an interview. While the latter would have been possible in some cases, the number of contributions would have been much lower – this is usual when interview and focus group methodologies are adopted.
The third method used was a literature review which both provided the historical, socio-economic and political background to the issue of poaching and also allowed me to formulate Research Question 3: Can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation? As there were many references to the green militarisation of anti-poaching efforts in the academic literature I decided that this was an important issue to focus on. The importance of this issue was also confirmed in responses to the research survey, where many respondents were concerned about the militarisation of anti-poaching efforts.

### 3.1. Method A: Database compilation of companies working with remote sensing technology for wildlife protection in East and Southern Africa

Initially a database of companies working with remote sensing technology for wildlife management was compiled by extracting the relevant information from a database of over 4000 press clipping documents. Each document contained approximately 10-20 news stories on issues relating to wildlife crime. I had access to these internal press clippings that were compiled on a daily basis for both the Policy Analysis and Public Affairs sections of the UNODC and a separate stream of press clippings created specifically for those working with the UN Global Programme for Combating Wildlife and Forest Crime. These daily press clippings contain the most relevant international news stories relating to wildlife crime and are created to keep those working within these UN departments informed about issues relating to their mandate. All the articles contained in the press clippings are open source and no confidential documents were accessed.

The documents I accessed date back to 2013 and the search terms used to find relevant articles are shown below. I compiled a list of relevant categories in which the related information was extracted. This forms the remote sensing wildlife crime database found in Appendix 2. I do not consider this database comprehensive as there are likely still companies not listed that are working with RS in the region that I have not found through the methodology outlined above. I intend to continue working on the database subsequent to publication of the thesis and the future intention is to use this database to display the information on an interactive web based map, geo referencing the projects and displaying them through Leaflet or QGIS. The purpose of this is to allow organisations and companies working with remote sensing technology for wildlife protection to become aware of other initiatives taking place in the same region and thus to learn from similar solutions. It is hoped that this will allow for increased collaboration between projects and provide a site to share resources, expertise and knowledge on difficulties and best practice.

The database was created to get an overview of the different initiatives underway in East and Southern Africa, to understand which organisations are mainly working in this field and what the main sources of funding are. The database also shows the kinds of technologies in use and the given purpose. This information is used to order the systematic study and answer the first research question of this thesis. **Research Question 1: Which remote sensing technologies**
are in use and which organisations are mainly working on their development? There are a great number of remote sensing technology initiatives in the study region, but to date there has not been a study looking at the specifics of these projects. I have presented the database in a systematic manner to provide new empirical data in this field.

### 3.2. Method B: Research Survey

The second method chosen was a research survey directed toward those working with wildlife crime. This was used in order to answer **Research Question 2: What are the main risks identified within the conservation community in relation to using remote sensing technology to specifically target wildlife crime?**

The survey was distributed through several of the UNODC media channels, including the UNODC main Facebook home page and the Facebook page of the United Nations Global Programme for Combating Wildlife and Forest Crime. The survey was also sent to all those who attended the United Nations for Outer Space Affairs conference on Space Technology and Applications for Wildlife Management and Protecting Biodiversity held in Nairobi in June 2016. I gave a short presentation at this conference on the research aims of this project. The survey was also sent to those on the mailing list for the UNODC daily press clippings. Additionally, I individually emailed the link to organisations and academics working with related technologies. Although this is a niche area of research I managed to get over fifty responses to the survey from those who are working with wildlife crime on a daily basis. The way the questions are phrased is shown in Appendix 1.

The respondents were not asked to provide their names but to briefly specify their role and the organisation they work with. The majority of respondents work with international conservation organisations or government agencies tasked with preventing wildlife crime. Organisations that represent more than two contributions to the survey include TRAFFIC - the leading NGO working with wildlife trade monitoring, The International Police (INTERPOL), the Kenyan Wildlife Service, employees of the United Nations Environment Programme (UNEP), World Wildlife Fund (WWF), Wildlife Conservation Society, United Nations Office on Drugs and Crime (UNODC), employees working with the UN Global Programme for Combating Wildlife and Forest Crime or in the research branch for the United Nations World Wildlife Crime Report and the United Nations Office for Outer Space Affairs (UNOOSA).

Respondents from other international conservation agencies include Save the Elephants, CITIES, African Regional Centre for Space Technology and Space Science and Amboseli Elephant Trust. Answers were also provided by government agencies working in East Africa i.e. the Lusaka Task Force agreement, the GIS office in the Department of National Parks (Kenya), the Wildlife Ministry of Tourism (Zambia) and the Ministry of Environment and Natural Resources (Kenya). The remaining respondents work either in academia, technology companies and environmental security think tanks or in organised crime investigation units.
The first question of the survey asks whether respondents have an awareness of remote sensing technology used for wildlife protection or if it is used in their workplace. This is asked so that answers from those who are not knowledgeable on the topic could be discounted along with those who do not work with technology in relation to wildlife crime.

The last question of the survey asks respondents whether they see any risks in the use of high-tech monitoring technology and asks them to briefly explain what these are. More than half the respondents believe there are risks and twenty seven respondents decided to further outline what they believe these are. The answers to this question are used to answer Research Question 3 in this thesis.

3.3. Method C: Systematic literature review

A systematic literature review of academic literature and policy documents was used to understand the socio-economic issues and political contexts surrounding the topic of poaching. The findings from this review allowed me to design and answer Research Question 3: Can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation? The answer to this research question is found in the Discussion section of this thesis. The topic of ‘green militarisation’ was raised frequently in the literature and was thus deemed as an important topic for analysis. This was also confirmed as an area of concern as identified in the research survey comments e.g. one respondent stated that “The militarization of anti-poaching efforts is a disturbing trend”.

The literature review includes only a small fraction of the extensive academic work on the historic and socio-economic political complexities of poaching - this is a well-studied topic. However, few studies were found on the use of remote sensing technology in anti-poaching efforts. The review was comprised of articles from a selection of academic journals and professional publications plus the use of some grey literature, which included news articles from well-established news sources. A preliminary scoping of the literature was conducted in February 2016. Initial searches drew an abundance of irrelevant results so search terms were further refined, re-formatted and re-trailed before the final selection was reached in April 2016. The following terms were experimented with: poaching, wildlife, GPS, drones, sensors, illegal hunting, East Africa, Southern Africa, crime, technology, remote sensing, among others. Terms that resulted in too many studies that were not relevant to the research questions were removed. The selection of terms needed to be inclusive but yet specific enough to have relevance to the research questions. The keywords that were settled upon remained largely the same across the different databases used, consisting of combinations of the following: remote sensing, technology, wildlife and Africa.

The scope of the review was then limited by the following exclusion criteria:

- Studies that have yet to be, or are not, peer-reviewed.
- Studies published prior to 2000.
• Studies not available in English.
• Studies focused on regions outside East and Southern Africa

Sources falling under this exclusion criterion may be of benefit to this review but due to time and author limitations these have been excluded. Searches were conducted through several academic databases including Web of Science, Scopus and the Directory of Open Access Journals.

3.4. Data quality limitations

The quality and the validity of the research survey results rely heavily on the expertise and experience of the respondents. As those working in international conservation and government agencies were predominantly those who answered the survey, it is reflective of this group. The limitation of this study is also that it relied heavily on the contacts of those working with the UNODC and those who attended the conference held by UNOOSA, UNEP and the Kenyan government. Thus, there is a bias in the results in that the majority of respondents who live in the research region are Kenyan. East African delegates are disproportionately represented and although the thesis seeks to cover Southern and Eastern African, there only a few respondents that I know of who are working in or with Southern African countries.

Another limitation is that the press clippings used as the basis of the database only date back to 2013 and I only had time to review literature that was published after 2000 on this topic. Although there were several rangers who answered this survey, which could be considered “local views” as they reside in the conservation area, there was no input from individuals living within or close to conservation sites that are affected by wildlife protection projects but are not directly involved in them. Another minor limitation is that I only accessed sources in English. However, the vast majority of countries in East and Southern Africa have English as one of their national languages, so this is not a major factor. It is hard to speculate on the generalisability of the findings from this study to other regions. As the technology analysed is the same as that used elsewhere, it could be assumed that similar social impacts would be found. However, saying this, tenure arrangements and the colonial history of conservation efforts vary in different regions on the continent and this would affect the impacts felt on the local level. The involvement of international organisations in national affairs also varies country-to-country and this affects how externally organised interventions are perceived on the local level.
4. Results

4.1. Research Question 1

Which remote sensing technologies are in use and what kinds of companies and organisations are mainly working on their development?

As previously mentioned there has been little academic analysis on the kind of remote sensing technologies being developed and deployed in conservation areas despite a proliferation of initiatives. This phenomenon is relatively recent, spurred by the drop in price of equipment, reduced energy consumption, improvement of battery life and miniaturization of technology. This has resulted in increased availability of sophisticated remote sensing systems for conservation purposes (Wall et al. 2014). Currently there are no independent empirical studies of anti-poaching technology, so there is little independent evaluation or validation on which systems have proven successful in their stated aims, or a comparison of which systems work best in particular environments.

To answer the first part of the research question, some of the different systems in use in East and Southern African, as shown in the database, will be outlined. This is not to laboriously list the initiatives in operation but to provide an overview to the reader of the types of technologies available. Examples of the kinds of systems in use are described under six categories, which are used to show the most common technological systems in use. These include patrol visualization tools, GPS trackers, sensors, drones, acoustic monitoring systems and camera traps.

Some of the initiatives described use a combination of these technologies and would fit under several categories but have been placed appropriately for ease of reading. The list of initiatives mentioned below is by no means exhaustive; please see Appendix 2 for a more comprehensive overview.

4.1.1 Which remote sensing/geospatial technologies are in use?

Patrol visualization tools are commonly used to improve patrol efforts by concentrating ranger movements in high-risk locations. These tools primarily rely on GPS tracking of both animals and rangers and geo-referenced coordinates of elephant carcasses and other important information, such as sightings of poacher activity. One of the largest and most used data collection systems for elephant conservation was launched by the CITES programme to Monitor the Illegal Killing of Elephants (MIKE). This project is used in more than 50 sites on the African continent and is funded by the European Union and based at UNEP in Nairobi. The tool relies primarily on two types of data: geo-referenced location of elephant carcasses and ranger patrol information e.g. routes, time and length of patrol. There is a choice of two formats depending on the capabilities and resources of the user group; either a paper based workbook that can be freely downloaded or a Geographic Information System (GIS) based system called the Spatial Monitoring and Reporting Tool (SMART). The interactive map
provides a point of review so that decisions regarding ranger patrol routes can be made in an informed manner.

There is a similar tool running in Garamba National Park in the Democratic Republic of the Congo (DRC) under the ‘Enough Project’ and supported by Digital Globe. Although the DRC does not fall in the study area used in this thesis, Garamba National Park is close to the Ugandan border, and African Parks, a South African based conservation company, is implementing the project. It is an interesting project to include due to the enormity of the park and the vulnerability of the animals, hence the need to concentrate ranger patrol efforts. This system uses satellite imagery to locate roads, rivers, land use and elevation. This information is then overlaid with the GPS coordinates of ranger bases and human settlements. Past events can be stored and poaching patterns revealed to show vulnerable locations where ranger efforts can best be targeted. This tool uses geospatial analytic software called Signature Analyst to predict where poachers may strike next.

GPS trackers are a commonly used tool to monitor animal movement and ranger patrol routes. These are being used in Uganda under The ‘Wildlife Intelligence and Leadership Development’ program (WILD Leo) which has embedded cameras into GPS tracking devices in order to take photos of animal carcasses, snares, poachers and other sites of interest. The technology, donated by the Netherlands Institute for the Study of Crime and Law Enforcement, has been used to train rangers from the Uganda Wildlife Authority and Uganda Conservation Society. Imagery is uploaded into a database and the photos are used for courtroom evidence to increase poacher prosecution and conviction rates, and also for crime mapping which can provide a basis on which to design anti-poaching patrols.

Another project based in Ngulia sanctuary in Western Kenya aims to better understand the technical training needs of the Kenyan Wildlife Service rangers. This project is under the guidance of the Stimson Centre, a security think tank based in the USA and partnered with technical experts from the University of Linköping in Sweden. Rangers are provided with smartphones that is used to note their observations on security and wildlife matters. Photo documentation with automatic geo-tagging is then collected. The app is used as a navigation tool; park rangers receive their position overlaid on a map with an interface that includes local landmarks such as waterholes, roads, trails, borders etc. The app allows them to map their patrol routes so they know where they are in relation to other rangers and to high-risk poaching spots etc.

GPS trackers have commonly been attached to wildlife in the form of collars, ear tags or embedded under an animal’s skin. This is used to monitor movements e.g. bird migrations. Various private companies around the world are developing these tracking devices e.g. savannah tracking, telemetry solutions, biotrack, sirtrack etc. In order to visualize elephant movements Save the Elephants in collaboration with Vulcan Tech, a private company based in Seattle, attached GPS trackers to elephants. This project tracked the movement of elephants and uploaded the data into the Google Earth platform. This then shows a simulation of their movements, the movement range, frequented routes etc. The male and female elephants were
assigned different colours to see if there were any noticeable differences in behaviour. This tool can be used to assist in the design of ranger patrol routes and allows knowledge acquisition of how elephants respond to land use and land cover change.

Another project supported by the Humane Society International called Real-time Anti-Poaching Intelligence Device (RAPID) has attached a heart rate monitor to rhinos in the form of a collar. When the heart rate increases or stops, this triggers a video camera implanted inside the rhino horn to turn on, a signal is then sent to the operator with the GPS co-ordinates of the animal so that rangers can go and investigate.

Sensors are used in many of the initiatives listed in the database. One example is an NGO called Wildland Security who developed a system called ‘Trail Guards’. This system offers surveillance of paths into vulnerable conservation areas and consists of concealed electronic sensors triggered by the motion of a large animal or by metal detection e.g. poachers carrying rifles or machetes. Fire detectors have also been installed and hidden in the trees as poachers often smoke meat before taking it to market. Once the sensors are triggered rangers are alerted and given the GPS co-ordinates of the event via satellite phone.

Similar to this project is an initiative by the Zoological Society London (ZSL). In collaboration with WWF and other organisations, they have designed an early warning system in use by the Kenyan Wildlife Service in Tsavo National Park in Kenya. This system uses magnetic military grade ground sensors and passive infrared heat detection sensors to send alerts over the Iridium satellite network to a server which is accessed by rangers to alert them to potential poaching events.

Camera Traps have long been used in conservation for the purpose of security, creating species inventories and monitoring conservation measures, etc. The ZSL and Kenyan Wildlife Service project described also employs camera traps that are camouflaged and hidden in the canopy. Once triggered by movement, they turn on and send an alert to rangers via satellite with the intruder's coordinates. This compliments the ground and infrared sensors of poacher movement.

In South Sudan’s Western Equatoria state, funds from the United States Fish and Wildlife Services, Bucknell University and Flora and Fauna International have been used to set up camera traps to monitor the stock and range of wildlife. Due to the political instability in South Sudan, there is approximately 300 km² of dense untouched forest where it is not known which species and how many exist, such as forest elephants. International teams then sifted through thousands of photos taken by the cameras to identify the species present in this forest belt. The initiative was set up to aid local wildlife authorities and to provide a means of employment for reformed poachers – these individuals were given the role of wildlife ambassadors and tasked with monitoring camera traps and adjusting GPS units in the fields.

UAVs (drones) also work as camera traps, often using infrared and thermal imaging to detect wildlife and humans around the clock over vast distances. The cameras can be mounted onto
UAVs or low-speed reconnaissance aircraft. Numerous parks in South Africa use UAVs, particularly Kruger National Park that is contiguous with Limpopo National Park in Mozambique. 94% of recorded rhino poaching took place in South Africa in 2014 (WWCR, 2016, p.70).

One clear demonstration of militarisation are the donations made by Denel Dynamics and The Ivor Ichikowitz foundation in association with Paramount, Africa’s largest privately held defence and aerospace company, to the South African National Parks authorities (SANparks). Donations include a $2.5million UAV and a gazelle helicopter with a night vision cockpit. The Seeker 2 UAV maintains 10 hours flight time to monitor two million hectares and is equipped with optical, infrared and radar sensors. Ivor Ichikowitz states, “The fight against rhino poachers in South Africa has become a war - and it is a war which requires the latest defence and security solutions.” (Ichikowitz, 2012). “During wartime, the strategic advantage always belongs to the force that has superior airpower. Essentially, although this is a unique ‘warzone’, the Gazelle will strengthen SANParks’s existing forces and bring this element to the Kruger National Park.” (Ichikowitz, 2013).

There are several UAV projects in Namibia that offer live video streaming to assist rangers in spotting poachers, tracking patrol locations and monitoring animal movements. One UAV project in Kenya integrates this UAV system with GPS-tagged rangers connected by a digital radio system so that the images generated can be used in collaboration with ranger positioning. Professors at the University of Maryland, Institute for Advanced Computer Studies (UMIACS) have developed a system whereby a Falcon UAV, infrared night vision camera is guided by a computer program that predicts the movement of rhinos and poachers. This system uses years’ worth of data collected by local game wardens and incorporates advanced programming using game theory in order to predict future changes in poaching behaviour. The South African Council for Scientific and Industrial Research (CSIR) in collaboration with the University of Pretoria’s Statistics Department and researchers from the Thales Research and Technology group of laboratories based in the Netherlands have designed a similar predictive modelling tool. This tool uses data mining algorithms to find patterns within poaching data. This acts as a ranger decision-making aid to allow for the best positioning of resources.

Acoustic Monitoring is a tool used to track animals and poachers. To combat wildlife crime a technology called ‘shotgun sensor’ is used which locates the geo-position of a gunshot so rangers can spot and arrest culprits. This technology is only useful for poaching incidents where guns are used. It has proven successful for police forces in the US, accurately locating crime spots.

4.1.2 What kind of companies and organisations are working on developing and implementing technology for conservation?

It is evident from the descriptions above and also in the more detailed database in Appendix 2, that the majority of developers are international NGOs or recently conceived NGOs dedicated
to developing technology for conservation purposes. These NGOs often work in collaboration with technology companies based in the US/Europe or university research groups and think tanks. The collaboration on the ground is predominantly with park rangers, patrol teams, conservation managers and national wildlife authorities. The expertise tends to originate in the northern hemisphere and is then deployed in conjunction with local wildlife services. In this regard, building up technological capacities is beneficial when training is adapted accordingly. As identified in the risks of the research survey described in the next section, it is important that there is continual funding available for training and maintenance of such systems otherwise they will fall into disuse when external actors leave. There are few projects that have military companies involved except in the case of South Africa where the Ichikowitz Family Foundation who have made several large donations of equipment. Thus, it is evident that while the issue of wildlife crime has been securitized at the international level, there exists few remote sensing technology projects in this region that could be considered as possessing a military character.

Connectivity is a big issue in many regions, particularly when systems are designed for real-time data transfer. However, lower costs in obtaining satellite network access are improving connectivity in rural areas. It has been claimed that the private technology sector is eager to enter these new wildlife markets, particularly in emerging and developing parts of the world, and it has been wildly speculated that the market for the use and capacity building of remote sensing technologies in these regions over the next few decades is worth upwards of $60 trillion (Bergenas, 2014, p.8). However, when looking at the main stakeholders working with these conservation projects on the ground in East and Southern Africa, there are few cases where private technology companies are heavily involved. Collaboration between private companies and ground based NGOs tend more often to be the case. Knowledge of local conditions is needed in the design phase as technologies need to be operable within field conditions, fit with existing operations and rangers need to be capable of operating the systems. These factors mean it is difficult for private technology companies to develop systems in a technology lab far away from the conservation sites. The design of the technology needs to consider the topography of the region and the character of the poaching threat in order to allow smooth transfer to the site conditions. Conservation agencies provide this knowledge link as they dedicate time to understanding local development needs and also have access to the decision makers in private high-tech development companies. The knowledge link required is perhaps why the majority of remote sensing technology projects are wholly or partly run by conservation agencies – they are best situated to ensure projects succeed. The technology needs to be simple, low maintenance and robust and there always needs to be a group of reliable rangers able to respond. While none of this sophisticated technology will solve the complex socioeconomic issues underpinning the rise in poaching, it is equipping rangers with the tools needed to give the animals a chance of survival.

In addition to the projects described above and others listed in Appendix 2 there are a variety of international competitions have been launched to fund the development of remote sensing technologies used for conservation purposes. To specifically design UAVs capable of conserving wildlife, an India-based NGO funded by Kashmir Robotics initiated ‘The Wildlife
Conservation UAV Challenge’ which rewards innovative designs. Another competition backed by The US Presidential Task Force on Wildlife Trafficking ‘The Wildlife Crime Tech Challenge’ received funding from TRAFFIC and USAID to design technical systems used for protecting wildlife. The Google Global Impact Award system donated $5 million to WWF to award to projects that have designed specialized sensors or wildlife tagging systems that can be used in conjunction with analytical software, in order to better detect and deter poachers.

To see which technologies are deemed as most beneficial by those who answered the research survey please see answer to Question 4 in Appendix 1. The risks associated with the deployment of these systems will now be analysed.

4.2. Research Question 2

What are the main risks of using remote sensing technology to specifically target wildlife crime?

The results from the research survey will now be summarised, with the direct use of responses made, before moving on to interpret the results in relation to observations made in the academic literature. All citations are from respondent answers in the research survey; these were made between May-July 2016. The respondents are unnamed for confidentiality reasons, in total there were 57 respondents to the survey but some did not answer all the questions.

The most cited concern raised in ten of the respondents’ answers regards the mismanagement of data and potential misuse of surveillance capability “The use of technology assumes that there is no corruption”. Security breaches were a common worry that would potentially make the life of poachers easier. It was suggested in several answers that criminal syndicates could involve rangers and the technology could be misused for other purposes i.e. the technology could be used by potential poachers or those working with conservation who seek to financially benefit from poaching. The UNODC WWCR (2016, p.43) explains that this is found to the case in some incidences where rangers charged with protecting species have been implicated in poaching activities. Data flows could be hacked to reveal locations of monitored species – the notion of a technology ‘arms race’ between rangers and poachers was also mentioned.

The second most cited risk was potential hostilities between local groups and those setting up and using the technology. These hostilities could be avoided through local inclusion in conservation strategies. The risk of “relying too much on tech and too little on locals” who may then “feel slighted by outsiders coming in and trying to ‘fix’ things without their buy-in” was identified. This may then cause “conflicts and a feeling of unbalance/unfairness arising from the poor living conditions of rural people” particularly when aircrafts or drones are flown over their lands and homes. Involvement of local communities is necessary to ensure that in resource-poor countries where local populations have pressing needs; government investment in expensive technology directed at animal protection does not signify further
marginalization. This needs to be considered particularly in cases where the benefits from protecting species, i.e. tourism income, are not felt at the local level. The importance of local inclusion was cited many times, and also the importance of gaining support from local government groups, management authorities and government ministries for technological applications. It is also necessary to have these groups on-board for those instances when it may be difficult to determine illegality for some species on a local basis. “Whatever remote sensing technology is utilised it needs to be accompanied by a clear, multifaceted, long-term community education campaign that states the purpose of the technology, identifies benefits, acknowledges risks and fears of the community and responds with appropriate policy and operational procedures.” The necessity of home-grown solutions to risks and input of traditional knowledge of animals and tracking in national programs was also raised. This is particularly important in areas that have a long history of disputes between conservation groups and locals and where the actions of conservationists can be seen as contradicting the interests and traditions of local communities.

The next most frequently raised concern was the high costs involved and the lack of funding to ensure maintenance of the system in the long term. “As with any emerging technology, there are risks associated with field testing; transfer costs can be prohibitively expensive”. The lack of local capacities and funds to maintain the systems were cited by six respondents, “Too often, donors supply equipment initially but do not provide funds for maintenance or repair”. It was widely perceived that without a long term strategy the equipment would be abandoned, sold, or misused for other purposes. It was also noted that expectations may exceed the true capacity of the technology and funding that could be used in training rangers for better ground patrols would be “diverted to expensive high tech surveillance that cannot replace rangers.” However the technology is not designed to ‘replace’ rangers, rather it aims to better concentrate ranger efforts in strategic positions – this will arguably make their job safer as it decreases the risk of ambush attacks.

The risk of increasing the militarised approach to conservation was raised by five respondents: “an overly law enforcement oriented approach may be implemented in countries with poor rule of law and governance” also the risk that too much focus was on reducing supply and not enough on reducing demand and this would lead to a technology arms race. One respondent answered, “The militarization of anti-poaching efforts is a disturbing trend”. Militarised actions entailing a ‘shoot-on-site’ policy is inappropriate in scenarios where poachers are ignorant of the level of illegality, live in poverty stricken conditions and have been hired to perform the kill by criminal groups who often take approximately 90% of the profit (UNODC, 2016, p43). It was also cited that the use of technology may “fail to distinguish between target and non-target individuals”

Other concerns include the risk of theft of valuable technology or damage to equipment. The risk of danger to operators was raised twice. However, the technology does not necessarily increase the risk; arguably it reduces the risk by giving rangers the foresight of when they will come into contact with poachers. The lack of follow up prosecutions on poachers was raised in several answers. This may often be due to weak state institutions and law enforcement

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capacity. The focus on detecting poachers is vital but there also needs to be the ability to react quickly and proportionately to the crime.

The use of decoy technology was also raised; as it can be very beneficial in cases where there is limited funding and decoy technology can act as an effective deterrence (personal communication with a professor at UMIACS). The idea that “Animal welfare in the use of high tech surveillance should be considered” was raised in one answer; however the minor ‘inconvenience’ of technology could save the species life in the long-term.

Besides outlining the risks involved in deploying this technology, the respondents were asked whom they believed should pay the most for the technology and which group was best placed to manage it. The latter question received 56 responses with most (39.29%) pointing to local rangers, conservation managers and wildlife authorities, Nearly 20% thought it important that national actors own and operate the technology while many other responses (21.43%) opted for ‘other’ and indicated that it would be best for both groups to work together. This tends to predominantly be the case, as shown in the database in Appendix 2. For a full breakdown of results from the research survey see Appendix 1.

In terms of who should fund the technology there was a clear majority response for ‘the government of the country in which the animals reside’ (55.17%), the second most opted for option was ‘international organisations with funds for nature conservation’ (22.41%). One respondent pointed out “These are expensive technologies and in many instances in will not be possible for the host country to meet the costs.” I was surprised at the results as I believed the vast majority of respondents would opt for international organisations with funds for nature conservation rather than the government of the country in which the animals reside. These technologies are expensive and the animals range in countries that have impoverished populations and governments with limited funds.

5. Discussion
5.1. Research Question 3

Can the increased use of remote sensing technologies to combat wildlife crime be regarded as an extension of the militarised approach to conservation?

As mentioned before, the concept of militarisation is ill-defined. One scholarly reference is to “the extension of military approaches, equipment and techniques to wildlife protection, as well as the deployment of armed forces in conservation activities” (Duffy, 2016) others do not define what they mean when using the term. With the definition above, the use of adapted military technologies would indeed be considered as an extension of a militarised approach, as it is the extension of equipment and techniques to wildlife protection. The association of war when drones are deployed stems from the fact that drones were originally invented for military use during the Second World War and are today primarily used for law enforcement, and less commonly for research purposes (Sandbrook, 2015). However as previously
mentioned, many of the technologies used for wildlife protection e.g. GPS were originally designed for use by the military, but this is not proof of militarisation. Many commonplace items e.g. duct tape, jerry cans, computers, cargo pants, could be considered military equipment as they were originally designed for this purpose.

On a practical level, many of the skills and techniques needed by conservation rangers have been developed best by the military, e.g. investigative techniques, survival skills and the ability to plan operations efficiently. The adoption of these military approaches need not have a negative connotation or be regarded as ‘green militarisation’. Rather, they strengthen ranger efforts to deter poaching. The detection equipment needed by rangers is the same equipment used by military groups, but this does not equate to militarisation. As has been shown in answering the first research question, remote sensing technologies are not predominantly used by organisations that possess a military character; rather they are predominantly in use by groups who are concerned with animal and ranger safety. In answer to the third research question, the use of remote sensing technology can be regarded as extension of the militarised approach to conservation depending on the definition of militarisation used. This concept requires clarity when applied.

By looking at the evidence from the groups involved in deploying RS technology in East and Southern Africa this is not being done in a militarised fashion. Military equipment is in use but the majority of organisations working with them do not possess a military character. This thesis regards the excessive use of violence as an example of militarisation e.g. the use of shoot-on-site policies, which have been applied at points in time in Kenya, Zimbabwe, Tanzania, the Central African Republic and Malawi (Neumann 2004). The use of RS technology could offer an alternative to shoot-on-site policies if it were accurate enough to allow increased capture and prosecution. The way in which these technologies are used will depend on the character and motives of those involved and also on the ethical and legal frameworks surrounding how poachers are dealt with. The push by conservationists to adopt these new technologies against poachers has been characterized as an arms race between poachers and wildlife rangers (Payne, 2015). The recent report from the US Presidential Task Force for Wildlife Crime quotes a top member of USAID saying, “Technology is a force multiplier in the ‘war on wildlife crime’, with potential to scale the reach, impact, and effectiveness of every intervention.” As the number of protected species decreases, and the use of these technologies increases, – as is found to be the case – the style in which these technologies are applied will become more important.

5.2. The socio-economic, historical and political context of anti-poaching efforts and the associated risks with using RS technology

The securitization of conservation is part of a longer history of colonial authorities outlawing hunting for local communities and taking over biodiversity rich lands for the enjoyment of the
colonial elite (Duffy, 2015). While the international community feels a moral obligation to protect endangered species, one only need imagine the same militarised approach, in the form of a shoot-on-sight policy which has existed in many African countries being applied to other endangered species on the IUCN Red List e.g. the Mediterranean monk seal in France, the marbled polecat in Greece or the kit fox in the USA (IUCN, 2016).

The colonial history of criminalizing hunting under the justification of conservation has been occurring for centuries and is essentially about vying ownership claims. Subsistence hunting was widely securitized in the colonial era with ‘poaching’ discursively constructed as something distinct from ‘sport hunting’, the latter for ‘civilized’ groups and the former for local populations. The contrast in the type of equipment used reinforces the discrimination, with the local groups relying on traps and snares, regarded as cruel, as opposed to the ‘civilized’ groups using a quick death from expensive rifles (Duffy, 2014). This distinction constructed in the colonial era no longer befits considering that poaching syndicates are increasing well equipped and heavily armed.

It has been acknowledged that local stakeholders can be alienated by the use of complicated and sophisticated technical systems. The deployment of RS technology systems can signal a move away from a more inclusive conservation and development project approach to a top-down system. However, this depends on how the technology is integrated into existing conservation practices. As has been observed in the case of aerial surveys, while they can be very useful for conservation purposes, they also have the potential to alienate human stakeholders (Hulme et al., 2014). For example, in one survey where farmers were asked how they felt about being monitored via satellite imagery, 58 % of Australian respondents and 75 % of UK respondents felt that satellite monitoring was ‘an invasion of their privacy’ (Purdy, 2011).

In the context of monitoring via the use of UAVs in East and Southern Africa this can be due to locals not understanding what drones are or believing flights over their land are forms of surveillance with malicious intent. This is cited as a concern in areas where local residents maintain strong mystical belief systems. One example is in Tanzania where there is a local belief in a supernatural bat called Popo Bawa that flies at night to paralyse and rape its victims (Sandbrook, 2015). It is easy to see how those who have no information on drones may perceive them with fear, especially if there exists a hostile relationship between local communities and the state, or a history of experienced violence from external actors. Alternatively, people may know what the drone is used for, but maintain misconceptions about its purpose – believing it to be sent by a private company, the military, a terrorist group or other (Sandbrook, 2015). These misconceptions can spark adversarial relationships or enhance existing ones. However, others have highlighted the positive aspect of this misconception i.e. when the word spreads that there is some evil ‘eye in the sky or in the trees’ watching their movements. These mystical misinterpretations may work to better deter locals than if they knew the true capacity of the equipment. The ethical dimension of this Foucauldian panoptic, all-seeing eye approach is questionable as it is knowingly manipulating belief systems to fit the conservation purpose and preying on the fear of communities who
may never have seen sophisticated electronic devices before. Counter to this, others have argued that technology can empower local communities as it provides them with a tool to collect useful data to improve local conservation practices and to be used in defence against those who may seek to take advantage of their lack of knowledge. This returns to the point made before, that technology derives its value not from how it is designed but from the purpose in which it is used and is dependent on the behaviour of those operating and managing it.

One concern only touched on in the research survey that deserves more attention is that while the technology is being used to prevent poaching of large iconic species, e.g. rhinos, elephants or mountain gorillas, it can simultaneously, or unintentionally, be used against those sourcing bushmeat i.e. non-target individuals may be caught in the cross fire. In the Afrotropics recent estimates of the annual consumption of wild meat sit at around 6 million tons (Nasi et al., 2011). This forms a critical component of nutritional security and diversity in both rural and urban areas of many African countries. The current scale of hunting is unprecedented and continues to grow as methods for hunting have become more sophisticated i.e. the use of firearms (Robinson & Bodmer, 1999). This has led to conservation efforts that criminalize bushmeat harvest in many regions of the world that were formerly traditional hunting grounds (Swamy & Pinedo-Vasquez, 2014). This criminalisation does not only undermine food security but does little to prevent biodiversity loss, which is more at risk from unsustainable land development practices than illegal hunting and gathering (WWCR, 2016, p.21).

In many ecological zones those hunting for bushmeat could easily be confused with those hunting for trophy animals for Asian markets. Before the kill it would be challenging for remote sensing technology to differentiate between these groups. Policies to protect large highly valuable mammals can impinge small-scale, livelihood-dependent hunting, which would then increase marginalisation of local communities and undermine their capacity to govern their own resources. This is a risk that needs to be avoided as more technology is rolled out to protect iconic species. Technology can act as a “force multiplier” and as such requires proper forethought on the wider social implications it may have. Validating findings from remote sensing detection should be ensured before action is taken. Scholars have raised the point that “the lack of validation in the remote sensing of crime can be troubling… drastic military or police actions are often used to intervene where crimes are detected with lasting ecological, economic and social impacts: lives, security and livelihoods can be at stake, not to mention law enforcement credibility and resources” (Kelly & Kelly, 2014). It is not always easy to validate crimes that are occurring in remote places. Digital information can be misread and misinterpreted, which can then lead to disproportionate responses.

5.3. The profile of poachers and the rewards

Hundreds of rangers and suspected poachers have been shot dead in recent decades. In 1987 President Mugabe of Zimbabwe authorized the park authorities to shoot suspected poachers on sight and a year later President Moi ordered the same for the Kenyan Wildlife Service. Then in 1989 the Tanzania park agencies were tasked with operation Uhai to “sweep the parks
and neighbouring communities of suspected poachers.” (Neumann 2014). In Malawi between 1998-2000 conservation staff were implicated in more than 300 deaths, 325 disappearances, 250 rapes, and numerous instances of torture and intimidation in the Liwonde National Park alone (Neumann, 2014, p.830). Considering these startling statistics, the importance of exercising caution when deploying detection technology becomes highly apparent.

Acknowledging the limited economic opportunities of those who opt to poach is necessary to stimulate a more humanitarian approach to dealing with the phenomena. The profile of poachers cannot be “described succinctly as they range from opportunists to dedicated elephant hunters” (WWCR, 2016, p.43). Most individuals tend to be described as “an average normal guy, a poor farmer who is trying to feed his family” (Bonner, 1992, p.21). In the case of Tanzania it has been claimed “illegal hunting in protected areas is often pursued as a coping strategy against poverty and as an employment opportunity in a limited resource environment for a growing population of youth” (Kidesghesho, 2016). Elephants range across many countries where there are huge economic problems, and abject circumstances can lure destitute individuals into poaching as just a few poaching successes can change their life. This is cited as the central reason why there are no wild rhinos left in Mozambique and why so many Mozambican poachers have been found in South Africa and Kenya (McCarthy, 2016). Monitoring the illegal killing of elephant analyses have shown that poaching levels are strongly related to poverty in and around sites (CITES, 2013). This point fits into the wider criminology debate on the victimisation of the poor and marginalised within legal systems.

The UNODC Wildlife Crime Report (2016, p.43) estimates that in the case of elephant tusks, poachers receive approximately 10% of the final retail profit with others along the criminal value chain taking the bulk of the profit. Those who work as conservation rangers on poor incomes also decide to collaborate with criminal poaching syndicates, accepting bribes in exchange for turning a blind eye (Loibooki, 2002). It has also been cited that government stockpiles of ivory are known to have gone missing in the past (WWCR, 2016, p.42). The risk of mismanagement and corruption was the most raised point in the research survey where respondents felt that the increased intelligence capacity on animals whereabouts that remote sensing technology offers could ‘fall into the wrong hands’ and be used for other means. The violence that can arise within, and as a consequence of, conservation efforts has been acknowledged and attempts have been made to try and minimize this in recent years. This is evident in the framework declaration of the Conservation Initiative on Human Rights that has been signed by many leading international conservation charities (IIED, 2010).

Humphreys & Smith (2011, p.140), have claimed, “Clausewitz’s warnings about the weakness of legal constraints suggest that ‘hard’ power is the only realistic answer to wildlife protection in many parts of the world.” Yet, the notion of necessary combat to deter poachers “sits on the horns of a philosophical dilemma.” (Humphreys & Smith, 2014, p.126) Who should be responsible for providing the funding to protect these animals? The answer to this question in the research survey shows that more than half (32) of the respondents (55.17%) believe “The national government in which the forest or wildlife reside” should be responsible to cover the costs of technological conservation efforts. But when the animals exist in poverty
stricken areas the use of limited government funding directed at high level technology will undoubtedly raise eyebrows. The use of remote sensing technologies is by no means a one-size-fits-all solution, it is important for organisations to consider the level to which rangers are already equipped and trained before investing in technologies. In some circumstances this may be a gross misuse of financial resources i.e. in cases where basic supplies like water bottles, vehicles, communication equipment and basic defence equipment is lacking. In some instances it has also been found that rangers can lack basic training and go months without getting paid (Payne, 2015).

There have been many claims that the proceeds of wildlife crime support the activities of insurgency groups, such as Al Shabab, LRA, Boko Haram, the Sudan People’s Liberation Army (SPLA) and rebels in DRC. However, these claims are often unsubstantiated, lacking empirical evidence and the rate of killing and extent of involvement is mostly unclear (Shaw & Rademeyer, 2016; WWCR, 2016). In some areas, insurgency groups harvest wildlife but the extent to which this is done will depend on the local context and level of accessibility to consumer markets. The recent UNODC WWCR shows that in many instances the resource base of wildlife in conflict areas could only offer minimal revenue to combatants and thus would not provide a sustainable income source. The statistics on poaching show that most of illicit ivory is coming from countries at peace (WWCR, 2016, p.21 & p.43).

Humphreys & Smith explain that “invoking notions of force in the name of protecting the environment, and wildlife in particular, is intuitively unacceptable for many concerned analysts – for environmentalists to dress their programmes in the blood-soaked garments of the war system betrays their core values and creates confusion about the real tasks at hand” (2011, p.121). The use of remote sensing technology to increase capture and conviction of poachers, while ensuring less blood is spilt in the name of conservation, would be a positive development. International goodwill to preserve species is laudable but these initiatives need the means to enforce policy without causing harm – the use of sophisticated technology could offer this solution by improving ranger capabilities to foresee the movement of poachers before it becomes a shoot-out scenario.

6. Conclusions

This thesis has discussed the complexities associated with the poaching of elephant and rhino in East and Southern Africa. By addressing three key research questions, the thesis has outlined the kinds of remote sensing technology projects in operation, the actors involved in their development and the risks that have been identified by those working with wildlife crime in the conservation community. These findings have been put in context with observations made in the academic literature regarding the militarisation of anti-poaching efforts.

The database compiled found that there is a diverse range of technology projects in operation. The majority of actors working with technology development and capacity building at the local level are conservation agencies, and both governmental and non-governmental at the national and international level. These agencies often work in collaboration with academic
departments based at universities (predominantly in the northern hemisphere) and private companies. Close to 40% of research survey respondents believe that local wildlife rangers, conservation managers and wildlife authorities are best situated to manage the technology. This tends to predominantly be the case on the ground often in collaboration with the other external actors mentioned. More than half of the survey respondents (55.17%) believe that the government of the country in which the animals reside should cover the bulk of the technology costs; this was a surprise to me as the technology can be very expensive, the animals range in low-income countries and the international community benefit from the existence of these species.

The research survey identified a number of risks with using RS technology to combat wildlife crime:

- Mismanagement of data
- Hostilities with local communities
- Lack of funding to ensure maintenance of the systems in the long term
- Misidentification of poachers
- Militarisation of anti-poaching efforts

The literature review in conjunction with the responses to the research survey show that militarisation of anti-poaching efforts is a concern that deserves attention. This thesis has found that the issue of wildlife crime has largely been securitized at the international level, both through the discourse applied to the issue and the involvement of law enforcement agents e.g. Interpol, UNODC, the US Department of Defence. It is clear from looking at the database of existing projects that the stakeholders currently involved in developing remote sensing systems are not doing so in a militarised fashion. The majority of projects have been implemented by those in the conservation community, working in collaboration with research institutes or in partnership with private companies. There is only evidence of an increase in militarised approaches to conservation efforts in one example in the region i.e. donations from the Paramount defence firm to SANpark rangers. The analysis of the militarisation of anti-poaching efforts has shown that when the ‘green militarisation’ term is applied is should be done cautiously and with clarity on the definition being used.

On a pragmatic level, many of the skills and equipment needed by conservation rangers have been developed best by, and for, the military. Saying this, the way in which the technologies can best be introduced to local wildlife authorities will be found from those in the conservation community, as they possess greater sensitivity toward the long-term impacts of introducing changes in resource poor contexts. The increasing sophistication of poaching syndicates and rate of slaughtered animal requires the security and conservation communities to work together to ensure that appropriate technology is deployed in such a way that it empowers local communities and minimizes the aggressive ‘shoot-on–site’ approach to conservation. The use of language is important when referring to tech systems; this point was evident in one response to the research survey where a respondent took umbrage with the use of the term ‘Surveillance UAV’. “Note: We avoid using the term "surveillance" in all
references to UAVs in conservation applications, as this unnecessarily raises privacy concerns. The use of UAVs in parks, protected areas and custodian lands focuses on "monitoring" and "rapid response" and not "surveillance". This answer shows the level of sensitivity maintained by some in the conservation community who wish to distance themselves from any contentious military expressions used on the issue of poaching.

This thesis fits into a larger discussion on the use of remote sensing technology for conservation purposes. It is not until the wider impacts of these technologies are fully understood that the benefits can be best harnessed and the risks involved minimized. This will require continued debate over policing methodologies as the power and use of this equipment increases and evolves. In terms of research, or lack thereof, in the application of remote sensing technology used to prevent wildlife crime, more is certainly needed. The following research aims are recommended for future research:

- Establish an empirical base on which technologies are best suited to which environments.
- Provide data on poaching rates in areas where technology is being used
- Design guidelines on how these technologies can best be introduced into resource poor areas.
- Design funding models that work in the long-term.
- Identify negative social impacts in using technologies and guidelines on how these can be mitigated

By providing an overview of the growing use of remote sensing technologies in anti-poaching efforts, this thesis has highlighted some important contextual factors and risks to consider. It has also shown that, by and large, the use of sophisticated technology is not an extension of a militarised approach to conservation in the study region. When conservation technologies are sensitively and smartly deployed they offer essential assistance to rangers. This strategy needs to be used in conjunction with other deterrence methods e.g. awareness campaigns to decrease demand in consumer countries, building local ranger capacities and building stronger law enforcement at borders, among others. It is hoped that this thesis will help to pave the way for more research and discussion on this important and emerging topic.
7. Acknowledgements

I am very grateful to the United Nations Office on Drugs and Crime (UNODC) for hosting me as a Visiting Research Scholar during the research period of this thesis and my gratitude goes specifically to Carlos Gómez Del Campo in the Policy Analysis and Public Affairs section and Rhiannon Hudson Jones working with The Global Programme for Combating Wildlife and Forest Crime. I also wish to acknowledge and thank Lorant Czaran from the United Nations of Outer Space Affairs (UNOOSA) for the invitation and sponsorship to attend the conference in Nairobi, Kenya on Space Technology and Applications for Wildlife Management and Protecting Biodiversity, July 2016. I much appreciate the efforts of Annalisa Donati at UNOOSA for connecting my research interest with this division. I give ample thanks to both my supervisor Ilmari Kailhko for his comments and to Martin Karlson for his help in refining the original thesis idea and for his very valuable evaluation comments. Martin is also credited with aiding the design of the questions used in the research survey as is Francesco Vuolo who was my tutor at the Institute of Surveying, Remote Sensing and Land Information at the University of Life Sciences and Natural Resources in Vienna.

I give my personal thanks to my family, Hannes Johansson and Unk for supporting me during the writing phase of this thesis.

Many thanks,

Isla Duporge

Uppsala, Sweden, 2016
8. References


Ferreira, S. et al. (2014) Chemical horn infusions—a poaching deterrent or an unnecessary deception? Pachyderm. (55), 54–61


Milliken, T & Shaw, J (2012) The South Africa – Viet Nam Rhino Horn Trade Nexus: A deadly combination of institutional lapses, corrupt wildlife industry professionals and Asian crime syndicates. [Online], Johannesburg:


List of figures

Figure 1. Duporge, I. (2016) Burnt Ivory Stockpile in Nairobi National Park [Photograph] In possession of: the author.
9. Appendix 1

1) Please briefly specify the organisation/company you work with and your role

I deleted answers from those who did not work in a relevant field or job role.

2) Do you or other in your workplace use remote sensing technology in relation to wildlife and forest crime?

This was asked to ascertain respondent’s awareness of the impacts of using RS technology.

3) Who do you believe is best placed to manage and use remote sensing technology in relation to wildlife and forest crime in Eastern and Southern Africa?

This question had a series of answer options including:

<table>
<thead>
<tr>
<th>Answer Choices</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local rangers, conservation managers and wildlife authorities</td>
<td>39.29%</td>
</tr>
<tr>
<td>International conservation groups e.g. WWF, UN bodies, TRAFFIC etc</td>
<td>14.29%</td>
</tr>
<tr>
<td>Those trained in defence and military operation e.g. private military companies (PMCs) or security companies</td>
<td>5.36%</td>
</tr>
<tr>
<td>The company or organisation that developed the technology</td>
<td>0.00%</td>
</tr>
<tr>
<td>It is important that national actors own and operate the technology</td>
<td>19.64%</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>21.43%</td>
</tr>
</tbody>
</table>

The respondents were then asked to rank a list of existing technologies that were in use (identified in the database) as to their use value. The answer options given were ‘Essential’, ‘Beneficial’ ‘Non-beneficial’ or ‘Other’, this answer was given for people to name technologies that were not identified in the list.

4) Please rate the use of the following technologies to detect wildlife poaching (leave blank if no opinion)

- Satellite imagery
- UAVs (drones)
- Stationary thermal sensors
- Infrared night vision cameras
- GIS systems to improve ranger patrol efforts
- Aerial surveys to monitor populations
- Geospatial analytic software e.g. predicative modelling/game theory using GPS co-ordinates
- Seismic ground sensors
• Collars on animals monitoring heartbeat with GPS tracking
• Other (please specify)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Non-beneficial</th>
<th>Helpful</th>
<th>Essential</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite imagery</td>
<td>5.66%</td>
<td>62.26%</td>
<td>32.08%</td>
<td>53</td>
</tr>
<tr>
<td>UAVs (drones)</td>
<td>7.55%</td>
<td>54.72%</td>
<td>37.74%</td>
<td>53</td>
</tr>
<tr>
<td>Thermal/Infrared sensors</td>
<td>3.77%</td>
<td>47.17%</td>
<td>49.06%</td>
<td>53</td>
</tr>
<tr>
<td>GIS patrol systems</td>
<td>0.00%</td>
<td>31.48%</td>
<td>68.52%</td>
<td>54</td>
</tr>
<tr>
<td>Aerial surveys</td>
<td>1.89%</td>
<td>39.62%</td>
<td>58.49%</td>
<td>53</td>
</tr>
<tr>
<td>Geospatial software</td>
<td>8.16%</td>
<td>55.10%</td>
<td>36.73%</td>
<td>49</td>
</tr>
<tr>
<td>Seismic ground sensors</td>
<td>25.58%</td>
<td>60.47%</td>
<td>13.95%</td>
<td>43</td>
</tr>
<tr>
<td>Heartbeat monitor/GPS</td>
<td>11.32%</td>
<td>50.94%</td>
<td>37.74%</td>
<td>53</td>
</tr>
</tbody>
</table>

5) Who do you believe should pay the most for the technology?

This question was asked to ascertain which source of finance was regarded as the most appropriate to fund the development and deployment of these technologies. The following answer options were given, plus an option to name other sources not listed.

<table>
<thead>
<tr>
<th>Answer Choices</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Those managing the conservation park or forest</td>
<td>1.72% 1</td>
</tr>
<tr>
<td>International organisations with funds for nature conservation</td>
<td>22.41% 13</td>
</tr>
<tr>
<td>The government of the country in which the animals/forest reside</td>
<td>55.17% 32</td>
</tr>
<tr>
<td>Private companies that develop the technology</td>
<td>3.45% 2</td>
</tr>
<tr>
<td>I have no opinion on this question</td>
<td>12.07% 7</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>5.17% 3</td>
</tr>
</tbody>
</table>

6) Do you see any risks in using high-tech monitoring for forest and wildlife crime in Southern and Eastern Africa?

The answer option provided was Yes, No or ‘I have no opinion on this question’ there was then a box offering respondents the chance to briefly explain these risks- this is outlined under Research Question 2 in the thesis above.
## 10. Appendix 2

<table>
<thead>
<tr>
<th>Project name and country site</th>
<th>The type of technology &amp; aim of system</th>
<th>Provider(s)</th>
<th>User group(s)</th>
<th>Species target(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring the Illegal Killing of Elephants (MIKE): Botswana, Democratic Republic of the Congo, Rwanda Kenya, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda Zambia and Zimbabwe. (50+ sites on the continent)</td>
<td>The MIKE programme relies primarily on two types of data: Information on elephant carcasses encountered and information on the level of law enforcement effort in the area. This information is collected by ground data then stored in a paper based or GIS system. This system assists rangers in monitoring and overseeing poaching events to better concentrate ranger efforts.</td>
<td>MIKE is owned and implemented by the range States of African and Asian elephants, with technical assistance and coordination of the CITES Secretariat-funded by the European Union. The Central Coordinating Unit is based at UNEP in Nairobi.</td>
<td>Rangers, conservation area managers, wildlife authorities and decision makers.</td>
<td>Elephants</td>
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<td>Poachers without borders: Democratic Republic of Congo: Garamba National Park.</td>
<td>Satellite imagery and predictive analytics-Digital Globe analysts were given the location and date of the elephant remains discovered between 2011 and 2013, elephant collar data, ranger patrol routes, and the locations of known poacher camps. Using this data, analysts conducted historical geospatial trend analysis, cost surface travel analysis, key terrain analysis, and predictive analysis using Digital Globe’s Signature Analyst™ geospatial</td>
<td>Satellite Sentinel Project, Digital Globe Inc. African Parks, (which manages Garamba on behalf of the Congolese government) and the ‘Enough’ project.</td>
<td>Rangers, conservation area managers, wildlife authorities and decision makers in Garamba</td>
<td>Elephants</td>
</tr>
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<td><strong>analytic software.</strong></td>
<td><strong>GIS interface-:</strong></td>
<td><strong>North Carolina Zoo, Zoological society London (ZSL), Wildlife conservation society, CITIES, , Frankfurt Conservation Society, MIKE, WWF</strong></td>
<td><strong>Park rangers, patrolling teams, conservation area managers, wildlife authorities and decision makers.</strong></td>
<td><strong>Site specific</strong></td>
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<td><strong>SMART- Spatial monitoring and reporting tool: DRC, Ethiopia, Madagascar, Mozambique, Malawi, Zimbabwe, Kenya, Zambia, Uganda, Tanzania,</strong></td>
<td><strong>Compatibility with a wide variety of GPS units and data collection devices. Enables the collection, storage, communication, and evaluation of data on: patrol efforts (e.g. time spent on patrols, areas visited and distances covered), patrol results (e.g. snares removed, arrests made), and threat levels. Used to sustain information flow between ranger teams, analysts, and conservation managers. (Open source-free technology) Anti-poaching, illicit bushmeat collection and illicit forestry activities also applicable for monitoring fishing grounds Data collection method aimed at helping protected area and wildlife managers better manage patrolling activities.</strong></td>
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<td><strong>Instant Detect (ID) Kenya</strong></td>
<td><strong>Seismic and magnetic military grade ground sensors- passive infrared heat detection sensors. The images and sensor alerts are then sent over the Iridium satellite network to a central satellite node that uses a Raspberry Pi computer in collaboration with Seven technologies group (UK)</strong></td>
<td><strong>Kenya Wildlife Service (KWS)</strong></td>
<td></td>
<td><strong>Rhino &amp; elephant</strong></td>
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near real-time to a secure server to be accessed by individual users. Cameras hidden in canopy. Originally started as a surveillance tool to monitor animal species then discovered it was useful for anti-poaching efforts.

Anti-poaching device - early warning system for rangers and for remote wildlife monitoring. Sensor alerts sent in near real-time to the user.

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<td>Hidden amongst the canopy electronic detection and communication devices. Burying radio-transmitting metal detectors alongside elephant trails leading into the park. Poachers carrying rifles or machetes will set trigger detector which then sends a radio signal to a treetop antenna. Also small fire detectors hidden in trees (Poachers frequently smoke meat from their kills to preserve it during transport to market). Rangers receive intruder's co-ordinates on satellite phones.</td>
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<tr>
<td>Project/Region</td>
<td>Technology Details</td>
<td>Provider</td>
<td>Author/Institution</td>
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<tr>
<td>Kenya (Ol Pejeta Conservancy, 90,000-acre reserve in Kenya)</td>
<td>Drone autopilot system flown at 500m. Thermal imaging cameras which can differentiate the shapes of animals at night. GPS-tagged rangers connected by a digital radio system. Anti-poaching detection and alert system</td>
<td>Airware (San Francisco-based tech company)</td>
<td>Kenyan Wildlife Service</td>
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<tr>
<td>Kenya- Amboseli Elephant Research Project (AERP)</td>
<td>The longest study of wild elephants in the world-10 elephant families collared with Savannah Tracking GPS-GSM collars. Used to understand the distributions and ranging patterns of families with regard to ecological conditions and social status- critical to facilitate land use planning in relation to areas that elephants need for their survival and future security.</td>
<td>Amboseli Elephant Trust</td>
<td>Unknown</td>
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<td>Kenya: Ngulia Rhino Sanctuary in West Kenya -Pilot project to gain a better understanding of the technical and ranger training needs at Ngulia.</td>
<td>Project Ngulia: Smartphone-based C3 software- an input device, where rangers note their observations on security and wildlife matters. Photo documentation with automatic geo-tagging. The app is also a navigation tool, where park rangers get their position overlaid on a map. The interface includes local landmarks such as waterholes,</td>
<td>The Stimson Centre (security think tank based in DC) and the Africa Peace Forum which is partnered with technical experts from the University of Linköping, Sweden.</td>
<td>Kenya Wildlife Service (KWS)</td>
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roads, trails, bunkers, borders, their patrol routes etc. Future sensor systems are being tested in Kolmården Wildlife Park in Sweden.

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<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Responsible Parties</th>
<th>Additional Information</th>
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<tbody>
<tr>
<td>Laikipia, Kenya Rift Valley-Grevy’s Zebra Technical Committee (GZTC)</td>
<td>Over 2 days 120 teams of scientists, schoolchildren and the U.S. ambassador to Kenya were given GPS-enabled cameras to take photos of zebra across 25km² of rangeland. Researchers then fed the photos into a &quot;hot spotter&quot; computer program, which is able to identify animals based on their coat design; zebra's stripes are a unique-natural barcode. This technology can also be used for giraffe spots and elephants ears. Used to estimate population size and to keep track of population decline.</td>
<td>Mpala Research Centre (Kenya) &amp; Harvard university</td>
<td>Data can advise governments how to best preserve the Zebra in this region.</td>
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<td>Domain Awareness Programme-Samburu National Reserve Kenya</td>
<td>GPS collar data is used in a database that manages elephant location data and can be used as a tracking system. This is also a visualization tool integrated into the Google Earth platform. Near real-time monitoring- location fixes made on the hour.</td>
<td>Save the Elephants in collaboration with Vulcan Tech private tech development company based in Seattle.</td>
<td>Save the Elephants</td>
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<tr>
<td>Namibia</td>
<td>WWF's Wildlife Crime Technology Project:Falcon UAVs (unmanned aerial vehicles) outfitted with</td>
<td>Google gave the WWF a $5 million Global Impact Award to develop new</td>
<td>Namibian park wardens and rangers. Namibia’s Ministry of</td>
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<td>Elephant &amp; Rhino</td>
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<tr>
<td>Location</td>
<td>Method</td>
<td>Organisations</td>
<td>species</td>
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<td>Namibia- Etosha National Park.</td>
<td>Aerial survey using 14 UAVs - technologically advanced radio systems, GPS tracking systems, sophisticated autopilot and flight stability systems and thermal imaging cameras. These are used to monitor 280,000 km².</td>
<td>Environment and Tourism.</td>
<td>Rhino</td>
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<tr>
<td>South Africa</td>
<td>RAPID- Real-time Anti-Poaching Intelligence Device. Collar worn by rhino embedded with satellite GPS, heart rate monitor and video camera installed in rhino horn. The collar broadcasts information on heartbeat and GPS location to a protect control centre. The collar tracks the animal’s heartbeat: when it rises or falls, a signal is sent to an operator. The centre then activates a</td>
<td>Next Generation Conservation Trust &amp; Namibian government</td>
<td>Rhino</td>
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<tr>
<td>Location</td>
<td>Description</td>
<td>Responsible Party</td>
<td>Technology/Equipment</td>
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<td>South Africa-Kruger National Park</td>
<td>Anti-poaching high-tech, low-speed reconnaissance aircraft equipped with quiet engine &amp; heat sensors to detect animals and humans &amp; Seeker 2 UAV. These have been deployed to assist in monitoring movement of suspicious people at night in two million hectare game reserve on South Africa’s eastern boundary. 16 hours flight time.</td>
<td>Ivor Ichikowitz Family Foundation-Paramount-Africa's largest privately held defence firm and Denel Dynamics donated aircraft &amp; UAV to South Africa National Park Service (SANpark).</td>
<td>Falcon UAV- infrared night vision camera guided by an UMD-designed computer program that predicts the movements of rhinos and poachers. The system uses several years’ worth of data collected by local game wardens to the computer model and ground-truth their software. The technology incorporates game theory and other types of advanced programing and is designed to predict future changes in poachers’ behaviour.</td>
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<tr>
<td>Location</td>
<td>Project Details</td>
<td>Technology Details</td>
<td>Supporting Organizations</td>
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<tr>
<td>South Africa-Kruger National Parl</td>
<td>Shot-spotter- acoustic system used to detect and locate gunshots.</td>
<td>Tech company based in San Francisco</td>
<td>Rangers in Kruger National Park</td>
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<td>Unnamed private game reserve adjacent to Kruger National Park-South Africa</td>
<td>Connected Conservation (pilot programme): Secure Reserve Area Network (RAN) created and installed with Wi-Fi hotspots around key poaching points. CCTV drones featuring infrared cameras, thermal imaging, and vehicle tracking sensors as well as seismic sensors on a secured intelligent network. Touch sensitive sensors on fences trigger alarm for rangers with GPS co-ordinates- early warning system with surveillance drones.</td>
<td>Dimension Data (SA) and Cisco</td>
<td>Rangers and conservation area managers</td>
</tr>
<tr>
<td>KwaZulu-Natal, South Africa</td>
<td>Aerial surveillance and monitoring using UAVs, infrared cameras and GPS systems- transmitting thermal imagery of wildlife and poachers.</td>
<td>Air Shepherd: The Linbergh Foundation and Ezemvelo in association with The Peace Parks Foundation</td>
<td>N/A</td>
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<td>South Sudan- 3000 square miles of dense forest in South Sudan’s Western Equatoria state. Forest belt untouched and under researched because of the decades of conflict in the area.</td>
<td>Monitoring stock and range of wildlife: Remote-sensing camera traps set to survey wildlife in the region. The research team sifted through more than 20,000 photos of wildlife, 1,190 of which included images of African forest elephants. Camera-trap findings expand the known range</td>
<td>Funded by a grant from the United States Fish and Wildlife Service’s Great Ape Conservation Fund with additional funding from the Woodtiger Fund, Bucknell University, and Flora and Fauna</td>
<td>Initiative for local wildlife authorities focused on turning community members who once poached elephants into elephant rangers. Reformed poachers are</td>
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<td>Location</td>
<td>Activity</td>
<td>Technology</td>
<td>Organization</td>
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<td>Uganda - five protected areas: Kibale, Kidepo Valley, Queen Elizabeth, Murchison Falls and Toro Semiliki Wildlife Reserve.</td>
<td>of forest elephants farther east than previously recorded.</td>
<td>International.</td>
<td>given role of wildlife ambassadors with the responsibility of monitoring camera traps and adjusting GPS units in the field.</td>
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<tr>
<td>Wild Leo- Wildlife Intelligence and Leadership Development program</td>
<td>Gathering photo evidence for purposes of prosecution and data collection during patrols. Rangers are trained to photograph signs of poaching such as snares and animal carcasses, the rangers create a spatial database that describes where poachers are operating within the reserve. Arrested poachers are photographed at the hunting site with recorded coordinates of the location; these photos can then be used in court to prove the hunting occurred inside protected area. 65 cameras in operation</td>
<td>Technology donated by the NSCR (Netherlands Institute for the Study of Crime and Law enforcement), a select team of UWA rangers collect photographic evidence of poaching activity using digital cameras embedded with GPS units. UCF has procured 17 geo-location cameras and 5 waterproof cameras for UWA and trained 50 UWA rangers in data collection and analysis.</td>
<td>The Uganda Wildlife Authority and Uganda Conservation Society</td>
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## Competitions to design anti-poaching conservation technology

<table>
<thead>
<tr>
<th>Competition name</th>
<th>Technology being designed</th>
<th>Aim of use</th>
<th>Organisation that initiated competition</th>
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<tbody>
<tr>
<td>Wildlife conservation: UAV challenge</td>
<td>Unmanned aerial vehicles (UAVs)</td>
<td>To prevent poaching of rhinos</td>
<td>Kashmir Robotics- (NGO)</td>
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<td>Wildlife Crime Tech challenge</td>
<td>16 Winners including 2 for remote sensing devices- the majority are for species identification using forensic and DNA techniques; others are IT &amp; web-based portals for information storage and exchange to map routes and species specific poaching. Instant detect only RS winner.</td>
<td>Tech that aids information gathering around poached species, improves information exchange between enforcement agencies and tracks movement.</td>
<td>USAID, National Geographic, the Smithsonian Institution, and TRAFFIC.</td>
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