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Imagining wildlife: New technologies and animal censuses, maps and museums

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ABSTRACT

By enabling the creation of networks of electronic sensors and human participants, new technologies have shaped the ways in which conservation-related organisations monitor wildlife. These networks enable the capture of data perceived as necessary to evidence conservation strategies and foster public support. We collected interview and archival data from UK-based conservation organisations with regard to their use of digital technologies for wildlife monitoring. As a conceptual device to examine these efforts, we used Benedict Anderson's (1991) work on censuses, maps and museums as social instruments that enabled the imagining of communities. Through a critical application of this framework, the technologically-aided acquisition of wildlife data was shown to inform the new ways in which conservation organisations identify and quantify wildlife, conceptualise animal spaces, and curate conservation narratives. In so defining, delineating and displaying the non-human animal world with the backing of organisational authority, new technologies aid in the representational construction of animal censuses, maps and museums. In terms of practice, large amounts of new data can now be gathered and processed more cost-effectively. However, the use of technologies may also be the result of pressures on organisations to legitimise conservation by being seen as innovative and popular. Either way, human participants are relegated to supporting rather than participatory roles. At a more abstract level, the scale of surveillance associated with instrumentation can be read as an exercise of human dominance. Nonetheless, new technologies present conservation organisations with the means necessary for defending wildlife against exploitation.

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1. Introduction

There has been a discernible proliferation of monitoring and recording projects of varying scales, frequently spearheaded by non-government nature conservation organisations, aimed at plugging the knowledge gaps without which we cannot sustainably use, manage and protect biodiversity resources (Catalogue of Life, 2015; see also Wilson, 2003). To expand monitoring capabilities, organisations have increasingly turned to digital technology platforms. Such expanded capacities address a perceived need within conservation communities to evidence gains, losses and impacts in more certain terms, partly in order to better inform the formulation of conservation policies (Sutherland et al., 2004; Burns et al., 2013). It also affords organisations opportunities to legitimise conservation causes by fostering wider public awareness and support against threats of species loss (Verma et al., 2015). In this paper, we focus on the new technological monitoring and recording efforts undertaken by conservation-related organisations, examining arrangements such as digital applications used to facilitate crowd-sourced identifications of camera trap images of endangered species, and tracking and visualisation set-ups depicting movements of birds. We analyse how these endeavours unfold in practice and examine implications these practices might have for human-wildlife relations.

1.1. Traditional wildlife monitoring schemes

Monitoring and recording schemes, undertaken by conservation-related organisations to capture evidence on wildlife presence, abundance and movement, have characteristically been labour-intensive endeavours. With traditional methods, such as capture-mark-recapture approaches or conventional survey

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methods, organisations were reliant on staff and volunteer power, and hand-written logs for data storage. Although this reliance on such resources meant a certain degree of advantage over technological methods in terms of cost and material resource demands, it came with a number of limitations. In addition to challenges of scale due to limited spatial and temporal coverage (Catlin-Groves, 2012), and issues with recording, storage, reproduction and dissemination of data, traditional methods required arguably intrusive human presence in spaces inhabited by the wildlife being monitored (Kucera and Barrett, 2011). Further, traditional modes of monitoring brought up issues of the reliability of data gathering methods, associated with lack of training, recruitment and retention of volunteers. For example, in terms of determining presence, judging the veracity of species sightings in a non-technological way posed challenges wrapped up in questions of expertise, objectivity and reputation. In the absence of visual evidence of high quality and digital platforms for quick verification by experts and wider public, the process of turning sightings, particularly of rarer species, into data points was arduous and marked by controversy (Roberts et al., 2009).

While more traditional methods have continued to be used to capture wildlife data, there has been a perceived need to increase the quantity of monitoring schemes (in terms of numbers of species and areas covered), while maintaining the quality of observations made. Conservation organisations have therefore had vested interest in adopting methods to increase scale and improving reliability (Catlin-Groves, 2012). Consequently, these organisations have consistently adapted popular techno-scientific innovations, much like biologists and ecologists (Hebblewhite and Haydon, 2010; Pimm et al., 2014). Pioneering organisational forays using technologies to capture wildlife data focused on adapting technical sensors for conservation purposes. Prototypes of devices such as tracking collars and camera traps arguably allowed for more unobtrusive access to certain species. However, they were limited for a number of reasons, including unwieldy size and weight, and cost restrictions. First generation devices were also suspect to low reliability since they were only marginally more autonomous than traditional methods, requiring manual intervention to correct technical shortcomings such as short battery life and limited data storage. More pertinently, the operation and implementation of early technological sensors were kept largely separate from the work of volunteers and the public, not least since the processes required considerable expertise.

1.2. New networks for monitoring wildlife

More recently, newer digital devices have amplified the monitoring and recording capacities of wildlife organisations in distinct ways (August et al., 2015; Arts et al., 2015). The use of these technologies may best be understood in terms of the creation of networks comprised of technical sensors (Porter et al., 2009) and human and animal participants (Catlin-Groves, 2012). First, there are newer or more advanced versions of devices, such as satellite-linked tracking terminals or video-camera 'backpacks' (animal-borne sensors) attached to individual wild animals and camera-traps photographing wildlife, that operate in tandem with automating technologies such as motion detectors. These devices constitute electronic sensors that enable the collection of wildlife data without a high degree of human intervention. For example, with satellite-enabled tracking using terminals, while capture and tagging by skilled personnel is still necessary, recapture is increasingly not required for monitoring the movement of a tagged individual over prolonged periods of time. Technological development has also led to miniaturisation and increasing cost-effectiveness, allowing for the tracking of smaller species and more individuals. Power sources often last much longer, and data transmission and storage capacities have increased vastly (Seegar et al., 1996; Tomkiewicz et al., 2010). In spite of the still existing challenges and diversity of technologies used, the installation of growing numbers of such devices in the field means that organisations are now in a better position than before to observe the otherwise unobservable and more remotely collect extensive amounts of new types of data (Porter et al., 2009; Hance, 2011).

Second, the digitisation of monitoring and recording initiatives has also meant that conservation organisations have been able to combine the capacity of increasingly autonomous technological sensors with human participants. This has been facilitated by the inclusion of internet-connected digital platforms on widely available personal devices such as mobile phones and cameras, and advancements in Global System for Mobile Communication (GSM) technology and Global Positioning System (GPS) facilities.

There are three key aspects to the inclusion of the human component in digital conservation monitoring and recording networks: data gathering, data processing and engagement. First, in terms of data gathering, as Catlin-Groves (2012) pointed out, personal computing and communication technologies now make the user part of a framework for data collection (see also Ferster and Coops, 2013). Through participatory Web 2.0 facilities such as social media and 'citizen science' platforms, 'amateur-expert' naturalists (Ellis et al., 2005; Dickinson and Bonney, 2010) and ordinary members of the public contribute wildlife data, effectively becoming 'citizen sensors' (Catlin-Groves, 2012).

Second, with data processing, digital advancements have created both the need for, and opportunity to employ citizens for the analysis of large amounts of newly generated data (Kelling et al., 2015). For example, in the absence of accurate image identification technologies for processing vast amounts of image-based data captured by new technological sensors, digital platforms for crowd-sourcing become a viable means by which the presence and identity of species captured within a picture may be accurately detected by public participants (Siddharthan et al., 2016). Illustrating the inclusivity, ease, reach and speed of such technologically-mediated data gathering exercises in ideal-case scenarios, Silvertown et al. (2013) and Bonney et al. (2009) cite examples of amateurs spotting, photographing and uploading images of particular insect and avian species to publically accessible digital forums, whereupon other site users identified the submissions as being of rare species.

Third, in relation to engagement, it has been noted that projects involving the wider public, such as digital 'citizen science' platforms, have tended to revolve around enhancing public awareness of the natural world, and raising the public profile of environmental science, rather than concentrating on data generation and processing alone (Catlin-Groves, 2012; Allan and Ewart, 2015). Part of the reason for this is the ease with which data can now be translated into more easily understandable formats (e.g., images) and disseminated for consumption by non-specialists. In one sense, Zastrow (2015), for instance, highlighted how new software has changed the way species distribution and bird migration data may be visualised, pointing out that resultant maps are often used in outreach efforts (see also August et al., 2015). Creating visuals based on public data contributions thus serves to make their participation tangible. In another sense, new forms of technological engagement have also increased the possibilities for encouraging new members of the public to provide data, and for drawing them into supporting conservation causes. These networks for wildlife monitoring and recording – consisting of both electronic and human components – may thus be seen as producing new and more knowledge compared to traditional approaches (Van der Wal et al., 2015), not least since knowledge develops hand-in-glove with new technologies (Haggerty and Trottier, 2013).

1.3. Human-animal relations and technology

Technological uptake by conservation organisations, as a response to the perceived need to produce data for more robust, evidence-based conservation management policies and to foster public support, are reshaping contemporary views about western human-animal relations. Scholars have highlighted that human-animal relations in the western context have historically been characterised by divisions between humans (associated with culture) and animals (associated with nature), and by relations marked either by domination of humans over animals or a more ethical arrangement where humans act as stewards of wildlife (Thomas, 1983; Serpell, 1986; Franklin, 1999).[1]

Such dualisms clearly play out when conservation practices are considered. Science-based modes of understanding wildlife have been read as exercises of human power over nature (Ingold, 1994), in no small part due to the underpinnings of utilitarian, resource-based perspectives of conservation management (Callicott, 1990). In such perspectives, humans constitute "*controllers of the natural world* [bearing] *full responsibility for the survival or extinction of wildlife species*" (Ingold, 1994: 11), in effect becoming curators of wildlife. Other scholars have also highlighted the ways in which biodiversity discourses are intertwined with regimes of power, being co-opted into prevailing neoliberal economic logic (Escobar, 1995; Hajer, 1995; Luke, 1995; Büscher, 2013), or aligned with human chauvinism, expressed as beliefs and practices that couch animals as resources existing only for human use (Pettman, 2011). Due to western conservation practices being enmeshed in these sorts of power structures, animals may be read as being extensively surveyed, quantified, represented, and regulated in matrices of knowledge through which animals are readied as exploitable commodities (Youatt, 2008).

However, there has existed a long-running schism in conservation practice, particularly following the rise to prominence of non-anthropocentric, less instrumentalist and eco-centrist perspectives (Callicott, 1990). While this camp generally did not deny the need for balancing economy and wildlife conservation, they influentially disavowed viewing humans as separate from or superior to nature. Rather, they advanced a paradigm of conservation based on the intrinsic, non-consumption-based value of wildlife, opposed to simply resource-based valuations (*ibid.*). The intertwining of these two perspectives has led to conservation practices that can be read in both critical and positive ways.

Technologically-driven monitoring and recording initiatives represent a newer conservation practice that can be understood as having both impulses. On one hand, the scale of instrumentation involved maybe read in terms of extending human domination over wildlife. On the other hand, organisations may perceive the need to employ certain strategies within the larger social context to legitimise conservation (Büscher, 2013) and enact what may be seen as a form of stewardship. While it remains unclear at this point which tendencies new technologies encourage more and how they do so, it is apparent that technologically-aided monitoring and recording efforts may be understood as being "*as much about power and political life and the boundaries between nature and society as it is about scientific information-gathering for conservationist ends*" (Youatt, 2008: 394; Braverman, 2014).

In this paper, we examined the technologically-mediated creation and operation of networks of digital sensors and human participants by investigating real-world wildlife monitoring projects undertaken by conservation-related organisations. In so doing, we unfolded how these representational practices were undertaken and considered their implications for both conservation outcomes and human-nature relations. In particular, we were interested in the real-world applications and limitations of digital networks in producing knowledge perceived as necessary for conservation management, and whether such practices extended human domination over wildlife, constituted stewardship towards wildlife, or represented other ways of relating to wildlife.

2. Methodology and case studies

Our larger research project was a qualitative investigation aimed at generating a deductive understanding of the role of new technologies in human-nature relations. The data we based this paper on emerged from fieldwork undertaken with various conservation-related organisations between January 2013 and May 2014. Semi-structured interviews were carried out with project-relevant staff members and volunteers from case studies that were selected based on potential for access. Our questions revolved around the use of new technologies by conservation-related organisations (e.g., "how is a particular technology being used?", "why/for what purpose is it being used?", "what are some of the challenges or limitations of the set-up?"). All interviews were transcribed for analysis. Publically-available text sources such as websites, press coverage of projects and symposium recordings also constituted data. The combination of methods (i.e., proportion of interviews in relation to archival data) was case-specific and dependent on access to participants.

The case studies we base this paper on include: (i) the Zoological Society of London's (ZSL) use of the camera-trap-image-based crowdsourcing application, Instant Wild; (ii) the use of various camera-based imaging techniques (e.g., time-lapse photography, thermal imaging, remote-controlled copters with mounted cameras) for research undertaken by the Royal Society for the Protection of Birds (RSPB); and (iii) the use of satellite tracking and mapping facilities in the cuckoo project spearheaded by the British Ornithological Society (BTO) and (iv) in the Eyes to the Skies red kites tracking project (see Fig. 1).

Instant Wild is a multi-purpose project created by the Zoological Society of London (ZSL), driven by advancements in the use of Global Systems for Mobile communications (GSM) technology for camera traps. In its main form, Instant Wild is a citizen science effort available as a website facility and downloadable application, designed to trial crowd-sourcing identifications on wildlife images caught on ZSL camera traps in the field. The project constitutes part of ZSL's efforts to monitor endangered species, and the set-up has in the past captured images of a scarcely recorded mountain mouse deer (on its Sri Lanka camera) and a critically endangered Javan leopard (on its Indonesia camera), thereby confirming the existence of these animals in those locations. Future plans for the wider project include setting up a grid of cameras for planet-wide biodiversity monitoring and anti-poaching surveillance. We conducted Skype and e-mail interviews with two technical advisors and the Instant Wild app and website developer. Transcripts from an Instant Wild symposium (2014) and notes from the website/app also constituted data material.

The cuckoo tracking project is a public research campaign by the British Trust for Ornithology (BTO), a monitoring and research-focused organisation specialised in bird monitoring. The focal project was initiated in the wake of a decline of cuckoos across large parts of the UK, and was one of several bird tracking projects carried out by the organisation. As at 2014, 31 cuckoos had been tagged as part of this project, and 12 birds continued to transmit data. Information gathered about cuckoo migration was disseminated publically through the organisation's website, social media and press coverage. We interviewed a senior scientist

[1] We also note that alternative, less anthropocentric conceptualisations understanding human-nature relationships in the western context as a partnership have also been articulated in the literature (Van den Born et al., 2001).

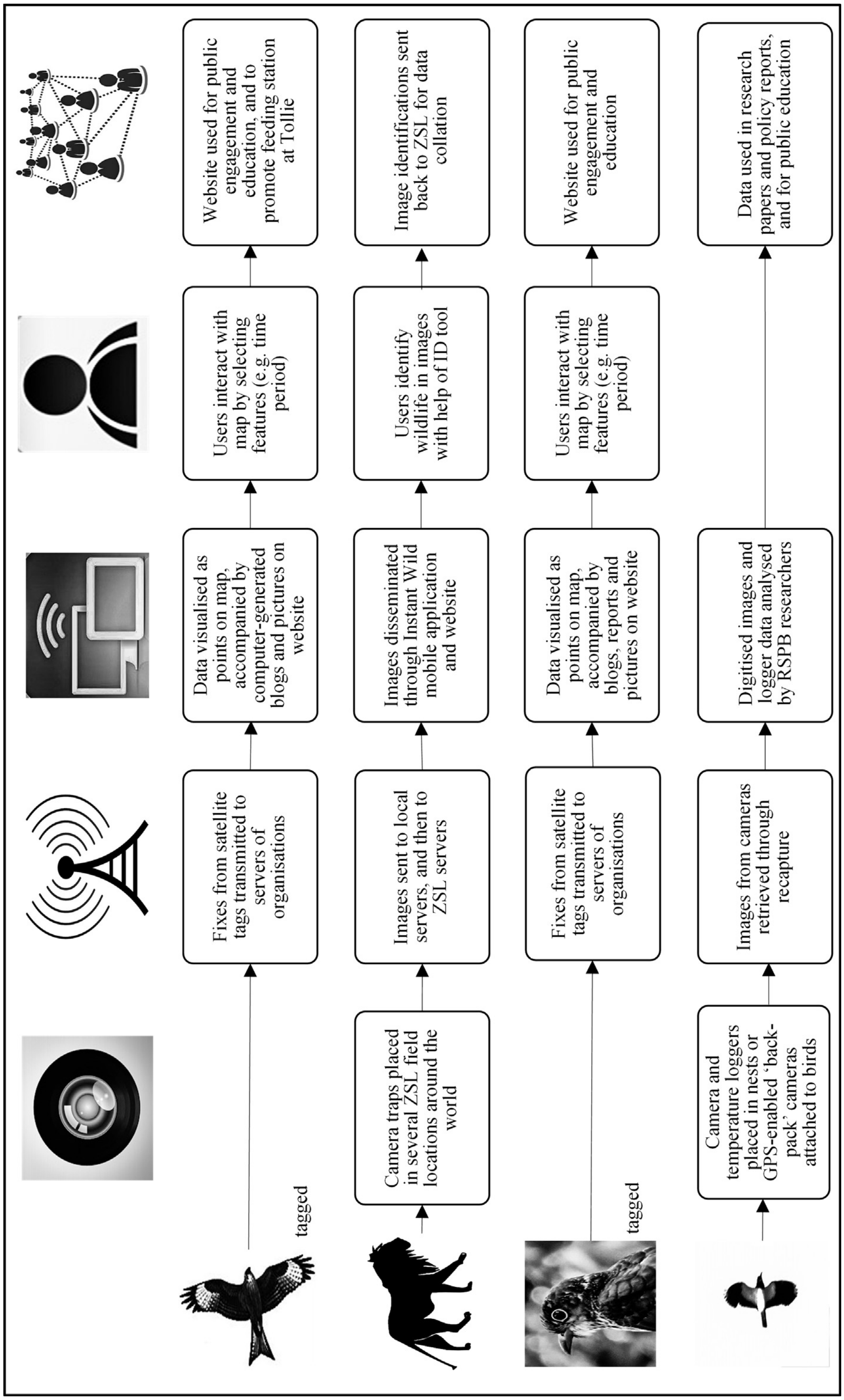

Fig. 1. How technologies mediate human-wildlife relations in the case studies. On the top horizontal line, the five icons represent, from left to right: (1) image-making technologies used, (2) data transmission methods, (3) how data was formatted, disseminated and/or analysed, (4) how users or visitors received these images, and (5) ways in which images and data were used publically. On the first vertical column, the four icons represent, from top to bottom: the 'Eyes to the Skies' red kites tracking project, Instant Wild, the cuckoo tracking project, and examples of technological projects by the RSPB (this figure is an adaptation of a figure used in our previous publication (Verma et al., 2015)).

associated with the project over the phone, and consulted textual material from the project's extensive website pages and media coverage.

The Royal Society for the Protection of Birds (RSPB) is the largest conservation organisation in Europe, focused on nature conservation. Amongst other remits, the RSPB undertakes research, and the organisation's conservation research unit has had a technical development team since the early 1990s. The technical development team has been instrumental in the design and deployment of electronic devices that serve as tools in research efforts undertaken by the organisation, including monitoring nest predation and tracking movement. These technological efforts have

Table 1
Comparison between the role of census, map and museum in the construction of national identities (Anderson, 1991) and how new technologies facilitate the construction of wildlife censuses, maps and museums.

	Role of census, map & museum in the construction of national identities (Anderson, 1991)	How new technologies facilitate the construction of wildlife censuses, maps & museums
Census	• Identification by ethno-racial categories • Systematic quantification of populations	• Identification by species & plotting of presence • Systematic estimation of species abundance
Map	• Demarcation of exclusive & bounded, secular spaces • Logo-isation of territorial spaces	• Tracking species to reveal patterns of movement • Mapping locations of importance
Museum	• Creation and maintenance of archives of collected cultural-historic objects • Curation (interpretation, selection, repackaging and display) to produce secularised cultural history	• Creation and maintenance of repositories of collected wildlife data • Curation (interpretation, selection, repackaging and display) to produce conservation narratives

revolved around birds, although other flora and fauna are also monitored as part of wider habitat conservation projects. We interviewed, in person, a technical staff member, a member of the IT department and a marketing staff member.

The Eyes to the Skies project had its roots in the reintroduction of red kites into the UK between the late 1980s and mid-90s. While numbers of this charismatic bird of prey have steadily increased in the England and the reintroduction has been deemed a success, red kite numbers have remained low in Scotland. This has been regarded to be partly due to raptor persecution. A satellite tagging project was started in 2009 to determine where and how birds were being persecuted. These efforts were accompanied by a larger public outreach campaign led by the RSPB. The campaign included a public website with interactive maps that showed locations visited by kites based on satellite tag data. These maps were later accompanied by a blog, where text was produced digitally using natural language generation systems (Ponnamperuma et al., 2013) The text produced was an amalgamation of various sources of information used to interpret the kite location data. We interviewed, in person, two management personnel, two operations officers, and three website developers.

Initial data analysis was carried out in an exploratory manner. From these early coding exercises and concurrent data collection, we elicited recurring themes running across all case studies relating to how and why organisations used new technologies. There were two key dimensions accounting for technological uptake by conservation organisations. While in this paper we focused more on the use of technologies by conservation organisations for the purpose of wildlife monitoring and recording, elsewhere we have written specifically about the use of such technological media for conservation outreach and public engagement (Verma et al., 2015). With regard to wildlife monitoring and recording, the themes we derived from further coding processes included data gathering and processing, counting, tracking, observing, creating evidence, display and technical limitations. Data in these themes seemed to point at three large functions of new technologies for monitoring: to create censuses, maps and exhibitions, which we detail in the proceeding section.

3. Conceptual framework: producing census, map and museum

We used part of Anderson's (1991) seminal work on 'imagined communities' as a device for interrogating technologically-aided practices of monitoring and recording wildlife by conservation organisations. In his study of the emergence of postcolonial nationalism, Anderson posited that there were particular arrangements, imposed in the first instance as an exercise of colonial imagination, which eventually came to unify groups of otherwise disparate peoples. In particular, Anderson identified three representation-dependent arrangements instrumental in constructing an imagination of particular populations: the census, the map and the museum. These were used, respectively, to identify by ethno-racial categories and quantify populations, to delineate and logo-ise territories, and to curate and reproduce a particular coherent 'picture' of the colonised community's history.

We noted and subsequently mapped parallels between Anderson's understanding and the processes at play when the conservation-related organisations we studied used technologies to understand and represent wildlife. Thus, here, we applied, as a conceptual rather than strictly categorising device, the triad of census, map and museum to the understandings of wildlife derived from the digital networks (Table 1). These three dimensions were not a priori concepts with which we designed our study. Rather, we found them to be a useful frame for making sense of our data, in order to provide nuanced examination[2] of the ways in which monitoring and recording initiatives resulted in the quantification, location and curation of the non-human animal world (see also Latour, 1986, 1988).

Although these dimensions can be treated as conceptually distinct, they overlapped in practice. For instance, censuses and maps often featured as components of museums (i.e., as socio-cultural artefacts or as wildlife data that formed part of particular narratives). Further, the technologies for conservation purposes in our case studies were multi-functional (e.g., used for both quantifying and mapping).

The broader point we drew from Anderson's work are the implications it has for understanding the configuration of human-wildlife relations. For Anderson, census, map and museum in their initial stages "*profoundly shaped the way in which the colonial state imagined its dominion*" and were a display of aspirations to "*total surveyability* [...] *to create, under its control, a human landscape of perfect visibility*". This "*style of imagining* [...] *was the product of the technologies* [and arguably, the] *deep driving power of capitalism*" (Anderson, 1991: 184–185). While his analysis contains profound critiques of mechanisms and agendas of the colonial state, Anderson's overriding purpose was to lay bare the surprising foundations by which postcolonial identities were initially produced. The images and discourses rooted in colonial imaginings and constructed representationally through censuses, maps and museums would later be re-appropriated and reworked into independence narratives.

Here, we underscore that the primary focus of this paper is on the production of census, map and museum by conservation organisations, rather than the latter dimension of consumption and re-appropriation, which would have added a different analytical perspective. Anderson's reading has direct parallels with the dualism within critiques of western techno-scientific modes of monitoring and recording wildlife, as discussed in the preceding section. There has been no lack of critical arguments in which techno-scientific forms of conservation management have been read as extending domination over wildlife (Rutherford, 1999;

[2] Compared, for instance, to Scott's (1998) critique of state efforts to deploy scientific principles for social organisation.

Smith, 2011), often due to the social contexts within which these practices occur. Wildlife mapping techniques using aerial surveys have been compared to panoptic efforts by colonial administrators in that the scrutiny of the activities of wildlife results in calculation and governance (Haggerty and Trottier, 2013). Traditional zoos have been portrayed as spaces of surveillance over animals (e.g., Acampora, 2005; Braverman, 2012). Comparisons have also been made between zoos and natural history museums, showing that while both are in the business of collecting and curating nature, there is a mausoleum aspect to museums since the collections of dead specimens represent a 'necrological census', a concept used by Anderson himself (Alberti, 2011). And, newer 'electronic zoos' (in reference to visual technological representations of animals) have, like traditional zoos, been understood as emphasising the dominant position of viewers and further displacing and marginalising animals by inscribing them into visible and controllable electronic spaces (Davies, 2000; see also Mitman, 1996).

However, there have also been analyses suggesting that certain techno-scientific efforts allow room for forms of stewardship over wildlife rather than simply expressing unrelenting human exploitation of wildlife. The quantification of biodiversity has been thought to have considerable pragmatic value (Lovejoy, 1994), enabling actors to "*afford a fighting chance to set effective conservation priorities*" (Scheffers et al., 2012: 509). Further, particular techno-scientific initiatives (see for instance Lawler (2001)) have also been understood as holding the potential to highlight "*species with which we necessarily have relations and, arguably, to which we have responsibilities*", thereby reinforcing human enmeshment with wildlife (Youatt, 2008: 409). With regard specifically to tracking technologies, Benson (2008, 2010) and Whitney (2014) have both suggested, based on extensive empirical studies, that the over-generalised concepts of surveillance and bio-political power cannot account for the complex breadth and contradictory use of such technologies. Benson (2008: 3, 2010), for instance, showed how "*technological, biological, and ecological factors made* [...] *control fragmentary and open to re-appropriation,* [creating] *vulnerabilities as well as capabilities* [and providing] *opportunities for connection as well as for control*."

In the following section, we apply the above conceptual framework to our data to show how technologies aided in the production of wildlife censuses, maps and museums. We illustrate how organisations and conservation practitioners have come to use new networks of digital devices and human participants to gather data on presence and abundance of species, map locations, and collect wildlife data while curating conservation narratives. In doing so, technical limitations and political concerns are also articulated.

4. Findings

4.1. Censusing wildlife

Contemporary digital conservation tools for wildlife monitoring projects were designed with the intention of using both technologies and people to aid organisations in building a picture of wildlife in particular areas. Two of the basic tasks required for this were the identification and quantification of wildlife species (Table 1). Gathering data on the presence (what species are present) and abundance (how many individuals of a species are present) of wildlife in particular locations were thus amongst the principal functions of digitally-enabled networks of technological sensors and human and animal participants.

A recurrent theme from our data was that the use of technologies was perceived by our focal organisations as overcoming spatial, temporal and resource limitations associated with traditional modes of wildlife monitoring and recording. As an interviewee from the RSPB Conservation Research Unit explained, "*newer technologies have really taken off* [...] *because you've only got* [a] *certain amount of staff* [and] *you've got big open areas to cover. So the only other way to do it is triggered cameras and things like that*." In the case of ZSL's Instant Wild, networks of technological sensors and human participants were employed as a viable and cost- and time-effective means of helping to answer conservation questions. As an Instant Wild member of staff explained when discussing the logic of using technologies for conservation:

> "[The technologies] *can help to answer key questions that have traditionally been either a) very time consuming, b) expensive, or c) very difficult to achieve without modern advancements.* [By] *passing the identification of camera trap images to the general public, conservationists can analyse the data quicker, which helps us make informed conservation decisions* [...] *Instant Wild* [also] *provides ZSL with the ability to quickly know if a rare and threatened species has been spotted, and helps us to build up a picture of species type and density in a particular area.*" (Instant Wild technical staff 1)

In the case of the Instant Wild application, in the first instance, advancements in image capture and data transmission technologies allowed researchers to gather observational field data in large volumes. Similar to devices used by the RSPB for monitoring nest predation, automated sensors operated without the need to have someone on site to constantly check motion-triggered equipment that gathered images of wildlife. This resulted in more data than could be processed by just a small pool of expert practitioners. Thus, while new technologies saved on resources used for data-gathering, these same technologies simultaneously created potential issues associated with large volumes of data. As a pre-emptive solution to address the labour-intensive task of identifying species within large numbers of captured images, crowdsourcing applications were trialled. This resulted in digital platforms such as the free-to-download mobile application *Instant Wild*, springboarding off advancements in mobile communications technologies, as well as a publically-accessible website by the same name.

These digital platforms drew the public into participating in processing camera-trap imagery. Such participation in turn meant that members of the public had to be trained in identification. Identification (ID) guides thus became an important feature of the application. The heavy emphasis on identification resulted in, as a staff member explained, correctly crowd-sourced mass identifications, which was perceived to have saved the organisation on resources. Although no official statistics or reports for identification accuracy had been released at the time of our fieldwork, Instant Wild staff members indicated the utility of the set-up:

> "*All the images are identified by the users, which is fantastic and saves us time going through and ID-ing the images. So that part of it is great. For instance, the camera's down at the moment, but there's a watering hole in Kenya that we're monitoring, that's where one of the cameras is.* [We have] *a good indication of what animals are coming to the watering hole, when within seasons. It's been running for two years, so we're getting really good information about the species that are coming into that watering hole, and the community are ID-ing those images* [...] *We did kind of a sample survey of accuracy of identification so we could get a good idea of whether or not* [users] *are ID-ing the species appropriately. We've gotten a really good rating of accuracy. So we feel quite comfortable that we are getting really good inside information from our users*" (Instant Wild operations staff)

The efforts to train the public eye, ensure an accuracy threshold, and to retain interest and involvement of 'citizen scientists' required to process such large volumes of data also partly accounted for the 'gamification' of the application: Registered users had profiles featuring their ranking, based on how many identifications they made and how quickly these were made. A member of the team expressed surprise at how application users became 'addicted' to the competitive aspect of contributing identifications:

> "*When you did an identification, it would tell you* [...] *what your ranking was, in terms of speed at identifying an image* [and] *how many you identified.* [...] *We had some issues with the database* [and because of that] *people had lost all their data.* [...] *Some people got very upset. They were like, 'I've identified every image since the very beginning, you know'.* [...] *it made me realise just how much impact it had had and how addictive it was at least for some people. They were quite attached to their rankings. So although it wasn't a game as such, there was a competitive element to it...*" (Instant Wild technical staff 2)

The need to ensure accurate identifications to gather presence data, as illustrated above, served a larger drive towards estimations of abundance and analyses of threats to abundance. This was expressed in aims to take annual stock of wildlife, as in the case of BTO's summary reports on cuckoo journeys. It was also expressed in assessments of whether the numbers of certain species of animals, particularly endangered ones, were increasing or decreasing (Instant Wild website). The application, when coupled with the use of satellite-linked cameras,[3] would, in the future, be used to gain a "*greater understanding of the numbers and all that's going on*" (Instant Wild operations staff). This would be achieved, in short, through the expansion of the network of electronic sensors and human participants.

While Instant Wild was a heavily technological system, the team recognised from the outset that there were risks. Beyond purely technical challenges, such as devices or components being incompatible across different countries, there was awareness of the pressure to use technologies seen as 'cutting edge'. The aim was therefore to create appropriate rather than purely innovative technologies. This was done by consulting user groups to determine how best a platform might be implemented, in a form that would ideally deliver the practical conservation outcomes desired by the organisation:

> "*There is a big risk with some of these technologies because it's much easier to start with what sounds cool and indeed what is the most cutting edge and develop that and try and plonk it into the field and try and get people to adopt it. And it's a terrible temptation because really cool stuff is what gets people excited. But of course, it might not always deliver the best conservation outcome. So we have to be quite disciplined in ensuring that we speak to* [...] *our user groups* [and] *try and understand what they need on the ground, then react to that and work closely with them.*" (Instant Wild symposium)

Practical considerations also heavily informed the implementation of new technologies in the organisations we studied. Apart from cost and utility of devices in relation to the aims of a given project, the length of projects, and the multi-functionality and customisability of technological set-ups across projects were factored in before implementation. Such prior analyses prevented organisations from using only 'exciting' technologies with limited applications:

> "*Sometimes, you'll have a one-year field project. Sometimes, it'll be a project which is two or three years. So they'll come to you, and we say 'we'll just try this first year'. But if that doesn't look very good, you try it second year* [and] *it's a bit better. By the third year, you'll have it just right.* [...If] *you've got just a one-year study, if* [a device such as a tracker] *doesn't work for that study,* [then you have to ask if] *there is going to be another application for it. If not, it's not worth the cost, time and effort.*" (RSPB technical staff member)

4.2. Constructing wildlife cartographies

In promoting a publically available citizen science mobile application, a presenter on a widely watched primetime nature show exhorted viewers to participate in recording species sightings, since "*without a map of where [species] are, we cannot actually articulate and implement any effective conservation for the species*" (ad verbatim, from an episode of Springwatch during the 2014 season).[4] Alongside the identification and quantification of wildlife species, the use of technological platforms for mapping species by the conservation organisations we studied had been perceived as being integral in delineating the spaces inhabited by wildlife to enable effective, targeted conservation measures. To this end, locating species to determine habitats, geographical hotspots and movement of species stood out as key functions of new digital networks. To illustrate some of the ways in which technological methods involving the use of geographic information systems (GIS) and imaging technologies have mapped wildlife, we use here the examples where individuals from particular species were equipped with satellite tags of weights appropriate for the species. These sensors sent location data at regular intervals, via satellite, to organisational databases. Based on such data, the tags allowed researchers to accurately 'follow' over time both small-scale movements and long-distance migratory travels of tagged animals.

In the case of the cuckoos, the project was undertaken to 'pinpoint areas of importance' that might turn up possible explanations for declining return numbers.[5] The data derived from the process of tagging the cuckoos were made tangible through the use of mapping software, which created visuals that could easily be consumed by a wider public; i.e., location coordinates were plotted using digital mapping software (GoogleEarth) as shown in Fig. 2. The cuckoo study revealed the species' first full migratory journeys and disclosed formerly unknown wintering sites of the birds in sub-Saharan Africa. Early capture-mark-recapture efforts in the form of bird ringing had previously been undertaken, but only one UK-ringed cuckoo had previously been found in Africa (in 1930).[6] In considering the comparatively rich results derived from new maps, our BTO interviewee mused that the cuckoo species in question, which the migration mapping showed to be spending most of its time outside of Europe, should have been called the African cuckoo rather than the European cuckoo. The mapping of these particular species created visual evidence that enabled the organisation to disseminate such information about the journeys made by wildlife to the wider public through news and social media platforms.[7] In all of our study cases, the techno-scientific projects were steeped in both explicit and implicit language of 'revealing', 'discovering' and 'precision'. There was emphasis on making visible the details

[3] This would be without using mobile telephone devices requiring SIM (Subscriber Identity Module) cards. At the time of our study, the system relied on SIM-enabled devices, which was perceived as limited partly because the cards had to be topped up, making the set-up less autonomous.

[4] http://www.bbc.co.uk/blogs/natureuk/entries/3fc5d9c9-ee31-3f65-adec-90b5e685a4b1.

[5] see also BTO cuckoo tracking pages: http://www.bto.org/science/migration/tracking-studies/cuckoo-tracking.

[6] http://www.bto.org/science/migration/tracking-studies/cuckoo-tracking/tracking-technology.

[7] see, for example: http://www.dailymail.co.uk/sciencetech/article-2140325/Mystery-backpacking-cuckoos-disappear-Sahara-migrate-Britain.html.

Fig. 2. Example of map of journeys made by tracked cuckoos (British Trust for Ornithology).

of creaturely movements that would, without technological mediation, be invisible or imprecisely understood. While visual sensors such as camera traps were seen as enabling organisations to collect an expanding body of wildlife data, GPS sensors and mapping technologies further amplified a sense of unprecedented access to wildlife, producing results that were described in revelatory terms, as being ‘amazing’. With the cuckoos, a degree of awe was expressed at the long, challenging and varied migration routes by the individuals. With gannets, the detailed and ‘exact’ verification of previous suspicions about feeding ranges resulted in surprise:

> “*...from our seabird data, we’ve got lots and lots of* [data]. [People] *would never have believed some of the tracking traces, just how far the birds have gone down, from sort of Orkney down to Aberdeen, off the sea, a lot of feeding. There’s big feeding areas actually. The areas we thought were important at sea are being proved by the GPS tracks. We know these things are reliable - five or ten metres on the tracking. It’s data that’s exact.*” (RSPB technical staff)

In the case of the red kites tracking project, these charismatic birds of prey were tagged partially as a surveillance measure to help determine whether, and if so where, persecution (notably poisoning) of this reintroduced species was occurring. The use of mapping technologies here enabled the taking of a form of necrological census, as discussed when describing our conceptual framework, of birds that faced persecution. Virtual maps - produced, visualised, accessed and stored entirely digitally - were presented alongside accompanying computer-generated blog texts drawing on multiple data sources to detail the movements of the satellite-tagged kites. In addition to the provision of ecological insight, by translating the habitats and journeys of these birds into visual digital maps accompanied by computer-generated text that interpreted these journeys, abstract knowledge of certain wildlife was made more concrete, accessible and readily disseminated. The maps thus also held the potential of encouraging a sense of connectedness and responsibility towards a species:

> “*It was about connecting communities* [...] *to try and make more people* [care about persecution and] *to give us a big platform from which* [to really] *get people to understand the magnitude of what was going on.* [...] [Adults] *appreciated having something they could manipulate. They could see times, and could get some idea of speed of flight as well, by looking at distance covered, and looking at what times that was between. So you could get quite a bit of information.* [... Children] *were amazed that they could get that much detail on their bird.*[8] *Because they had ownership of it, they were keen to see where it would go, what it would do.* [...] *They were excited about it ‘cause they could sometimes see if the birds had been close to their school.*” (red kite operations staff)

However, technologically-driven locating and mapping of species raised particular concerns. For instance, where the maps of red kite journeys were used partly as a measure to monitor persecution pressures and to create awareness that countered these pressures, there emerged a double bind. The digital dissemination of increasingly accurate species locations brought about concerns from some interviewees that the data and maps could in fact be used to inform potential persecutors of more precise nest locations. This led to considerations of whether certain data points would have to be obscured before public dissemination. Further, there

[8] Some of the satellite-tagged red kites were named by pupils from schools visited by the project’s staff members.

were socio-political restrictions that posed challenges to cross-border wildlife monitoring, such as those emerging during the implementation of Instant Wild field devices. In addition to technical incompatibilities, such as SIM cards or memory card sizes varying from country to country due to mobile sales restrictions, there were also data protection, copyright and security issues with regard to the use and dissemination of images produced in particular countries.

4.3. Curating electronic museum-zoos

We conceptualised the process of curating digital museum-zoos as covering three aspects: the gathering of data into repositories of wildlife information, the maintenance of such archives, and the interpretation, repackaging and display of particular strands of information. Here, we focus mainly on this third, conceptually richer aspect, which may be collectively thought of as the process of creating 'exhibitions'. We examine some of the ways in which particular data content was interpreted and converted into easily reproducible forms such as images for consumption by and dissemination, and by which such information was used to constitute wider narratives, aimed at public audiences as well as within conservation circles. In the preceding sections, technological platforms have already been shown to be used by conservation organisations for identification and quantification (censusing), and location (mapping) of wildlife. Such data partly served the perceived need for tangible, observable and scrutinisable data on wildlife loss or gain within conservation circles. However, as the discussion on mapping began to suggest, new technologies also produced information invoked by organisations to constitute wider narratives by which the public was made aware and supportive of conservation causes.

Following on from the preceding section therefore, the cuckoo and red kite tracking maps illustrated that digitisation allowed for data to be plotted for consumption by a public audience. This added dimension afforded by electronic wildlife monitoring sensors created public interest and awareness of particular species, expanding the circle of people better disposed to engage with conservation monitoring projects in various ways, including participating in causes, joining the organisation as members and donating money. With the red kites, the use of technologies created opportunities for the organisation to engage the public more easily with organisational initiatives. Raw data from satellite-tagged kites was converted into consumable visuals accompanied by computer-generated blogs. A staff member who had used these maps in outreach efforts explained that this had the potential of driving public interest, particularly in terms of membership:

> "*By speaking to people and saying* [...] *have a look at the website, there's information there, it gives then people the chance to feedback into this.* [...] *By giving somebody something to do, like you can report a wing tag back to us - that makes people sort of better disposed to what we're doing.* [...] *It's the birds that are writing these blogs*[9] *and making the maps with the aid of technology. They're out there doing their things, and without any physical input from us* [...] *I think that's the appeal of this, and marketed properly, that could drive a lot of* [public interest]." (red kite tracking marketing staff)

Here, we also highlight the interviewee's point regarding the integral participation of the red kites in the tracking and blogging process. In this regard too, it is interesting to note the case of Merida, a female kite that was named after an adventurous Disney heroine. However, Merida never ventured very far from her original nest, and in 'refusing' to personify her namesake, did not produce particularly 'exciting' blogs and maps.

Apart from the reproduction of images that accompanied the display of visualised data, there was also the aspect of reproduction for the purposes of curating coherent and evidenced conservation narratives. In describing the deployment of new technologies to monitor nest predation, a senior technical staff member within the conservation research unit of the RSPB discussed the perceived capacities of new visual technologies to provide evidence of ecological interactions. Establishing such evidence was perceived as enabling the organisation to plan conservation management strategies differently based on a better grasp of the facts. Equally as important was that the visual results provided by the imaging devices were seen as being easily reproducible and implicitly objective proof for mass dissemination, since pictures were considered as being far more incontrovertible compared to the results of traditional surveying methods:

> "*Since about 2005, we've been using cameras from in here at* [specified reserve where lapwing numbers have been declining] [...] *it doesn't take too long if you're just looking to see the fate of a nest.* [...] *The thing about the technology, from my point of view, is you get the sort of black or white answers.* [...] *You can go out on a survey, and they say, 'oh, we got me results but it was a windy day', or it was something that you can always kind of construe the results how you want them.* [...] *You get a nest camera* [and] *you can identify the causes, whether the nest was flooded, whether they just abandoned, whether something predated the nest. I've got loads and loads of pictures of predation. It's all there, nobody can argue with the results. You put it straight in, in a report, in a paper, done.*" (RSPB technical staff)

What also emerged again from the above narrative is that the technologies enabled a 'necrological census' of certain species. The focus of technologically-aided research and monitoring was often on declining species or on the demise of animals, wherein scale of threat translated to the 'case for conservation'. This underlying impulse for preservation through monitoring and recording also appeared to motivate the public dissemination of some electronically-produced wildlife visuals through other visual monitoring technologies, such as live webcams feeds used by the RSPB for public engagement purposes. The focal species of such projects were often vulnerable or rare species.

However, as much as organisations perceived that digital facilities had the capacity to generate public interest through exhibition and to develop coherent narratives through reproduction of data, there were challenges with using new technologies for curation purposes. Some of these had to do with the technical process of archiving and maintaining repositories, particularly in situations where there was input from large numbers of human participants. For instance, with Instant Wild, when they first launched their app, the load on the server was stretched to its limit due to the volume of users the app attracted. Other challenges arose with regard to exhibition (for example, to do with digital data security, as pointed out in the preceding sub-section on mapping). However, there was an organisational learning curve with regard to the pitfalls of using web and mapping technologies to gain visibility and public following:

> "*We thought, like everyone else, we must have a website.* [...] *And we had that incredibly naïve view that you build a website, you put it on the internet, and the whole world suddenly finds it and thinks it's wonderful. Complete rubbish.* [...] *There's a number of websites out there that follow satellite tracked birds of one sort or another* [that are] *actually very dull. Looking at 'oh the red kite is here*

[9] Here, the interviewee was referring to the use of Natural Language Generation systems to digitally derive textual interpretations from various sources of data. This digital function was used to form the blogposts accompanying mapped visuals of the movements of the tagged red kites.

today, and it's there tomorrow, and it's there the next day' actually isn't that interesting [...] *The only way you engage people is by bringing it to life to some extent, through blogs or having the website a bit more interactive that people can actually contribute to in some way.*" (red kites tracking management staff)

5. Discussion

Overall, where there have previously been piecemeal efforts to understand the various ways in which wildlife has been calculated, tracked and exhibited, our examination has covered the breadth of new technological efforts undertaken by conservation organisations that have produced wildlife censuses, maps and museums. At a practical level, we traced how contemporary modes of digitisation enabled the creation of networks comprised of technological devices and human and animal participants. We found that these digitally enabled networks were perceived as amplifying the monitoring capacities of nature conservation organisations. In producing data for conservation organisations, the use of new technologies was seen as instrumental in the production of new or vastly expanded knowledge about wildlife.

However, our findings highlighted issues emerging from the implementation of these new technological networks. In relation to the processes underlying the production of knowledge about wildlife, our interviewees felt that there was a risk of using technology for its own sake. This was tied to the acknowledgement that their organisations operated in a wider context in which the legitimacy and value of conservation causes were linked to the appearance of innovation (Igoe et al., 2010). There was, for instance, awareness of the pressure to defend the need for conservation by generating mass support through the use of particular technologies, as in the case of the red kites tracking project. Within such a context, some interviewees expressed concerns about the premium placed on 'cutting edge' set-ups, rather than on the most appropriate monitoring methods. Nonetheless, the implementation of technologies presented a learning curve of sorts for organisations. There were indications of increasingly measured approaches taken and best practices being established. This included factoring in practicalities before implementation (e.g., considering project lengths and alternative applications of technological set ups), as with the RPSB; designing more engaging elements into set-ups, as in the case of the red kites tracking project; and focusing on relevant, real-world conservation questions while working in partnership with user groups, as in the case of Instant Wild.

Although digital technologies were perceived as amplifying the capacity of organisations to monitor and record wildlife, the new networks we investigated came with novel technical challenges. First, in a case of the "*same technologies that contribute to nature conservation* [being] *used for purposes that conflict with conservation aims*" (Arts et al., 2015: 664), new forms of techno-scientific data-gathering in our case studies amplified particular security issues. For example, in the case of the red kites, increasingly accurate data pinpointed the presence and location of the vulnerable species. This raised concerns of potentially enabling further persecution. Related to this, ownership of data and images emerged as an issue, particularly in cases where wildlife was monitored across borders. Second, the successful use of new technologies in one area (e.g., data gathering resulting in a 'deluge') motivated the perceived need for technological solutions in other aspects (e.g., data processing). Third, across all of our case studies, there were concerns with the levels of engagement and retention of human participants when using digital technological platforms for monitoring and recording wildlife. This need to capture and create lasting affinities with participants to the wildlife, and by extension to the organisation's cause (see also Verma et al., 2015), was particularly pronounced with crowdsourcing participants and digital citizen science efforts, accounting also for the gamification of such platforms (see also August et al., 2015; Sandbrook et al., 2015).

In terms of knowledge produced, there were concerns with the links between new network-derived knowledge and conservation practice. Our findings pointed to an organisational intention to use data derived by digitally-enabled networks in the formulation of conservation management outcomes. In some instances, there was evidence that new knowledge was informing conservation practices, as in the case of RSPB's strategies with nest predation. Here however, we note that it could be argued that the technologies studied are limited in that they can only be used with a relatively small number of animals, creating a class of 'unloved others' (Rose and Van Dooren, 2011; Hatley, 2011) which escape surveillance and management. While such a strand was not immediately present in the data we collected, there are distinct trends towards miniaturisation and an expansion of monitoring networks, which suggest that the numbers of currently 'excluded' species may be dwindling. However, in several instances with our case studies, human 'components' of digitally-enabled wildlife monitoring networks were noticeably relegated to supporting and consuming roles (i.e., as recipients of curated information designed to make them aware of conservation causes), rather than being integral participants in knowledge-building processes. The increased inclusion of the public in conservation-related projects thus raises questions of whether there is a need to better define the roles and capacities of participants.

In this regard too, we reiterate that our study focused on the production of technologies rather than on their use. Future research could specifically address how such technologies are re-appropriated by different groups of users (Oudshoorn and Pinch, 2003). Similarly, we did not address the question why some organisations (deliberately or otherwise) eschew technological modes of monitoring. Lastly, we did not compare the implications of different technologies: It could be argued that from a producer's perspective, new approaches are not unambiguously positive, given that these devices imply losses associated with previously used techniques, for instance with less technologically mediated experiential knowledge (Fazey et al., 2006). In this vein, following scholarship on the role of emotion in conservation (Milton, 2002), we have argued elsewhere that technologically mediated ways of engaging with wildlife involve fundamental tensions between cognition and emotion, both for conservation organisations and the public targeted by these efforts (see Verma et al., 2015). This in turn has consequences for the multiplicity of knowledge about wildlife produced (Law and Lien, 2012). While our participants did not explicitly reflect on these, more targeted work in the future might be able to shed light on the relationships and dynamics between the knowledges generated by different technologies.

In terms of implications for human-animal relations, our findings illustrate how, at least on the surface, through the efforts of digitised networks, wildlife appears to have been increasingly and thoroughly surveyed, mapped and curated. Following writers critical of anthropocentric techno-scientific projects (Shukin, 2009; Pettman, 2011), the use of the technologies we studied could be construed as situations where humans exerted new forms of calculated dominance over wildlife. The panoptic impulses of such monitoring methods appeared obvious with the prolific use of increasingly automated cameras (see also Chambers, 2007) and arguably intrusive animal tagging components used in some of our case studies, and with the interest in 'revealing', 'discovery' (Youatt, 2008) and 'precision' (see Section 4.2). Wildlife was also, to an extent, formulated instrumentally, with numbers, locations and conditions monitored for management based on anthropocentric values and commodity logic (Robertson, 2006; Grove, 2013).

Further, if we agree that science-based knowledge always involves some loss of being (Davies, 2000, paraphrasing Zizek), then encouraging the public to participate in technological-scientific modes of relating to wildlife may be said to reduce the diversity of wildlife to numbers, map points and curated narratives (see also Benson, 2014). Here, rather than contending that the animal world has "*been completely counted up and figured out*", it would appear that it has at least become "*calculable in principle*" (Bennett, 2001: 59), with its value measured by economics and potentiality determined by technology (paraphrasing Szerszynski, 2005: 5).

However, underlying such critiques is the view that even non-instrumentalist conservation efforts operate within a larger socioeconomic context where wildlife is quantified for human use. We suggest that techno-scientific efforts undertaken by conservation-related organisations are nonetheless vital, and that "*not all actor-networks, surveillance techniques, nor the environmental policies they imply and support are equal*, [and this is] *potentially obfuscated by over-generalised notions of biopower*" (Whitney, 2014: 86; see also Benson, 2008, 2010). Here too, it is worth highlighting Latour's (2011: 5) suggestion that one solution to confronting the current 'ecological crisis' is "*to become attentive to the techniques through which scale is obtained and to the instruments that make commensurability possible*". New technological efforts may therefore be read in ways other than purely as exercises of human domination over wildlife (see also De Groot et al., 2011). First, we found that technological monitoring brought conservation organisations into confrontation with other social actors, for example given the surveillance aspects of the red kites tracking and Instant Wild projects. In these instances, rather than the straightforward control, regulation and management of wildlife, technological monitoring measures were targeted at other humans i.e., poachers and persecutors.

Second and more crucially, our findings indicated that technology-driven projects increased the capacity of organisations to curate narratives that engaged public imagination and support, and to provide more precise and detailed evidence of loss. For instance, as we showed in Section 4.3, the maps and images derived from new modes of technological monitoring enabled conservation organisations to authoritatively influence societal discourses by (re)shaping and more effectively disseminating particular narratives about wildlife, natural history and nature conservation. Additionally, institutionally recognised and increasingly extensive forms of data also provided these organisations with the leverage and evidence required, for instance, to push for stronger policies (see also Yearley, 1996). The actions engaged in by conservation organisations in these two regards may thus be read as one of the few viable methods that conservation organisations, as stewards working to defend the interests of wildlife, may be able to ready wildlife *against* exploitation, rather than *for* it.

However, we acknowledge here that one of the implications of the framework we outlined in Section 3 is that the identity resulting from censusing, mapping and museum exhibition can be reworked and re-appropriated by peoples subject to these colonising imaginations. It is apparent from our findings that the animal participants in the process remain generally passive subjects within the new digital monitoring networks, largely since wildlife have no choice regarding the techniques and processes deployed to study them. Nonetheless, there are indications that animals can occupy 'active' and central roles enabled by newer technologies. This may be illustrated, for instance, by the natural-language computer-generated blogs capturing the movements of tagged red kites, which cannot be written without some degree of participation and 'collaboration' of the birds, resulting in a partnership of sorts between animal, machine and human.

We thus suggest here that new technologies can aid organisations in enacting more considered conservation practices and encouraging more benign human-wildlife relations, even within a larger context of utilitarian approaches to nature. However, there remains a crucial need for continued reflexivity in examining the intentions informing the use of new technologies for nature conservation, as well as in considering the consequences of deploying these devices, particularly with consideration of the role of animal participants.

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