Chapter

How Technology Can Transform Wildlife Conservation

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Abstract

Wildlife is under threat from various kinds of human activities, such as habitat destruction, illegal wildlife trade, spread of invasive species and diseases, and from the human impact on the Earth's climate, which is changing the nature of wild habitats. Advances in technology give conservationists, scientists, and the general public the advantage to better understand the animals, their habitats, and the threats they can face. In this chapter, I provide a review of the benefits of the use of technology to animal ecology and conservation. Two major approaches are being recognized to conserve threatened and endangered wildlife species. The first encompasses protecting the species within their habitat, and the second involves breeding and caring individual species ex situ. The use of technological applications in captivity, such as satellite imaging and assisted breeding technologies, is focused to enhance animal welfare and to influence zoo visitors' awareness of conservation-related behavior. Given the increasing demands on protecting wildlife, it seems a fair time for us to pause and ask what could be the best way to use technological innovations and to stimulate a closer collaboration among conservation practitioners, animal behaviorists, biologists, computer and system scientists, and engineers, to mention but a few.

Keywords: technology, animal conservation, animal tracking, interactive technology, animal welfare

1. Introduction

The earth is gifted with an enormous diversity of natural ecosystems comprising a vast range of wild flora and faunal species. Nonetheless, global environmental changes such as climate change, deforestation, desertification, and land use impact negatively on plant and animal life. In the present day, the animal world is under severe attack; more than 1210 species of mammals, 1469 of birds, 2100 reptilians, and 2385 species of fish are threatened [1]. Activities such as illegal wildlife trade, spread of invasive species and diseases, and the human impact on the Earth's climate is changing the nature of wild habitats. On account of this, various conservation strategies, initiatives, and technological solutions have been at the lead during the past couple of decades [2]. Two distinct approaches to the protection of wild species are considered, in situ and ex situ conservation. The Convention on Biological Diversity (CBD) defines *in situ conservation* as "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings," and *ex situ conservation* as "the conservation of components of biological diversity outside their natural habitats" [3]. Available technological solutions have eased, in practical terms, the demanding task of traditional means to study animals in their natural habitats.

Habitat preservation (*in situ* conservation), in an ideal world, should always be the highest priority and the most important single approach to protect entire ecosystems and many species simultaneously; however, the constant threat to habitat and wildlife populations and their potential annihilation makes their conservation especially challenging [4]. Although the *ex situ* conservation of wildlife species is never preferred over supporting natural places, the importance of zoos' conservation role has grown greatly over the past three decades [5]. Its role involves research that enhances the science and practice of conservation, field conservation projects, and supporting and engaging with conservation of animals in their natural habitats [5]. A modern zoo should strategically integrate both ex situ and in situ conservation [5]. Simultaneously, zoological parks and aquaria have radically increased efforts to improve animal welfare, through increasing understanding of animal cognition and behavior, where a variety of technological applications is currently being used with the same principles [6]. Technological innovations are also being used to promote conservation education. Zoos are in a special position to educate the public as they receive millions of visitors annually and can become a critical player in global conservation efforts.

This chapter reviews only some of the technology currently available for conservation. This review focuses primarily on tools that can be applied in both conservation approaches; the goal is to highlight how technology can offer insight into species conservation and how the evolution of technology can bring people of different research fields to work together and achieve lasting conservation solutions.

2. Technology-based wildlife in situ conservation

2.1 Bio-logging and bio-telemetry

Bio-logging and bio-telemetry have different forms of collecting information, but both comprise the monitoring of physiological, behavioral, or environmental information of organisms that are difficult to observe or often otherwise unattainable [7, 8]. Bio-logging technology records and stores the information in an animal-borne device (archival logger), and the information is downloaded once the logger is retrieved, unlike the bio-telemetry technology, which sends the information to a receiver that is emanated from the device carried by the animal [8]. For instance, Block states that the integration of environmental data with animal collected data has been simpler with the use of emerging electronic tagging and the remote sensing satellites, which provide a more precise and rapid environment sampling and higher resolutions of global views. New approaches using both technologies are changing the capacity to conduct ecosystem-scale science and to improve the capacity of scientists to explore unanswered ecological questions [9].

The technology of Global Positioning System (GPS) allows scientists to obtain precise movement patterns of an animal through GPS telemetry where the animal location and its distance to survey sites can be quantified [10]. Such technology has helped to identify, for example, the use of unpredicted habitats [11], to explore the social dynamics of reintroduced species [12], and to reveal unfamiliar life history characteristics of threatened species [13]. Animal-borne technology (referred to as animal-borne video and environmental data collection systems—AVEDs) gathers high-resolution datasets that can measure the animals' physiology, behavior, demographics, community interactions, and the environment animal inhabits [14]. A vast variety of these sensor types to collect data on wild animals' internal and external states have been packaged into lightweight units [14]. For example, in birds, lightweight geolocators or satellite transmitters have allowed practical reconstruction of the migratory routes and wintering areas for large and small birds, which can give opportunities to test predictions about migration strategies [15]. Animal-borne devices are also advantageous for testing hypothesis about drivers of habitat use. For example, a study on southern elephant seal (*Mirounga leonina*; [16]) in the Southern Ocean, which looked at the geographic distribution of core foraging areas and behavior and assessed the relative quality of the habitats regionally, demonstrates clear advantages of using satellite tracking systems and their assistance to understand more about the animal's response to varying environmental conditions and population viability. This information is vital for developing conservation-oriented management actions.

2.2 Camera traps

Camera traps are remote devices equipped with a motion or infrared sensor that automatically record images or videos [17]. They have become an important wildlife research tool; the decreasing cost gives researchers additional opportunities to monitor and reach a larger number of wildlife populations. Traditional approaches, such as visual, capture and trapping methods, can be labor-intensive and can require hundreds or thousands of person hours; whereas, camera traps can multiply the number of observers and make them more cost efficient [18]. The use of this technology has increased to address questions of species' distribution, activity patterns, population densities [19, 18], and among other questions.

Camera traps offer a practical approach to answer many questions about wildlife besides the density or estimation of animal populations. Behavioral studies using camera traps, such as the first ever done by Gysel and Davis (1956) where they essentially described a simple system to photograph wildlife, help us understand how different species use their habitat [20]. For instance, Bauer et al. [21] examined scavenging behavior of puma in California through camera traps and telemetry. While puma are known to be opportunistic predators, their results indicated that pumas are also opportunistic scavengers. A more recent study in chimpanzees (*Pan troglodytes*; [22]) examined community demographic changes (births, deaths, emigrations, immigrations) and community composition (age/sex structure). The authors found that camera traps allowed for a practically accurate approximation of demographic composition and variation within and among social groups. They also highlight that such technology may provide more accurate and precise measures of fine-scale group abundance.

2.3 Additional technologies

The emerging technology of synthetic biology is rapidly expanding and currently applied to conservation. This field is capable of editing natural genomes in an extremely precise manner, through deleting a target gene and/or inserting a synthetic one (CRISPR/Cas9 technology), which can bring the efficacy of genetic modification to a new level [23]. Some examples of the main conservation problems with possible solutions through the application of synthetic biology are as follows: (a) habitat conversion by creating or modifying microorganisms that consume hydrocarbons in order to clean up oil spoils [24] or by using systems to produce man-made palm oil and so reducing tropical forest alteration [25]; (b) overexploitation, where production of materials that can substitute rhino horn ivory or deep sea shark squalene [26]; and (c) invasive species, where the use of chromosome alterations and gene drives to stop reproduction in these species. The latter is yet associated with esthetic, moral, and ethical issues in which Piaggio and colleagues [23] call for a robust decision-making and a risk-assessment framework in the application of synthetic biology to conservation concerns.

Track plates offer a further efficient method to detect wildlife, and they have been used in an array of ways to monitor several animal species. Originally, track plates were developed to monitor rodents' abundance, and were subsequently adapted for use with carnivores [27]. Back in the 1980s, such tools commonly comprised an aluminum plate in a plywood box, and usually, a bait was placed near the back of the box. The negative track impressions were created after the underlying plate surface was revealed, when the animal's foot removed soot [27]. Other tracks of mammals were and are created by using, for instance, smoked kymograph paper [28] sand, ink-coated tiles [29], mineral oil mixture and carbon black [30], or contact paper and dispersed printer toner [31]. Track plates are considered economical and reliable devices that can provide robust measurements of animals' abundance. For example, Connors et al. [32] used track plates to measure abundance and local predation risk created by white-footed mouse (*Peromyscus leucopus*) foraging activity, and they conclude that such devices were a trustworthy means of quantifying local risk of attack by terrestrial mammals without significantly modifying the spatial distribution of risk. A more recent study by Smith et al. [33] confirms that a well-designed trap to enclose the track plate can be fairly inexpensive, nonintrusive, and an easy monitoring tool. They specifically looked at whether breeding phenology of a generalist predator was associated with human responses to climate change. For this, they assessed seasonal abundance of small mammals using presence/abundance data collected from track plates, along with motion-activated trail cameras to obtain visual corroboration of the identity of small mammals visiting traps.

Environmental conditions can be diverse as a result of new extremes temperature and precipitation patterns and novel assemblages and interaction species due to the human-assisted spread of exotic species [34]. In light of this, Wood et al. [34] state that such environmental changes call for conservation to become more predictive. The development of technology which helps to predict key conservation outcomes including animals' distribution, their demographic and physiological states, and their interactions between individuals and species is urgently needed. A study on Canada lynx (*Lynx canadensis*; [35]) assessed behavioral differences with changing environmental conditions by developing a multiscale prediction model of lynx distribution and found within their results that individuals tend to use more mature, spruce-fir forests than any other structure stage or species. The authors, through the insights gleaned from their approach, state that understanding and predicting habitat use is essential in conservation management, particularly for species that are threatened or endangered.

3. Technology-based wildlife ex situ conservation

The International Union for the Conservation of Nature states that ex situ collections include "whole plant or animal collections, zoological parks and botanic gardens, wildlife research facilities, and germplasm collections of wild and domesticated taxa" [36].

The world is facing an alarming loss of biodiversity, where inflation of extinction rates is mainly driven by human actions [37]. Zoos and aquariums have taken different conservation actions to mitigate threats to species and their extinction in the wild. They have contributed to the genuine improvement in IUCN Red List status of species through captive breeding and reintroduction conservation measures [38]; however, their contribution to conservation of species goes further than that.

3.1 Digital technology

The use of technology in educational settings, such as guidebooks and handled computer tour guides in museums or tourist destinations, is becoming more common nowadays. Zoological parks and aquaria institutions have long used technology to promote conservation education. The increase of digital technologies use offers the public a more meaningful animal encounter, while building a higher interest in educational activities, conservation campaigns and in conservation itself [39]. Interactive computers at exhibits show short movies and information about a particular specie, influencing visitors' awareness of conservation issues and conservation-related behavior [6]. Some institutions allow and invite visitors to take immediate conservation action on an issue of their choice by directly contributing money [6].

Live web cameras operated by zoos display videos of the animals at the zoo on websites, which are available to the general public. For example, the Dublin Zoo has live webcams to see live footage of the animals from wolves, penguins, elephants, and from the African Savanna area. This technology explicitly seeks to motivate conservation awareness through appealing experiences, which bring animals and humans together.

Further applications of technology in captive environments, such as animal behavior and animal conservation, have the objective to increase animal welfare and to benefit scientific research on many areas. For instance, animal cognition research, which benefits significantly from the use of technology, can be an effective way to evaluate the mood, behavior, and welfare of zoo-housed animals [40]. In a recent study [41], researchers measured anxiety responses to noisy, unpredictable, and repeated events on simple cognitive tasks in three different primate species: chimpanzees, *Pan troglodytes*, Japanese macaques, *Macaca fuscata*, and western lowland gorillas, *Gorilla gorilla gorilla*. This kind of investigation of the animals' subjective or affective experience is important to understand about the animal's state of wellbeing, which can be important to their survival and reproduction [41]. Another application in welfare research is to provide the captive animals with more control over their environmental enrichment and surroundings. Control of environmental elements, such as access to outdoor areas or to privacy, temperature, sounds, and with nontechnological objects can be one of the keys to improving their welfare [42, 43].

3.2 Technology devices

The use of animal-attached technology by researchers in zoos has increased remarkably over the last 10 years. Welfare and behavioral scientists can monitor movement patterns, locomotor activity, track use of space, health issues, postural behaviors, and a range of behaviors indicative of positive welfare and so understand a bit more the animal's view of its social and physical environment [44].

Devices such as GPS are applied in zoos to examine questions about patterns of movement, activity levels, or habitat use. This technology has also been used in assessing relationships among animals. A study on African elephants [45] collected GPS coordinates to calculate the average distances between individuals with the aim of determining the social structure of individuals to potentially improve management in determining appropriate group setting to ensure the individual and group well-being.

Accelerometers are also used in zoo animals to regularly monitor baseline patterns of behavior and to detect signs of discomfort or disease.

Knowledge of an animal's behavior through these kinds of devices on captive animals can inform and contribute to the species management and conservation. Researchers illustrate [46, 47] the value of collecting data from captive individuals. For instance, technological devices are commonly calibrated in captive animals before using them in wild counterparts, this involves time-synchronizing behavioral observations with the associated device readings [47].

4. Conclusion

The use of technology in conservation should be seen as force that can transform the work of researchers from across all fields interested in the protection of species. There is a serious need to understand the efficacy of both in situ and ex situ approaches to maximize their value for studying remaining populations. Furthermore, collaborations between ex situ and in situ communities can equally provide useful information, and for that reason, both approaches should be complementary rather than discordant.

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