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COMPASSIONATE TECHNOLOGIES AND VULNERABLE ANIMALS
Visual Tools for Moral Prioritisation

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ABSTRACT
This article defends a moderate negative welfarist and prioritising framework for assisting wild animals, arguing that the most severe and remediable suffering should receive moral priority. It examines how emerging visual technologies — including thermal imaging, drones, computer vision, augmented reality, robotics, and satellite systems — enable prevention, monitoring, and rescue interventions that can reduce both natural and anthropogenic harms to wild animals. The integration of these tools with ethical principles can inform targeted, evidence-based policies in Europe, thereby improving the welfare of the most vulnerable individuals without causing greater ecological disruption. The article concludes that technological assistance represents a feasible and morally justified extension of our duties towards wild animals.

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1. Normative Reasons for Assisting Wild Animals

In contemporary ethical theory, the interests of non-human animals have ceased to be a marginal issue and have become a central axis of debate (Cochrane, 2018; Horta, 2022; Korsgaard, 2018; Nussbaum, 2023; Sebo, 2025; Singer, 2023). At the heart of this development lies sentience as the decisive criterion. Sentience has become increasingly accessible to scientific investigation thanks to advances in animal welfare science (Broom, 2014), an interdisciplinary field that integrates contributions from neuroscience (Paul et al., 2020) and ethology (Dawkins, 2008). Indeed, a growing body of empirical research shows that numerous organisms exhibit both the neurophysiological substrates and behavioural indicators compatible with subjective experience, including the capacity to feel pain, pleasure, and other basic emotions. The scientists who signed the Cambridge Declaration pointed to the existence of neuroanatomical, neurochemical, and neurophysiological substrates of conscious states, as well as the capacity to display intentional behaviours. Consequently, "the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness" (Low et al., 2012).

Classical utilitarians such as Jeremy Bentham and Henry Sidgwick regarded pleasure and pain as symmetrical in their moral relevance: "classical value hedonism holds that happiness and suffering are equally important from a moral point of view" (Mayerfeld, 1999, p. 99). In contrast to this symmetrical version, negative welfarism is the axiological thesis according to which the reduction of suffering carries greater moral weight than equivalent increases in happiness or pleasure. Consequently, it is morally more important to prevent a harm than to produce a good of similar magnitude.

Karl Popper (1962) expressed this intuition by stating that there is no symmetry between suffering and happiness, or between pain and pleasure: "in my opinion human suffering makes a direct moral appeal, namely, the appeal for help, while there is no similar call to increase the happiness of a man who is doing well anyway" (p. 284). Following what has been termed "the Moore-Mayerfeld view" (Hurka, 2010, p. 200), it can be concluded that pain constitutes a greater moral evil than the good represented by pleasure. From an axiological perspective, this implies that the elimination of suffering (or negative welfare) takes priority over the promotion of welfare: "negative value hedonism holds that suffering carries greater moral significance than happiness, so that the alleviation of suffering takes precedence over the promotion of happiness" (Mayerfeld, 1999, p. 99).

According to this perspective, we should choose the course of action—among all feasible options—that leads to the greatest reduction of suffering. The promotion of welfare is subordinated to the moral urgency of minimising harm, which implies prioritising assistance to the most vulnerable sentient beings. In this sense, we can agree with Mayerfeld when he states that "the suffering of non-human animals carries no less moral weight than the suffering of humans, and that consequently the duty to relieve suffering applies with equal force to both" (p.117).

This does not mean completely ignoring the positive aspects of welfare or happiness. It means that alleviating suffering takes priority over promoting pleasure when decisions must be made about the allocation of often scarce available resources. Such welfarism should not give rise to extreme reasons or interpretations, such as concluding that the sacrifice of all lives to prevent future suffering is the most reasonable outcome (Smart, 1958). On the contrary, it is a moderate or weighted negative welfarism: suffering counts more, but happiness also counts to some degree.

In addition to this moderate negative welfarism, a prioritarian principle is incorporated. The objectives of negative welfarism could be limited to the total minimisation of suffering. But with prioritarianism we introduce a dimension of justice: it is not enough to reduce suffering in the abstract; it is urgent to identify who suffers most, that is, not all suffering matters equally, but the suffering of those who are worst off must carry greater weight.

Parfit (1991) formulated the Priority View in these terms: "on the Priority View, benefits to the worse off matter more, but that is only because people are worse off than others. Benefits to them would matter just as much even if there were no others who were better off" (p. 23). For Richard Arneson (2022), standard utilitarianism "has built into it no special solicitude for the wretched of the Earth, and this is a defect"(p. 2): an improvement in welfare for someone already well-off would count equally to an improvement for someone in extreme misery, provided the increment is the same. But if we adopt moral prioritarianism, the worse an individual's situation, the greater moral importance attaches to improving their welfare. This view rejects that equality has intrinsic value in itself and asserts that there are normative reasons to urgently assist the worst-off simply because of their worse condition (not because of abstract comparative considerations of justice).

For egalitarianism, “equality is itself to be preferred—or perhaps, rather, that inequality is itself to be avoided” (Crisp, 2003), but the focus of prioritarianism lies in the value of helping whoever is worse off, without comparisons between individuals in terms of their inequality. In this sense, this prioritarianism follows the Pigou-Dalton condition: transferring welfare from someone better off to someone worse off, without other losses, improves the overall state. What matters is not the existing gaps but the benefit to those who suffer most.

Prioritarianism postulates a concave value function of welfare: increments in welfare carry greater moral value the lower the individual’s starting point. In Tännsjö’s interpretation (2015), the classical utilitarian thesis asserts that “each equally large amount of happiness is equally morally important” (p.244). In contrast to this linear view, prioritarianism proposes a concave function: “the lessening of the unhappiness (the suffering) of those who are worse off counts for more than the lessening of the unhappiness (the suffering) of those who are better off” (p. 245). The intensity of this priority depends on the curvature of the function: at low levels of welfare (intense suffering), the slope is very steep (each improvement counts a great deal), but at high levels the slope is flatter (each improvement counts less).

In summary, under classical utilitarianism each unit of welfare carries the same weight, that is, “according to traditional utilitarianism, given the opportunity of bringing about either outcome, there is no reason to choose one over the other” (Crisp, 2003, p. 746). But under prioritarianism, lifting someone out of extreme suffering produces enormous moral value, whereas making someone who is already in a state of welfare a little happier yields diminishing returns (decreasing slopes, concave curves), with progressively lower moral value.

Consider a case study. We can think of three types of animals suffering the consequences of a wildfire. Type 1 animals, whose situation will not reach positive welfare, for whom analgesia and/or euthanasia are the most appropriate decisions. Type 2 animals, with severe suffering but recoverable. These animals can move from negative to positive welfare after receiving veterinary care, allowing reintroduction into the wild. Finally, Type 3 animals, vulnerable animals that require supplementary feeding to improve their situation, but with diminishing returns. This means that successive units will contribute progressively less to their welfare.

Under egalitarianism, resources would be distributed homogeneously among the unsalvageable, the recoverable, and the non-critical, producing a proportional improvement that does not optimise the situation of those with the most intense suffering. In contrast, prioritarianism, by not focusing on the gap between individuals but on benefiting those who are worst off, would first concentrate high-intensity resources on Type 2 (critical but salvageable), apply palliative care to Type 1, and postpone or reduce marginal expenditure on Type 3 (healthy wildlife with supplementary feeding) until no critical cases remain uncovered. The same package of resources generates more weighted welfare when directed to those who suffer greatly and can cross into positive welfare.

The welfare of wild animals is an emerging field that goes beyond traditional species conservation: it focuses on reducing suffering and promoting positive living conditions for individuals in the wild (Fernández-Mateo, 2024). In Europe, where conservation programmes abound, explicit attention to the welfare of each wild animal remains limited. However, recent advances in visual technologies—aligned with the normative criteria outlined above—offer new opportunities to monitor and improve their welfare. By visual technologies we mean those based on the capture and processing of optical information, such as infrared thermal cameras, computer vision systems (including artificial intelligence applied to images), drones equipped with visual sensors, high-resolution optical satellite sensors, and even augmented reality tools. These technologies, both in their current state and in emerging developments, can be applied in various contexts: prevention of harm and monitoring of animal health, rescue interventions, protection against threats, and active improvement of wildlife welfare.

Some authors, such as Horta (2017), argue that the lives of animals in nature are far from idyllic: they are full of episodes of extreme suffering and often end prematurely and violently. Indeed:

> since the death of nonhuman animals also involves the deprivation of the goods they might have otherwise enjoyed if they had not died, it seems to follow that death harms them too. Thus, all things being equal, they have an interest in not being harmed, by continuing to live (Faria, p. 21).

This would imply not only refraining from harming them but also assisting them when they suffer from natural causes—whenever it is within our power and we are certain that no greater harm will be caused.

This view challenges the idyllic vision of nature and abstract ecological values such as ecosystem stability, integrity, or beauty (Faria, 2023, p. 106; Palmer, 2013, pp. 196–197). In nature, animals face multiple intertwined sources of suffering: physical injuries—often severe or fatal—that inevitably lead to death after extreme suffering; adverse weather conditions—causing death from extreme cold or heat—including suboptimal conditions for individuals; constant fluctuations in food and water; parasitism and disease, which cause direct pain and weaken animals, increasing their vulnerability to other threats (Faria, 2023, pp. 69–80). All of this creates a landscape of negative welfare for wild fauna that could be remedied through active intervention mediated by new visual technologies.

In Europe, where wildlife legislation and management have typically focused on species and populations, this paradigm shift would involve incorporating animal welfare considerations into decision-making. Under a moderate version of negative welfarism, a view would be adopted that prioritises those in situations of intense suffering (Type 2) who can escape it and enter scenarios of positive welfare (Type 3). In this way, we can affirm that there are decisive reasons "to prevent or reduce the suffering nonhuman animals endure in the wild but also to avoid their deaths whenever we can—with the proviso that they would have lives of positive net value" (p. 33).

The following sections will investigate how current and future visual technologies can contribute to this ethical approach, improving the welfare of wild animals in Europe. Distinctions will be made between already available technologies and emerging ones, and their applications will be explored in: (1) prevention of harm and suffering, (2) monitoring of health and living conditions, and (3) rescue interventions. Each section will combine evidence from current projects with analysis of their development potential, drawing on academic references and recent practical examples.

2. Prevention of Harm and Suffering

One of the most direct ways to improve the welfare of wild animals is to prevent them from suffering harm, whether through accidents, injuries, or premature deaths. Current visual technologies have proven to be highly effective tools for preventing many of these situations. It is important to emphasise that, at all times, we adopt a non-idealised view of the problem: the goal is to reduce harm, not to "eradicate it completely". In human contexts, we do not consider immunisation campaigns "unworkable" simply because they do not eliminate a disease forever; the same applies to non-human animals. Therefore, the relevant benchmark is the expected value of harm reduction, not the achievement of a perfect ideal.

2.1 Detection of Fawns Before Agricultural Activities.

Every spring, thousands of roe deer fawns and other cervid young are killed or mutilated when run over by mowers and hay machinery across Europe. Some studies have shown the existence of simple deterrent methods (Jarnemo, 2002). However, recent research has recognised that acoustic devices alone are insufficient to prevent mortality during mowing, recommending their combination with other measures, such as the use of drones equipped with thermal cameras to locate fawns before cutting (Stehr et al., 2025). The use of drones fitted with thermal cameras could represent a revolution for the development of moderate negative welfarism: aerial thermography is an efficient, ethical, and economically viable tool for the protection of wildlife (Cukor et al., 2019). From an ethical prioritarian perspective, these technologies enable efforts to be concentrated on preventing the most severe suffering through evidence-based, selective interventions.

Recent studies on the spatial ecology of roe deer fawns have identified patterns of bed-site selection that can guide detection flights: "specific attention should be paid to those parts of the field with particularly dense vegetation, likely far from the woodland edge or road, particularly as hidden fawns in dense vegetation are hard to detect" (Baur et al., 2023, p. 10). Integrating these scientific findings with aerial thermal search systems would optimise operations and save thousands of animal lives each season. Indeed, various projects have already confirmed their usefulness. Germany pioneered these methods in 2014. With government support, a pilot programme was launched to reduce the problem: it is estimated that around 100,000 fawns die each year in Germany due to harvesters (Agence France-Presse in Berlin, 2014). In Switzerland, thanks to these drones, the number of fawns killed annually has dropped from hundreds to thousands saved each season: in 2025 alone, thermal drone teams rescued 6,451 roe deer fawns in Swiss fields, a record that surpassed the previous year (5,159 rescued in 2024) (SWI swissinfo.ch, 2025).

2.2 Warning Systems to Avoid Collisions with Infrastructure

Accidental collisions cause significant suffering and mortality in wildlife, depriving animals of multiple positive experiences. Two prominent areas are wind farms and vehicle traffic. In the case of wind turbines, while they provide green energy, their blades represent a lethal danger to birds and bats: "wind turbine collisions are a leading anthropogenic cause of bat deaths and cause a significant number of bird deaths (600,000 to 949,000 bats and 140,000 to 679,000 birds annually in North America)" (Rethink Priorities, 2022). The curtailment technique, by preventing turbines from rotating during periods of low wind speed—when bat activity is high and electricity production is low—eliminates most of the risk without significantly affecting energy generation. This is because, when the wind blows stronger (above 6–7 m/s), bats reduce their activity due to turbulence hindering hunting and stable flight, resulting in low collision risk (Whitby et al., 2024).

This technique could be complemented by innovative visual technologies. For example, high-resolution cameras with artificial vision have been installed to continuously monitor the sky around turbines and identify approaching protected birds. Systems such as IdentiFlight employ machine learning algorithms to recognise species in seconds and order temporary turbine shutdown to prevent collisions. The technology holds potential to significantly reduce eagle deaths at wind farms, provided identification algorithms and turbine reaction speed are optimised (Duerr et al., 2023).

A moderate negative welfarism would seek to reconcile the economic benefits generated by electricity companies at wind farms with necessary limitations to mitigate bird and bat mortality. Technology and ethics would combine to produce a normative expansion that includes wind farm permits conditioned on the inclusion of "wildlife welfare" clauses, individual animal mortality reporting, and welfare audits. Part of the profits would fund the installation of visual/AI systems for collision prevention, generating new wildlife welfare seals or certifications. In other words, the transition from Business Ethics to Sentient Business.

With regard to roads, wildlife anti-collision systems based on vision are under development. The refinement of automatic detection systems—which identify the presence of animals on roads through various algorithms, issuing immediate alerts to drivers or nearby vehicles—would prevent many accidents (Singh et al., 2025). This represents a non-invasive, preventive technological strategy that enables coexistence between humans and wildlife through intelligent infrastructure, harmonising human needs with the interests of other animals.

Finally, it is foreseeable that, with the decreasing costs of the most effective technological strategies—wildlife passages, infrared sensors, dynamic signage, speed reduction, and systems based on artificial intelligence and big data (Balčiauskas et al., 2025)—these visual alerts will become widespread in the coming decades.

2.3 Non-Lethal Human-Wildlife Conflict Mitigation

Another area of suffering prevention is the management of conflicts between human and non-human interests without resorting to lethal methods such as control hunting or poisoning. Here, computer vision and artificial intelligence offer compassionate alternatives. A concrete example involves granivorous birds (such as starlings) that devastate crops. Until now, many farmers have relied on traditional deterrents or even selective culls, which are contrary to the ethical approaches proposed: "in one year, the USDA's Wildlife Services culled 1,028,642 European starlings responsible for agricultural crop damage, because other mitigations are ineffective. […] More effective mitigation measures would hold value and could prevent culls" (Rethink Priorities, 2022). However, recent articles describe systems that use artificial intelligence to detect the actual presence of birds and activate deterrent stimuli only when necessary (Aman & Wang, 2024; Marcoň et al., 2021). This would have enormous moral value by minimising avoidable suffering.

The use of non-lethal visual technologies can be interpreted as a direct application of welfarist principles in rural environments. In this case, both the birds affected by lethal methods and the farmers who suffer significant economic losses find themselves in situations of relevant disadvantage. The implementation of AI-based solutions that deter without harming satisfies the prioritarian criterion of minimising negative welfare by simultaneously reducing animal suffering without worsening human welfare. These technologies not only provide an effective and preventive response to human–wildlife conflict but also embody a form of compassionate justice that prioritises the most vulnerable.

3. Monitoring Health and Living Conditions

To improve the welfare of wild animals, it is essential to know how they are faring, to detect health problems or suffering—often hidden—and to understand the complex environment in which they live, which is frequently affected by human infrastructure. Current visual technologies provide non-invasive means of monitoring animals in their environment, yielding data that were previously impossible to collect systematically. The following sections discuss advances in the visual tracking of the physical and environmental condition of wildlife, which enable early interventions or inform potential assistance measures.

3.1. Remote Detection of Diseases and Injuries

Infrared thermography (IRT), based on the detection of infrared radiation emitted by bodies, enables the identification of thermal variations associated with pain, stress, disease, or emotional states, without the need for physical contact. Its non-invasive, rapid, and silent nature makes it a particularly promising tool in contexts where direct human intervention may generate additional fear or suffering (Animal Ethics, 2022). This technology offers three main applications for assisting wild animals: location, health diagnosis, and stress measurement.

First, IRT is crucial for locating and estimating populations, outperforming traditional methods in complex habitats (Prosekov et al., 2020) and proving especially effective for detecting nocturnal or cryptic animals, whose body heat contrasts strongly with the cold night-time environment.

Second, the technology allows non-invasive detection of diseases and injuries by identifying anomalous thermal patterns, such as localised inflammation (heat) or fever. Specific studies have used IRT to assess heat loss due to sarcoptic mange in wolves (Cross et al., 2016) or to diagnose hypothermia in hedgehogs (South et al., 2020).

Finally, IRT is employed to measure stress, as the physiological "fight or flight" response causes vasoconstriction and detectable cooling in regions such as the ocular or nasal areas, as observed in chimpanzees (Dezecache et al., 2017).

These detection capabilities translate into direct practical assistance for mitigating both natural and anthropogenic harms (Fernández-Mateo, 2024). In the case of natural disasters, drones equipped with IRT are already used "to find animals trapped or stranded due to natural disasters, such as flood, fire, drought, earthquake and volcanic eruption, in the same way that these systems are now being used to detect humans in similar situations" (Animal Ethics, 2022, p. 32). Regarding anthropogenic harms—for example, those caused by agricultural activities—IRT is fundamental for saving the lives of cryptic animals: it enables drones to detect ground-nesting birds (Israel & Reinhard, 2017), or the already mentioned example of fawns hidden in vegetation before agricultural machinery injures them (Cukor et al., 2019).

3.2. Monitoring Critical Environmental Conditions

The climate crisis is recognised as an unprecedented threat, supported by countless reports from experts and international institutions (Ripple et al., 2025). Reports from the United Nations IPCC, statements presented at successive COPs, and resolutions adopted by the United Nations General Assembly identify the environmental crisis as a risk to all sentient beings. Habitat degradation, rising temperatures, and the increasing frequency of wildfires generate massive suffering in wildlife, causing injuries, malnutrition, and mortality among vulnerable species and individuals. In response, visual technologies emerge as key tools for large-scale monitoring of habitats, detecting potentially harmful scenarios for fauna.

Satellite technologies provide an effective means of monitoring ecosystem functions and detecting large-scale functional alterations (Pettorelli et al., 2018). Vegetation indices derived from remote sensing enable continuous assessment of vegetation cover and productivity, which are closely linked to the ecosystem services that support wildlife. The integration of multispectral optical data from the European Space Agency's Sentinel-2 programme has made possible detailed monitoring of vegetation dynamics and drought episodes in European grasslands, providing a key tool for analysing the effects of climate change on resource availability (Kowalski et al., 2023). These vegetation indicators, obtained through remote observation, allow high-precision inference of food availability for herbivores and other primary consumers (Zuleger et al., 2025). In this way, European agencies can identify, via satellite, regions where extreme drought has reduced pasture in natural parks, anticipating possible wildlife famines. This information opens the door to targeted interventions, such as emergency forage supplementation or temporary relocation of animals to more productive areas, in order to prevent mass starvation deaths and improve the welfare of affected individuals.

Thermal remote sensing from satellites and aircraft enables the detection of incipient wildfires with high sensitivity. Simultaneous monitoring of land surface temperature and fuel moisture via satellites allows early identification of conditions most conducive to intense and prolonged fires, offering a practical tool for wildfire management and early response (Maffei et al., 2021). Fire prevention and control have primarily been oriented towards protecting people and ecosystems, but from our perspective, the extreme suffering caused by next-generation wildfires would lead us to detect fires early with the aim of evacuating wildlife from critical areas (Fernández-Mateo, 2024).

The use of drones equipped with thermal cameras constitutes “the second most common practice for wildlife protection” (Ivanova et al., 2022, p. 10), facilitating rapid operations for both rescue and deterrence. For example, they can be fitted with loudspeakers to emit sounds that drive wildlife away from fire-affected zones. Drone-mounted thermography has proven capable of detecting biologically generated heat sources even under dense vegetation cover, in conditions of reduced visibility or in inaccessible terrain. The study by Rietz et al. (2023) shows how thermal cameras mounted on drones can locate both live animals and carcasses, depending on the stage of the biological process: live animals through their metabolism, and dead ones through the heat generated by decomposition. In this way, following a wildfire or natural disaster, thermal differences can reveal the presence of animals—live or dead—that would be impossible to identify visually. Finally, a widely reported example is that of Doug Thron, a drone pilot who collaborates in global disasters: using a drone with a thermal camera, he flies over areas devastated by hurricanes or fires, detecting injured or isolated animals—from pets trapped under rubble to koalas perched on burnt trees (Curiosity Stream, 2021; Reuters, 2021).

4. Rescue Interventions

Despite prevention efforts, many wild animals face situations of immediate danger or extreme suffering in which rescue intervention is necessary. Floods (Vidal, 2014), wildfires (Boffey, 2025), episodes of extreme cold or heat (Carrington, 2025), polluting spills (Vinter et al., 2025), and even natural events such as falls into ravines, generate emergencies for wildlife.

Traditionally, wildlife rescue has been limited and artisanal—often carried out by volunteers or local institutions with scarce resources. However, the most innovative visual technologies are multiplying the effectiveness and reach of these rescues, enabling more animal lives to be saved in critical situations. As mentioned earlier, drones equipped with thermal cameras have become valuable allies for locating surviving animals after natural disasters. In the case of wildfires, for example, once the flames are under control, rescue teams can deploy drones over the burnt areas.

4.1 Augmented Reality Equipment for Rescuers

Augmented reality (AR), which overlays digital information onto the real world, is beginning to assist those conducting animal rescues. In wildfires, rescuers could use AR glasses with integrated thermal cameras to locate live animals amidst smoke or under vegetation without needing to look at separate screens, that is, without losing time by glancing away from the drone display. The design of a modular interface for AR displays—for example, the machine learning module known as the Robust Vision Module, which detects relevant objects in a rescue scenario (Oregui et al., 2024)—could be adapted using datasets of thermal wildlife images, enabling the identification of animals such as foxes, deer, or large birds. Unmanned aerial systems (UAVs) equipped with artificial intelligence and thermal or multispectral sensors (Boroujeni et al., 2024) could be employed to detect surviving wildlife, assess destroyed habitats, and monitor species movements in affected areas.

In the post-wildfire context, the tools described enable the mapping of safe zones, identification of water sources and shelter, and coordination of rescue operations with minimal human intrusion. AR can display safe routes while rescuers approach an injured animal. Traditionally, rescue teams and their remote support organisations (operating from safe zones) have relied on radio communications to exchange information (such as victim geolocation, hazardous areas, and points of interest). However, radio communications lack visual representation of information, suffer from interference, and require effort to interpret the data, sometimes leading to confusion. The VizCom-AR system (Nalamothu et al., 2024) uses AR to present in rescuers' field of view information from remotely operated drones—such as thermal maps, obstacles, danger zones, or safe routes—so that they can orient themselves and make decisions without diverting their gaze from the physical environment.

4.2 Vision-Assisted Rescue and Veterinary Care

The use of drones with visual technology can be decisive in rescues. Numerous concrete examples point to a qualitative shift: wildlife rescue ceases to be a matter of luck or instinct and becomes a professional task supported by visual data that provide greater precision, speed, and reach. In operational terms, "Remotely piloted aircraft-derived data were more accurate and more precise than the traditional data collection method, validating claims that RPA are a highly beneficial tool" (Hodgson et al., 2018, p. 1164).

All these technological applications are accompanied by real, effective cases. In the United Kingdom, various rural police units used drones equipped with thermal cameras to locate a group of deer poachers in Nottinghamshire (The Newsroom, 2018). Along the Atlantic/North European coasts, drone photogrammetry is a key tool for monitoring the health and conservation of large cetaceans without interfering with their behaviour (Napoli et al., 2024). In France, authorities used a drone equipped with loudspeakers playing orca vocalisations to guide a sick orca that had become trapped in the Seine after straying from the open sea. The operation, coordinated by marine mammal experts, aimed to avoid invasive methods and protect both the animal and the rescuers (Reuters, 2022).

Veterinary telemedicine (Abu-Seida et al., 2024) is already used to guide remote decisions and improve animal welfare in rapid intervention scenarios, for example through video calls. Biologists and veterinarians often use dart projectors to sedate or treat animals, but air-powered or firearm projectors can cause serious injuries if the shot energy is too high. Technological innovation, however, can increase the precision and safety of teleinjection systems: through a LiDAR-sensor-controlled electromagnetic launcher, the shot force can be adjusted according to distance, reducing the risk of injuring animals during rescue, treatment, or research procedures (LaRocco et al., 2024). This system, combined with soft darts and microneedles that release medication, could revolutionise field veterinary care, making interventions more compassionate and effective. In immobilisation operations, night-time thermal optics and video-output visors—which transmit the image in real time to a mobile device or tablet so that a remote veterinarian can validate identification—help identify the correct individual and fire the dart in the appropriate posture (standard immobilisation manuals recommend impacting large muscle masses and avoiding the head/abdomen), reducing failed attempts and thus suffering from pursuit or stress (Wild Wonderful World, 2022).

Visual recognition technologies are in constant progress and evolution, but they also have an ecological footprint that must be minimised—from their construction using polluting materials to their operation in terms of electricity consumption. The development of more innovative drones—using future biodegradable materials—must be balanced against their evident benefits, since "drone ecology has clearly provided insights that otherwise would not have been possible or that could not have been achieved as effectively or efficiently" (Anderson et al., 2025, p. 675).

From a prioritarian negative welfarist perspective, every wild animal rescued from an agonising death or intense suffering is a valuable end in itself. Although it is not possible to save all individuals who suffer in nature, these rescue stories show that we can assist many with the appropriate tools.

Moreover, these efforts generate an educational and symbolic effect: society perceives that wild animals matter morally and that institutions also care about an injured deer or a trapped fox, not only about pets or high-profile endangered species. This expands our moral circle and creates greater public support for wildlife welfare policies.

5. Emerging Technologies and Future Prospects

When considering the future, it is evident that many of the technologies discussed will continue to evolve and new visual tools will emerge, further expanding the possibilities for improving animal welfare by reducing their negative welfare.

5.1. More Advanced and Ubiquitous Artificial Intelligence

In just a few years, we could have "virtual guardians" in every forest: networks of cameras and microphones powered by AI that not only detect threats but also continuously assess the condition of animals. For example, they could "observe" whether an animal is limping, whether a mother has lost her offspring, whether there are fewer young than expected in a season—a sign of reproductive problems—and alert the new generation of welfare biologists.

A crucial point highlighted by researchers is the need to ensure that these AI applications deliberately prioritise animal welfare, rather than solely other objectives that are not aligned with it (Fai Tse et al., 2025). In other words, as administrations integrate AI into wildlife management, a clear axiology must be designed that prioritises animal suffering, so that it is not used for non-welfarist purposes, such as maximising population without regard for individual interests. That is to say, alternative methods—such as relocation to safe areas or contraception—should be employed instead of culling when, for example, overpopulation is detected (Horta & Rozas, 2025).

5.2. Augmented and Virtual Reality for Education and Peaceful Cohabitation

The ethical use of technology can improve animal welfare by changing human attitudes. For example, applications of virtual reality (VR) could increase empathy by allowing citizens to "experience" the life of a wild animal. Adopting the perspective of animals through Immersive Virtual Environments (IVEs) "offer a wider array of sensory information than video, allowing users to see, hear, and feel environmental damage, participants perceived greater spatial presence and felt that their experiences as an animal were more genuine" (Ahn et al., 2016, p. 411).

We cannot overlook the uses of technology in awareness campaigns about animal exploitation. For instance, the "iAnimal" series by the organisation Animal Equality, a 360° VR experience that places the viewer in the perspective of an animal inside an industrial farm or slaughterhouse. Analysis of these tools confirms the potential of VR "to immerse the viewer in an embodied experience, the particular relevance for animal advocacy films is the potential to experience empathy with the animal subjects, to witness, and even to identify with them as they become victims of institutionalized violence" (Cecil, 2021, p. 50). In this way, VR can challenge the dissociation that consumers have with the consumption of animal-derived foods.

Finally, the argument that AR can reduce disturbance to real wildlife is a central theme in the debate on Virtual Wildlife Tourism (VWT). Scholars posit that VWT (using AR or VR) can be an ethically superior form of ecotourism, as it eliminates physical disturbance to habitats and the animal stress inherent in traditional observation tourism (Burns & Cowell, 2023).

5.3. Automation and Robotics

Alongside vision, robotics will enable action without waiting for direct human intervention. Imagine autonomous rescue drones stationed at strategic points that, upon detecting an animal at risk—through fixed cameras or satellites—take off independently to deter a threat or deliver emergency supplies while human teams arrive. Small ground robots equipped with vision could also assist injured wildlife by mimicking the natural movements of local species, as demonstrated in the experiments with crocodile- and lizard-shaped robots by Melo et al. (2023). These biomimetic robots not only integrate more seamlessly into ecosystems, thereby avoiding animal stress, but can also approach closely enough to record physiological data, capture images, or administer contactless treatments. African experience shows that biomimicry and collaborative autonomy between robots and remote sensors can transform conservation, turning technology into an extension of ecological work rather than an artificial intrusion.

5.4. Global Data Integration

In the future, all these digital sensors will form an integrated wildlife information system. With Big Data algorithms and visualisation tools, managers will have dashboards displaying near-real-time indicators of welfare across multiple populations.

For example, indicators such as "average surface temperature in bat colonies (estimated by infrared thermography from thermal cameras)" or "number of young detected nocturnally in colony Y (from thermal drone)" could be displayed—both approaches have already been methodologically explored: thermography has been used to census and characterise bat colonies and as a non-invasive indicator of health/stress (Hristov et al., 2008), while thermal drones have been applied to quantify Pteropus young (Meade et al., 2025). Similarly, a "robustness index" for roe deer in a reserve could be derived from drone photogrammetry—measuring body size and condition—a line of research already validated in large mammals (Berger, 2012).

The European Union is laying the foundations for integrating these data streams: the Copernicus Land Monitoring Service publishes annual series of high-resolution phenology and productivity data (Copernicus Land Monitoring Service, 2025). The High-Resolution Vegetation Phenology and Productivity (HR-VPP) is a set of data layers derived from images captured by the Sentinel-2 satellites of the Copernicus programme. The welfare of wild animals depends largely on the availability, quality, and seasonality of their habitat, particularly plant resources: food, shelter, shade, and microclimates. The HR-VPP precisely measures this—phenology (when vegetation sprouts, flowers, or dries) and productivity (how much biomass or energy an area produces in each season). When these data are correlated with populations of herbivores, pollinators, or forest-dependent species, they can predict periods of ecological stress—for instance, lack of pasture, overheating, or loss of shelter—that serve as indicators of suffering or mortality risk.

The Destination Earth (DestinE) project, driven by the European Commission (European Commission, 2025), represents a decisive step towards planetary intelligence capable of simulating, monitoring, and anticipating interactions between natural systems and human activities. Through its "digital twins" of climate, biodiversity, and ecosystems, this infrastructure combines satellite observations, high-resolution modelling, and artificial intelligence to provide predictive scenarios of environmental impacts. In this context, the integration of biological and ecological variables opens the possibility of creating "dynamic indicators of animal welfare", particularly for fauna affected by wildfires, droughts, or changes in vegetation productivity. By linking Copernicus productivity and phenology data (HR-VPP) with DestinE simulation models, vulnerability and resilience maps could be developed to anticipate episodes of suffering or scarcity in populations of herbivores, migratory birds, or threatened species. In this way, Europe would not only advance in climate and territorial management but also in a new form of compassionate governance of the living world, where digital data and compassionate welfarism converge to protect wildlife on a transforming planet.

6. Conclusion

A moderate negative welfarist and prioritarian position asserts that we have decisive reasons to use technology responsibly when the expected balance is clearly positive for animal welfare: under scientific supervision, multisectoral collaboration, and transparency. At the level of European policies, it would be beneficial to establish frameworks that facilitate controlled intervention (international pilot projects) and share best practices among countries. It would also be valuable to update the training of wildlife managers so that they incorporate knowledge both at the normative level and in the use of technology—for example, courses for park rangers on drone handling, or for wildlife veterinarians on telemetry—specifying how vulnerable wild fauna will be attended to. The long-term vision would formally incorporate the welfare of wild animals into animal welfare strategies, thereby expanding the circle of moral concern beyond companion animals.

It is true that there are many needs and scarce resources. Yet a moderate negative welfarism maintains that many resources devoted to pursuing human welfare do not add an additional unit of happiness, suffering from the law of diminishing returns in welfare. In contrast, the fight against avoidable suffering should be the priority objective of institutions: suffering is objectively bad, whereas happiness—subjective and variable—matters, but is not a solid criterion for designing policies. If we adopt the view that suffering matters regardless of species, and that certain individuals are in a significantly worse situation, some resources that generate diminishing curves of moral value—an additional unit does not imply a significant difference in welfare—could be redirected to prioritise the most vulnerable. Moreover, many technologies originated from human uses—rescue drones in civil protection, security AI—and can be adapted to the situations described in this article at marginal cost compared with global expenditure. Just as a thermal drone can be used to search for missing persons, it can also be used to assist other animals.

In conclusion, emerging visual technologies outline a realistic possibility for significantly reducing forms of suffering in nature that we currently regard as inevitable, thereby improving the welfare of wild animals. By uniting technological innovation with a justified normative framework, Europe has the opportunity to lead the way towards a relationship with wildlife based on compassionate coexistence. Of course, practical limitations will always exist, but between total inaction and total intervention there is a vast space for gradual and incremental improvements. The next decade will bring advances that we can scarcely glimpse today, with visual AI and robotics playing central roles. The key will be to ensure that technological uses are subject to clear normative principles, thereby increasing the number of individuals experiencing positive welfare curves.

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