Airplanes, cameras, computers, wildebeests: The technological mediation of spaces for humans and wildlife in the Serengeti since 1950

Simone Schleper
Maastricht University, the Netherlands

Abstract
Drawing on the concept of technological mediation, this article examines the spatial politics of observation technologies and associated practices that have been used to monitor the movement of migratory wildebeests in the Serengeti from the 1950s until the 2000s. It shows that key technologies, and the types of research collaborations they sustained, mediated notably different normative ideas about human–wildlife interaction and the sharing of space in and around protected areas. During the 1950s and 1960s, observations of animal migration were conducted by airplane. Direct observation was characterized by the study of movement of migratory ungulates, such as the wildebeest, and humans across space in real time. Aerial observations depended on a close cooperation between scientists and park authorities, and on the knowledge and observational skills of game wardens. The experience of the movement of animals and people in real time allowed, to some degree, for experimentation with forms of human land-use. During the 1970s, many small-scale and short-term projects shifted the research focus toward data recording by camera. Aerial photographs created supposedly complete spatial overviews of inhabitation, which supported interpretations of spatial conflicts between humans occupying the park’s surrounding areas and animal populations inside the park. From the 1980s onward, computer technology allowed for long-term calculations of past and future trends in population densities of individual species. The understanding of the wildebeest as a keystone species and the Serengeti as a baseline ecosystem turned communities of local pastoralists and agriculturalists into a future threat. As observation technologies are here to stay, it remains important to pay attention to technologies’ potential roles in creating additional distances between researchers and research subjects. Historical insights, such as the ones presented in this article, can help reflect on how various

Corresponding author:
Simone Schleper, P.O. Box 616, Maastricht 6200 MD, the Netherlands.
Email: simone.schleper@maastrichtuniversity.nl
forms of remote sensing may mediate normative views on human–wildlife interactions and consequentially affect local livelihoods.

**Keywords**
20th-century conservation and research policy, animal movement, human–wildlife interaction, Serengeti National Park, technological mediation

**Introduction**
For many decades, the East African Serengeti has been a place of interest for local wildlife authorities, researchers, and international conservation organizations concerned with the negotiation of space for animals, humans, their movements, and their territorial claims. In fact, there are few other regions that have resulted in as large a number of ecological studies as the Serengeti–Mara ecosystem in today’s Tanzania and Kenya (e.g. Pearsall, 1957; Sinclair, 1979; Sinclair et al., 1994, 2008, 2015; Talbot and Talbot, 1963; Watson, 1967). The Serengeti, in this respect, has been considered a “living laboratory” for conservation in East Africa more broadly, at least since the 1960s (Holdo et al., 2009; Tilley, 2011). Today, the 40,000 km$^2$ of the larger Serengeti–Mara ecosystem include a number of areas with different protection statuses, most of them in Tanzania, such as the Serengeti National Park, the Ngorongoro Conservation Area, the Maswa, Grumeti, Ikorongo, and the Kijereshi Game Reserves, the Loliondo Game Controlled Area, and the Ikona and Makao Wildlife Management Areas. In Kenya, the Maasai Mara National Reserve is counted as part of the ecological system. Early on in the history of the national park, ungulate migration, the “synchronous large-scale return movement” of the Serengeti wildebeests, zebras, and Thomson’s gazelles across wide distances, played a crucial role in strategies to protect Tanzanian and Kenyan environments (Hopcraft, 2010: 7; Msoffe et al., 2019). Environmental historians have shown how East African landscapes, the Serengeti especially, have come to epitomize wild nature for both the international science community and popular audiences, particularly those from the global North (Mitman, 2012; Shetler, 2007). Evoking in Western visitors images of how other vast landscapes, such as the North American plains, must have looked before the introduction of commercialized hunting in the mid-19th century, the Serengeti has been under protection in one form or another since late 19th-century German colonial rule (Gissibl, 2016). Authors have rightfully pointed out how international conservation interests have been mobilized to justify continued foreign intervention also after Tanzanian independence (Neumann, 1998; Schauer, 2018). This discourse on East African nature as world heritage in need of international protection and aid has been embraced by the Tanzanian government and wildlife authorities, too, which have used the spectacle of the Great Migration to buttress the country’s extensive wildlife tourism industry (Gardner, 2016; Lekan, 2020).

During the 70-year history of ecological research in the Serengeti, the methods and techniques with which wildlife has been monitored, data collected, stored, and circulated underwent significant changes, especially after the intensification of research in the 1960s and 1970s. Historians who have studied the role of observations in ecological field research have already highlighted how fieldwork has often been marked by a particular closeness of the researcher to the animal research object and a spatial embeddedness in the ecosystem under investigation (De Bont, 2009; De Bont and Lachmund, 2017; Kohler, 2019; Reidy and
Vetter, 2010). In the case of species with large habitats and high mobility, then, such as the migratory wildebeest, observers had to overcome the varying distance to the researched species by means of technologies of observation and monitoring. From the 1950s onwards, ecologists relied on a range of instruments, such as airplanes, cameras, radio trackers, and computer simulations to understand the movements and health of animal populations (Haraway, 2007; Schwarz, 2003; Vetter, 2017). In this article, I examine the intellectual and technological history of the ways in which migratory wildebeests have been researched since the 1950s as part of a landscape inhabited by both animals and humans. With this I do not aim to rewrite leading narratives in political ecology which have focused on the continued domination of African nature conservation by Western expertise (Brockington, 2002; Hodge, 2007; Neumann, 1998). Rather, I aim to add so far missing insights into the roles that different technologies have played in mediating researchers’ spatial and temporal distance to, and their experience of, their research objects, including animals, landscapes, and people.

That these technologies, assisting ecological observation, just like laboratory instruments, were not simply extensions of the researchers’ senses, is widely understood in the history of field ecology. Often claims to expertise depended on the appropriation of monitoring technologies and the skills required to use them (Benson, 2014). By bridging the distance to the observed animals, monitoring technology supported wildlife ecologists’ “authority to speak on their behalf” (Benson, 2010: 190). Technological tools, however, do more than buttress professional authority. By shaping the ways in which we experience, understand, and communicate the world around us, their use has ontological consequences, too (Daston, 2008; Gabrys, 2016; Jørgensen, 2013). Authors such as Jeanne Haffner and Jennifer Gabrys, for instance, have shown how aerial views, at least since the 1950s, have resulted in an understanding of environmental data from around the planet as globally interconnected (Gabrys, 2016; Haffner, 2013). Sebastian Grevsmühl has traced this “view from above” back to the emergence of photography, air travel, and urban planning in the 19th century (Grevsmühl, 2014). Authors such as Sabine Höhler, Bill Ranking, Perrin Selcer, and Peder Anker have moreover discussed how aerial observation, which had emerged at the beginning of the 20th century in a military context, created synoptic views, linked to technocratic visions and accounting that, in the postwar period, shifted political power from the nation state to international organizations (Anker, 2001; Höhler and Ziegler, 2010; Rankin, 2016; Selcer, 2018).

So far, however, the view from above has mostly been studied as an absolute phenomenon, while the differences in types of experiences, data, and forms of expert knowledge produced by individual technologies have received little attention in studies of observation (Vidal and Dias, 2015). In this article, I show that by zooming in on different technologies, we can discern important differences in the ways that both animal migration and human land-use were experienced. These had direct consequences for the type of conservation advice formulated. In my analysis, I draw on the concept of technological mediation from the field of science and technology studies (STS) (e.g. Rosenberg and Verbeek, 2015). The postphenomenological concept of technological mediation suggests that our relationship with the world, including our moral judgment, is fundamentally shaped by our use of particular technologies and that no such relationship exists independently of the technologies we use. Phenomena, such as animal migration or human population pressure, only emerge in the interplay between observer and observation technology (Barad, 2003; Haraway, 2007; Idhe, 1990). As such, the concept holds valuable insights for understanding the role of particular observational technologies in ecological fieldwork and in making recommendations about the management of protected areas for wild animals and
people. Analyzing the reports, scientific publications, and personal correspondences by Serengeti researchers and members of zoological societies from the 1950s to the 2000s, I show that in the 1960s, the direct tracing of migratory wildebeests by airplane, in some cases, allowed for more flexibility in local land-use and conservation recommendations. This changed in the 1970s, when aerial photography supported a return to colonial ideas about spatial conflict between animals and humans. When in the 1980s and 1990s, preservationist views made room for early forms of community-based conservation, the introduction of computer modeling, to some degree, inhibited approaches that truly benefitted local pastoralist communities.

**Tracing: Direct aircraft observations and migration patterns, 1950s and 1960s**

First published accounts on animal migrations originated in the context of colonial game management. When in the 1910s and 1920s, game wardens of the Kenyan Game Department noticed a fluctuation of wildebeest counts on their territory, they speculated about the animals’ seasonal movement to German territory in today’s Tanzania (Talbot and Talbot, 1963: 53). In 1955, what had been a problem for local game management attracted the interest of the international scientific community, when the administration of the British Territory of Tanganyika announced a decision to partition the Serengeti National Park which had been established in 1951. The political dimensions of this plan and its colonial heritage have recently been discussed in great detail by Thomas Lekan (Lekan, 2020). The separation of the park into two conservation areas would have lifted the strict conservation status of the central plains, an important grazing area for ungulates. International preservation societies such as the International Union for Conservation of Nature (IUCN) and the British Society for the Preservation of the Fauna of the Empire (SPFE) proclaimed their dismay, fearing that land-use by pastoralists would lead to overgrazing, erosion, and desertification, a fear that dominated the colonial conservation discourse in East and South Africa (e.g. Harroy, 1944). In the postwar period, colonial landscape and wildlife protection had become an international issue and the members of the IUCN and the SPFE feared that the partition might encourage other East African governments to rethink and potentially downsize the areas set aside for conservation (Adams, 2004: 68; Huxley, 1961; Lekan, 2020: 105–110). After international disapproval, the Tanganyikan Administration allowed William Harold Pearsall, a botanist at the University of London and fellow of the Royal Society, to seek out the possible ecological consequences of the suggested changes to the park’s boundaries (Pearsall, 1957: 71). Despite the preservationist fears that stimulated the international debate, some of the research into wildebeest migration, which followed would in fact support mixed forms of land-use, encouraged by the experiences mediated by direct tracing of migratory ungulates from small aircrafts.

When Pearsall visited the Serengeti in 1956, the national park was shaped like a triangle, located in the North of today’s Tanzania, east of Lake Victoria, with hilly land in the West, the central plains, and volcanic crater highlands toward the East (Pearsall, 1957: 74). Pearsall investigated the vegetational changes which occurred in the different areas during the annual rains, and linked the movement of wildebeests to different patterns of precipitation during the wet and the dry season. Ungulate movement, he described, took place mainly between the plains, the Western hill lands close to Lake Victoria, and the Northeast at the border with Kenya, with some movement in the Ngorongoro crater area (Pearsall, 1957: 78–79). Pearsall understood the protection of the Serengeti plains as requiring heavy
management and planning, as, due to the high mobility of many hoofed species, population counts could be affected by changes at all stages of their journey, while a changed population size would affect migration routes in return. Based on Pearsall’s findings, the partition was halted, but the boarders of the park were moved to include the northern region between Banagi and the Kenyan boarder in 1959, two years before Tanzanian independence. The Ngorongoro crater region in the Southeast was turned into a conservation area where the protection of flora and wildlife was less strict. Yet, with the new northern extension, the protected territory, overall, had been increased, to the satisfaction of the international conservation community (Pearsall, 1957: 127).

Pearsall’s study stimulated new research interests in the ecological linkages between animal movement and the spatial design of protected areas. Between 1959 and 1963, another study of the Serengeti ecosystem and its mammal populations was conducted by the two American biologists Martha and Lee Talbot. Lee Talbot had briefly visited Tanganyika in 1956 for a survey of the Serengeti plains for the Wildlife Management Institute and the American Committee for International Wild Life Protection. In 1959, Lee and his wife Martha returned to continue this initial research. The Talbots’ project on the Serengeti’s ecology was sponsored by the Foreign Field Research Program of the National Academies of Sciences and the National Research Council of the United States, with additional funding by the New York Zoological Society (NYZS) and the Government of Kenya. The objective of the project was to study the interrelations of various wild animal species with soil, climate, and the Maasai and their livestock, which increasingly interested the conservation community, also against the backdrop of colonial fears of overgrazing (Lekan, 2020: 105; Talbot and Talbot, 1963: 10). In order to conduct a manageable study of the ecosystem, the Talbots—like Pearsall—decided to put the seasonal migration of ungulates at the center of their inquiry, focusing on the western white-bearded wildebeest which was particularly dominant when it came to “biomass, migrations, predation, contact with man, and impact on the landscape” (Talbot and Talbot, 1963: 10). After several months, the Talbots found that there were indeed seasonally recurring patterns, but that the wildebeests’ migratory behavior was irregular, with “no two seasons’ movements […] the same” (Talbot and Stewart, 1964: 819; Talbot and Talbot, 1963: 53–56).

In the early years of Tanzanian independence, between 1962 and 1966, these observed irregularities by the Talbots informed another international research project, the Serengeti Research Program, funded this time by the United Nations Food and Agricultural Organization (FAO), and coordinated by John Owen, a Ugandan-born British conservationist, at the time director of the Tanzanian National Parks (TANAPA). The study focused on migration as an important parameter in guiding the management of the park and the potential “utilization of living natural resources” (Sinclair, 2012: 231; Watson, 1966: 18). Murray Watson, a doctoral candidate at the University of Cambridge with a flying license, was hired as a consultant by the FAO study to research the ecology of the park’s wildebeest population more closely. Watson, who conducted his study with George Jolly from the Unit of Statistics at Edinburgh University, and with the support of the British Agricultural Research Council, was part of an emerging strand in British conservation with utilitarian ambitions that understood conservation as resource management, firmly rooted in science (Schleper 2017; Benson, 2015; De Bont, 2020; Evans, 1992). Between 1962 and 1965, Watson observed large parts of the wildebeest population in the Tanzanian part of the ecosystem, flying twice a week for several hours. Tracing wildebeests in real time, he found that animals moved from the plains to the western hills and then to the North, occupying the southeastern part of the plains in the wet season and the hills and some of the western part of the northern extension during the dry season. Watson, like the Talbots,
linked their movement to the preference for short green grass (Pennycuick, 1975: 66–70). Watson was not the first one to use aerial observation. Bernhard Grzimek, the director of the Frankfurt Zoological Society (FZS) and his son Michael had used a zebra-striped Cessna to conduct animal censuses in the Serengeti plains in the 1950s in their campaign for keeping the park as large as possible (Lekan, 2020). Pearsall, too, and a few years later, the Talbots referred to aerial observation methods (Talbot and Stewart, 1964: 823). Watson’s emphasis on live tracing and direct recording of observations was particular, however. The Grzimeks, in their endeavor to capture the aesthetics of the plains had used photography and film. Watson recorded ecological data in context. Watson’s observations, then, represented a particular interpretation of animal migration and landscapes, mediated by a particular set of methods and technologies, namely observation by aircraft in real time.

In the 1960s, direct aerial observation had become important in zoology. Aerial observation made possible the study of migration “of large and fast-moving animals in remote and difficult terrain” (Milton and Darling, [1966] 1977: 114). Real-time aerial observation and the tracing of wildlife migration were closely related to game management, for which the use of aircrafts was essential to reach difficult terrain, to track poachers, and to locate injured animals. Naturally, large protected areas, where game management and scientific research were closely intertwined, such as the East African savanna, were the testing grounds for aerial observation in zoology (Watson, 1977). From the four seasonally migrating species in the Serengeti, direct aerial observation focused predominantly on the wildebeest. Wildebeests were the animals easiest to spot from an airplane. While the striped pattern of the zebra in the African sun made their spotting from the air difficult, the wildebeest had a light patch on its back, which facilitates observations of individual animals from above (Milton and Darling, [1966] 1977; Pearsall, 1957: 80). Wildebeest migration, experienced as a constant but irregular flow of movement, this way, not only stood in for the behavior of other ungulate species in the Serengeti, but also determined spatial management strategies for the Serengeti National Park and its surrounding areas.

Watson, especially, was a keen defender of aerial surveys and observational flights to study wildebeest in real time (Watson, 1967). His method included reconnaissance flights, which he conducted together with Myles Turner, chief game warden of the TANAPA, to understand the geography of the area, followed by a stratification of the surveyed terrain into different sub-regions, taking into consideration animal density, geography, and landscape. Over each region, strips were flown, determined by two markers attached to the wing strut to “give the appropriate width” when the airplane was flying at a height that allowed for closer observation and counting (Watson et al., 1969: 50). Within a region, strip samples were chosen, covering 5–20% of the total region. Watson stressed the need for direct counting from the airplane, as this allowed to take into consideration wildebeest movements through different types of terrain, as well as encounters, for instance when migrants mingled with resident herds (Watson et al., 1969: 50–56). In 1965, Turner and Watson published a paper on the usefulness of aircrafts for both game management and wildlife research (Turner and Watson, 1965). The paper in *Oryx* gives a telling account on how field research in the early 1960s was conducted in East African national parks. Research and park management demanded researchers’ and game wardens’ mobility and displacement over vast distances. In addition, aerial mobility allowed game wardens such as Turner, who, at first, had been critical of the use of aircrafts, to fulfill core conservation tasks, including monitoring the placements of traps and snare-line fences, which potentially threatened herds of animals on the move, and recovering lost tourists (Turner, 1988). By the mid-1960s, the “warden’s flying movement”, according to Watson pioneered by Kenyan game ranger Denis Zaphiro and by Turner in the Serengeti, had become widespread (Watson, 1969: 70). For
researchers like Watson, using small airplanes allowed for the detailed and constant plotting of the route of migratory mammals. This movement was placed into new causal contexts by observing the environments through which wildebeest moved at different times of the year, including the type of plant species they fed on (Turner and Watson, 1965: 16).

Live aircraft views supported a particular way of doing research and of experiencing wildlife in protected areas that tied in with an understanding of conservation as resource management. The emphasis was on using the same qualitative, empirical methods as in the field and on wildlife management-related questions. After all, the “best results [were] obtained when reconnaissance [was] planned in relation to the question awaiting solutions” (St Joseph, 1977b: 14). Context mattered more than the formulation of generalizable insights, especially where wild animals moved in close proximity to local human residents. Live observation bridged the distance to the animals in spatial and temporal terms, allowing the retrieval of direct data on the ecological circumstances of the animals and the land. Reporting on his experiences in the 1960s, Watson’s publications stressed that real-time aerial observations were essential to wildlife ecology for conservation purposes. A variety of indicators linked to animal herds, their routes of movement, the landscape through which they moved, as well as any human activities or interaction with wildlife in the area could be directly integrated into the interpretation of routes and population counts. Photographs, in contrast, taken through the polycarbonate windows of the aircraft, were often blurry and lacked this type of immediate and ever-changing context (Watson and Tippett, 1979: 33, 46–49, 57).

Live migration research by airplane, then, mediated a particular form of ecological expertise as management of change. The Talbots, through their membership in international organizations, such as the IUCN, were connected to influential figures in the early post-colonial network, which connected African park authorities and international research communities. An important contact was the British ecologist Hugh Lamprey, in the 1950s directing the Tanganyika Game Department. Lamprey gave the Talbots access to the facilities of the national parks in Tanganyika and Kenya, which included the use of airplanes and pilots (Talbot and Talbot, 1963: 14–15). The aerial studies from the 1950s and early 1960s were thus marked by a close cooperation between individual researchers and local park employees of European decent, such as the one between Watson and Turner, who exchanged ideas and functioned as research teams. In fact, locally residing game wardens were considered excellent observers, as they usually stayed in the park for long periods (Turner, 1977, 1988). The tight on-air collaboration that Watson portrayed for game warden–researcher teams might have been an idealization. Watson later described how often observation and counting was done by the pilot alone, as the co-pilot, subject to the plane’s sudden movements, frequently suffered from motion sickness (Watson and Tippett, 1979). Yet, for the type of research questions asked, local game wardens possessed important knowledge of the observed terrain.

Game wardens held crucial positions for applying the findings of the joint observations to conservation, land development, and other modernization measures according to utilitarian British examples. Since the Conference of the Fauna of British Eastern and Central Africa held in May 1947 in Nairobi, long-standing local hunting traditions had been increasingly suppressed (Neumann, 2002). Expansion of the national parks and protected areas had led to the loss of local communities’ traditional hunting and grazing rights in more and more areas (Kiddeghe, 2008: 1866). Many colonial game wardens had witnessed how resident communities, who used to hunt in protected areas for meat, were now accused of poaching. As a consequence, individual game wardens began to promote a more people-centered approach to conservation (Graham, 1973; Parker, 2004). Although partly based on false
ideas about pastoralism, researchers like Watson believed that local hunting, which, he thought had been pursued by the Maasai before they settled east of the park in the Ngorongoro and Loliondo regions, was the “most effective form of direct human exploitation” of the park’s resources, and should be controlled but legalized as long as it did not obstruct the annual migration of the park’s ungulates and with it the health of the overall ecosystem (Watson, 1965: 545). By the mid-1960s, a number of European and American expats and African-born game wardens of European decent experimented with forms of land-use that combined conservation and cultivation. By observing wildebeests’ routes, game wardens could steer the grazing of cattle to areas outside of the annual migratory corridors, and, in game-controlled areas such as Loliondo toward the Northwest of the national park, and could ensure that hunting did not surpass the 10% of migratory animals which was considered unproblematic (Watson et al., 1969). Overall, live aerial tracing, and the directly applicable data it resulted in, created a particular experience of the ecosystem as a “continuous process” and of human–wildlife interaction as changing and requiring local intervention (Watson, 1969: 70). In contrast to international agendas to preserve the Serengeti as a supposedly pristine place without human interference, projects such as Wilson’s tolerated human activities such as pastoralism and to some extent agricultural cultivation and hunting where these did not disturb the annual migration patterns of wildebeests in the park and its direct surroundings.

Mapping: Photographs and the ecological recording of habitats, 1970s

Between 1969 and 1971, scientific interests in migratory wildebeests culminated in a new international project and the institutionalization of ecological research at the Serengeti Research Institute (SRI). The institute was founded after a long struggle between continental and British scientists over the need for fundamental versus applied research and in an attempt to keep international access to the Serengeti area after the slow but steady Africanization of government institutions, including the wildlife sector under Julius Nyerere’s Tanganyika African National Union (Schauer, 2019: 186–190). This struggle remained evident throughout the institute’s early years. In 1967, Owen described the objective of the institute as the study of the Serengeti region to provide the evidence base for the rational management and conservation not only of the Serengeti ecosystem, but also of other national parks in Tanzania (Lamprey, 1967: 1). This agenda was supported by influential figures in the Tanzanian wildlife regime, such as Lamprey, who was appointed the first scientific director of the institute. At the same time, a recognized research institute, such as the SRI, could improve the new independent government’s international standing. The TANAPA, too, hoped to benefit from the institute’s international prestige. Already in 1969, Mr. Maeda, the Tanzanian middleman between the institute and the TANAPA, stressed that the SRI needed to expand its international research program (SRI, 1969a). Concerns about international prestige soon led to a focus on fundamental rather than applied research. Studying the Serengeti as a representative ecosystem for the East African savanna resulted in a different type of access to and experience of the land, it’s animal and human inhabitants, which was mediated by aerial photography. With the improvement of camera equipment, cheaper film, and higher resolution images, by the late 1960s, aerial photography was used in various disciplines that were concerned with the mapping and recording of large topographies, such as geology, geography, soil science, archaeology, plant ecology, and increasingly also zoology (St Joseph, 1977a). The use of photography by SRI researchers soon led to a return to notions of spatial competition between wildlife and humans.
One of the institute’s core program points was to expand Watson’s work on the migration of ungulates. This ecological monitoring program was however more ambitious than the individual projects by the Talbots and Watson, which had only formulated first hypotheses on deeper ecological causes of ungulate migration. Now, the quest to understand the underlying biological laws for animal migration and its ecological consequences formed the core of the research projects on precipitation, vegetation, wildfires, and predators hosted by the institute. In 1969, the new ecological monitoring program began (Sinclair, 2012: 115). The institute hired Michael Norton-Griffiths and Henry Croze, two recent graduates from the University of Oxford to set up a regular aerial survey of the ecosystem, covering about 26,000 km² with systematic flights (SRI, 1969b: 5). Norton-Griffiths and Croze had three small aircrafts at their disposal, a Piper Super Cub, given to the park by the NYZS and then handed over to the scientists, another Super Cub sponsored by Texas A & M University for their own researchers who were amongst the temporary staff hosted by institute, and a Cessna financed with money loaned to the SRI by the national park. During their monthly flights, Norton-Griffiths and Croze flew airstrips located seven miles apart for a total of 24 hours. Monthly flights were used to record animal distribution and movement, as well as rainfall, grazing, cultivation by human inhabitants in the park’s surrounding areas, and land erosion (SRI, 1970b). In addition, a radio-tracking project was initiated in 1971 with funds by the NYZS and the American textile-aviation conglomerate Textron Inc., to experiment with the tracking of large mammals by airplane (SRI, 1970b: 15, 23). Norton-Griffiths’s and Croze’s main aim was, however, not the real-time observation of wildebeest movements for ad hoc land-use management decisions, but the creation of maps for the long-term study of land inhabitation by animals and people. For the purpose of mapping, they drew heavily on photographic methods, which, after several months, allowed the researchers to create a more complete spatial overview of the ecosystem (Maddock, 1979: 108).

In 1968, Alexander MacFarlane, a geographer working at the SRI had used aerial photographs to create a set of maps based on 5 km²-squares, to be used with a “mechanical data recording system”, which was to be introduced in the next year in the form of a card punch computer (SRI, 1969a: 6). For a meeting of the institute’s scientific council in January 1969, an aerial photography specialist was flown in. Much time was spent on designing and equipping a new photo interpretation room and new darkrooms. In spring 1969, Norton-Griffiths mounted motorized cameras on the SRI aircrafts to record on photographs aerial views of landscapes and vegetation within which migratory species were present or absent at the moment of data collection. The idea was that over time—the estimation was 20 to 30 years—data recorded on the photographic grid, would not only provide information about the movement of ungulates, but would also allow to derive conclusions on environmental causes and “stimuli” behind the movement of animals. These stimuli could relate to both natural causes and human activities, relevant to both ecological theory and conservation practices (SRI, 1969b). Vegetation, which could be recorded using repeated series of photographs, was regarded as the “most sensitive indicator of any […] changes in the environment such as climate, soils, or animals influence” (SRI, 1969b). Setting up the new program with a focus on vegetation covers and occupancy maps, including signs of agriculture or overgrazing by domesticated cattle, meant leaving behind the focus on individual species and their changing movements. This was much to the dismay of ecologists like Lee Talbot, who in 1970 was surprised to find that no one was working on the ecology of the wildebeest, which he considered one of the most important species from both an ecological and park management point of view (SRI, 1970b).

The focus on photography and vegetation mapping in the long-term monitoring project had consequences for the way human mobility and land-use were experienced by individual
researchers. Air photography helped to coordinate the work in large and diverse research teams during long-term programs, as photographs could be stored and shared across sub-projects (Watson, 1977: 124–126). As such, the form of data recording was useful for the SRI, as from the beginning, externally funded short-term projects for fundamental ecological research outweighed the efforts spent on the ecological monitoring program (SRI, 1969a). Many of the visiting scientists were doctoral candidates who, once their project was completed, moved back to their home universities (Lamprey, 1967). Aerial photographs functioned as immutable mobiles between the different smaller projects (Latour, 1986). In late 1970, the decision was made to split up the working areas of the permanent team, based on MacFarlane’s maps. Accordingly, the ecosystem was divided into the plains, the western corridor, and the northern extensions to be studied by three teams of scientists. The teams were to be multidisciplinary, consisting of ungulate ecologists, vegetation experts, soil scientists, woodland specialists, and experts in aerial photography to ensure proper recording (SRI, 1970c: 33). Several scientific advisors, including Lee Talbot and the Oxford zoologist John William Sutton Pringle, were concerned that the fundamental research and the long-term focus would result in a lack of applicability to park management. Nevertheless, both Lamprey and Norton-Griffiths agreed with the plan to leave behind the “one-man-one-animal” approach, to accelerate the collection of ecological data without “following your problems around the ecosystem” (Lamprey et al., 1971; SRI, 1970a: 4). After the division of the Serengeti in smaller research areas, aerial photography became even more important in reassembling spatial overviews of the three separate areas. Population counts were continued using aerial photography of sample areas (SRI, 1969b). In order to infer any information on the causes of movement, however, one needed to wait for ecological monitoring data from the rain gauges, the vegetation studies, as well as the results from individual experiments with captured animals on physiology and digestion (SRI, 1970c).

By the mid-1970s, then, the focus on ungulate migration to understand basic ecological processes and to devise successful land-use strategies had disappeared. Rather than annual changes, photographically captured habitats evoked a sense of permanence. While researchers such as Watson had confirmed the usefulness of photography-based maps for some of ecological questions pertaining to changing quantities, such as numbers of wildebeests in a particular area, Watson had stressed that maps were not suitable to record “phenomena with dynamic spatial and temporal qualities”, such as animal movement (Watson, 1969: 74–77). In the 1970s, then, photographic mapping encouraged a return to a discourse on human settlements, cultivation, and agriculture as in spatial competition with wild animals and as main causes for the degradation of soils and natural environments, which had dominated colonial conservation policies. Had there previously been room for pastoralists to follow migratory animals through the park and for experimental agriculturalism in the fringes of the protected areas, aerial photography suggested permanence rather than changing land-use. Photographs and recorded data points, not requiring an actual participation in the research, encouraged the temporarily and spatially removed viewers to focus on inhabitation and the competition for space. For instance, Feroz Jafferali Kurji, one of the few Tanzanian scientists at the institute, studied human settlements in and around the Serengeti ecosystem, working on his master thesis at the Department of Geography at the University of Dar es Salaam (SRI, 1973). His project found a place in the institute’s monitoring program under the title of “human ecology”. Human ecology had emerged as a scientific concept in 1920s Chicago, where urban sociologists applied the type of systems thinking increasingly used in ecology to inter-human relations in the city. By the mid-1970s,
with the rise of widespread environmental concern in the Western world, human ecology focused on the degrading effect of human socioeconomic practices (Anker, 2001; Kingsland, 2005). In the context of postcolonial Africa, this concern was phrased in terms of human settlements and land degradation through fires and farming, which could be photographed from the air. Using aerial photography and district population counts, Kurji initially conducted two studies, on the demography and the land-use by human populations living close to the park and inside the game protected areas. He found that in more than half of the game reserves around the Serengeti, human settlements had emerged and grown since 1959. Especially the Ngorongoro Conservation Area had experienced an increase of human population from 8,500 people in 1966 to over 18,000 in 1976 (Kurji, 1976). Other smaller research projects at the institute, too, supported the underlying fear of human “encroachment” not alone by agricultural practices, but also by pastoralists grazing their cattle close to the park. Ethological research at the institute into the behavior of ungulates led to the physiological comparisons between wild wildebeests and Maasai livestock, such as the zebu cattle. After the eradication of rinderpest in the 1970s, this research suggested a direct competition between cattle and migrating wildebeests and buffalos for grazing spaces and water (Kreulen and Hoppe, 1979; Sinclair, 1972).

In many ways, the fragmentation of data collected during the 1970s had consequences for forms of recognized expertise. Photography allowed the synthesis of data at a later stage. This way of data collection and need for synthesis a posteriori resulted in a shift of expert knowledge to visiting international experts rather than locally based wardens. Despite the original intentions behind the monitoring program by local administrators such as Owen and Lamprey, the observations of the early 1970s were little applicable to the management of the national park. In fact, the daily park management was left to TANAPA, which lacked the staffing and funding of the institute. This lack of cooperation between SRI researchers and local park authorities was further reinforced by the Africanization of the Tanzanian National Park authorities and Nyerere’s politics of national self-reliance (Bjerk, 2011; Schauer, 2018). In turn, visiting researchers conducting fundamental research for international prestige and the advancements of their careers were often skeptical toward working with African park wardens and researchers. When Lee Talbot asked in 1970 why the institute was not hiring Tanzanian researchers to conduct and pass on long-term studies, the scientific council pointed out the lacking academic degrees and education of field assistants (SRI, 1970b). At the same time, few of the visiting scientists fulfilled their teaching duties at the University of Dar es Salaam (Mcharo, 1973). Scientific specialization was however at least as big a driver behind the distanced relationship. Previously, game wardens, who had lived in the park, had brought to the attention of researchers, at least to some extent, the local customs of cultivation and pastoralism. The research institute, however, depended on the steady inflow of individual scientists and projects with their own funding. In fact, it was easier, Lamprey wrote in 1967, “to find people to carry out individual short term projects”, than to enter long-term research agreements with Tanzanian authorities (Lamprey, 1967). There was also the apprehension within the scientific council that investing too much into long-term migration studies would mean that the institute would lose its pioneering role, “no longer obtain[ing] the very best people in its field” (SRI, 1970a). Overall, the interest in experimental forms of shared land-use between agriculturalists and migratory mammals diminished (SRI, 1970b). When in 1977, the monitoring program was closed at the onset of war between Tanzania and Uganda, research into the migration of the Serengeti mammals had taken on a very different form from the applied conservation research by Watson.
Projecting: Computer models and population densities, 1980s–2000s

In the 1960s and 1970s, Nyerere’s government continued to follow preservationist ideas about wildlife management from the colonial era, based on the state’s control of farmers and herders (Gardner, 2016: 17). When between 1973 and 1976 the socialist government relocated members of all ethnic groups to comply with the Ujamaa policy of villagization, this led to new settlements and new forms of agropastoralism by the Maasai, also in the game reserves surrounding the national park. The simultaneous prohibition of cultivation in some of the park surrounding areas, such as in the Ngorongoro Conservation Area following the Wildlife Conservation Act of 1974, stimulated international concern that poaching would increase. In fact, during the war with Uganda, in a period of economic instability that weakened the strict Tanzanian protection regime, poaching became a more widespread issue, and was critically observed by international conservation NGOs. A study from 1978 partly financed by the FZS suggested that hunting by the Maasai had become more economically oriented, including hunting for ivory (Kideghesho, 2008: 1866; Makacha et al., 1982: 439). At the same time, international organizations had less access to Tanzanian wildlife due to stricter regulations by Nyerere’s government (Nelson et al., 2009). By the 1980s, the Tanzania’s commitment to conservation, having established nine national parks, was seen as exemplary for independent African states. Yet the international conservation community was worried to see the experiment fail, as the economically stricken state struggled to finance its wildlife sector (IUCN, 1982: 30). Increasingly, initiatives by international organizations and NGOs questioned the viability of strict preservation, devising strategies for resource use and conservation instead, to satisfy both the needs of wildlife and humans (Gardner, 2016: 41–42; Malpas and Perkin, 1986: 5). In the early 1980s, for instance, IUCN members were involved in developing regional conservation strategies to demonstrate the benefits of conservation for local economies (Schleper, 2019). The Serengeti was the first region on the African continent for which such a strategy was published. On first sight, the program of the Regional Conservation Strategy for the Serengeti (SRCS) resembled the 1960s calls for more experimental land-use. During the 1980s and 1990s, however, a new concern for animal population densities inside the park, mediated by the use of computer modeling, resulted in only halfhearted attempts at what came to be called community-based conservation.

With SRI research discontinued, in 1985, a new attempt at creating a monitoring program was initiated, involving the FZS and the World Wildlife Fund, the sister organization of the IUCN that partly funded the IUCN’s work on the regional conservation strategies. Again, the idea was to design a long-term ecological monitoring program for the Serengeti (SEMP), this time with a bigger investment in computer technology, as funding was only available for a handful of field researchers (Borner, 1985: 4). At the same time, the NYZS together with former SRI researcher Tony Sinclair, now working at the University of British Columbia, set up a monitoring project in the Ngorongoro Conservation Area (Faust, 1987). From 1986 onwards, then, research into the Serengeti ecosystem was continued. In both programs, computers were to replace additional field workers by synthesizing old and projecting new data. The motivation for the new programs was on the one hand monitoring for management, the failed ambition of the SRI’s research during the 1970s, and on the other hand the centralization and synthesis of SRI data which, so far, had had little practical use for TANAPA. Kenneth Campbell, an ecologist and programmer was hired for this purpose and for the training of Tanzanian monitoring specialists, which was considered essential for the long-term implementation of the SRCS (Campbell, 1986: 2–3). Soon, however, Campbell had to abandon his original plans to simply synthesize the wide range of
ecological data previously collected by SRI researchers. The specialization and disintegration of the previous monitoring program had caused problems at its closing. As most scientists working at the SRI during the 1970s had taken with them their data, little came of the synthesis of fundamental research for more applied purposes originally envisioned for the SEMP. Only the wildebeest censuses, to which Sinclair had contributed, and rainfall data, which had been collected with the help of local game wardens, was still available to Campbell in Seronera (Borner, 1985). By 1988, the local team decided to abandon most of the rainfall data, too, which was found to be unreliable, with different metrics on the rain gauges, and the gauges unevenly spaced throughout the different research zones (Campbell, 1989). Starting over, the aerial reconnaissance flights and occupation mapping of the early 1970s were resumed, using the old 5 km²-grid system. These flights were conducted with an aircraft, financed by the FZS to support TANAPA’s antipoaching efforts (Faust, 1987; Grzimek, 1979). Again, aerial photographic samples rather than observers’ records were used for wildebeest censuses, data on vegetation, and land-use (FZS, 1989: 6). New data suggested that wildebeest numbers had remained stable at 1.3 million, which was interpreted as a sign that the park’s ungulate population, during the 1970s, had reached a natural density (Borner, 1994: 7–8). With slow progress at first, systematic research into migration routes was picked up again in the 1990s. In 1999, the Swiss zoologist Markus Borner, who coordinated the FZS’s research efforts in East Africa, together with Sinclair, used GPS collars to track seven female and one male wildebeest with an antenna mounted on a Cessna 182 aircraft (Thirgood et al., 2004). Comparing their findings to data from the 1970s, they concluded that migration routes had since then shifted westwards and partly outside of the national park (Stabach, 2015: 114ff.). In addition, an aerial survey on human populations in the Serengeti and surrounding areas, including Ngorongoro, Tarangire, Selous, Ruaha, Rungawa, Rutua, Karavi, Mogowosi, Buriji, and Iba, was conducted. By 1988, the survey concluded that human land-use had increased in all of these areas (Sinclair and Mbano, 1988).

These data fed into schemes for community-based conservation, which during the 1980s and early 1990s, predominantly focused on investigating if hunting and game cropping should be allowed in the areas surrounding the park, to decrease the predicted “pressure” of human communities on the park itself (Loibooki et al., 2002; Tanzanian Ministry of Natural Resources and Tourism and IUCN, 1991). The abundance of the wildebeest made it the most logical candidate for game cropping in the context of the SRCS (e.g. Boshe, 1986). Game cropping had already been part of the Talbots’ and later Watson’s ideas for resource utilization, in the spirit of conservation as science-based resource management that emerged in the 1960s (De Bont, 2020). However, while researchers returned to older methods, they were not concerned with the ad hoc management of land-use or the mapping of inhabited spaces. New data collected in the 1990s and the use of computer models to understand the relationship between different ecological variables shifted research interests toward understanding long-term trends. With the help of computed projections, it was now possible to compare data recorded 30 years prior with current findings and to forecast future developments (Sinclair, 1998). In 1991, Sinclair and the marine biologist Ray Hilborn organized a workshop at the Serengeti Wildlife Centre in Arusha to synthesize existing knowledge and to identify remaining data gaps. At the workshop, they discussed a QuickBASIC computer model, using data from the 1960s, the 1970s, and newly collected data from the SEMP, to understand the interrelation between vegetation growth, ungulate populations and predator numbers, as well as human activities inside and outside the national park, such as tourism and hunting. The computer model calculated, within three minutes, animal populations trends until 2020 based on variables such as rainfall patterns, disease outbreaks, or poaching.
policies (Hilborn, 1995: 617–634). These computer simulations, too, focused on the wildebeest. The wildebeest was not only the ecosystem’s most dominant species in terms of biomass. By now it was also the species best studied, providing an abundance of data for model making. Findings based on wildebeest data became problematic for community-based conservation efforts that aimed at experimenting with legalizing hunting. The understanding of the wildebeest as a variable in future predictions of population densities was in conflict with wildebeest cropping schemes. In the mid-1990s, Simon Mduma, a Tanzanian doctoral student at the University of British Columbia, used Hilborn’s predictive model in a project supervised by Sinclair to calculate life tables for wildebeest populations, based on mortality and growth factors, rainfall, food, adult and calf survival, the possible effects of hunting, and potentially sustainable hunting rates (Mduma, 1996). Mduma concluded that despite theoretically viable hunting rates, a consequential limitation of poaching was not guaranteed and experimentation was not encouraged. While potential legal hunting was calculated as sustainable for 40,000 wildebeests per year, researchers like Mduma, Hilborn, and Sinclair feared that failures to prevent illegal hunting would decrease the population density to an extent that affected all other species in the ecosystem.

When working with computer models wildebeests were experienced as key factors in the overall dynamics of the ecosystem. They became a keystone species, dominating all of the Serengeti ecosystem’s natural processes (Mduma et al., 1999; Sinclair et al., 2007). The term keystone species had first been used in the 1960s to describe the ecological role of dominant predators. By the 1990s, the concept had been transferred to herbivores and was used in an applied ecological, conservation context, often in connection with computer models (Caro, 2010). Not alone keystone populations were perceived as determining the future health of the ecosystem. The Serengeti ecosystem itself was understood as a test case for modeling ecological processes. For researchers like Sinclair, concerned with long-term trends and projections, the Serengeti presented a “baseline” area to study and model ecological processes in animal populations without human interference (Carruthers, 2017: xxii; Sinclair, 1998; Sinclair et al., 2002). The intact migration routes of migratory wildebeests, buffalos, gazelles, and zebras within the Serengeti National Park, as well as the ecosystem’s dense biodiversity, made the park especially valuable for this type of research. It was therefore necessary that the Serengeti remained under strict protection status, excluding from the park and surrounding buffer zones all human activities besides research. Even human activities in the game controlled areas surrounding the park, which were regularly transited by wildebeests as part of their annual migrations was undesired. (Sinclair et al., 2007). Sinclair’s reasoning, while based on a scientific line of argumentation, linked in with the preservationist agendas of the Tanzanian government and ambitions to expand national park tourism (Gardner, 2016: 25–26). At the same time, the focus on human population pressure was in direct contrast to calls in the SRCS to consider the needs of local human communities.

The use of computers, too, influenced the type of recognized expertise. Despite the SEMP’s original ambitions to include and train African staff, the focus on modeling populations of keystone species, and on the Serengeti as a baseline ecosystem contributed to the continued exclusion of African researchers. Again, research was not done with the help of local park authorities, but rather with that of international organizations, especially the German FZS, which provided researchers and technology. In 1980, the Tanzanian government had established the Serengeti Wildlife Research Institute (SWRI) lead by Karim N. Hirji of the University of Dar es Salaam, an overarching institute with five research centers of which the former SRI was one. Yet, as Hirji had to spend much time traveling between his family in Dar es Salaam and the institute in Seronera, research progressed only slowly. While at first there had been negotiations about whether the new monitoring program was a
scientific project, or a conservation management initiative, which would fall under the authority of the TANAPA, the park authorities lacked the financial means to participate in the program and the negotiations came to a halt. The FZS, thus, became one of the main organizers behind the new monitoring program. Only from 1988, two Tanzanian colleagues, Asukile Kajuni, with a background in range management from Texas Technical University, and G. Mngongo with a bachelor degree from Dar es Salaam University and administrative experience in the Regional Wildlife Office, joined the team. While Kajuni improved the communication with TANAPA, both Tanzanians, according to Borner and Campbell, lacked the experience to take over more technical or leadership roles within the program. According to Campbell, their training, especially in the use of cameras and computers progressed only slowly (Sinclair and Mbano, 1988). The ability to use technology, here, was used both to exclude and to excuse exclusion. The cooperation between the FZS and TANAPA staff improved only after a negative report by Sinclair and B.N.N. Mbano from the Wildlife Division of the Ministry of Tourism, Natural Resources and Environment, Dar es Salaam. In 1988, the SEMP became part of the Tanzanian Wildlife Conservation Monitoring (TWCM) project, which cooperated more closely with the SWRI and TANAPA (Sinclair and Mbano, 1988). Yet, until the present day, the TWCM depends on the financial assistance and computational expertise provided by organizations such the FZS and the NYZS (in 1993 renamed Wildlife Conservation Society) (Goldman, 2003).

In the 1980s and 1990s, then, the resumed monitoring program in the Serengeti, aided by better cameras and stronger computational power, functioned as a “watchdog” over people and wildlife. Regular and systematic long-term “surveillance” of animal and human population densities by means of projection was considered necessary to understand “on time” potential long-term trends and threats (Borner, 1990: 9–10). Research into the underlying socio-economic problems of poverty in park near areas was not part of the TWCM (Boshe, 1986). By the mid-1990s, community-based forms of wildlife management were still mostly limited to the reluctant cropping of migratory mammals in the game controlled areas surrounding the park. Due to the short time that migratory wildebeest spent in the cropping areas and the costs of purchasing game meat, the benefits of these community-based initiatives went to the more affluent households, while illegal hunting in and around the park continued (Holmern et al., 2002). Arguably, the pastoralists Maasai, whose land rights were challenged by expanding monitoring activities benefited least from early community-based conservation projects (Nelson, 2000: 112–115). Since the late 1990s, the FZS has started to invest in qualitative surveys and questionnaires in order to understand local motivations behind participation in conservation or hunting. However, as mediated by computer projections, many of these surveys, too, start from the assumption that human populations outside the park form a potential threat to wildlife populations and to stable migration routes within the park, if not now then in future (Mduma et al., 1999).

**Conclusion**

This article used the concept of technological mediation to investigate how different observation and monitoring techniques, the type of data they produced, and the type of expertise they required, led to different experiences of the Serengeti as a space shared by animals and humans. With my analysis, I aimed to expand the notion that nature conservation in the 20th century has been dominated by a single view from above that resulted in consistent technocratic visions of nature. Examining scientific and technological approaches to monitor the movement of migratory wildebeests in the Serengeti from the 1950s until the 2000s, I have shown for three historical phases that key technologies and associated practices
sustained particular forms of research collaborations and mediated different normative ideas on human–wildlife interaction and the sharing of space in and around protected areas. Over time, these technologies have contributed to the increased perception of incompatible human and wildlife interests in protected areas. Yet, zooming in on three forms of technological mediation allowed me to point out noteworthy differences.

During the 1950s and 1960s, observations of animal migration by airplane were characterized by the study of movement of both wildebeests and humans across space in real time. Aerial observations were dependent on the cooperation between scientists and park authorities, and on the knowledge and observational skills by game wardens. Although partly guided by misconceptions about pastoralism, the experience of the movement of animals and people in real time allowed—to some degree—for experimentation with forms of human land-use. During the 1970s, these forms of cooperation changed when ecological research became more established. With many small-scale and short-term projects, the focus shifted toward data recording in aerial photographs and maps, which created supposedly complete spatial overviews of inhabitation. Using photographs to coordinate and record data for later use encouraged the splintering of research agendas and a focus on quantitative research questions, such as land occupation. As a consequence, human settlements near parks became regarded as in spatial competition with animal populations inside the park. From the 1980s onward, computer technology allowed for long-term calculations of past and future trends in population densities of individual species. Data collected for projection provided the least flexibility in conservation planning. The understanding of the wildebeest as a keystone species and the Serengeti as a baseline ecosystem turned communities of local pastoralists and agriculturalists into a constant future threat. This perception was in conflict with contemporary plans for the inclusion of local human interests.

While overall, developments in observation technology correspond with larger narratives of postcolonial fortress conservation, this article has shown that observation technologies can bridge the distance between researchers, animals, land, and local people, as well as create new ones, both spatial and temporal in nature. This remains true for present-day observation tools. A recent project by the FZS, for instance, aims at developing smart algorithms for automated population counts, based on real-time images taken in a number of sample areas in the Serengeti National Park (Torney et al., 2016). In this case, the real-time imaging has the potential to increase the understanding of the dynamic character of animal movement and distribution across the ecosystem. Yet, while the algorithm is trained by ecological experts with experience in the field, the focus is on animal counts as a single indicator for a healthy ecosystem and hence does not embed animal activity and interactions into their ecological environments. Other projects that rely less on computational modeling pay comparably little attention to the ecological and social embedding of their collected data. The citizen science project “Snapshot Serengeti” by researchers from Minnesota, Oxford, Chicago, and Harvard lets volunteers identify snapshots of animals taken by photo traps installed throughout the park (Swanson et al., 2015). While the project constitutes an attempt at democratizing the ecological research process and the project allows for various types of camera encounters, here too, snapshots are analyzed remotely and without little knowledge of either the ecological or the social context in which they were taken. As observation technologies as well as the views from above they generate are here to stay, it remains important to pay attention to technologies’ potential roles in creating additional distances between researchers and research subjects. Historical insights, such as the ones presented in this article, can help us reflect on how various forms of remote sensing may mediate normative ideas on human–wildlife interactions, conservation expertise, and consequentially affect local livelihoods.
Highlights

- Since 1950, observation technologies have played an important role in bridging the distance between ecological field researchers and Serengeti wildlife.
- Key techniques have been aerial observation (1950s, 1960s), aerial photography and mapping (1970s), and computer modeling of populations (1980s onward).
- Observational technologies mediated different normative views on the Serengeti as shared by humans and wildlife, shaping regional conservation policies.
- Historical insights can help reflect on how present-day remote sensing technologies may mediate experiences of human–wildlife interactions.

Acknowledgements

Earlier research related to this article has been conducted during a fellowship at the Leibniz Institute of European History (IEG), Mainz. I thank my colleagues Raf de Bont, Joeri Bruynincks, and Jens Lachmund for reading earlier versions of this article.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This publication is part of the project Moving Animals: A History of Science, Media and Policy in the Twentieth Century (with project number VI.C.181.010) which is financed by the Dutch Research Council (NWO).

ORCID iD

Simone Schleper https://orcid.org/0000-0002-4906-9813

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