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From Environments to Infrastructures of Survival: The Case of the Northern Bald Ibis

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Since 2013, Northern Bald Ibises, large migratory birds, have been reintroduced into the European habitat, almost 400 years after their local extinction. What distinguishes this from other reintroduction projects is that the environment that is made available to animals live "in the wild" is not a geographically bounded site. Rather, it's a transcontinental expanse. This necessitates a different understanding of the relationship between the work done by the reintroduction project and the environment it seeks to create. We use an interdisciplinary perspective, combining visual arts, media studies, and geography, to make visible how the notion of environments folds into the concept of infrastructure through their analogous functions as dynamic, relational spaces that contain and are contained by. Critical mapping provided an important tool to bring together the complexity that is normally separated into the concepts of infrastructure and environment. They are connected by human interventions that aim to foster those relations that support the circulation of the birds, and to disentangle those that impede it. To be successful, the work of relating human and non-human actors has to adjust continuously outside each actor's control. Thus, the environment comes into view as something in need of continuing more-than-human maintenance and care, in order to serve as an infrastructure for survival. **Key Words: data, environment, human-animal relations, infrastructure, rewilding.**

INTRODUCTION

Since 2013, Northern Bald Ibises (*Geronticus eremita*), large migratory birds, have been reintroduced into the European habitat, almost 400 years after the local population became extinct. While the definition of a wild animal may have at one time suggested living independently of humans, this is clearly not the case for the Northern Bald Ibis (NBI) as it is today for most undomesticated animals (Lorimer 2015; Kelly and Landres 2023; von Essen et al. 2023). After all, across the many contentions around the notion of the Anthropocene, it is widely understood that "human activities have become so pervasive and profound that they rival the great forces of Nature" (Steffen et al. 2021), leaving no earthly space and species untouched.¹ Climate change and biodiversity loss are testaments to the destructive violence of this "touch." However, work in rewilding (Pettorelli and Durant 2019; Blythe and Jepson 2020), reintroduction and reconciliation ecology (Rosenzweig 2003b) shows that also less destructive or even restorative forms of intervening are not only possible, but given the scale of destructive disturbance, urgently needed.

What distinguishes the reintroduction of the NBI from other projects is that the environment which is made available to wild animals is not a geographically bounded site (e.g. Ward and Prior 2020) or even a more broadly defined field (Marr et al. 2022). Rather, it's a

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transcontinental expanse, encompassing summer breeding areas on the Northern slopes of the Alps, wintering habitats in Southern Europe and numerous, changing and at times unpredictable migrations routes in between. This necessitates a different understanding of the relationship between the work done by the re-introduction project and the environment it seeks to create.

In this article, we use an interdisciplinary perspective, one where visual arts, media studies and geography converge. We aim to make visible how the notion of environments folds into the concept of infrastructure through their analogous functions as dynamic, relational spaces that contain and are contained by. Environments and infrastructures both act as containers and conduits by enclosing and shaping the entities within it. At the same time, these entities also shape them. As this paper argues, the perceived differences between the environment, often understood as the unplanned total sum of all the processes it contains (as in “urban environment”), and infrastructure, often understood as the outcome of deliberate planning (as in bridges that serve as animal crossings) are much less clear-cut. We use a critical mapping approach to bring together heterogeneous elements that make up the rewilding project, without having to make an *a priori* distinction between the two concepts. Indeed, the need to adjust to, and repair climate change damage suggests a need to reframe them as increasingly coextensive and mutually constitutive. From the point of view of the renaturation of the previously extinct NBI, the existing environment needs to be turned into an infrastructure for survival, through deliberate interventions into a field too vast and complex to be amenable to control through planning (even planning that lets “nature take the driving seat” (Knepp Wildland, quoted in, Overend and Lorimer 2018).

METHODOLOGY

To make visible this interspersedness, we draw on science and technology studies (STS) and their notion of heterogeneous networks as a way of tracing the practices that go into making this specific infrastructure. Paying close attention to these practices allows us to characterize *infrastructuring*, the ongoing work of creating, maintaining and adapting an infrastructure, less as a process of building objects, than as a process of shaping environmental individuation (Venn 2010), that is, the actualization of a new set of relations, characteristics, and entities—such as a (re)wild(ed) animal in a densely cultured landscape. A common approach in STS is “attending to practices” in all their messiness (Law 2017: 31). We did so by following the actors through visits of four field-sites in Germany, Austria, and Spain; by way of in-depth, repeated interviews with seven of the main actors in the reintroduction project over the course of three years; across the scientific literature by and about the project, mainly in the field of conservation biology; and through tracking media coverage and social media engagements. From the latter, we scraped data² to gauge the public’s interest in, the interaction with the animals. This forms the empirical basis of our synthesis of how infrastructuring the environments of the NBI involves the creation of new entanglements as well as relinquishing pre-existing ones. In a first step of analysis, we used artistic methods of “critical mapping” (Hutchinson and Foster 2004; Schranz 2021), to organize the various actors according to their logical and functional proximity to one another. One of the great advantages of mapping is that it can articulate co-presence and multiplicity, without having to revert to a single, linear ordering and narrative. Another advantage of the mapping approach is that it does not have to organize its elements into preexisting categories, such as infrastructure or environment, but can focus solely on relationships, whatever it is they

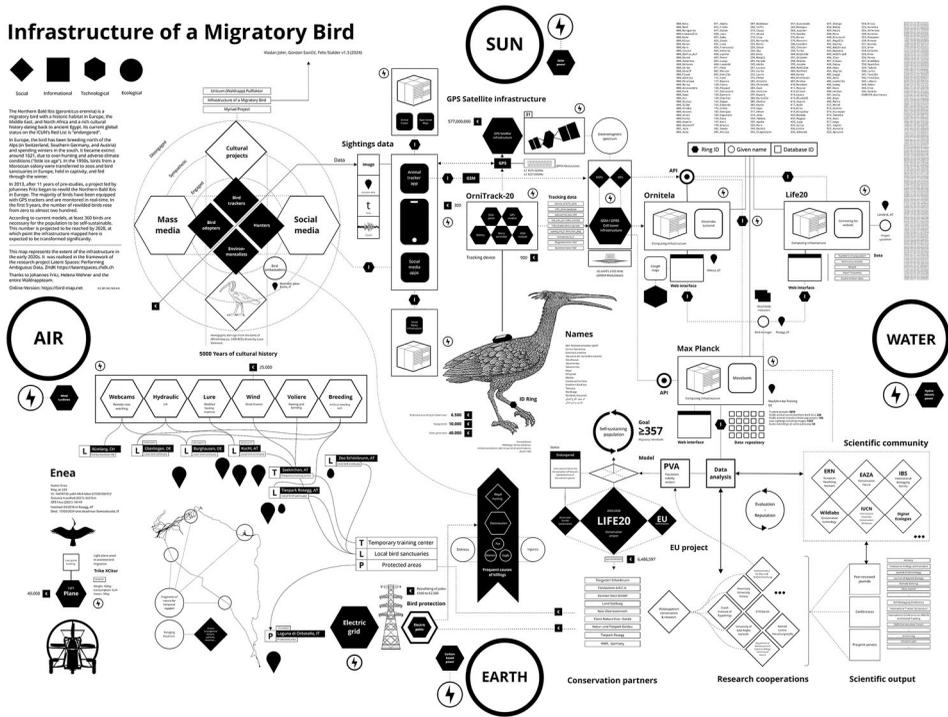


FIGURE 1 Vladan Joler, Gordan Savičić, Felix Stalder. Infrastructure of a Migratory Bird, 2022-24. (detail) full interactive map is available at <https://bird-map.net>.

connect. This allowed us to stay close to the “messiness” found in the field, while already reducing complexity by focusing solely on the relationship among heterogeneous entities. We called this map “Infrastructure of a Migratory Bird” (see Figure 1) to highlight the deliberate work that goes into creating an environment in which this bird can re-acquire its instinctive migratory habits.³ The aesthetic choice of using highly abstracted, flat, black icons furthers this notion of abstraction. The bird, in the middle of the map, can be said to be the effect produced by the extensive actor-network we mapped, while at the same time, shaping it.

One of the insights that emerge from this mapping are the existence of four distinct clusters (in the sense of relational density) or quadrants (in the sense of visual organization) that characterize the most intensive areas of work and that highlight the heterogeneity of social, technical, informational and biological actors involved in it. On the top left of the map is a cluster of elements which are shaping the public’s understanding of and the relationship to the bird, we call it in the following the “media-cultural” cluster. The top right comprises elements generating real-time data flows through which the birds are monitored, and the biologists can decide whether to make adjustments to their interventions, the “techno-social” cluster. Bottom left are discontinuous areas connected and adapted to make room for the bird, the “bio-social” cluster. Bottom right

are institutional networks that make up the project, provide funding, and negotiate scientific interpretation, the "scientific-administrational" cluster in the following.

Contrary to many STS studies, particularly when studying scientific practices, we do not critically engage with the methods used by the biologists themselves, as this is already covered in the conservation biology literature (Fritz et al. 2017; Böhm et al. 2021; Grogger et al. 2022; Wehner et al. 2022). Instead, we structure our account of the processes of (dis)entangling through the empirically informed delineation and description of the four main clusters, as they became visible through the mapping. Here, we call them "bio-social" where physical human-animal-habitat relationships are shaped, the "techno-social" where technological mediation through tracking takes place, the "media-cultural" where the relation between the animals and the wider public is shaped, through mass media but also social media, which can then lead to direct human-animal encounters, and, finally, the "scientific-administrational" where the critical institutional entanglements of the project within the scientific community and within EU funding structures are created, adapted and maintained. These "sites" are heuristic devices to structure our account. Their contours emerge from the network-centric focus of this method, which does not follow established ontological categories, spatial or institutional boundaries, but foregrounds connective density within heterogeneous actor-networks. Each of these sites can be thought of as a cluster of dense relationships, producing a particular aspect of the overall environment of the ibis. In the next section, we describe how each of these sites—the bio-social, the techno-social, the media-cultural, and the scientific-administrational—individuates the NBI and gives it form through this folding and unfolding of infrastructure and environment.

THE CULTURAL HISTORY OF THE NORTHERN BALD IBIS

The first modern description of the bird stems from Conrad Gessner's monumental, richly illustrated *Historia Animalium*, published in Zurich in 1555. Here, a juvenile bird is depicted with high accuracy, and it is noted that the birds were regularly hunted as their meat was regarded as a delicacy. Cooler climates during the 16th and 17th centuries ("little ice age") in Europe increased ecological (older and wetter summers) and human pressures (increased hunting due to food scarcity) on the population, and the last bird was reported north of the Alps in 1621 in Graz (Roland 2022). A mix of climatic and anthropogenic pressures led to the collapse of the local population. For much of the 19th and early 20th century, Gessner's drawing was regarded as depicting a fantasy animal because nobody in Europe had seen such a bird for several hundred years. The "discovery" of a colony living in Morocco by European naturalists prompted the realization that the drawing was accurate and that the bird once lived north of the Alps. In 1928, the first animals were transferred from a Syrian colony to a zoo in Basel, Switzerland, but they did not survive for long. A more successful program in zoos in their once historic breeding region was started in the 1950s, with imports of animals from Morocco (Schenker 1976). Over time, several hundred birds were born in these programs. Globally, a low point was reached in the mid-1990s, when only about 700 birds remained in the wild, mostly in Morocco, and the species was put on the IUCN's red list as "critically endangered" in 1994 (IUCN 2018).

In the late 1990s, the biologist Johannes Fritz was working on a research station in Upper Austria, where a free-flying colony was set up for behavioral studies (in the tradition of Konrad Lorenz's famous research with gray geese). However, it quickly became clear that the species showed a motivation for migration, but there were no obvious habitats to migrate to. Unlike in some smaller bird species,

the migration route of the NBI is not genetically determined, but socially learned. But there were no birds to learn from. That knowledge had disappeared with the last bird in 1621. Given the densely populated area north and south of the Alps, it was unclear if a suitable winter habitat existed at all, let alone how they would ever find it. In 1996, the movie “Fly Away Home” was released, which dramatized the experiences of Bill Lishman who trained Canada geese to follow his ultralight aircraft. This widely popular movie inspired Fritz to think about the possibility of showing newly released birds the way to a suitable habitat (interview with the authors 2023). The listing of the species by IUCN as critically endangered created the possibility of applying for funding for preliminary research into breeding spaces, foraging areas, winter habitats, methods of assisted migration, and the modeling of population dynamics to determine the threshold of a viable population.

The feasibility study came to a positive result, and the grant applications to the European Life Program, which funds applied science for conservation, were successful (2014–2019, 2021–2028). The first birds were reintroduced and led to their human-chosen winter habitat in the Laguna di Orbetello, a small nature preserve on the west coast of Tuscany, in 2013. During the seven years of the program’s life cycle, about 200 birds were introduced and several generations of birds were born in the wild. Yet, the number of birds necessary to have a self-sustaining population was modeled to be 357 (Drenske et al. 2021), hence a second project cycle was started in 2021. This will last until 2028, and the number of reintroduced birds is projected to reach the threshold of population “self-sustainability” (Drenske et al. 2023). In the process of the project, a vast, constantly evolving infrastructure is being assembled, responding to opportunities and pressures.

The renaturation of an animal into a habitat from which it has disappeared a long time ago is, of course, not a simple act of opening the gates of the cage and letting the animal free, an iconic scene in many documentary films. What is necessary is a long-term adjustment between the needs and capacities of the animals and the affordances of the environment, which includes human and non-human elements. Given the geographic size of an environment suitable for a migratory bird, this is a massive challenge that needs to rely on (dis)entangling existing elements, transforming their character in mostly subtle ways. By reframing infrastructure through the notion of environment as formulated by media studies, we emphasize its relational character over aspects of building durable objects. The next section will develop this (almost) entirely relational notion of infrastructure, and we will then use it to trace the work of creating an environment in which the birds can live as a migratory species.

INFRASTRUCTURING THE ENVIRONMENT AS SHAPING (DIS)ENTANGLEMENTS

We will now look more closely at the four clusters through which the work for infrastructuring the environment occurs, that emerged from the mapping (see [Figure 1](#)). All of these clusters are co-present and, to some degree, co-constitutive, as the visual maps are capable of showing. The sequential order required by the text is not implying a prioritization of the clusters

The Bio-Social

What makes an animal belong to a habitat? For many, it is not only a matter of ecological fit but also of historical record, in an often contentious discussion of native vs. invasive species. As for

the summer habitat at the Northern slopes of the Alps (Southern Germany, Switzerland, Austria), the ecological fit is, perhaps surprisingly, rather unproblematic. 400 years of history since its disappearance have not altered the landscape in ways that would make it fundamentally inhospitable to the NBI. Sources of food and places of shelter are still potentially available, even if modern infrastructures, particularly power lines, have added new dangers. However, the basis of belonging based on the historical record is more contentious. While there can be no doubt that the bird once lived in the area, is this enough to make it count as a “native” species? Conrad Gessner’s historical image clearly documents the presence in the area, yet whether that is an indication of a sustained presence is disputed (Landmann 2015, 2017; Schenker 2017; Roland 2022). If not, then the infrastructure would lead to the introduction of an exogenic species, rather than a re-introduction of a native species. Whether the distinction between endo- and exogenic species matters, and therefore what kind of infrastructure for wild animals should be created/maintained is an axiomatic question in the field (Kelly and Landres 2023). The answers depend on how one sees the relationship between humans and “nature” and whether “nature” is a more or less homeostatic system (something that conservation biology can save or even restore) or, under climate change, one of unprecedented dynamism through which species can become ill-adapted to their native habitats.

The transformation of the bio-social through a process of individuation can be seen at three points: the migration and the nesting places, the electricity grid around the nesting places, and the cultural attitudes of people. These heterogeneous entities create, adapt and maintain the conditions and processes of ordering that sustain the rewilded birds. There are two types of nesting places. First, there is an aviary, to which about two dozen birds are transferred a few days after they hatched in zoos or sanctuaries. They are hand-fed for 4 months by two “foster mothers,” biologists who spend up to 10 hours a day with the birds to develop a close bond so they can lead them in assisted migration. The aviary and the temporary camp that springs up around it are themselves sites of intense infrastructuring, with flows of goods and people in and out of it. These flows are highly organized not only because they are vital to keep the birds alive, but also because they navigate a tension in the human-animal relationship that emerges out of this infrastructure. Birds whose habits are to be shaped for living in the “wild” must not get overly accustomed to the presence of humans and their caring. On the other hand, to be capable of following an assisted migration, the birds need to have a very close bond with the person(s) doing the assisting. In practice, this means that only the two biologists are allowed in or even near the aviary, which is surrounded by signs instructing to keep distance and be quiet. The second breeding sites are “natural” sites, rocky cliffs where the birds can construct their nests away from predators. These are inhabited by birds that return from their winter habitat to breed in the wild. While in some areas, such rocky cliffs are a natural occurrence, in others they are simulated through an artificial wooden construction. In both cases, the infrastructure put in place enables continuous monitoring, sometimes through webcams, and regular visits by members of the team. They not only monitor the breeding from up close, but also remove plastic from the nests if necessary. Local information campaigns sensitize the population to the presence of the birds and provide contextual information to make sense of this new presence, subtly modulating attitudes and behaviors of people (we will return to this aspect in the section “the media cultural” below). But even if the habitat has not changed dramatically in terms of food sources and places of shelter, it has in many other aspects. One of the most problematic is the presence of the electricity grid, which poses a constant danger of electrocution. Indeed, next to natural predators and illegal

hunting, the power grid is the third main cause of premature death (Maccagnan et al. 2022). There are ongoing negotiations by the project team with the operators of the power lines led to the transformation of an as yet small number of the poles into safe resting places for large birds, as well as more comprehensive legislative efforts to mandate such protections across wider areas (Antal 2010).

The main challenge in terms of creating a winter habitat was to find an area that provided the preconditions to be transformed by the infrastructural intervention, to become compatible both with biological requirements and land-use patterns. Not many areas could be identified. The area chosen was the “Laguna di Orbetello,” a small nature preserve (approx. 8 km²) managed under the Natura 2000 program of the European Union. What made it suitable was not only that there are people on the ground managing the preserve who can monitor the birds during the winter, but that the preserve, which by itself is too small, was surrounded by extensive agriculture, providing ideal foraging grounds. So, an agreement between the project team and the local management of the preserve was drawn up, and the surrounding population was informed. Thus, lightly yet sufficiently transformed, both the nature preserve and the surrounding fields and villages became part of the infrastructure.

The Techno-Social

Now, the bird has to find their winter habitat selected by humans. As already mentioned, the choice of habitat is socially learned from older birds in the flock, which, obviously, are not present for the first generation of re-introduced birds. The modulation of their behavior, creating a bond and getting used to flying behind an ultra-light plane, has taken place as part of their hand-rearing. The starting point (the aviary) and the endpoint (the winter habitat) has been selected, but what about the route in between? Several elements determine this: the capacity of the birds, thermal upwind (which the birds need to rely on to save energy) (Wehner et al. 2022), the capacity of the ultra-light plane, places to touch down and spent the night (which, for the birds, requires a mobile aviary), and the biologists’ assumptions about how the birds might remember their routes through visual landmarks such as river valleys, mountain passes, and so on. Over time, the biologist learned to understand the navigation better, or, perhaps more correctly, learned about their lack of understanding. The birds don’t seem to navigate by sight. Rather, according to Fritz’s observation mentioned during one of our interviews, they appear to remember the location and then fly straight towards it. How exactly they do this is yet unknown.

However, climate change has become a massive factor, altering the environment and the birds’ relation to it. 2022 has been a year of dramatic climate impact. One has been the observation that due to warmer months in fall, the birds start their migration later and reach the Alps when there are no longer sufficient thermal upwind to help them fly across high altitudes. Waiting for upwinds that would not happen this late in the season, many had to be rescued from facing certain death at the foot of the mountains. The other has been an unusually strong storm in Italy, killing almost 10% of the population in the winter habitat. While extreme weather events are unpredictable in the specific, they are already included in the model as “stochastic events” (Drenske et al. 2022) and are therefore not an immediate threat per se to the creation of the environment as intended, if they don’t occur too often (which could be the case in the future due to extreme weather).

The shift in the migration season is a different matter. These are not stochastic but introduce a structural break in the relationship between the birds and the thermal upwinds. That cannot be re-related by clever infrastructuring. Rather, it requires a substantial reconfiguration of the entire infrastructure. As of 2023, the assisted migration no longer flies cross the Alps but bypasses them, taking a route along its Western edge, through France and into Spain, where a sedentary colony was introduced in 2004 (Böhm et al. 2021). This triples the length of the migration route to about 2300 km. The viability of the geographic re-configuration remains to be seen, but the fact that it can be attempted at all is due to the other dimension of the infrastructure being able to accommodate and support it.

Once the birds have reached their winter habitat, the relationship between the birds and humans is modified dramatically. A further step in their individuation towards a “wild animal” takes place here in that their previously very close bond to the foster mothers is dissolved. This is emotionally challenging (at least for the humans) and never entirely successful. Birds and foster mothers recognize each other even years later, as we could observe during an unplanned encounter of one foster mothers with a previously released bird. “I have a friend in the wild,” one foster mother put it in an interview with the researchers. Still, direct contact is severely reduced, and the bond is mediated. In the first phase of the project, almost all birds have been fitted with a tracker, a small, off-the-shelf device. Once attached, the tracker provides close-to-real time information about its location, altitude, movement, and charging status. This information is transmitted over cell phone networks into a data center operated by the Lithuanian company providing the trackers. From there, the project team can access the data through an API, and follow the individual birds as they move around space. This is the job of a dedicated “bird manager” who checks on this data regularly for anomalies, such as a sharp drop in altitude or a lack of movement. This provides essential information to locate and, if necessary, support a bird on the ground. It also provides large amounts of behavioral data that has yet to be analyzed.

The data are also fed into Movebank, a large global repository for animal tracking data created and maintained by the Max Planck Institute of Animal Behavior, as part of an international consortium. From there, the data are fed into a public facing smartphone app, Animal Tracker, which allows the interested public to follow the movements of wild animals, usually rendered as a path on a map. It also enables users to upload their own sightings of specific animals, turning the app into a citizen science project. Since its release in 2014, the app has been downloaded more than 100,000 times from the Google Playstore alone.

The Media-Cultural

The Animal Tracker app is an important part of the infrastructure that modulates primarily human habits in ways that sustain the renaturated birds. The app can create an affective relationship by individualizing the animals for people who do not have, and should not have, close contact with them (Blue 2016). In the app, each tracked bird appears with its human-given name (which does not indicate biological sex) introducing, quite deliberately, an element of anthropomorphization that/which functions as a “low-cost engagement tool” (Auster et al. 2023). However, the app reaches a relatively small number of (rather dedicated) people. Additionally, all forms of social and broadcast media are being enrolled into this infrastructure, from newsletters, social media (Facebook and Instagram) to regular appearances in broadcast media. Indeed,

the project is very popular with journalists, ranging from the NYT (most recently, Hruby 2023), to TV documentaries and regional and local media. It probably helps that the project itself, as already mentioned, was partly inspired by a popular movie and is reproducing its strong and appealing imagery (birds following an ultralight plane) while communicating an essentially uplifting story: an animal being brought back from extinction.

Perhaps, the group of people whose habits need to be modulated most strongly are hunters, particularly in Italy (Natali et al. 2024). The force of the law, which makes hunting endangered species illegal in general, is not enough. About 30% of all deaths of NBIs occurring in Italy are caused by poachers (Maccagnan et al. 2022). Since legislation alone does not suffice, public relation campaigns (and, if applicable legal cases) are undertaken. For this purpose, Hannibal, a female bird who was shot in Rome but survived yet remained unable to fly, was transferred to a sanctuary near Rome to serve as a spokesperson, or ambassador for the species in the pushback against hunting. As these are social birds, a second one, Jakob, unable to fly after colliding with a power line, was also transferred to Rome a year later.⁴ Thus, they became part of the infrastructure, actively engaged in “in-forming” people. Anti-hunting messages and imagery also become embedded in social medial, creating another node of media-cultural infrastructuring aimed at the transformation of people, from predators or supporters of the birds, another form of environmental individuation.

The Administrative-Scientific

Creating this infrastructure requires extensive administrative and scientific apparatuses that are highly self-reflective and intertwined. Indeed, it’s an entire cluster in the overall mapping of the project, which provides the organizing capacity to create to other three clusters. The administrative part is composed of personal and institutional networks for the mobilization, coordination, and cooperation of those people who do the main work of infrastructuring. This is a large network of existing institutions, most of them with a focus on animal conservation, inside and outside captivity. The core of this network is a small non-profit company, *Waldrappteam Conservation and Research*, created for this very purpose. It is, arguably, the only part of this infrastructure which is exclusive to it. We might say it is the leading actor in this project, but that depends on the perspective. From the perspective of the EU Life Program, which provides 60% of the funding, a much larger and more established institution, the Zoo Schönbrunn in Vienna, is the project lead, even if their role in the infrastructuring process is more limited. But receiving major EU funding requires certain institutional capacities (particularly in financial management) that are hard for small organizations to build up. Since the EU does only provide 60% of the overall budget of the current cycle, roughly 11 million Euros over 7 years, the rest needs to be provided by further partners, which can be institutions that provide in-kind support, or individual people, who provide funding through donations and acquiring symbolic godparenthood (the authors also became godparent of one bird named Akh, in 2023).

This institutional work is a continuous process of reflective self-actualization and legitimation, in which scientific evaluation of the project plays a critical role in its ongoing development. This evaluation focuses not only on the project goals, reaching a specific number of birds successfully living migratory lives, but also on collective knowledge production in the field of conservation biology, thus affecting the state of the art in the field which is influenced by and influencing

experiences and possibilities of the ongoing project itself. This is done in a steady stream of scientific publications, reports, and presentations, some of which are referenced in this article. It is this knowledge that makes the project understand itself and creates legitimacy for its further existence and for the birds. This is both a reflexive and a projective activity, at times based on a highly abstract models, such as the population viability analysis that ran through hundreds of different scenarios to reach a consensus of the feasibility of the long-term success of the project (Drenske et al. 2022). Scientific knowledge production quite often feeds directly into the process of infrastructuring itself, for example, when building a wind channel to determine the position and the method of attachment (wing-loop or leg-loop harness) of the tracker to minimize harm for the bird (Mizrahy-Rewald et al. 2023). Here, some of the most abstract and embodied aspects of the infrastructure meet directly and relate to one another. They do so in ways that perpetuate the infrastructuring of the ibis. The dis(entangling) of relationships undertaken to maintain the migratory character of the bird yield a processual dynamism whereby infrastructures, environments and bird (and human) behaviors adapt and evolve over time and space.

ENVIRONMENTS AS INFRASTRUCTURE

What emerges from this account is the extensiveness and the scale of work necessary to turn an existing, densely cultured environment into an infrastructure on which a previously extinct species can circulate on its migratory routes. In the following, we want to reflect theoretically on the kind of environment thus produced.

Drawing on media studies, we understand an environment as mediated processes that create the conditions of physical existence and social meaning. They are, as Peters (2015: 2) puts it, “containers of possibility that anchor our existence and make what we are doing possible.” Such a notion of environment was brought into media studies first by Harold Innis (1950, 1995) who theorized media in terms of expressing a “bias” towards space or time, and then by Marshall McLuhan (1964) who viewed media as broadly transformative rather than as narrow conduits for content. In this perspective, a new technology is seen as shaping a wide set of social, cultural, and material relations. Studying a technology, then, requires an account of the ways in which these relations are being changed, ultimately also shaping the technology itself. Media, here, are less a means of communication, but rather a means of organization. This idea was taken up by “media ecology” which emerged in the 1980s and focused on the transformation of the psychic and social order through new media technologies (Meyrowitz 1985; Postman 1992; Levinson 1997). Since then, the focus has expanded from how media transform human cultures to how they affect more-than-human conditions. Parikka (2015: 62) speaks of “a continuum of medianatures where the natural ecology is entirely entangled with the technological one.” Thus, changes in the technological make-up of more-than-human processes affect the biophysical in the same way that they are affected by it. Peters (2015), pointing to the same phenomenon of media being part of the conditions of existence, speaks of “elemental media.” Studies of “environmental media” or the “becoming environmental of computation” (Gabrys 2016) take up such notions of digital media being intrinsically woven into processes of biophysical ordering (Haff 2023).

The notion of media as ordering devices, and of a change in media as a change in ordering, shares many similarities with recent conceptualization of infrastructure. Both focus less on single

(if large) objects, but rather on distributed, enabling and enabled conditions. McLuhan framed this in terms of the figure/ground relationship (Logan 2011), Geoffrey Bowker (1994) called it the “infrastructure inversion.” Both highlight the need to foreground what normally appears in the background as a taken-for-granted enabling capacity. This call has been taken up widely in the burgeoning field of infrastructure studies, particularly in anthropology and geography.

Larkin (2013: 329) defines infrastructures as “matter that enable the movement of other matter.” He goes on to point out that “their peculiar ontology lies in the facts that they are things and also the relation between things. As things, they are present to the senses. Yet, they are also displaced in the focus on the matter they move around.” It’s important to stress that there is more to relationality than simply the relations between things that comprise the material system. As Star (1999: 380) noted, “one person’s infrastructure is another’s topic, or difficulty. ... Infrastructure is a fundamentally relational concept, becoming real infrastructure in relation to organized practices.” In other words, to understand what the infrastructure comprises, we need to define to whom the assemblage serves as infrastructure. In the case of the re-introduction project studied here, it is the bird for whom things are put into specific relations.

As a theoretical device, infrastructure can function as a kind of “imagination systems ... to valorize a range of ways of integrating knowledge of phenomenal interconnections, allowing us to recompose knowledge from multiple sources with diverse positionalities” (Bergmann and Lally 2021, quoted in Stallins et al. 2023: 5). This is pronounced when considering non-human perspectives. Either by accounting for how animals interact with infrastructures (Parks 2019; Krieg et al. 2020) or becoming part of infrastructures themselves (Gutgutia 2020). Reconciliation ecology (Rosenzweig 2003b) provides a way of thinking about “redesigning anthropogenic habitats so that their use is compatible with use by a broad array of other species” (Rosenzweig 2003a: 194). The goals of such interventions that aim to create space for non-domesticated animals and plants, is no longer to separate them into specially designated, protected areas, but focus on environments for co-habitation (Society and Space n.d.). Barua (2021), drawing on Bourdieu, conceptualizes infrastructure in this context as non-human habitus, understood as systems of durable, transposable dispositions which structure and are structured by regulated and regular practices. “Infrastructures configure,” he writes, “a creature’s lifeworld by modulating habit—its sensory and sentient world-making activities and rhythms, and by furnishing habitat—a creature’s dwelt environment and its very medium of inhabitation.” (2021: 1473). But even as this perspective enlarges our understanding of non-human needs and affordances into the picture, leading to calls for “animal centric design” (Webber et al. 2022) infrastructures are still often conceptualized, at their core, as planned constructions.

The environment of migratory birds, extending over thousands of kilometers, is much too large to revolve around deliberate physical constructions. The notion of environments as infrastructures we put forward here does not put built objects at the center, rather focuses on the work of creating, adapting and maintaining the conditions, processes of ordering, from which particular forms of life can emerge. Thus, the infrastructure is primarily relational, aimed at forming “a complex surrounds” (Simone 2015). It shapes a process of environmental individuation, in which various entities realize specific characteristics, they are “in-formed,” through relations to each other (Bluemink 2020). Here, a species that lived a sedentary life in captivity is transformed into a migratory species capable of living “in the wild.” The notion of infrastructure as ongoing work allows accounting for how habit is modulated and elements are adapted to each other as part of

an infrastructure assembled for a wild animal. While the notion of assembling might imply a master-creator and, eventually, a finished product, assembling this particular infrastructure is a process with many unruly actors which need to be brought and kept in particular relations to one another. And not only need they be kept in relation, but these relations have to be constantly adapted to changing circumstances, such as the changes introduced to the migration route as a reaction to climate change, necessitating an entire new network of sites and partners along the new route. This indicates that the work of assembling will never be quite done, and that “production” and “maintenance” of this infrastructure are essentially indistinguishable activities. This connects to studies that see maintenance, often from an explicitly feminist perspective, as one of the defining aspects of infrastructuring. Shifting the focus away from the heroic, often very moments of planning and construction (Siemiatycki et al. 2020), towards the more mundane practices of upkeep and repair (Graham and Thrift 2007; Mattern 2018).

OUTLOOK

Critical mapping provided an important tool to bring together the complexity that is normally separated into the concepts of infrastructure and environment. Thus, it provided a first indication of the folding into each other of these concepts through concrete practice of rewilding a migratory bird (see, Figure 1). Thus, what emerges from the theoretical reflection conducted here is the understanding of the environment as something in need of continuing more-than-human maintenance and care, in order to serve as an infrastructure for survival. Because of the complexity of the actor-network—a vast number of heterogeneous, loosely coupled actors, that can enter into various configurations, some surprising, some predictable—the human interventions are meticulously planned, yet not in control. There is a constant mutual shaping. The human interventions aim to foster those relations that support the circulation of the birds, and to disentangle those that impede it. To be successful, it needs to adjust continuously the work of relating human and non-human actors alike.

This is fundamentally a biopolitical process. Jamie Lorimer (2015: 2) stresses that under the conditions of the Anthropocene, the “world is hybrid—neither social nor natural. It is nonlinear rather than in balance. Futures will not be like the past and will be shaped by human actions. Multiple natures are possible.” Thus, he argues, there is a need to understand how one of these possible natures is made real. More specifically, he calls for a close examination of what happens when creating wild nature is explicitly attempted through conservation efforts, which, in his view, are always interventionist bringing about new, future natures, rather than restoring old, past nature. Turnbull et al. (2023: 4), point out that “potentials afforded by digital mediation and technologies, which do not inherently disengage nor reconnect humans to nature. Rather, they foster the potential for both, depending on socioeconomic, ecological, cultural, historical, and geographical context.” Thus, there is always biopolitics involved, selecting one nature over possible others.

The notion of environments as infrastructures brings to the fore the work of relating and separating, which takes places across many different locales, or network clusters, and involves a wide range of actors and acts of (digital) mediation. By following these actors and the processes of mediation, the NBI provides a case study to illuminate the creation of a new environment, based

on direct and mediated encounters between humans and non-human, and to examine how they and their environments are governed for mutual survival in the Anthropocene.

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NOTES

1. One contention concerns whether the problem lies with human activity in general, as suggested by the term Anthropocene, or with specific political-economic configurations, as terms such as “Capitolocene” or “Plantationocene” suggest (Moore 2015; Wu and Xu 2024). We use the term in the spirit of Anna L. Tsing (2021: 203) who points out that it is “far from perfect—but it alerts us to the massive environmental problems of our times ... The livability of the earth is in danger from human disturbance, and we are going to have to decide if we will do anything about it.”
2. We used an existing, though largely undocumented, API from Movebank, a large global repository of animal tracking data, to retrieve all images that users had uploaded via the Animal Tracker app.
3. The actual map consists of a relational graph (shown here), three scales (spatial, temporal, financial). For the focus of infrastructuring as environment, the scales are not necessary and thus not shown in this paper. For a discussion of the temporal scales, see Sollfrank and Stalder (2025). The full map is available at <https://bird-map.net>.
4. Newsletter, Waldrapp Team, Sept 29, 2022. <https://www.waldrapp.eu/2022/09/29/hannibal-3> (accessed 01. February 2025).

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