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Digital sonic ecologies: encountering the non-human through digital sound recordings

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Introduction

In a degraded part of Australia's Great Barrier Reef, where the coral was bleached and the fish had lost interest, scientists suspended a loudspeaker underwater. For six weeks in 2017, this speaker broadcast the recorded digital sounds of a nearby 'healthy' reef in an attempt to restore the ecosystem through acoustic enrichment. It worked: the fish followed the sound and, at least temporarily, reinhabited the site.[1]

On the site AllPredatorCalls.com, one can browse 'one of the largest selections of electronic game calls on the Internet'. A popular choice is the MOJO Triple Threat E-Caller: retailing for 239.99 USD, it includes an SD card holding eighty sounds and a spinning feathered appendage which, together, are 'irresistible' to animals like coyotes and deer.[2] Users also have the option of downloading additional sounds for the device. For instance, for 300 USD, one can purchase '50 … top killing sounds in an easy to download .ZIP file'.[3]

In a Hawaiian swamp in 1986, Jim Jacobi recorded one of the last known Kauaʻi ʻōʻō birds using a handheld tape recorder. The recording captures a male bird singing half of a duet – calling out to a mate, with no response. Seemingly, there is no one left to call back. When the recording was digitised in 2019, it circulated online rapidly: news articles, podcast episodes, and remixes all lamented the tragic loss of this now-extinct species to destructive colonial capitalism. Listeners widely report that they find the recording heartbreaking, and they can't listen to it without crying.[4]

This chapter examines human encounters with non-human beings and places through digital sound, and the role digital sound plays in interspecies relations. In all of the above vignettes, digital sound recordings seem to, for better or worse, 'enhance' human–non-human encounters, ostensibly resulting in livelier reefs, easier kills, and deeper relationships. However, there are more to these encounters than initially meets the ear: these relations are multiple, partial, and politically charged. What does it mean to listen to an animal that can't listen back? Whose voices are recorded, by whom, and

where do they end up? What are the implications of trying to 'trick' non-humans through digital sound? What about the physical infrastructures that make these encounters possible?

Digital sound can reflect, enable, alter, and intensify human–non-human relationships to variegated, complex, and sometimes unexpected ends. In this chapter, we first reflect upon the recent proliferation of digital sound archives and sonic ecological monitoring techniques and technologies, asking what types of human–non-human relationships they represent and afford. Here, we explore the promises of digital archives and ecological monitoring systems, including their contributions to environmental conservation efforts and their ability to forge new kinds of encounters with the non-human world. Along the way, we highlight some concerns that have been raised in relation to these modes of listening, such as the role of Big Tech companies in producing ecological data sets and the asymmetrical power relations that are reproduced through digital listening. Second, we consider how digital sound alters material ecologies in multi-faceted ways, ranging from the luring or deterring of non-human beings to the environmental damage involved in creating and consuming this ostensibly intangible medium.

Throughout the chapter, we draw upon recent case studies and relevant literature from across the natural and social sciences, as a means to highlight the status of what we term 'digital sonic ecologies'. Through this term, we aim to critically theorise the multifarious interrelations between the digital, the sonic, and the non-human. Our chosen case studies throughout this chapter address just some of the ways that digital sonic ecologies manifest as we begin to investigate the promises and tensions of this terrain. We thus end our discussion by identifying new avenues for further critical research in this area. Though cognisant of literature that eschews human–non-human binaries, here we retain the framing of 'human–non-human relationships' to reflect and assess the stated promises of many digital sonic interventions, as well as to foreground the asymmetrical power relations often perpetuated by them.

Digital bioacoustics and environmental sound archives

The scientific study of animal communication through sound, termed bioacoustics, blossomed during the latter half of the twentieth century, though it has a longer history. This has been facilitated by the introduction of relatively lightweight and mobile recording technologies and, as Rachel Mundy outlines, the advent of the spectrograph recorder, which enabled researchers to visualise the frequency and amplitude of animal sounds.[5] Bioacoustic

methods are now used to detect and identify species, trace changes in animal communication across time (often as a result of anthropogenic pressures on aural space), model animal populations, and chart speciation events.

Digital sound recording technologies deepen and extend these long-standing promises of bioacoustics research. The flexibility, durability, and portability of digital recording technologies has enabled bioacoustics researchers to reach near-omnipotent levels of ecological eavesdropping in ways previously unimaginable. Entire ecosystems can be sensed through digital sensors to ascertain their ecological health across long durations of time. Emerging digital technologies and infrastructures combine to make the invariably vast data sets that such systems produce both manageable and comprehensible. Autonomous recording units relinquish the need for constant monitoring by a human operator while recording, and AI systems can detect and log specific sounds either in real time or after recording has ceased.

Concerns have been raised about the role of Big Tech firms in the rapid growth of such sonic data sets, related to the expanding capacity for surveillance and data commodification.[6] Yet there is also a burgeoning number of scientists and activists that are deploying open access digital recording technologies (Raspberry Pi-based recorders are favoured devices) to create decentralised networks of environmental sensors capable of not only monitoring animal calls but also alerting communities to particular environmental threats. Early warning detection systems, such as those that identify the sound of chainsaws as a proxy for illegal deforestation, are emerging tools for conservation efforts. Nonetheless, questions remain about the power relations, privacy, and invasiveness inherent to the production, processing, storage, and dissemination of such big data. Who gets to eavesdrop? On whose behalf? Who has access to the reams of data produced by omnipotent digital sensors, and on what terms?

In addition to species and ecosystem monitoring, omnipotent digital recording techniques are used as a means of engaging broader publics with the non-human world that faces various anthropogenic pressures. Online livestreams of coastal hydrophones continuously recording along cetacean migratory routes are particularly popular in this regard.[7] These enable listeners to encounter species that cannot ordinarily be detected through the human ear or the listening body, the alterity of deep underwater spaces, and the ubiquitous noise pollution that emanates from shipping and other coastal industries, which these species have to contend with. Terrestrial soundscapes streaming online in real time are also becoming a common sound art practice, while long-form digital soundscape recording is now a particular genre of slow radio broadcasting and podcasting.

Digital sound technologies have not only propelled the growth of data collection in the present; they have also reconfigured historical sound

archives. Museums, libraries, and research institutions that hold extensive environmental sound archives are being reshaped by digital sound technologies, in terms of the types of recordings being archived, their distribution, the spaces of their audition, and their use. With a few clicks, one can access hundreds of thousands of digital audio recordings through websites such as British Library Sounds, xeno-canto, and the Macaulay Library.[8] The Macaulay Library, part of the Cornell Laboratory of Ornithology (CLO), is a juggernaut of sonic environmental data, with more than 2 million audio recordings representing over 12,000 animal species. The Library's digital collection comprises both born-digital recordings, often uploaded to the site by amateur recordists, and digitised recordings from the CLO's archive of historical tapes. In a matter of minutes, one can sonically travel from an Atlantic puffin's burrow in 1951 New Brunswick to a Sri Lanka frogmouth calling in a forest in Kerala in 2020, to the last known recording of the (now extinct) Kauaʻi ʻōʻō in 1986 Hawaii. For those with internet access, these websites offer sonic ecological encounters far exceeding what would be possible 'in person' in a lifetime. Marketed to scientists, educators, activists, artists, and the public, they aim to encourage and enhance the building of relationships with the natural world.

Single-species recordings of birds and other animals form the backbone of the majority of recordings within environmental sound archives. This is a function of their historic role as repositories of recordings for population-level bioacoustics research, and as reference sites for the identification of species by professionals (mostly scientific taxonomists) and amateurs alike. Nonetheless, there has been a relatively recent and rapid expansion of soundscape-style recordings being archived. For instance, Cheryl Tipp, curator of the British Library's Wildlife & Environmental Sounds (WES) collection, has noticed a shift to atmospheric recordings of rural and urban landscapes, which can be explained by the emergence of digital technologies. First, the accessibility of digital recording devices has democratised sound recording beyond a relatively small cadre of professional and hobbyist wildlife recordists. Notably, increasing numbers of sound artists and experimental musicians are depositing soundscape-style recordings within the archive. Such contributions to the archive, often positioned as creative productions rather than scientific data sets, blur the boundaries between the WES and adjacent musical collections in the Library. Second, the emergence of online repositories of birdsong and calls, notably xeno-canto, and bird identifier apps that can be used in the field has led to a transformation in the ways people access and consume single-species recordings as they are no longer tethered to a physical location. This has meant that the curator is now reluctant to actively seek out such recordings for the WES archive (Figure 2.1).

Figure 2.1 Inside the WES archive at the British Library, Euston Road, London. The boxes in the stores contain single-species recordings that are in the process of being digitised. (Photograph: Jonathan Prior. All rights reserved and permission to use the figure must be obtained from the copyright holder.)

When considering human–non-human relationship building as an outcome of digital sound archives, there are certainly limits to such capacities, especially in relation to single-species recordings. For starters, the 'encounter' of listening to non-humans in this way is almost entirely one-sided: the digital animal cannot listen back. This relationship between the listener and listened-to is thus one of asymmetrical power relations,[9] an asymmetry that begins with the necessarily non-consensual extraction of animals' voices by the recordist. Further, many digital recordings focus not only on single species but individual animals, eliminating background sounds to the deficit of that animal's complex ecological context. Akin to zooming in on a subject with a camera, such recordings use particular microphones, equipment placement, and editing techniques to 'hone in' on individual animal subjects.[10] Soundscape ecologist Bernie Krause criticises such recordings as an exercise in 'fragmentation' that 'distorts a sense of what is wild by giving us an incomplete perspective of the living landscape'.[11] Rather than eschewing all individual animal recordings, however, we would suggest more creative, ecologically attuned techniques, for instance using close mic-ing techniques and non-standard recording

technologies (bat detectors, contact microphones) to spatially frame individual animal sounds. This has the potential to amplify and modulate those sounds that are usually imperceptible to humans – for example, the ultrasound of a bat in flight or Orthoptera stridulation – and those individual animal sounds that are otherwise overwhelmed by the complexity or total volume of soundscape-style approaches. We hear ample opportunities here for affective encounters with individual animals – often those that are less acoustically charismatic – in an ecologically meaningful way; that is to say, moments of attunement that may forge positive relations with non-humans, particularly for those species that tend to be misheard or neglected.[12]

Mediation is apparent in many aspects of digital sound archives: which animal is recorded, which segment is uploaded, which recording and editing technologies are used all make a difference to what kinds of relationships are possible with or through digital sonic natures. Given such issues of mediation, we might ask whether we should continue to think of digital sound recordings as representations at least mildly akin to hearing a species 'in the flesh' or if they should be recognised as something else entirely. William M. Adams raises this in regard to 'digital animals' at large, asking if digitalisation 'involve[s] the creation of new digital lives, which have no analogue in nature'.[13] This provocation is particularly interesting in relation to the sonic, as sound studies scholars routinely discuss sound as something (or some relation) that has agential and affective capacities in excess of its source.[14] Also, one never encounters the same sound twice. On playing back a digital recording, the vibrations emitted may be informed by the same stored information each time, but the sounds heard are always new, as they are shaped by the auditory space, technologies, and bodies of the listening event.[15] We might, then, recognise each press of the play button as a discrete sonic event which, though informed by an initial recording encounter and the layers of mediation that followed, has distinct affective and relational capacities. Here, a relationship may be forged *with* the digital sound recording rather than *through* it to the animal represented.

Even after all this is considered, listening to a digital recording of an animal remains a palpable experience. As Rachel Poliquin observes regarding taxidermied animal bodies, despite, and sometimes because of, the layers of abstraction and mediation in animal representation, something of an animal's 'magnetism' remains in taxidermy. She argues that the physical proximity afforded by taxidermy still 'engenders emotional intimacy' between the human and animal-thing.[16] Though sound is not a proximate physical object, the physics of listening can also forge these intimacies. Unlike taxidermy, sound is not an object but an event – an affective, relational, ephemeral force that vibrates through our entire bodies, literally moving us.[17] Listening to a sound recording is therefore intimate

and embodied, a potent force for collapsing boundaries between the listener and listened-to.[18] As such, listening *through* digital sound recordings to the species they represent may engender more compassionate relationships with non-humans than, say, viewing a digital image of the same animal. The cultural-political impacts of whale sound recordings have made this clear,[19] and digital sound archives make such affective sonic encounters widely accessible.

It is, nonetheless, difficult to quantify what such relationships might 'do' and to what extent they 'matter' in our time of ecological crisis. A web-based children's game called *BeastBox* created by DJ Ben Mirin with the CLO, for instance, advocates for the importance of encountering digital animal sounds in a more participatory medium. In this game, players act as 'Wildlife DJs', layering digital animal sounds with ecosystem recordings and beatbox beats. Mirin hopes that this game will help you, the player, to open 'a pathway for you to find your own sense of connection and love for nature so that you can be inspired to protect it'.[20] This follows the *raison d'être* of many animal representations: the *hope* that encountering virtual animals will inspire empathy towards, and thus actions to save, 'actual' animals. As demonstrated by Adam Searle, Jonathon Turnbull, and William M. Adams in their study of peregrine falcon nestcams, relations of more-than-human care can indeed emerge from virtual encounters with animals.[21] However, encounters afforded by applications like *BeastBox* – containing many animal voices out of time and context – are less discrete and their impacts are thus trickier to measure. At their most potent, these encounters *could* result in the 'interspecies epiphanies' that Jamie Lorimer describes in his exploration of non-human charisma. Here, childhood encounters with particular non-human beings can be 'the foundations for a lifetime attachment, interest, and concern'.[22] Though Lorimer explores encounters in the flesh, it is interesting to consider if such life-changing epiphanies could also occur through mediated digital encounters such as *BeastBox*, where the curiosity and awe afforded by creating music with non-human sound recordings could provide a spark towards future conservation action.[23]

What of those animals that are beyond saving? While for much of the twentieth century species rarity was treated with excitement and fascination by the custodians of wildlife sound archives, it is now tinged with regret as the biodiversity crisis unfurls. For Cheryl Tipp, the British Library's sound archive is a means of preserving environmental sonic heritage, including the sounds of extinct species: 'in these situations, sound recordings become acoustic relics of something precious that will never return. Sound archives act as the final protectors of expired voices, and have a core role in preserving the memory of our biophonic past'.[24] Similarly, the Director of the Macaulay Library, Mike Webster, asserts that sound archives act as sonic

time capsules, preserving how the world used to sound and contemporary sounds for future listeners. Though he believes all the sounds in the archive are important, the sounds of extinct species are absolutely irreplaceable, akin to 'a Rembrandt or Van Gogh'.[25] The archive, then, has an emerging role as a space for ecological memorialisation.[26] At the same time, we need to be acutely aware of the active role that sound recordings play in shaping the future of rare and declining species populations. While we may instinctively celebrate the digitisation of wildlife sound archives because this increases public accessibility and engagement with them, a movement towards unconstrained access raises serious questions for conservation ethics, which we explore in more detail in the following section.

Aside from their assumed ability to promote empathy towards the non-human world, digital sounds are also positioned as a means to create therapeutic spaces for humans.[27] There are abundant apps and long-form audio streams of nature sounds available to aid listeners with meditation, stress relief, and sleep, which draw upon vast online digital archives. Such digital resources are emerging as an important, and profitable, component of the expanding 'wellness' industry, wherein digitised nature is positioned as a surrogate for in situ nature experiences, mental health services, and corporate wellbeing procedures. However, in their investigation of the potential use of digital environmental sound in clinical settings, Victoria Bates and colleagues reject the notion that such sounds should be interpreted as surrogates for the 'real thing', and contend that they produce fundamentally different types of listening experiences to in situ listening.[28] Others have critiqued the social effects of the rapid rise of this use of digitised nature, including sound. In her analysis of digital nature in relation to health and wellbeing, Samantha Walton argues that digital nature apps are cheaper than 'balancing workloads, hiring more staff, or paying struggling workers fairly – providing a perfect sticking plaster for a neoliberal society committed to the project of "unbundling" responsibility for self-care, rather than creating a community dedicated to compassion and quality of life for all'.[29]

Digital sound and material ecologies

Digital sound recording can impact material ecologies in various ways, ranging from the use of digital voices to lure animals to local habitats, to the extractive terrains of recorded sound that involve more distant places. For a long time, the idea persisted that sound is an intangible medium, and even more so in its virtual form. Recent work on the political ecology of recorded music and media archaeology has challenged the notion that digitalisation involves dematerialisation by tracing the deep time of digital media and the

ecological damage caused by sound technologies, including digital forms.[30] Indeed, institutional digital archives have large material footprints, which runs counter to the rhetorical nebulousness of the digital 'cloud'. Data centres that sustain digital library systems are resource intensive in terms of electricity and water use.[31] The British Library's own digital library is replicated across five UK data centres, or 'nodes'. Each centre stores a copy of all digitised recordings, and they are networked with one other; if files on one server become corrupted, then they are restored by the network.[32] Thus, digitised sound archives require constant material reproduction.

If we consider the environmental history of recorded sound, every new format, whether it is shellac, vinyl, tape, or digital data, has come with its distinctive histories and geographies of extraction. The process of extraction that makes digital sound technologies possible involves raw materials, more-than-human labour relations, supply chains, toxic waste, and obsolescent media that are distributed unevenly across the globe. Today, it is possible to stream the first commercial wildlife sound recording in an instant via the British Library History of Recorded Sound collection.[33] This very first recording of a captive nightingale (*Luscinia megarhynchos*) was originally made by the bird collector Carl Reich, who had an aviary in the German city of Bremen, together with the engineer Max Hampe. Released in 1910 by the Gramophone Company, the recording with the title 'Actual Bird Record made by a Captive Nightingale' marks the beginning of commercial wildlife sound recording, a genre that would grow increasingly popular in subsequent decades. Reich released many more records of captive birds, mostly of blackbirds, canaries, thrushes, and other species that were renowned for their versatile song. Copies were distributed widely across Europe, the US, Russia, and Australia.[34] Listening to the digitised song of the nightingale on a computer or mobile phone, we can detect hisses and crackling sounds. The surface noise reveals the historical traces of now obsolete formats. In this case, the audio file we can stream online is a digitised version of a 78 rpm shellac disc from 1910 on which the nightingale was initially recorded. Thus, this audio file appears immaterial only if we fail to hear the acoustic traces of past physical media embedded in digital sound.

Shellac is an interesting material to reflect on encounters with the nonhuman in digital sound archives. Shellac discs or '78's' reveal the more-than-human agency involved in the production of value in multiple ways. First, shellac, the raw material that was used as a binding agent in the manufacture of records, is created by the labour of the lac bug (*Kerria lacca*), a South Asian scale insect. When we discuss the potential role of sound recording in conservation, we also need to consider those places and more-than-human relations that have been affected dramatically by the extraction of raw materials. The extractive frontiers of shellac include forests in

India, the more-than-human labour of shellac beetles and human harvesters, the local knowledge these highly skilled workers had of distant places and ecosystems, and supply chains and labour relations that – at the time of the first nightingale recording – were deeply exploitative and structured by colonial relations.[35] We can trace such environmental conditions and 'hidden infrastructures' that undergird every recording format, ranging from the petrochemical relations of plastic embedded in vinyl to the networks of fibre optic cables, server farms, routers, consumer electronics, and software involved in the making of digital sound.

Second, the 'Actual Bird Record made by a Captive Nightingale', like the myriad commercial bird recordings to follow, was in fact made by an actual bird whose song was captured for its particular musicality or acoustic charisma. Charismatic species, including those that are valued for their musicality, can be helpful agents in efforts to generate public enthusiasm and funding for conservation efforts.[36] There is also a certain nostalgia that fuels contemporary virtual encounters with the sounds of extinction. Birdsong can recall childhood memories and produce a sense of place. With the disappearance of many farmland birds from the acoustic landscape, a particular sense of loss is invoked, as has been recently expressed with reference to rural England.[37] But what about those birds whose song holds little value to the human ear, that merely squawk, or animals whose voices are not represented in sound archives at all and that don't fall into categories of value such as rarity, charisma, or extinction?

If we are to take seriously the provocation to centre sonic ecologies beyond human sound worlds,[38] it is important to also consider how digital sonic ecologies impact animals' sonic worlds. Intentional interventions into animals' sonic space include the use of digital sound recordings to lure animals to specific locations for scientific surveys and conservation efforts to repopulate habitats. The howlbox, for example, is a device to count and monitor wolves in remote locations without an observer needing to be present. The box repeatedly broadcasts digital recordings of wolf howls and then switches to record the howls made by wolves in response. Researchers at the University of Montana developed this cost-effective device in 2007 with funding from the Nez Perce Tribe, in anticipation of the removal of grey wolves from federal protections under the U.S. Endangered Species Act that would also end federal funding for the monitoring of wolves.[39] Interestingly, in the case of wolves, human-simulated howls have been found to elicit more wolves to respond than recordings of real wolf howls.[40]

This case study is mirrored in the proposed removal of the ivory-billed woodpecker (*Campephilus principalis*) from the Endangered Species Act due to their presumed extinction.[41] The extinction of this species is perhaps the most controversial event in US conservation history, and 'ivorybill

searchers' still trawl the Southeastern swamps of the US to capture evidence of the species' survival. Both grassroots and institutional searchers have taken advantage of the public digitisation of an ivory-billed woodpecker recording from 1935, which searchers use to train their ears, as a benchmark against which modern putative ivory-billed woodpecker recordings are measured and as a playback resource to try to locate surviving birds. Some searchers have claimed to hear surviving ivory-billed woodpeckers respond to the playback of the digitised historical recording which, if true, is an intriguing example of digital sonic ecologies in its multispecies, multigenerational, and digital/analogue hybridity. However, as with grey wolves, some searchers have found non-digital methods to be more effective, such as simulating the species' distinctive 'double-knocks' by banging wood against trees or canoes.[42]

A more popularised practice is the use of digital playback in birding, wherein birders broadcast digital sound recordings in bird habitats to increase their chances of seeing a species. Methods include playing mating calls and alarm calls or broadcasting the sounds of predators. Playback has a long history, but the accessibility of digital bird sounds and ease of playing them (often simply from digital sound archives accessed on mobile phones) means this practice has proliferated in recent years. Playback is controversial, as birds' response to digital predators, mates, and alarms is thought to potentially cause unnecessary stress, tricking them into expending energy that could be better utilised for actual threats and survival.[43] Despite these concerns, some studies have found birds habituating to and ignoring digital sounds over time.[44] Here, we can see that the birds are not just passive victims of humans' sonic intrusions, but that non-humans can have their own varying and evolving relationships with and within digital sound.

In the previous section, we saw how digitised recordings held within sound archives may help to forge compassionate relationships with the non-human world. However, digitised recordings are not inherently innocuous in configuring human–non-human relations. Cheryl Tipp notes that she has been approached on a number of occasions by people – mainly located in North America – seeking digitised animal vocalisation recordings to use as hunting aids. Similarly, the pet trade is interested in accessing digitised recordings to help track and capture increasingly rare, and thus lucrative, species. Such requests are turned down on the basis of a commitment to a preservationist ethic that extends beyond species recordings to encompass their non-digitised, living populations. However, Cheryl expressed concern that sound archives internationally are reducing the number of curators while increasing the number of AV specialists employed to digitise and publicise their collections as quickly as possible, which will have ramifications for the ethical custodianship of these recordings.

Beyond these practices to lure animals in the contexts of hunting, conservation, or birding, digital sound recordings are also used as a sonic weapon against birds and other animals in urban, agricultural, or infrastructural spaces where their appearance is considered a threat or nuisance. Around many airports, for example, larger birds whose presence might endanger human air travel are deterred with various technologies including the playback of biosonic alarms and distress calls. Digital sound deterrents are also part of the everyday 'hostile architecture' of cities. There is a flurry of commercial products available, including ultrasonic bird repellers that make use of high frequencies that can't be heard by humans and thus don't interfere in human sound worlds. However, there is no significant empirical evidence that ultrasound has an effect on birds.[45]

One example that has gained media and political attention is the auditory conflict emerging from the presence of Javan mynas (*Acridotheres javanicus*) in Singapore's central tourist areas, including Orchard Road and the residential neighbourhoods of Potong Pasir, where local residents complain about the flocks of birds and their collective squawking causing noise and a lack of sleep.[46] Considering birdsong as noise pollution stands in stark contrast to the charismatic or meditative potential of digital bird recordings discussed earlier. Such real-world sonic relations with birds in cities also call into question the presumption that 'encounters of listening' are always one-directional, fully intentional, and under the control of human listeners. Javan mynas are good urban adaptors, with well over 100,000 birds currently inhabiting Singapore. The Indonesian bird was first introduced to Singapore as a songbird through the caged bird trade in the 1920s. It is native to Java and Bali, where it is now highly endangered. The myna's appropriation of urban space sparks ongoing public debates about whether to battle these birds with various techniques including bioacoustic repellents, hawk patrols, chemicals, and modification of their habitats, or whether to accommodate them and consider Singapore an urban refugium for exotic escapees that might even help save endangered species.[47] These debates also raise wider questions about the colonial and racial legacies underpinning concerns around the presence of non-native birds in cities, including their circulation along trade routes shaped by colonialism.[48] Myna birds have been considered a problem in Singapore since the 1980s, when their numbers started to grow alongside urbanisation processes. Among the numerous methods of wildlife management that have been tested on myna birds is the broadcast of looped digital recordings of myna distress, alarm, and pre-flight calls close to roosting trees. But recent studies show that bioacoustic methods alone are of little effect as the birds quickly habituate to these sonic events.[49] This deviation of non-human bodies from the intended effects of biopolitical management through digital means calls into

question the overbearing power asymmetry often ascribed to 'the digital'. It also highlights that, especially in light of the sonic intensity of cities that birds inhabit, digital sound is only one element shaping non-human sensory worlds.

While it is clear that humans and birds alike suffer the damage loud sounds can cause to auditory receptors, we still know very little about how different species of birds hear. The wider effects of digital sound on urban ecologies, the corporeal vulnerability of animals towards excessive sound, and the changing relationships between sound, late capitalism, and urban space that can affect both human and animal health are still largely unclear. In Berlin and other cities, informal outdoor music events and mobile parties in public parks that have sought to compensate for the closure of clubs during the COVID-19 pandemic sparked debates among nature conservationists about the impact of amplified music on urban ecologies.[50] In Tulum, Mexico, a conservationist has recently warned about the negative effects of electronic music raves on birds, monkeys, and other animals.[51] These examples question the idea of the resurgence of nature in cities during the pandemic that proliferated in the media.[52] Rather, they show that in some places we can observe the contrary effect, with increasing pressures on animals through human-induced noise and the intensive use of parks and nature spaces. Preliminary studies on urban and marine ecologies have begun to investigate how animal bodies respond to music events. In Miami, Florida, for example, scientists have measured elevated sound pressure levels caused by the Ultra music festival. Sound pressure in the air and the coastal underwater soundscape caused significant endocrine stress responses in Gulf toadfish (*Opsanus beta*).[53] A study of Daubenton's bats (*Myotis daubentonii*) roosting in the roof of Brinkburn Priory in Northumberland has shown that loud sounds and bright illumination on summer festival nights make bats emerge at a later time of day, so the timing of music festivals can be crucial for bat ecologies.[54] These exploratory studies point to the need for further research that examines how amplified music and digital sound affect the acoustic spaces of non-humans in and beyond cities.

Conclusion

In this chapter, we have charted some of the ways in which digital sound can shape encounters between humans and non-humans, with a particular focus on digital sound archives and sonic ecological monitoring techniques and technologies, and how digital sound alters material ecologies. Here, we demonstrated how the use of digital sound recordings, from lures to sonic weapons, have repercussions for interspecies relations among multispecies

communities. Throughout the chapter, we have discussed some of the limitations and limits to current research. To conclude, we will now describe areas for future research that we envisage would fruitfully build upon and expand digital ecologies scholarship in the sonic sphere.

There are ethico-political tensions between the affective dimensions of experiencing non-human others through digital sound recordings and the environmental damage involved in producing and consuming digital media. These cannot be easily resolved and warrant further investigation. Looking towards the future of digital sound recordings, we need to question 'our expectations of instant access and infinite storage' engendered by digital media.[55] We might want to further explore digital sonic ecologies from a political ecology perspective. Such a perspective involves geographically tracing how digital sound recordings and their 'metabolic vehicles' (minerals, cables, wires, server farms) that are used in conservation efforts in one place produce the destruction of habitats and livelihoods elsewhere. Following feminist epistemologies, future work might also consider, for instance, the implications of sonic surveillance and the data sonification of animal voices.

Second, there are wider ethical questions that need to be addressed when producing and using digital sound recordings in the field. Thus far, there are few ethical protocols asked of researchers working with digital sound recording as an investigative method beyond conventional human procedural ethics, such as using consent forms and participant pseudonyms for human subjects.[56] As the preliminary research on digital sound recording for the tracking and monitoring of animals we have discussed has shown, sound recording devices and digital sound data can be misused for extractive purposes and to detrimental ends. There is also a significant set of questions raised by the often non-consensual nature of field recording, both in the extraction of sounds and their performance. Such questions arise in the use of sonic monitoring and control technologies, but also might be considered in relation to a recent trend of digital sonic transmission in ecological sound art.[57] Further research could help explore in more detail the ethical considerations and protocols that are needed for using digital sonic methods in and beyond the field, and in developing sensitive and caring multispecies methodologies that involve digital sound recording.[58]

A third strand for future directions involves further engagement with the role of curating digital sound archives. As the curator Cheryl Tipp highlights, we currently see a proliferation of digital sound recordings flooding archives and online platforms while, at the same time, the role of curation is significantly underfunded.[59] This situation conflicts with the importance of ethical custodianship and the need to contextualise the various local and global power relations digital sound recordings are embedded in and the types of specific technologies that have been used in the recording process.

There is also still much research to be done on the presence of non-human others in digital and digitised sound archives, and contemporary and future researchers will rely on the expertise of curators and archivists providing context to such sources. Further to this, we think an important component of future digital sonic ecologies research will be to focus on the colonial relations embedded within and reproduced through formal institutional sound archives, as scholars have considered in other contexts.[60]

Lastly, many case studies discussed in this chapter have centred on 'acoustically charismatic' species, neglecting the vast majority of extant species. This is partly a reflection of the field itself, including available archival sources that are overwhelmingly dominated by bird recordings, and the focus of contemporary research within fields such as bioacoustics, but it also reflects our own expertise and interests and thus the limitations of this chapter. We hope that future research will push beyond species deemed to be of positive sonic aesthetic value to also encompass the ugly, the mundane, and those sounds that do not equivocally and directly engender either positive or negative responses due to their alterity.[61]

Notes

1 Gordon et al., 'Acoustic enrichment can enhance fish community development.'
2 Mojo Outdoors have a range of devices and decoys: https://mojooutdoors.com/products/predator
3 Predator University, 'Tony's top killers.'
4 E.g., the thread beginning u/AwesomeFrito, 2020. See www.reddit.com/r/Naturewasmetal/comments/ew7e0u/song_of_the_last_kauai_oo_singing_to_a_mate_that/.
5 Mundy, 'Birdsong and the image of evolution.'
6 Ritts and Bakker, 'Conservation acoustics.'
7 Hydrophones are waterproofed microphones that can be used in aquatic environments. Many online streaming projects exist, but hear for example the Monterey Bay Aquarium Research Institute's Soundscape Listening Room: www.mbari.org/soundscape-listening-room/.
8 Xeno-canto is an online repository of birdsong and bird call recordings. Users can freely upload and download recordings which are held under a Creative Commons licence. See: www.xeno-canto.org/.
9 Regarding asymmetrical power relations as enacted through digital technologies, see Turnbull et al., 'Quarantine Eencounters with digital animals.'
10 Bruyninckx, *Listening in the Field*.
11 Krause, *The Great Animal Orchestra*.
12 See Bear, 'Being Angelica?' for an examination of the agency and affective capacity of individual animals, in this case an octopus named Angelica viewable in a UK aquarium.

13 Adams, 'Digital animals.'
14 E.g. Born, 'On nonhuman sound'; Gallagher, 'Sound as affect'; Robinson, *Hungry Listening*.
15 Gallagher, 'Field recording and the sounding of spaces.'
16 Poliquin, *The Breathless Zoo*, p. 136.
17 Gallagher, 'Field recording'; Gallagher, 'Sound as affect.'
18 Born, 'On nonhuman sound.'
19 See Ritts, 'Environmentalists abide.'
20 Bascomb, 'Nature and the beat.'
21 Searle et al., 'The digital peregrine.'
22 Lorimer, 'Nonhuman charisma,' p. 921.
23 The participatory nature of *BeastBox* could increase the likelihood of future conservation action by users. However, these encounters are still one-sided, and thus retain the issue of asymmetrical power relations discussed elsewhere in this chapter.
24 Cheryl Tipp, 2018, personal communication.
25 Mike Webster, 2022, personal communication.
26 For a creative sonic response to extinction, listen to the work of Sally Ann McIntyre in Boyle, 'The silence of the Huia.'
27 Berland, *Virtual Menageries*.
28 Bates et al., 'Beyond landscape's visible realm.'
29 Walton, *Everybody Needs Beauty*, p. 251.
30 Devine, *Decomposed*; Parikka, *A Geology of Media*.
31 Siddik et al., 'The environmental footprint of data centers.'
32 See www.bl.uk/legal-deposit/security-for-publications. Interestingly, the location of one of these data centres is unknown – even to Cheryl Tipp – for security reasons.
33 The sound recording can be listened to here: www.bl.uk/collection-items/nightingale-first-commercially-available-wildlife-recording-1910.
34 Tipp, 'The birth of wildlife sound recording.'
35 Melillo, 'Global entomologies.'
36 Lorimer, 'Nonhuman charisma.'
37 Adams, 'Listening and loss.'
38 Gallagher et al., 'Listening geographies.'
39 The Trump administration removed the grey wolf from federal protections under the Endangered Species Act in the lower 48 United States in 2020, a decision that was overturned by a federal judge in February 2022, restoring protection to grey wolves and prohibiting wolf hunting and trapping in states outside of the northern Rocky Mountains. For the discussion around the funding by the Nez Perce Tribe, see Johnson, 'A bid to lure wolves.'
40 Brennan et al., 'Testing automated howling devices.'
41 United States Fish and Wildlife Service, 'Endangered and threatened wildlife and plants.'
42 See Gallagher, *The Grail Bird*.
43 Due to such concerns, many organisations dissuade playback while birding, particularly when it comes to endangered birds (e.g. *Australian Wildlife*

Conservancy and *Environment and Climate Change Canada*). However, empirical research on the actual impact of digital playback on birds is limited.

44 Harris and Haskell, 'Simulated birdwatchers' playback.'
45 Beason, 'What can birds hear?'
46 See Choo, ' "Cacophony" of mynah birds.'
47 Gibson and Yong, 'Saving two birds with one stone.'
48 Barua, 'Feral ecologies.'
49 Jaimipak et al., 'Effects of distress.'
50 Personal communication with the Berlin-based nature conservationist Rainer Altenkamp.
51 Olufemi, 'Noise pollution is harming wildlife in Tulum.'
52 Searle and Turnbull, 'Resurgent natures?'
53 Cartolano et al., 'Impacts of a local music festival.'
54 Shirley et al., 'Assessing the impact of a music festival.'
55 Devine, *Decomposed*, p. 187.
56 A lack of protocols is the case for much qualitative and especially ethnographically focused research on non-human others that takes place outside the traditional laboratory space. See Oliver, 'Beyond-human ethics.'
57 For instance, the project 'Radio Amnion: Sonic transmissions of care in oceanic space' claims to quietly transmit digital sound art compositions in the Pacific Ocean's Cascadia Basin during each full moon, with the intended listening audience of 'the Ocean itself'; see: https://radioamnion.net/#about.
58 See Wright, 'Listening after nature' for an initial survey of what this might sound like.
59 Cheryl Tipp notes that outside of the WES, The Macaulay Library, and the Animal Sound Archive at the Museum für Naturkunde Berlin, funding streams are not consistent for dedicated wildlife and environmental sound archives.
60 See, for example, Nannyonga-Tamusuza and Weintraub, 'The audible future,' p. 206.
61 An important deviation from the foregrounding of positive aesthetic value in wildlife recording is Michael, 'Toward a dark nature recording.' Michael advocates for a 'Dark Nature Recording,' celebrating practices like Chris Watson's track *Vultures, Nine Birds Feeding on Zebra Carcass, Itong Plains, Kenya* that starkly resists the romantic aesthetics of nature sound recording. For a discussion about the overwhelming focus on positive sonic aesthetics in environmental aesthetics scholarship, see also Prior, 'Sonic environmental aesthetics and landscape research.'

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